CHEMICAL APPARATUS

Plate V.

Fig.1.

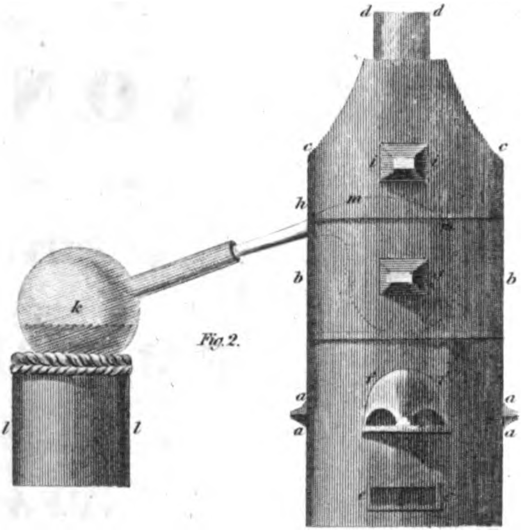


Fig.2.

Fig.3.

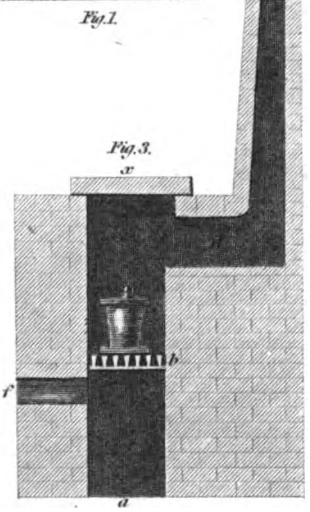


Fig.4.

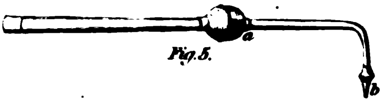
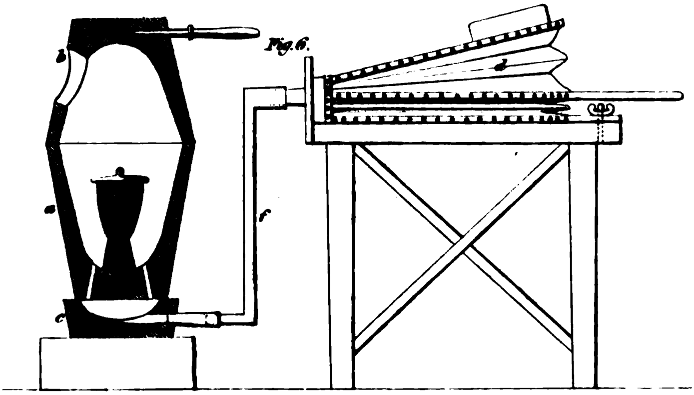


Fig.5.

Fig.6.



Cooper sculp.

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A

DICTIONARY

OF

PRACTICAL AND THEORETICAL CHEMISTRY,

WITH ITS APPLICATION TO THE
ARTS AND MANUFACTURES,
AND TO THE
EXPLANATION OF THE PHÆNOMENA OF NATURE:
INCLUDING THROUGHOUT
THE LATEST DISCOVERIES, AND THE PRESENT STATE OF
KNOWLEDGE ON THOSE SUBJECTS.

WITH PLATES AND TABLES.

BY WILLIAM NICHOLSON.

PRINTED FOR RICHARD PHILLIPS, No. 6, BRIDGE-STREET.

1808.

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ADVERTISEMENT.

THIS work, though formed on the basis of the Dictionary in two volumes quarto, published several years since, by the same Author, is in effect AN ENTIRELY NEW WORK; the articles being either considerably enlarged, or entirely re-written, and in every instance being adapted to the present improved state of Chemical Science.

A
DICTIONARY
OF
CHEMISTRY.

ABSORBENT. The more soluble earths, more especially the porous friable specimens, were formerly distinguished by the name of absorbent earths. This division comprehended clay, lime, and magnesia; but modern chemists have justly rejected the denomination as vague and indefinite.

Absorption. By this term chemists understand the conversion of a gaseous fluid into a liquid or solid on being united with some other substance. It differs from condensation in this being the effect of mechanical pressure, or the abstraction of caloric. Thus, if muriatic acid gas be introduced into water, it is absorbed, and muriatic acid is formed; if carbonic acid gas and ammoniacal gas be brought into contact, absorption takes place, and solid carbonate of ammonia is produced by the union of their ponderable bases.

There is a case of condensation, which has sometimes no doubt been mistaken for absorption, though none has taken place. When an inverted jar containing a gas confined by quicksilver is removed into a trough of water, the quicksilver runs out, and is replaced by water. But, as the specific gravity of water is so much inferior to that of quicksilver, the column of water in the jar resists the atmospheric pressure only with 1-14th the power of the quicksilver, so that the gas occupies less room from being condensed by the superior pressure, not from absorption.

Abstraction. In the process of distillation, the volatile products which come over, and are condensed in the receivers, are sometimes said to be abstracted from the more fixed part which remains behind. This term is chiefly used when an acid or other fluid is repeatedly poured upon any substance in a retort, and distilled off, with a view to change the state or composition of either. See Distillation.

Acescent. A substance which becomes sour or acid by spontaneous decomposition is said to be acescent. This word is sometimes used, but less properly, instead of acidulous, or subacid, to denote a substance slightly acid.

Acetats. The salts formed by the combination of the acetic acid with alkalis, earths, and metals. Of these little is yet known.

Acetits. The salts formed by the combination of the acetous acid with alkalis, earths, and metals. For the alkaline and earthy salts, see Acid (Acetous); and for the metallic, the respective metals.

Acetous. Of or belonging to vinegar, or the acetous acid. See Acid (Acetous).

Achromatic. Telescopes formed of a combination of lenses, which in a great measure correct the optical aberration arising from the various colours of light, are called achromatic telescopes. Some of these have been made wonderfully perfect, and their excellence appears to be limited only by the imperfections of the art of glass-making. The artifice of this capital invention of Dollond consists in selecting, by trial, two such pieces of glass, to form the object lenses, as separate the variously coloured rays of light to equal angles of divergence, at different angles of refraction of the mean ray; in which case it is evident, that, if they be made to refract towards contrary parts, the whole ray may be caused to deviate from its course without being separated into colours. The difficulty of the glass-maker is in a great measure confined to the problem of making that kind of glass which shall cause a great divergence of the coloured rays with respect to each other, while the mean refraction is small. See Glass; also Aplanatic.

Acid. In the infancy of any science, when the attention of its cultivators is chiefly employed upon substances that differ from each other by great and obvious variations, it is easy to establish criterions, by which the classification of bodies may be effected: but when any particular branch is carried to a considerable degree of perfection, there will always be found a variety of articles, which form a connection between one class and another, and render it difficult to draw the line of discrimination. Acids were formerly distinguished by the popular criterion of the taste which is peculiar to them, and is denoted by the word sourness. Modern discoveries have, however, exhibited acids, in which the leading properties are too obscure to be of any great utility in determining their nature when unknown; and it is only from the general assemblage of properties, that they can be distinguished. These properties are,

1. Their taste is sour, and, unless diluted with water, corrosive. 2. They change blue vegetable colours to red. 3. Most of them unite with water in all proportions; and many have so strong an attraction to that fluid, as not to be exhibited in the solid state. 4. At a moderate temperature, or in the humid way, they combine with alkalis so strongly, as to take them from all other substances. 5. They combine with most bodies, and form combinations attended with many interesting phænomena; upon the due explanation of which great part of the science of chemistry depends.

There are a considerable number of instances in which combustible substances are converted into acids by being burned. Thus sulphur, by combustion, affords sulphuric acid; azotic air, repeatedly ignited by electricity, affords nitrous acid; and phosphorus, by burning, is converted into phosphoric acid. The analogy of other facts appears to justify the general position, that acids consist each of a peculiar basis, altered by combustion; and, as it is now generally admitted that the vital or truly respirable part of the atmosphere, that is oxigen, is absorbed during combustion, it will follow that an acid consists of a combustible substance united with oxigen.

This is indeed the simplest way of stating the result. But it is of the greatest importance, in scientific pursuits, to be cautious in simplifying our deductions. General hypotheses are most commonly constructed, by overlooking such concomitant circumstances in natural events as are least striking; but which, nevertheless, cannot be reasoned out of the course of the actual processes. When this expedient is used to obtain a delusive show of simplicity, the business of inquiring into the phænomena which are exhibited around us degenerates into a war of words, and the facts are no longer impartially displayed; such facts being always esteemed of greatest value as seem most effectual in supporting the favourite system. It must be confessed, however, on the other hand, that all useful investigation must necessarily tend to the discovery of general truths, and the developement of the simple laws of nature; that systems, formed in the less perfect state of any science, will of course be founded on fewer facts, and will, by successive emendation, become more and more complicated; and, consequently, that the real improvement of any theory will almost always consist in the rejection of principles formerly held to be essential to the science.

Oxigen, however, does not always form acids, and acids may be formed without the presence of oxigen. And if we suppose oxigen to be neutralized in the former case, as when hidrogen by its combination with it forms water, in which no acidity can be discovered; how is it that this same hidrogen, when combined with sulphur, possesses the properties of an acid? Hence Berthollet infers, that the principle of acidity must be something different from oxigen; and he is inclined to revive an old doctrine, that it is the matter of fire.

Several ingenious attempts have been made to ascertain the strength of acids, and the real quantity of saline matter contained in such as cannot, by any means hitherto devised, be deprived of water. Both these objects are very difficult to be obtained, and the latter, more especially, does not seem to be determinable by any other process, than such as shall actually leave the acid in a pure state, without the presence of water or any other substance. The prospect of this appears to be so unpromising, as almost effectually to discourage any attempts at performing it. The former inquiry seems to be within our power, provided the determination of the strength of acids be understood to imply nothing more than to deduce a method of ascertaining the quantity of acid, of a given density, which may be contained in any given measure of the same acid, more or less diluted with water. Experiments carefully made, by adding certain regulated quantities of water to equal portions, of the densest acids, will exhibit a series of densities or specific gravities, which, being tabulated, will serve to indicate the quantities of the densest acid which may be contained in any other portions of the same acid examined at the temperature of the original experiments, or with a due allowance for any variation between the temperatures. The utility of such tables has long been admitted in the mixtures of water and alcohol. See ALCOHOL.

A very usual method of ascertaining the comparative strengths of different acids, consists in saturating them with alkaline salt; that acid being supposed the strongest which requires the greatest quantity of alkali to cause the total disappearance of its acid properties: concerning which, however, see ATTRACTION. Against this, it is an insurmountable objection, that the acids do not differ from each other merely in strength, as estimated by this criterion, but are principally distinguished from each other by their several attractions to other substances, which follow no constant law deducible from experiments made with alkalis. So that the acid, which requires the greatest quantity of alkali for its saturation, will not maintain the same precedence when applied to earths, metals, or combustible bodies. As the method of examination by alkalis may nevertheless have its uses, especially in acids of the same kind, it is proper to observe, that the best mode of using the alkali is in a solution of a determinate specific gravity, as the real quantity of alkali may thus be ascertained with more accuracy, than if it were in a dry form. Distilled water must be used, and the specific gravity of this should be previously determined. The alkali too should be perfectly freed from carbonic acid, by boiling with quicklime, as directed under the article POTASH. By this test the proportional strength of different specimens of the same acid may be accurately known.

The acids hitherto discovered have been usually distributed into classes, accordingly as their radicals are derived from the mineral, vegetable, or animal kingdom. A more scientific mode has lately been attempted, that of classing them by the number of their radicals: but in the present state of our knowledge this mode is very imperfect, as some of the acids have never yet been decomposed, so as to ascertain whether they have in fact one or more radicals. Thus far therefore it is defective: and the difference at the same time is rather nominal than real; for the acids derived from the mineral kingdom are all considered in this arrangement as being compounds, while those from the other two are confounded together, as consisting of three or more ingredients; two only, the prussic and lithic, having four.

We are at present acquainted with 31. Of these, 16 are obtained from the mineral kingdom. 1. The sulphuric acid. 2. The sulphurous. 3. The nitric. 4. The muriatic. 5. The oxigenated muriatic. 6. The hyperoxigenated muriatic. 7. The carbonic. 8. The phosphoric. 9. The phosphorous. 10. The boracic. 11. The fluoric. 12. The arsenic. 13. The arsenious. 14. The molybdic 15. The molybdenous. 16. The chromic.

The vegetable kingdom furnishes us with 12. 1. The acetous. 2. The acetic. 3. The oxalic. 4. The malic. 5. The citric. 6. The tartarous. 7. The mucous. 8. The gallic. 9. The benzoic. 10. The succinic. 11. The camphoric. 12. The suberic.

From the animal kingdom 3 are obtained. 1. The prussic. 2. The lithic. 3. The sebacic

Besides these, there are 6 doubtful. 1. The melitic, from the mineral kingdom. 2. The moroxylic, from the vegetable 3. The amniotic. 4. The bombic. 5. The laccic. 6. The rosacic; all from the animal kingdom.

ACID (ACETIC). Radical vinegar, as this acid was formerly called, after having been considered as the acetous acid simply in a concentrated state, was long presumed to differ from it in being more oxigenised; whence it was distinguished, according to the principles of the new nomenclature, by the termination in *ic*.

From some late experiments of Mr. Pérès, however, and more recently of Chaptal, it appears to differ from the acetous acid by an abstraction of part of one of the ingredients of its compound base, the carbon, while the proportions between the oxigen and hidrogen remain the same in both.

The following is one of the experiments by which this conclusion is supported:

A hundred parts of each of the acids, the acetous and acetic, being saturated with pure potash, and the solutions evaporated, each affords a white, foliated deliquescent salt. Equal parts of each of these salts being put into two retorts, and exposed to an equal, graduated, and violent heat, two or three drops of a fetid and acrid water, without any acidity perceptible to the taste, passed over from the acetate; while the acetite gave out only some fumes, diffusing a similar smell. Both the salts melted and grew black; and as the heat was augmented, the retorts and receivers were covered within with a white vapour, which ultimately disappeared. A black residuum was left in each retort, and being washed by repeated affusions of boiling distilled water, the remainder, when dry, exhibited all the characters of oxide of carbon. The quantity of this oxide of carbon obtained from the acetate was 1-17th of its weight; that from the acetite 1-13th.

Thus, as all the vegetable acids yet known consist of a binary radical, compounded of hidrogen and carbon, which are combined with oxigen, and differ only in their relative proportions, this has perhaps as fair a claim to be considered as a different acid, as at least some of the others; though, while it is classed as a modification of the acetous, its termination is appropriate, as it virtually contains more oxygen, if it be not formed by an addition of this principle to the acetous acid itself.

Indeed it would appear probable, from some experiments since made by Mr. Dabit of Nantes, that there is an actual addition of oxigen. On distilling a mixture of acetite of potash and sulphuric acid, the product was acetic acid: on substituting muriatic acid for the sulphuric, acetous acid was obtained; but when he added black oxide of manganese to the latter mixture, acetic acid was formed. In none of these cases was any carbonic acid emitted, till toward the end of the distillation.

This acid has been generally obtained by distilling the crystallized acetit of copper. This being reduced to powder, and put into a glass or earthen retort, a fluid possessing little acidity first rises, which is soon succeeded by a very powerful acid. The receiver is then changed to obtain the latter separate. This acid has a greenish hue, from a small portion of oxide of copper coming over with it, and requires to be rectified by distillation with a gentle heat. It may thus be obtained perfectly colourless, if the fire be not urged too much toward the end of the operation, and the portion of oxide of copper left in the retort be not distilled too dry. The residuum of the first distillation is a brown copper-coloured powder, frequently exhibiting a metallic appearance on the sides of the retort: it is a powerful pyrophorus, contains but little oxide, and a little carbon.

This process requires some care, that the acid may be perfectly divested of the deleterious principles of the copper. Mr. Badollier, an apothecary of Chartres, recommends, as an easier method, the distillation of a mixture of equal parts of acetite of lead and sulphat of copper, by a moderate heat; when he says the acid will come over perfectly pure: but this has not succeeded in the hands of some other chemists, who always found the product contaminated with sulphurous acid. All danger of impregnation with copper, however, may be avoided, by obtaining the acid from acetit of soda, distilled with half its weight of sulphuric acid. Indeed Pérès, who has been already quoted, affirms, that he obtains a large quantity of acetic acid, as colourless and pungent as the radical vinegar of the shops, by distilling two parts of good white wine vinegar with one of sulphuric acid, and bringing the mixture suddenly to ebullition.

Acetic acid is transparent and colourless like water. Its smell is extremely pungent and acrid. When applied to the skin, it reddens and corrodes it in a very short time. It is exceedingly volatile, wholly evaporating on exposure to the air; and when heated in the open air takes fire readily. At 50° below 0 it freezes. It unites with water in any proportion, and on mixture with it heat is evolved. It forms salts termed acetates with earths, alkalis, and metals, which differ from the acetites, though their nature has not yet been much examined. It acts with more energy than the acetous on metals. It dissolves camphor, and the essential oils, as was observed by the elder Mr. Henry of Manchester; and a preparation of this kind, first made by him, is sold by the name of *aromatic vinegar*.

It is used for smelling to in cases of faintness, little crystals of sulphat of potash being put into a bottle, and moistened with it for this purpose. This mixture is commonly called *volatile salt of vinegar*. A few drops of sulphuric acid, added to a phial of the acetite of potash, make a strong smelling bottle by the evolution of the acetic acid.

This acid is sometimes contaminated with sulphurous acid, which may be known by the vapour occasioning an unpleasant sensation in the lungs; with sulphuric, which may be detected by muriate of barytes; with copper, which supersaturation with pure ammonia will show; with lead, the test of which is sulphuret of ammonia. Its specific gravity should be at least 1·060. —*Lagrange.* — *Thomson.* — *Fourcroy.* — *Parkinson.* — *Henry.* — *An. de Chimie.*

Acid (Acetous). This acid is produced by a peculiar fermentation from vinous liquors. See Fermentation (Acetous). Its qualities depend much on the method of exciting and of conducting that fermentation. The wine which in France is generally converted into vinegar, and which for its cheapness is generally employed for this purpose, is such as has become already sour; although the better and the more spirituous the wine is, and also the more of the vinous spirit that can be retained in the vinegar, the better and stronger this will be. Becher says in his Physica Subterranea, that having digested wine in order to convert it into vinegar in a bottle hermetically sealed, he found, that although a longer than the ordinary was required, the vinegar produced was much stronger than when free air is admitted. Cartheuser also affirms, that the strength of vinegar may be much increased, by adding some ardent spirit to the wine before it is exposed to the acetous fermentation.

Different methods are practised by manufacturers for making vinegar, who are generally believed to be possessed of some secret for this purpose. Nevertheless, no more seems requisite in the preparation of good vinegar, than to employ wine, and to conduct the fermentation in the most advantageous method; in the same manner as good wine can only be made from good must, and by a well conducted fermentation. The principal part of these operations is performed by nature.

The method of making vinegar consists in mixing the wine to be fermented with its dregs and its tartar, and in exposing this liquor to a heat of about seventy or eighty degrees. This fermentation seems to require more heat than the spirituous. It also excites more heat and tumult; and although it ought to be allowed to proceed briskly, yet it is necessary from time to time to check it.

Boerhaave describes, in his Elements of Chemistry, the following process, which seems to be well contrived for the making of vinegar.

Take two large oaken vats, or hogsheads, and in each of these place a wooden grate or hurdle at the distance of a foot from the bottom. Set the vessel upright, and on the grate place a moderately close layer of green twigs, or fresh cuttings of the vine. Then fill up the vessel with the footstalks of grapes, commonly called the cape, to the top of the vessel, which must be left quite open.

Having thus prepared the two vessels, pour into them the wine to be converted into vinegar, so as to fill one of them quite up, and the other but half full. Leave them thus for twenty-four hours, and then fill up the half-filled vessel with liquor from that which is quite full, and which will now in its turn only be left half full. Four-and-twenty hours afterwards repeat the same operation, and thus go on, keeping the vessels alternately full and half full during twenty-four hours till the vinegar be made. On the second or third day there will arise in the half-filled vessel, a fermentative motion, accompanied with a sensible heat, which will gradually increase from day to day. On the contrary, the fermenting motion is almost imperceptible in the full vessel; and as the two vessels are alternately full and half full, the fermentation is by this means in some measure interrupted, and is only renewed every other day in each vessel.

When this motion appears to have entirely ceased, even in the half-filled vessel, it is a sign that the fermentation is finished; and therefore the vinegar is then to be put into casks close stopped, and kept in a cool place.

A greater or less degree of warmth accelerates or checks this, as well as the spirituous fermentation. In France it is finished in about fifteen days, during the summer; but if the heat of the air be very great, and exceed the twenty-fifth degree of Reaumur's thermometer, (88½° Fah.,) the half-filled vessel must be filled up every twelve hours; because, if the fermentation be not so checked in that time, it will become violent, and the liquor will be so heated that many of the spirituous parts, on which the strength of the vinegar depends, will be dissipated, so that nothing will remain after the fermentation but a vapid liquor, sour indeed, but effete. The better to prevent the dissipation of the spirituous parts, it is a proper and usual precaution to close the mouth of the half-filled vessel, in which the liquor ferments, with a cover made of oak wood. As to the full vessel, it is always left open, that the air may act freely on the liquor it contains; for it is not liable to the same inconveniencies, because it ferments but very slowly.

In the Dictionnaire Portatif des Arts et Métiers, another method is described, by which a very good vinegar is commonly made at Paris from the lees of wine. For this purpose all the wine contained in the lees is pressed out and put into large casks, the bung-holes of which are left open. These casks are put into a hot place, and if the fermentation proceeds too fast, it must be checked by adding more fresh wine. The process is very similar to the foregoing.

In this country wine of course is not used, but other matters susceptible of undergoing the vinous fermentation; as an infusion of malt, cider, melasses, the refuse raisins left after making raisin wine. Many persons make a good vinegar for domestic purposes by exposing coarse sugar or melasses, mixed with water, to the heat of the sun in summer, in a vessel not closely stopped.

The appearances which accompany the acetous fermentation, resemble much those that occur in the spirituous fermentation. In both fermentations an intestine motion, a swelling, a hissing noise, and an ebullition may be perceived. There are, nevertheless, essential differences between them. Besides that the products of the vinous and acetous fermentations differ exceedingly, the heat produced by the former is scarcely sensible, while that produced by the latter is considerable. Again, there is reason to believe that the vapour which exhales from vinegar during fermentation is not noxious, as the vapour of fermenting wine is; at least, it has not been observed to produce such bad effects. On the contrary, as the acid of vinegar more and more disengages or unfolds itself, it seems to acquire more power to retain the basis of carbonic acid, which is the truly dangerous part of the vapours of fermentation. Lastly, vinegar does not deposit tartar as wine does, even although it has been made with wine that had not deposited its tartar. But the sediment of vinegar is a viscid, oily, and very putrescent matter. The grape-stalks used in the making of vinegar, to promote and increase the fermentation, are covered over with this matter during the operation. They are generally washed clean, and carefully preserved, to promote the fermentation of more vinegar, because the acid with which they are soaked acts powerfully as a leven or ferment. The casks also which have been used for the preparation of vinegar are to be cleansed from the abovementioned viscid matter, and kept for the same use, as they are rendered fitter than new casks for the preparation of vinegar. The concrete mucous sediment produced from the slow decomposition of vinegar, and called mother, is likewise an acetous ferment, and is used for this purpose by the country people in France.

It appears that the strength of vinegar is impaired by too speedy fermentation in vessels not at all stopped, most probably from the escape of alcohol, which certainly contributes to its fermentation. Hence small casks or vessels imperfectly closed, are best suited to this process. In England the vinegar makers use several hundreds of casks disposed in the open air, with the bung-hole upwards, and covered each with a tile to exclude the rain. Beer is brewed of a proper strength from malt for this express purpose. The addition of hops is not here used.

Milk also affords vinegar by fermentation. This fluid does not afford ardent spirit enough to favour the operation, which therefore requires either the addition of a small portion of spirit, or a considerable heat, such as that of a warm oven for two or three days.

Much ingenious reasoning has been offered by philosophers on the effects of the acetous fermentation, and the component parts of vinegar. The leading and established facts are, that mucilage is necessary for the production of this acid by fermentation, and that oxygen is absorbed in the process. From the order of convertibility of vegetable acids into each other, it appeared highly probable, that these had one common basis, and differed only in the greater or less degree of acidification. And in fact it is now known, that they have all the same radical, consisting of hidrogen and carbon; but, these differ in their proportion to each other, as well as in the relative proportion of oxigen.

Vinegar thus prepared, however, is not pure acetous acid, as it contains likewise mucilage, tartar, colouring matter, and frequently the malic and citric acids. In this state it is very subject to decomposition; but Scheele discovered, that if it be made to boil for a few moments, it may be kept afterwards a long time without alteration. When distilled at a temperature not exceeding that of boiling water, till about two-thirds of it have passed over, all these impurities are left behind, and the product, commonly known by the name of distilled vinegar, is pure acetous acid. If it be not distilled gently, or too much be drawn off, it acquires an empyreuma.

Glass vessels are preferable for the distillation of vinegar; as well as for most other chemical operations, where their size and the required heat will permit. Earthen or stone ware vessels may also be used. For larger quantities a copper alembic with a glass head and worm pipe of pure tin is recommended. Some direct that the inside should be tinned, and others that it should be smeared with grease. This last contrivance does not seem to promise much advantage, and may vitiate the acid, since Rozier remarks, that fat oils and vinegar have some action on each other in distillation. There is probably nothing to fear from the bare copper, if the vinegar be poured in hot. For the confectioners have long since remarked, that hot vinegar does not corrode or receive any impregnation from the copper vessels, though there is much danger in suffering it to remain in them cold. This has been explained, not from the difference of temperature, but the exclusion of the external air by the vapo of the hot fluid, which in neither case act on the copper, unless oxigen be pres to be absorbed.

Though the acetous acid is commonly product of the acetous fermentation, ve may be obtained by other means. The insip saccharine, mucilaginous, and extractive m ters of vegetables may be converted i this acid by various processes. The sp taneous action of the sulphuric acid up them always changes them in part i acetous acid. Fourcroy remarks, that t mere tendency of concentrated sulphu acid to saturate itself with water is a ve active cause of the alteration it occasions vegetable substances. This alteration co sists in three different though simultaneo effects: on one hand it unites a portion their hidrogen with a portion of their ox gen to form the water with which it sat rates itself: on the other, carbon is sep rated, which imparts to the mixture a brow and even black colour, and soon precip tates to the bottom of the acid; at th same time a third portion of these matte passes to the state of acetous acid, whic remains mixed with the sulphuric, and ma be separated from it by distillation; so tha there is no vegetable substance, whic treated in the cold way with this poten acid, does not yield more or less acetou acid, on being afterward subjected to th action of fire.

Nitric acid, which has such a powerfu tendency to destroy vegetable compounds always forms from them a little aceto acid, at the same time with the mucous an oxalic, and perhaps even malic acid. Crel showed long ago, that alcohol itsel was partly converted into acetous acid when treated with the nitric. Even the muriatic acid, though much less powerful than the sulphuric or nitric, effectuates a similar conversion, when allowed to stand a considerable time on vegetable substances. But above all the oxigenated muriatic acid, notwithstanding its little solubility, being received in the state of gas into vegetable juices, or solutions of vegetable substances, has the property of converting part of them into acetous acid. Thus, on treating alcohol by this agent it is converted much more into acetous acid than into ether; and for this reason the muriatic ether is always acid, and but little in quantity.

It has been supposed, that all the other vegetable acids were capable of passing to the state of acetous acid, and that this was the common term of their acidification; but it has by no means been fully proved. If in fact the tartarous acid, as well as the malic, appear to be susceptible of this conversion; and if the tartarous acidule may be considered, from its constant presence in wine, as the ferment that induces its acetification, and as affording a matter itself that becomes acetous acid: the same cannot be said of the oxalic acid, the strongest and most unalterable of all the vegetable acids, and one that resists all spontaneous alteration, in the same circumstances under which the tartarous acid and tartrits are decomposed and destroyed.

Neither does the acetous fermentation absolutely require to be preceded by the vinous, as was formerly supposed, and too implicitly believed on the authority of Boerhaave. In reality, says Fourcroy, all vegetables are capable of undergoing the acid or acetous fermentation, without having experienced the vinous. This is the case with leaves and roots; with cabbages soured in water, to make sour crout; starch or farina in starch-makers' sour waters; and dough itself, which, if it be suffered to ferment a little too violently, becomes acid, and gives a very perceptible sour taste to the bread made of it. In the instances just given it was imagined, that an imperceptible vinous fermentation first took place: but we cannot admit a vinous fermentation, of which we have no proof and no appearance, in the sap of trees at the moment of its extraction, and in extracts speedily prepared, all which contain acetous acid. The urine too of man, and of some animals, certainly does not undergo the vinous fermentation, yet it readily affords this acid by an intestine movement of its own component parts. We must conclude, therefore, that there is an acetous fermentation independent of the vinous, as well as a formation of acetous acid in matters not in the state of wine.

The acetous acid is perfectly limpid, of a tolerably pleasant smell, a pungent acid taste, and of a specific gravity not exceeding 10·005. It is more volatile than decomposable, and exposed alone to the fire evaporates entirely. It has no action on hidrogen, carbon, phosphorus, or sulphur. With the mode in which it is affected by the potent acids, we are not yet fully acquainted; though it is known that, concentrated sulphuric acid being poured on 2 parts of acetite of potash, in a tubulated retort, and exposed to a gentle heat, sulphurous acid and acetic acid will be given out with great effervescence; and nitric acid decomposes it into water and carbonic acid. It weakly dissolves the boracic acid, and absorbs the carbonic. Charcoal, according to the discovery of M. Lowitz, has the property, when powdered and mixed with the acetous acid, of retaining the acid part, and allowing the watery to evaporate, at the heat of 212°. If the charcoal be afterward exposed to a strong heat, the acetous acid is driven off; and thus Lowitz obtained it in a very highly concentrated state.

The acetous acid unites with all the alkalis and most of the earths, and with these bases it forms compounds, some of which are crystallizable, and others have not yet been reduced to a regularity of figure. The salts it forms are distinguished by their great solubility; their decomposition by fire, which carbonizes them; the spontaneous alteration of their solution; and their decomposition by a great number of acids, which extricate from them the acetous acid in a concentrated state. It unites likewise with most of the metals.

With barytes the saline mass formed by the acetous acid does not crystallize; but, when evaporated to dryness, it deliquesces by exposure to air. This mass is not decomposed by acid of arsenic. By spontaneous evaporation, however, it will crystallize in fine transparent prismatic needles, of a bitterish acid taste, which do not deliquesce when exposed to the air, but rather effloresce.

With potash this acid unites, and forms a deliquescent salt scarcely crystallizable, called formerly foliated earth of tartar, and regenerated tartar. The solution of this salt, even in closely stopped vessels, is spontaneously decomposed: it deposits a thick, mucous, flocculent sediment, at first gray, and at length black; till at the end of a few months nothing remains in the liquor but carbonate of potash, rendered impure by a little coaly oil.

With soda it forms a crystallizable salt, which does not deliquesce. To this salt no name has been generally given, though it has very improperly been called mineral foliated earth. According to the new nomenclature it is acetite of soda.

The salt formed by dissolving chalk or other calcareous earth in distilled vinegar, formerly called salt of chalk, or fixed vegetable sal ammoniac, and by Bergman calx acetata, has a sharp bitter taste, appears in the form of crystals resembling somewhat ears of corn, which remain dry when exposed to the air, unless the acid has been superabundant, in which case they deliquesce. By distilling without addition, the acid is separated from the earth, and appears in the form of a white, acid, and inflammable vapour, which smells like acetous ether, somewhat empyreumatic, and which condenses into a reddish brown liquor.

This liquor, being rectified, is very volatile and inflammable: upon adding water it acquires a milky appearance, and drops of oil seem to swim upon the surface. After the rectification, a reddish brown liquor remains behind in the retort, together with a black thick oil. When this earthy salt is mixed with a solution of sulphate of soda, the calcareous earth is precipitated along with the sulphuric acid, the acetous acid uniting with the soda, makes a crystallizable salt, by the calcination of which to whiteness, the soda may be obtained. This acetous calcareous salt is not soluble in spirit of wine.

Of the acetite of strontian little is known, but that it has a sweet taste, is very soluble, and is easily decomposed by a strong heat.

The salt formed by uniting vinegar with ammonia, called by the various names of spirit of Mindererus, liquid sal ammoniac, acetous sal ammoniac, and by Bergman alkali volatile acetatum, is generally in a liquid state, and is commonly believed not to be crystallizable, as in distillation it passes entirely over into the receiver. It nevertheless may be reduced into the form of small needle-shaped crystals, when this liquor is evaporated to the consistence of a syrup.

Westendorf, by adding his concentrated vinegar to carbonate of ammonia, obtained a pellucid liquid, which did not crystallize, and which by distillation was totally expelled from the retort, leaving only a white spot. In the receiver under the clear fluid a transparent saline mass appeared, which being separated from the fluid, and exposed to gentle warmth, melted, and threw out abundance of white vapours, and in a few minutes shot into sharp crystals resembling those of nitre. These crystals remain unchanged while cold, but they melt at 120° and evaporate at about 250°. Their taste at first is sharp and then sweet, and they possess the general properties of neutral salts.

With magnesia the acetous acid unites, and, after a perfect saturation, forms a viscid saline mass, like a solution of gum arabic, which does not shoot into crystals, but remains deliquescent, has a taste sweetish at first, and afterward bitter, and is soluble in spirit of wine. The acid of this saline mass may be separated by distillation without addition.

Glucine is readily dissolved by acetous acid. This solution, as Vauquelin informs us, does not crystallize; but is reduced by evaporation to a gummy substance, which slowly becomes dry and brittle; retaining a kind of ductility for a long time. It has a saccharine and pretty strongly astringent taste, in which that of vinegar however is distinguishable.

Yttria dissolves readily in acetous acid, and the solution yields by evaporation crystals of acetite of yttria. These have commonly the form of thick six-sided plates, and are not altered by exposure to the air.

Alumine, obtained by boiling alum with alkali, and edulcorated by digesting in an alkaline lixivium, is dissolved by distilled vinegar in a very inconsiderable quantity. A considerable quantity of the earth of alum, precipitated by alkali, and edulcorated by hot water in Margraaf's manner, is soluble in vinegar, and a whitish saline mass is then obtained, which is not crystallizable. From this mass a concentrated acetous acid may be obtained by distillation. Or to a boiling solution of alum in water gradually add a solution of acetate of lead till no further precipitate ensues. The sulphate of lead having subsided, decant the supernatant liquor, evaporate, and the acetat of alum may be obtained in small needle-shaped crystals, having a strong styptic and acetous taste. This salt is of great use in dyeing and calico-printing. The alumine must be recently precipitated, and 240 parts of the acid dissolve only 20 5-7ths.

Acetit of zircone may be formed by pouring acetous acid on newly precipitated zircone. It has an astringent taste. It does not crystallize; but, when evaporated to dryness, forms a powder, which does not attract moisture from the air. It is very soluble both in water and alcohol; and is not so easily decomposed by heat as nitrat of zircone.

The acetous acid has no action upon siliceous earth; for the needle-shaped crystals observed by Durande in a mixture of vinegar with the earth precipitated from a liquor of flints, do not prove the solubility of siliceous earth, as Leonhardi observes.

Concerning the action of vinegar on alcohol, see ETHER. This acid has no effect upon fat oils, except that when distilled together, some kind of mixture takes place, as the Abbé Rozier observes. Neither does distilled vinegar act upon essential oils; but Westendorf's concentrated acid dissolved about a sixth part of oil of rosemary, or one half its weight of camphor; which latter solution was inflammable; and the camphor was precipitated from it by adding water.

Vinegar dissolves the true gums, and partly the gum resins, by means of digestion.

Boerhaave observes, that vinegar by long boiling dissolves the flesh, cartilages, bones, and ligaments of animals.

The Count de Lauraguais obtained a highly concentrated acid from verdigrise, in an icy form. This form has hitherto been entirely ascribed to the cupreous particles combined with, or at least acting upon it; but M. Lowitz has shown, that the acetous acid itself possesses the property of assuming a crystallized form.

This chemist prepared a concentrated acetous acid (alkohol aceti) by congelation in the following manner:—He froze a whole barrel of vinegar as much as possible, then distilled the remaining unfrozen vinegar in a water bath; by which means he at first especially collected the spirituous ethereal parts; the vinegar, which next comes over, he froze again as much as possible, and afterward purified it, by distilling it again with three or four pounds of charcoal powder. By this means he never failed to procure a very pure, sweet-smelling, highly concentrated acid; the agreeable odour of which, however, may be still further improved by the addition of a proper quantity of the ethereal liquor collected at the beginning of the first distillation, but which must be previously dephlegmated by two or three rectifications.

After the distillation on the water-bath was over, that no acid might be lost, he removed the retort, with the charcoal powder which remained in it, to a sand-bath; and thus he obtained, by means of a strong fire, a few ounces more of a remarkably concentrated acid, which was of a yellow colour.

Having collected about ten ounces of this concentrated acid, he exposed it to a cold equal to 195 of de Lisle's thermometer; in which situation it shot into crystals from every part. He let what remained fluid drop away from the crystals into a basin placed underneath, first in the cold air, and afterward at the window within doors. There remained in the bottle snow-white finely foliated crystals, closely accumulated upon each other, which at first he took to be nothing but ice: on placing them upon the warm stove, they dissolved into a fluid which was perfectly as limpid as water, had an uncommonly strong highly pungent, and almost suffocating acetous smell, and, in the temperature of 145 of de Lisle's scale, immediately congealed into a solid white crystallized mass, resembling camphor.

The quantity of this glacial acid amounted to two ounces; and the following are the most remarkable properties which it exhibits in this uncommonly beautiful crystallized state:

1. In a temperature of 145 degrees, the previously liquefied glacial acid begins to shoot into beautiful arborescent and plumous figures, exactly in the same manner as water that undergoes a gradual congelation. There is at this time a considerable extrication of air-bubbles, and at length the vinegar congeals into a crystallized and completely solid mass.

2. This crystallized glacial acid requires a temperature of at least 126, in order to become fluid again.

3. The crystallization of the fluid glacial acid is soonest effected by placing it in water mixed with snow or ice.

4. If only a part of the crystallized glacial acid be melted, by the application of the warm hand an appearance of very fine crystallizations is afforded, provided the warmth of the room is not greater than 130 degrees. This may be repeatedly produced. If it be suffered to remain undisturbed in this temperature, large spicular crystals are seen to shoot up along the sides of the bottle, considerably above the fluid, and frequently to bend over to the opposite side, in the form of an arch, till they dip into the liquid acid again.

5. One of the most remarkable phænomena is this, that, by exposure to an increasing cold, a great variety of excessively delicate vegetations, resembling a sublimation, take place in the empty part of the bottle. Although they stretch out very far, and hang as it were floating in the empty part of the bottle, they only adhere by a very small point. They are so extremely thin and transparent, as not to be discernible in certain directions; and they frequently exhibit all the various colours of the rainbow.

6. By placing the glacial acid in snow, the four following equally pleasing appearances may be produced:

If, as exactly as possible, the smallest degree of cold in which the glacial acid is capable of beginning to freeze, be applied, there are immediately formed, on opening the bottle and shaking it a little, an immense number of extremely thin floating crystals, which are in the form of equilateral triangles, quadrangular planes, &c., and exhibit, especially in clear weather, the finest variety of colours.

On increasing the cold, and afterwards opening and shaking the bottle as before, beautiful, shining, thin crystals, of a quadrangular, pentangular, hexangular, radiated form, fall to the bottom, and exactly resemble flakes of snow.

In a still greater degree of cold, little radiated balls, or globular lumps, fall down to the bottom, increasing very quickly in size during their descent.

Lastly, if the refrigeration be carried to its highest pitch, and the bottle be opened and shaken before the crystallization has spontaneously begun, the acid congeals throughout, with an extraordinary quickness, into a compact snow-white, striated mass.

For the production of these appearances, it is necessary that the glacial acid be previously brought into a perfectly liquid state.

7. The internal surface of the bottle, in which the glacial acid is kept, is frequently covered over with the finest delineated figures, some of which are crisped, after the manner of the frost on windows; others, on the contrary, are of an angular, jagged, or rectilinear form, amongst which are also sometimes to be seen, quite distinct from the other figures, equilateral triangles.

8. When the glacial acid begins to crystallize in a quiet place, the surface of the still fluid acid is covered over, as soon as some spicular and arborescent crystals shoot from the bottom upwards, with a crust as shining and smooth as a mirror; underneath which, however, a large concavity is immediately afterwards formed by the air, which is extricated in great abundance, and mounts upwards.

9. Glacial acetous acid in its solid or crystallized state, notwithstanding the great quantity of air-bubbles that are entangled in its whole mass, occupies much less space than it did in its fluid state.

After M. Lowitz had attended to these striking properties, and had observed that the acetous acid in this state is of such an extraordinary strength and purity as to be in its highest degree of perfection, he took all possible pains to find out a method of obtaining in the glacial form all the acetous acid contained in vinegar.

The strength of each sort of vinegar, which it was necessary for him to know in his experiments, by degrees he ascertained in the following manner: viz. To one drachm of vinegar he added, drop by drop, a clear solution of equal parts of salt of tartar and water, till all at once a cloudiness or precipitation appeared. Although, on the appearance of this sign, the acid is already supersaturated with the alkali, yet it seems to be a more accurate test for ascertaining its strength, than the cessation of effervescence; for, as the point of saturation approaches, the effervescence becomes so imperceptible, that it is almost impossible to determine with precision when it is really at an end. Every five drops of the alkaline solution, which he finds it necessary to add to the vinegar, till the precipitation takes place, he reckons as one degree. Thus, for example, if a determinate quantity of vinegar requires 25 drops for this effect, he denotes its strength by five degrees. This is about the strength of good distilled vinegar.

That vinegar, which in consequence of its concentration is capable of crystallizing in a great degree of cold, he calls crystallizable vinegar; the crystals separated, after the crystallization is completed, from the remaining fluid portion, he calls glacial vinegar; and lastly, to the fluid residuum he gives the name of mother ley of vinegar.

From a great number of experiments he found, that vinegar must have at least twenty-four degrees of concentration, before it can be brought to crystallize by exposure to the most intense cold. Vinegar must be of the strength of 42 degrees at least, in order to become glacial vinegar; viz. in this state of concentration it has the property of crystallizing in a degree of cold not exceeding that in which water begins to freeze.

He found that charcoal, on being distilled with vinegar in a water-bath, possesses the singular, and hitherto unknown property, of imbibing a certain quantity of the acetous acid in a very concentrated state, and of retaining it so strongly, that the acid cannot be separated from it again, but by the application of a considerably greater degree of heat than that of boiling water. Upon this circumstance is founded the new method which he discovered of concentrating vinegar, so as to obtain all its acid in the purest state, viz. that of a glacial vinegar.

Let a barrel of vinegar be concentrated by freezing in the manner before described, and let the concentrated vinegar thus obtained, free from all inflammable or spirituous parts, be put into two retorts: add to each of them five pounds of good charcoal reduced to a fine powder, and subject them to distillation in a water-bath. When no more drops of acid come over, put the distilled liquor into two fresh retorts; and after adding five pounds of charcoal powder to each, proceed as before to distillation in a water-bath. In the mean time, the two first retorts are to be placed in a sand-bath, that, by means of a brisk fire, the crystallizable acid which is retained in the apparently dry charcoal powder may be expelled from it. The heat must be strong enough to make the drops follow one another every two seconds; and when, in this degree of heat, 20 seconds intervene between each drop, the acid which has been collected must be removed; for what follows is hardly any thing else but mere water. In this manner about six ounces and a half of crystallizable acid, which is generally of the strength of between 36 and 40 degrees, may be collected from each retort. As soon as the distillation by the water-bath in the two other retorts is over, the distilled liquor is to be poured back again into the first retorts, upon the charcoal powder, which remains in them, and which has been already used; and from each of these retorts the remaining crystallizable acid (which generally amounts to as much as the first quantity) is to be abstracted by distillation in a sand-bath. These operations may be alternately repeated, till all the acid of the vinegar which had been concentrated by freezing, is converted into crystallizable acid; or until the distilled liquor, constantly becoming weaker and weaker at every repetition of the distillation, comes over at length in the state of mere water; which, with the above-mentioned quantity of charcoal powder, generally happens at the fourth or fifth distillation. Now, in order to obtain the greatest part of the pure acid contained in the crystallizable vinegar, in the form of glacial acid, it must be set to crystallize in a great degree of cold; and the mother ley must be afterwards thoroughly drained from the glacial acid, by letting it drop from the crystals, first in the cold, and then in the room before the window. The mother ley may be rendered further crystallizable, by distilling it with a little charcoal powder; the weaker part which comes over first being put aside. But if a person wish to keep the crystallizable acid (which far exceeds Mr. Westendorf's in point of strength) for other purposes, and without separating any glacial acid from it, he must distil the whole of it again with charcoal powder in a sand-bath.

M. Lowitz found by accurate experiments, that by means of this curious process ten pounds of vinegar concentrated by freezing to the nineteenth degree, may be made to yield 38 ounces of crystallizable vinegar, from which 20 ounces of glacial acid may be obtained.

What constitutes the excellence of this

method is, that the concentration and purification are effected by one and the same medium, viz. the charcoal powder; in consequence of which, both intentions are fulfilled at the same time.

The crystallization of the acid is, at the same time, the means by which it acquires its highest degree of concentration, and its greatest purity; for the extraneous matter, which cannot otherwise be parted, even with the assistance of the charcoal, from the genuine acid, is thus separated from the pure acetous crystals, and left behind in the mother ley.

It was this extraneous matter, which cannot well be separated from the pure acetous acid by any other means but by crystallization, that led Dr. Amburger, agreeably to the results of his experiments, to draw conclusions contrary to Mr. Westrumb's theory, respecting the convertibility of the acetous acid into the acid of sugar.

M. Lowitz, in the course of his experiments relative to this process, for concentrating and purifying vinegar by charcoal powder and crystallization, made the following observations:

1. With one pound of charcoal powder very little more than ten drachms of crystallizable acid is obtained; and this is the case, whether the vinegar, which is to be distilled over it, be strong or weak, in a large or in a small quantity. It is taken for granted, however, that the vinegar shall contain at least as much acid as the charcoal powder is capable of imbibing and retaining in the distillation by the water-bath.

2. The quantity of crystallizable acid which is obtained, is in a direct ratio to the quantity of charcoal powder employed.

3. The least cold in which crystallizable acid, prepared by means of charcoal powder, shoots into crystals, is that of 175 degrees.

4. In the first distillation a yellow crystallizable acid comes over: but in the subsequent distillations by which the acid is purified from all its colouring or inflammable matter, it is always obtained perfectly limpid like water.

5. Crystallizable acid of the strength of 38 degrees, yielded glacial acid of 54 degrees of concentration, whilst the strength of the mother-ley amounted only to 28 degrees.

6. All glacial acetous acid is not of an equal strength.

7. M. Lowitz thinks he has observed that glacial acetous acid is stronger, in proportion to the intenseness of the cold by which it has been produced.

8. In a cold of 183 degrees, he obtained glacial acetous acid of the strength of 54°, which he finds to be the highest degree of concentration that the acetous acid is capable of obtaining.

9. As the water-bath, though it insures success, is often inconvenient, and takes up a great deal of time, it may be dispensed with by a skilful management of the fire; which, however, requires very great attention.

M. Lowitz, in the further prosecution of the experiments which concentrated glacial acetous acid, observed many other curious phænomena, which are as follow:

If vinegar concentrated by freezing be distilled very slowly, and without any addition, there comes over, at last, a small quantity of crystallizable acid, from which, by means of a great degree of cold, a little glacial acetous acid may be procured. This method, however, is not only very tedious, but the acid thus obtained is highly impure and empyreumatic.

By abstracting a large quantity of common distilled vinegar, over charcoal powder, first in a water-bath and afterwards in a sand-bath, crystallizable acetous acid may in like manner be obtained; but, on account of the great proportion of water in distilled vinegar, this method is extremely tedious.

Reflecting on this property of glacial acetous acid, viz. that it requires for its liquefaction a degree of warmth considerably greater than that in which the completely liquefied glacial acid is capable of crystallizing, M. Lowitz was led to discover a method by which crystallizable acid may be made to crystallize in a cold 15 degrees less than that which was before required, viz. Into some previously liquefied glacial acid he dipped a thin cotton wick, crystallized the acid by placing it in snow, and then in a cold of 158 degrees applied the same wick, with the crystals adhering to it, to the surface of some crystallizable acid of the strength of 38 degrees; there immediately formed round the end of the wick a number of needle-shaped crystals, which visibly increased in size; the surface of the acid became covered over with an icy crust; a great number of radiated crystals, exactly resembling flakes of snow, gradually sunk to the bottom of the bottle, where they continued to accumulate; and at length the acid, throughout, shot into fine large crystals. By this mode of treatment, it is rendered unnecessary to wait for a cold of 175 degrees; so that we have it in our power, at all times, to obtain acetous acid in the state of very beautiful transparent crystals, of a regular prismatic shape, and several inches in length.

From two pounds three ounces of perfectly dry acetate of soda, and a pound and a half of highly concentrated sulphuric acid, M. Lowitz prepared, according to Mr Westendorf's method, 13 ounces of an alcohol aceti, of the strength of 32 degrees. By exposing it in the night-time to a cold of 174 degrees, and by applying to its surface some crystals of glacial acetous acid, adhering to a cotton-wick, he immediately brought it to crystallize; and the next morning, in a cold of 182 degrees, he found it formed into beautiful prismatic crystals, which were three inches in length. After the mother-ley was poured off, these crystals weighed three ounces two drachms and a half. He distilled this mother-ley, the strength of which still amounted to 24 degrees, with two pounds of charcoal powder, in a water-bath: the acid which came over into the receiver had a very sweet smell, and was now only of the strength of 16 degrees. From the residuous powder he afterwards obtained, by distillation in a sand-bath, two ounces six drachms and a half of a smoking crystallisable acid, of the strength of 36 degrees.

The properties of this glacial acid, prepared from Mr. Westendorf's vinegar, are precisely the same as those of the glacial acid which is obtained by means of charcoal powder alone; whence it follows, that the acid is not altered by its combination with a foreign body (viz. the alkali), and its subsequent separation from it; or that the charcoal produces the same effect as the alkali.

After much reflection, M. Lowitz was so happy as to find out another very effectual method of separating the acetous acid from the other substances combined with it, so as to obtain it at once in the state of a glacial acid of the greatest possible strength. The separating medium which he thought of, is a sulphate of potash supersaturated with sulphuric acid, a salt, in which, conformably to his purpose, the sulphuric acid exists in a perfectly dry and dephlegmated state:

His first business was to contrive an easy method of preparing this salt, the properties of which have been hitherto but little examined; and after various trials, he hit upon the following successful process;

Mix together in a tall matrass seven parts of water with an equal quantity of sulphuric acid, and to the very hot mixture add, as quickly as the effervescence will permit, four parts of salt of tartar or levigated pot-ashes. As soon as the mixture becomes cool, the supersaturated sulphate of potash shoots into fine large crystals. After the whole is become quite cold, and the cystallization is at an end, the liquor (which may serve again for a fresh mixture of the same kind) is to be poured off, and the salt which remains in the matrass is to be shaken together, and to be well rinsed as quickly as possible with cold water, in order to cleanse it from all the sulphuric acid which adheres to its surfaces, and which would otherwise be prejudicial to the dry acid. The crystals are afterwards to be dried by exposure to the fire, and to be triturated to a very fine powder, which, just before it is used, must be again thoroughly exsiccated.

By means of this salt, a highly concentrated glacial acetous acid may be obtained in the following manner:

Let three parts of acetate of soda, prepared with vinegar distilled over charcoal, and evaporated to perfect dryness, be melted in a strong heat; then pour it out, and rub it to a very fine powder. Mix this powder very accurately with eight parts of supersaturated sulphate of potash, that has been previously well dried, and in like manner reduced to a fine powder; put the whole into a retort, and distil it with a gentle heat, in such a manner, that along with the drops some vapours also may be perceived to come out of the neck of the retort; but by no means so that the receiver shall be filled with these vapours. Notwithstanding the moderate heat, the acetous acid comes over very fast; and the quantity of glacial acid, of the strength of 54 degrees, which is thus obtained, amounts to nearly two parts, and possesses all the characters which have been before described.

By this process, seven pounds of glacial acetous acid may be obtained from 300 pounds of common vinegar; and from five pounds of distilled vinegar, of the strength of five degrees, two ounces of glacial acid may be procured in the space of six hours.

This glacial acid generally acquires an unpleasant smell, from which, however, it may be completely freed by distillation with charcoal powder, in the proportion of at least five or six parts of the latter to one part of the acid: or, to three ounces of this acid add about a drachm of perfectly dry and finely pulverized acetate of lime; shake them well and repeatedly together, and let the mixture remain exposed to the sunshine till the disagreeable smell is entirely gone; then redistil the vinegar in a gentle heat.

In its purification, whatever be the way in which it is effected, this glacial acid is unavoidably lowered some degrees in strength.

The melting of the acetated soda only serves for the expulsion of all the watery parts from the salt; but a glacial acid of the strength of between 46 and 50 degrees may be procured from a merely exsiccated acetate of soda.

For the production of glacial acetous acid, by means of the supersaturated sulphate of potash, not only the acetated soda, but also well dried acetate of lime may be employed.

How much preferable this last process, with sulphate of potash saturated with an excess of acid, is to the other, in which glacial acetous acid is prepared from Mr. Westendorf's vinegar, will appear from a comparative statement of the following particulars:

1. In the direct separation by means of sulphuric acid, we are restrained from adding to the acetated salt as much of the sulphuric acid as is necessary for the expulsion of all

the vinegar contained in the acetated soda, lest the required acetous acid should be too much debased by sulphuric or sulphureous acid: whereas, in the separation by means of the supersaturated sulphate of potash, no harm at all can arise from adding an excess of the sulphate, for the purpose of dislodging the whole of the acetous acid contained in the acetated soda; for the superfluous portion of sulphuric acid, combined with the alkali, adheres to it too strongly, and is too fixed in the fire, to be disengaged, and raised up, by that gentle degree of heat which is sufficient for the separation of the acetous acid.

2. In the affusion of a very concentrated sulphuric acid upon the thoroughly dried acetate, we are far from being able to make the sulphuric acid penetrate the salt in an equal manner; which, however, is a matter of great consequence: whereas, in the trituration of the acetate with the supersaturated sulphate of Mr. Lowitz, the most equal commixture of both salts is readily effected.

3. During the affusion (though it be performed with the greatest caution) of highly concentrated sulphuric acid, a great heat is excited, whereby some of the acetous acid is instantly consumed, a volatile sulphurous acid is produced, and part of the acetous acid is dissipated and lost in the form of vapour. But nothing of this kind takes place in M. Lowitz's last invented method; for there the salts do not begin to act reciprocally upon each other till the fire is applied.

4. The acid prepared according to Mr. Westendorf's method, always contains an admixture of the sulphuric; which, however, for the reason already assigned, is by no means the case with the glacial acetous acid of M. Lowitz, provided the management of the fire is properly attended to.

5. Twenty-four ounces of acetated soda, treated with sulphuric acid, give only 12 ounces of a barely crystallizable acid, of the strength of 32 degrees, from which, at most, only six ounces of glacial acid can be procured. On the other hand, the same quantity of acetated soda (previously fused) treated with the supersaturated sulphate of potash, yields nearly 16 ounces of glacial acetous acid, of the strength of 54 degrees.

6. Glacial acetous acid cannot be obtained from M. Westendorf's vinegar, except in winter, and by exposure to a very intense cold: but in the last described method of Mr. Lowitz, an exceedingly strong glacial acid may be immediately prepared at any time.

7. The supersaturated sulphate of potash may be prepared from various pharmaceutical residua; for instance, from the sulphate of potash which remains after the purification of pot-ashes, and the residuum from the liquor anodynus; and even the residuum, after the preparation of glacial acetous acid by means of supersaturated sulphate of potash, may, when the sulphate of soda which is produced is separated from it, be made to serve again, on the addition of fresh sulphuric acid, for another similar process.

A weak glacial-acetous acid may be concentrated in the following easy and at the same time entertaining manner:

Place the bottle containing the fluid glacial acetous acid, which is to be concentrated, up to its neck in a vessel full of ice and water: in another quantity of previously concentrated glacial acetous acid, surrounded in like manner with ice, dip a thin cotton-twist or wick; as soon as some crystals are perceived to have attached themselves to the wick, apply the same to the surface of the glacial acid, which is to be concentrated, and it will be seen to shoot into considerably large crystals. In the course of an hour or two, let the weaker part, which still remains fluid, be poured off, into another bottle, from the concentrated and crystallized glacial acid.

In winter this concentration of the glacial acetous acid may be effected in the following still more simple manner:

Pour the glacial acid, which is to be concentrated, into a glass bottle or jar with four sides; crystallize the acid by placing it in snow, or by exposure, in any other way, to cold; and then place it in a warm room, before the window (where, however, the rays of the sun are prevented from entering), in such a manner that one side of the bottle may come into close contact with the cold pane of the window. In the course of ten or twelve hours, the strongest part of the acid will arrange itself, in clusters of crystals, all along that side of the bottle which touches the pane of the window, whilst on the other side of the bottle which faces the room, the much weaker portion of the vinegar is found in a perfectly fluid state: so that all that remains to be done, is to pour off this fluid part into another bottle.

From the weaker portion that is separated in the concentration of the glacial acetous acid, more glacial acid may yet be obtained, by exposure to cold, and more especially by means of the before-described process with the cotton wick: and even the still weaker mother-ley, which remains at last, may very easily be brought to crystallize afresh, by the help of a gentle distillation.

Decisive experiments, and those frequently repeated, convinced M. Lowitz, that the 54th degree is the highest pitch of concentration to which glacial acetous acid is capable of being brought. Notwithstanding all the pains he took, he never was able, either by distillation, or by any of the other concentrating methods already mentioned, to push the concentration of glacial acetous acid even a single degree further; on the contrary, the acid was rendered weaker by some degrees in all such attempts.

The reason of this seems to be, that the acetous acid, like some of the mineral acids, when still further dephlegmated, or deprived of its watery parts, is no longer capable of remaining in a condensed state, but probably assumes an aërial or gaseous form; otherwise, in the further abstraction of its watery parts, how could there be such a constant diminution of its strength, evidently owing to a loss of acid?

Upon this principle we can easily account for the extraordinary quantity of air-bubbles, which are produced as often as the glacial acetous acid passes from the fluid to the solid crystallized state. The white appearance of the crystals depends on the same cause.

Hence, too, we see the impossibility of having a glacial acetous acid which shall retain its solid crystallized form during summer, unless it be kept in a place where the warmth never exceeds, at most, 126 degrees. Thus, for example, in a cellar the temperature of which remains constantly at 131 degrees, summer and winter, a strong glacial acetous acid would never become fluid; but if the same acid should be brought into this cellar in a perfectly liquefied state, it would never crystallize there, on account of the difference between the temperature required for the crystallization, and that which is necessary for the liquefaction of glacial acetous acid.

By very accurate experiments M. Lowitz found, that the least cold which suffices, without the application of ice or snow, for the crystallization of a perfectly fluid glacial acetous acid of the strength of 54 degrees, is that of 132 degrees. All that is needful is, after letting the glacial acid stand some time in water of the abovementioned temperature, to open the bottle, and shake it a little, so that the external air may enter and have free access to the acid.

Lastly, we may at all times obtain glacial acetous acid in a crystallized form by means of an artificial cold; viz. Pour the acid into a thin slender bottle, wrap round this some rag moistened with a little rectified sulphuric ether, and whirl it about briskly in the air.

It is a circumstance worthy of notice, that the weakest glacial acetous acid, in respect to the quantity of alkali necessary to its saturation, is stronger than the strongest nitrous acid. On this test, however, see ATTRACTION.—*Bergman.*—*Margraaf.*—*Wenzel.*—*Crell's Annals.*—*Thomson.*—*Journ. de Phys.*—*An. de Chim.*—*Poerner.*

ACID (AMNIOTIC). On evaporating the liquor amnii of the cow to one-fourth, Vauquelin and Buniva found, that crystals form in it by cooling. These are contaminated by a portion of extractive matter, from which they may be freed by washing with a very small quantity of water. These crystals are white and shining, slightly acid to the taste, redden litmus paper, and are a little more soluble in hot than cold water. They are likewise soluble in alcohol. On ignited coals they swell, turn black, give out ammonia and prussic acid, and leave a bulky coal. With the alkalis this acid forms very soluble salts, but it does not decompose the carbonate without the assistance of heat. It does not precipitate the earthy salts, or the nitrats of mercury, lead, or silver. The acids precipitate it from its combinations with alkalis in a white crystalline powder. Whether it exist in the amniotic liquor of any other animal is not known.

The title of this compound to be considered as a distinct acid however is disputed, as it is said to be only a prussiat of ammonia.—*An. de Chime.*

ACID (ARSENIC). The earlier chemists were embarrassed in the determination of the nature of the white sublimate which is obtained during the roasting of cobalt and other metallic ores, known in commerce by the name of arsenic: its solubility in water, its power of combining with metals in their simple state, together with other apparently heterogeneous properties, rendered it difficult to determine whether it ought to be classed with metals or salts. Subsequent discoveries have shown the relation it bears to both: when treated with combustible matter, in close vessels, it sublimes in the metallic form (see ARSENIC); combustion, or any analogous process, converts it into an oxide; and when the combustion is carried still further, the arsenical basis becomes itself converted into an acid.

We are indebted to the illustrious Scheele for the discovery of this acid, though Macquer had before noticed its combinations. It may be obtained by various methods. If six parts of nitric acid be poured on one of the concrete arsenious acid, or white arsenic of the shops, in the pneumato-chemical apparatus, and heat be applied, nitrous gas will be evolved, and a white concrete substance, differing in its properties from the arsenious acid, will remain in the retort. This is the arsenic acid. It may equally be procured by means of the oxigenated muriatic acid; or by heating concentrated nitric acid with twice its weight of the solution of the arsenious acid in muriatic acid. And Landirani informs us that the arsenious acid may be converted into the arsenic by repeated sublimations, the air being renewed every time; for thus the arsenious acid imbibes the requisite quantity of oxigen from the atmospheric air present in the operation. In either case an acid is obtained, that does not crystallize, but attracts the moisture of the air, has a sharp caustic taste, reddens blue vegetable colours, is fixed in the fire, and of the specific gravity of 3·391. Fourcroy says it contains at least a sixth part of its weight of oxigen; but Berthollet estimated it at not more than a tenth.

If the arsenic acid be exposed to a red heat in a glass retort, it melts and becomes transparent, but assumes a milky hue on cooling. If the heat be increased, so that the retort begins to melt, the acid boils, and sublimes into the neck of the retort. If a covered crucible be used instead of the glass retort, and a violent heat applied, the acid boils strongly, and in a quarter of an hour begins to emit fumes. These, on being received in a glass bell, are found to be arsecious acid; and a small quantity of a transparent glass, difficult to fuse, will be found lining the sides of the crucible. This is arseniate of alumine.

Combustible substances decompose this acid. If two parts of arsenic acid be mixed with about one of charcoal, the mixture introduced into a glass retort, coated, and a matrass adapted to it; and the retort then gradually heated in a reverberatory furnace, till the bottom is red; the mass will be inflamed violently, and the acid reduced, and rise to the neck of the retort in the metallic state mixed with a little oxide and charcoal powder. A few drops of water devoid of acidity will be found in the receiver.

With sulphur the phænomena are different. If a mixture of six parts of arsenic acid and one of powdered sulphur be digested together, no change will take place; but on evaporating to dryness, and distilling in a glass retort, fitted with a receiver, a violent combination will ensue, as soon as the mixture is sufficiently heated to melt the sulphur. The whole mass rises almost at once, forming a red sublimate, and sulphurous acid passes over into the receiver.

If pure arsenic acid be diluted with a small quantity of water, and hidrogen gas, as it is evolved by the action of sulphuric acid on iron, be received into this transparent solution, the liquor grows turbid, and a blackish precipitate is formed, which, being well washed with distilled water, exhibits all the phænomena of arsenic. Sometimes too a blackish gray oxide of arsenic is found in this process.

If sulphurated hidrogen gas be employed, instead of simple hidrogen gas, water and a sulphuret of arsenic are obtained.

With phosphorus phosphoric acid is obtained, and a phosphuret of arsenic, which sublimes.

The arsenic acid is much more soluble than the arsenious: according to Lagrange, two parts of water are sufficient for this purpose. It cannot be crystallized by any means; but on evaporation assumes a thick honey-like consistence.

No acid has any action upon it: if some of them dissolve it by means of the water that renders them fluid, they do not produce any alteration in it. The boracic and phosphoric are vitrifiable with it by means of heat, but without any material alteration in their natures. If phosphorous acid be heated upon it for some time, it saturates itself with oxygen, and becomes phosphoric acid.

The arsenic acid combines with all the earthy and alkaline bases, and forms salts very different from those furnished by the arsenious acid.

All these arseniates are decomposable by charcoal, which separates arsenic from them by means of heat.

The arseniat of barytes is insoluble, uncrystallizable, soluble in an excess of its acid, and decomposable by sulphuric acid, which precipitates a sulphate of barytes.

Of the arseniat of strontian nothing is known, but no doubt it resembles that of barytes.

With lime-water this acid forms a precipitate of arseniat of lime, soluble in an excess of its base, or in an excess of its acid, though insoluble alone. The acidulous arseniat of lime affords on evaporation little crystals, decomposable by sulphuric acid. The same salt may be formed by adding carbonat of lime to the solution of arsenic acid. This acid does not decompose the nitrat or muriat of lime; but the saturated alkaline arseniats decompose them by double affinity, precipitating the insoluble calcareous arseniat.

If arsenic acid be saturated with magnesia, a thick substance is formed near the point of saturation. This arseniat of magnesia is soluble in an excess of acid: and on being evaporated takes the form of a jelly, without crystallizing. Neither the sulphat, nitrat, nor muriat of magnesia is decomposed by arsenic acid, though they are by the saturated alkaline arseniats.

Arsenic acid saturated with potash does not crystallize. This arseniat, being evaporated to dryness, attracts the humidity of the air, and turns the sirup of violets green, without altering the solution of litmus. It fuses into a white glass, and with a strong fire is converted into an acidule, part of the alkali being abstracted by the silex and alumine of the crucible. If exposed to a red heat with charcoal in close vessels it swells up very much, and arsenic is sublimed. It is decomposed by sulphuric acid; but in the humid way the decomposition is not obvious, as the arsenic acid remains in solution. On evaporation, however, this acid and sulphat of potash are obtained.

If arsenic acid be added to the preceding salt, till it ceases to have any effect on the sirup of violets, it will redden the solution of litmus; and in this state it affords very regular and very transparent crystals, of the figure of quadrangular prisms, terminated by two tetraëdral pyramids, the angles of which answer to those of the prisms. These crystals are the arsenical neutral salt of Macquer. As this salt differs from the preceding arseniat by its crystallizability, its reddening solution of litmus, its not decomposing the calcareous and magnesian salts like it, and its capability of absorbing an additional portion of potash, so as to become neutral, it ought to be distinguished from it by the term of acidulous arseniat of potash.

With soda in sufficient quantity to saturate it arsenic acid forms a salt crystallizable like the acidulous arseniat of potash. Pelletier says, that the crystals are hexaëdral prisms terminated by planes perpendicular to their axis. This neutral arseniat of soda, however, while it differs completely from that of potash in this respect, and in becoming deliquescent instead of crystallizable on the addition of a surplus portion of arsenic acid, resembles the arseniat of potash in its decomposition by charcoal, by acids, and by the earths.

Combined with ammonia, arsenic acid forms a salt affording rhomboidal crystals analogous to those of the nitrat of soda. The arseniat of ammonia, which is produced likewise in the decomposition of nitrat of ammonia by arsenious acid, is decomposable in two ways by the action of heat. If it be gently heated, the ammonia is evolved, and the arsenic acid is left pure. If it be exposed to a violent and rapid heat, part of the ammonia and part of the acid reciprocally decompose each other; water is formed; azotic gas is given out; and the arsenic sublimes in a shining metallic form. Magnesia partly decomposes the arseniat of ammonia, and forms a triple salt with a portion of it.

Arsenic acid saturated with alumine forms a thick solution, which, being evaporated to dryness, yields a salt insoluble in water, and decomposable by the sulphuric, nitric and muriatic acids, as well as by all the other earthy and alkaline bases. The arsenic acid readily dissolves the alumine of the crucibles in which it is reduced to a state of fusion; and thus it attacks silex also, on which it has no effect in the humid way.

We know nothing of the combination of this acid with zircone.

By the assistance of a strong fire, as Fourcroy affects, arsenic acid decomposes the alkaline and earthy sulphates, even that of barytes; the sulphuric acid flying off in vapour, and the arseniat remaining in the retort. It acts in the same manner on the nitrat, from which it expels the pure acid. It likewise decomposes the muriats at a high temperature, the muriatic acid being evolved in the form of gas, and the arsenic acid combining with their bases, which it saturates; while the arsenious acid is too volatile to have this effect. It acts in the same manner on the fluats, and still more easily on the carbonats, with which, by the assistance of heat, it excites a brisk effervescence. Lagrange, however, denies that it acts on any of the neutral salts, except the sulphate of potash and soda, the nitrat of potash, and the muriats of soda and ammonia, and this by means of heat. It does not act on the phosphats; but precipitates the boracic acid from solutions of borats when heated.

Arsenic acid does not act on gold or platina; neither does it on mercury or silver without the aid of a strong heat: but it oxides copper, iron, lead, tin, zinc, bismuth, antimony, cobalt, nickel, manganese, and arsenic.

This acid is not used in the arts, at least directly, through indirectly it forms a part of some compositions used in dyeing. It is likewise one of the mineralizing acids combined by nature with some of the metallic oxides.—*Fourcroy.*—*Lagrange.*—*Thomson.*

Acid (Arsenious). Fourcroy was the first who distinguished by this name the white arsenic of the shops, which Scheele had proved to be a compound of the metal arsenic with oxigen, and which the authors of the new chemical nomenclature had consequently termed oxide of arsenic. As, however, it manifestly exhibits the properties of an acid, though in a slight degree, it has a fair claim to the title; for oxides and acids are perfectly similar in this, that both consist of a base united with oxigen, and the only difference between them is, that the compound in which the acid properties are manifest is termed an acid, and that in which they are not is called an oxide.

This acid, which is one of the most virulent poisons known, frequently occurs in a native state, if not very abundantly; and it is obtained in roasting several ores, particularly those of cobalt. In the chimneys of the furnaces where this operation is conducted, it generally condenses in thick semitransparent masses; though sometimes it assumes the form of a powder, or of little needles, in which state it was formerly called flowers of arsenic.

The arsenious acid reddens the most sensible blue vegetable colours, though it turns the sirup of violets green. On exposure to the air it becomes opake, and covered with a slight efflorescence. Thrown on burning coals, or a hot iron, it evaporates in white fumes, with a strong smell of garlic. In close vessels it is volatilized; and, if the heat be strong, vitrified. The result of this vitrification is a transparent glass, capable of crystallizing in tetraëdra, the angles of which are truncated. It is easily altered by hidrogen and carbon, which deprive it of its oxigen at a red heat, and reduce the metal, the one forming water, the other carbonic acid, with the oxigen taken from it: as it is by phosphorus, and by sulphur, which are in part converted into acids by its oxigen, and in part form an arsenical phosphuret or sulphuret with the arsenic reduced to the metallic state. Hence Margraaf and Pelletier, who particularly examined the phosphurets of metals, have asserted they might be formed with arsenious acid. Its specific gravity is from 4·000 to 5·000; and according to Berthollet it appears to consist of 93 parts arsenic, and 7 parts oxigen.

It is soluble in fifteen times its weight of boiling water, but requires eighty times its weight of cold. The solution crystallizes, and the acid assumes the form of regular tetraëdrons according to Fourcroy; but, according to Lagrange, of octaëdrons, and these frequently varying in figure by different laws of decrement. It crystallizes much better by slow evaporation, than by simple cooling. The solution is very acrid, reddens blue colours, unites with the earthy bases, decomposes the alkaline sulphurets, and forms with them a yellow precipitate, in which the arsenic approaches the metallic state. There are even some metals, which act upon the solution, and have a tendency to decompose the acid, so as to form a blackish precipitate, in which the arsenic is very slightly oxided.

The action of the other acids upon the arsenious is very different from that which they exert on the metal arsenic. By boiling sulphuric acid dissolves a small portion of it, which is precipitated as the solution cools. The nitric acid does not dissolve it, but by the help of heat converts it into arsenic acid. Neither the phosphoric nor the carbonic acid acts upon it; yet it enters into a vitreous combination with the phosphoric and boracic acids. The muriatic acid dissolves it by means of heat, and forms with it a volatile compound, which water precipitates: and the oxigenated muriatic acid acidifies it completely, so as to convert it into arsenic acid.

The arsenious acid combines with the earthy and alkaline bases. The earthy arsenites possess little solubility, and hence the solutions of barytes, strontian, and lime, form precipitates with that of arsenious acid.

This acid enters into another kind of combination with the earths, that formed by vitrification. Though a part of this volatile acid sublimes before the glass enters into fusion, part remains fixed in the vitrified substance, to which it imparts transparency, a homogeneous density, and considerable gravity. The arsenical glasses appear to contain a kind of triple salt, since the sand and alkalis enter into an intimate combination at the instant of fusion, and remain afterward perfectly mixed. All of them have the inconvenience of quickly growing dull by exposure to the air.

With the fixed alkalis the arsenious acid forms thick arsenites, which do not crystallize; which are decomposable by fire, the arsenious acid being volatilized by the heat; and from which all the other acids precipitate this in powder. These saline compounds were formerly termed livers, because they were supposed to be analogous to the combinations of sulphur with the alkalis.

With ammonia it forms a salt capable of crystallization. If this be heated a little, the ammonia is decomposed, the azote is evolved, while the hidrogen, uniting with part of the oxigen of the acid, forms water.

Neither the earthy nor alkaline arsenites have yet been much examined; what is known of them being only sufficient to distinguish them from the arseniats.

If we except the nitrats and oxigenated muriats, the other salts have but little action on the arsenious acid. It has no action on the sulphats, muriats, or fluats; except that, if muriat of soda be heated with the arsenious acid, a portion of the muriatic acid it contains is given out. Assisted by heat it expels the acid of carbonats with effervescence, and unites with their bases. It precipitates the acid from borats with difficulty.

But the nitrats, and the superoxigenated muriat of potash, act on the arsenious acid in a very remarkable manner. On treating the nitrats and arsenious acid together, the nitrous acid, or nitrous vapour, is extricated in a state very difficult to be confined, as Kunckel long ago observed; part of its oxigen is absorbed by the arsenious acid; it is thus converted into arsenic acid, and an arseniat is left in the retort. The same phænomena take place on detonating nitrats with arsenious acid; for it is still sufficiently combustible to produce a detonation, in which no sparks are seen, it is true, but with commotion and effervescence; and a true arseniat remains at the bottom of the crucible. It was in this way chemists formerly prepared their fixed arsenic, which was the acidulous arseniat of potash mentioned in the preceding article. The nitrat of ammonia exhibits different phænomena in its decomposition by arsenious acid, and requires considerable precaution. Pelletier, having mixed equal quantities, introduced the mixture into a large retort of coated glass, placed in a reverberatory furnace, with a globular receiver. He began with a very slight fire; for the decomposition is so rapid, and the nitrous vapours issue with such force, that a portion of the arsenious acid is carried off undecomposed unless you proceed very gently. If due care be taken, that the decomposition proceeds more slowly, nitrous acid first comes over: if the fire be continued, or increased, ammonia is next evolved: and lastly, if the fire be urged, a portion of oxide of arsenic sublimes in the form of a white powder, and a vitreous mass remains in the retort, which powerfully attacks and corrodes it. This is arsenic acid. The superoxigenated muriat of potash, too, by completely oxiding the arsenious acid converts it into arsenic acid, which by the assistance of heat is capable of decomposing the muriat of potash that remains.

The arsenious acid is used in numerous instances in the arts, under the name of white arsenic, or of arsenic simply. In many cases it is reduced, and acts in its metallic state.

Some attempts have been made to introduce it into medicine; but, as it is known to be one of the most violent poisons, it is probable that the fear of its bad effects may long deprive society of the advantages it might afford in this way. An arsenite of potash was extensively used by the late Dr. Fowler of York, who published a treatise on it, in intermittent and remittent fevers. He likewise assured the writer, that he had found it extremely efficacious in periodical headach, and as a tonic in nervous and other disorders: and that he never saw the least ill effect from its use, due precaution being employed in preparing and administering it. Externally it has been employed as a caustic to extirpate cancer, combined with sulphur, with bole, with antimony, and with the leaves of crowfoot; but it always gives great pain, and is not unattended with danger. Febure's remedy was water one pint, extract of hemlock ℥j, Gouland's extract ℥iij, tincture of opium ʒj, arsenious acid, gr. x. With this the cancer was wetted morning and evening; and at the same time a small quantity of a weak solution was administered internally. A still milder application of this kind has been made from a solution of one grain in a quart of water, formed into a poultice with crumb of bread.

In cases of persons poisoned by arsenious acid it has been usual to administer oils, milk, and similar remedies. But these, at the moment, are said to be frequently more dangerous than useful; and in their stead alkaline sulphurets dissolved in water, or water highly impregnated with sulphurated hidrogen gas, are strongly recommended.

As it is an object of considerable importance, when a person is suspected of having been poisoned by arsenic, to ascertain the truth of the fact, we insert the following directions from Mr. Henry's excellent Epitome of Chemistry: Let the stomach be removed entirely from the body, a ligature being previously made at each orifice, and its whole contents washed out into an earthen or glass vessel. The arsenic, on account of its specific gravity, will settle to the bottom, and may be obtained separate by washing off the other substances by repeated affusions of cold water. These washings should not be thrown away, till the presence of arsenic has been clearly ascertained. It may be expected at the bottom of the vessel in the form of a white powder, which must be carefully collected, dried on a filter, and submitted to the following trials.

Boil a small portion of the powder with a few ounces of distilled water, in a clean Florence flask, and filter the solution. To part of the solution add a portion of water saturated with sulphurated hidrogen gas; and if arsenic be present a golden-yellow sediment will fall down, which will appear sooner, if a few drops of acetic acid be added. A similar effect will be produced by sulphuret of ammonia. To another part of the solution add a single drop of a weak solution of carbonat of potash, and afterward a few drops of a solution of sulphat of copper; and the presence of arsenic will be manifested by a yellowish green precipitate. Or a portion of the suspected powder may be boiled with a dilute solution of pure potash, and with this precipitate a solution of sulphat of copper, when a similar appearance will ensue still more remarkably, if arsenic be present. The colour of this precipitate is perfectly characteristic: it is that of the pigment called Scheele's green. Similar experiments may be made at the same time with actual arsenic, as standards of comparison, to identify the presence of the supposed arsenic with greater certainty. Any of the sediments produced by the foregoing experiments may be collected, dried, and laid on red hot charcoal; when a smell of sulphur will arise, and be followed by that of garlic.

But the most decisive test is by reducing the arsenic to a metallic state, in which its characters are less equivocal. For this purpose, let a portion of the white sediment collected from the contents of the stomach be mixed with three times its weight of black flux, or with two parts of very dry carbonat of potash, and one of powdered charcoal. Procure a tube of thin glass, eight or nine inches long, and one sixth of an inch in diameter, sealed hermetically at one end. Coat the closed end with clay for about an inch, and let the coating dry. Then put into the tube the mixture of the powder and flux, and if any should adhere to the inner surface, let it be wiped off by a feather, so that the inner surface of the upper part of the tube may be quite clean and dry. Stop the end of the tube loosely with a little paper, and heat the coated end only on a chafing-dish of red hot coals, taking care to avoid breathing the fumes. The arsenic, if any be present, will rise to the upper part of the tube, on the inner surface of which it will form a thin brilliant coating. Having broken the tube, and scraped off the reduced metal, a little of this may be laid on heated iron, when, if it be arsenic, a dense smoke and garlic smell will be perceived: you may likewise put a small quantity between two polished plates of copper, surround it by powdered charcoal to prevent its escape, bind the plates tightly together with iron wire, and expose them to a low red heat. If the included substance were arsenic, a white stain will be left on the copper.

It is to be observed, that neither the stain on copper, nor the garlic smell, will be produced by the white oxide, or arsenious acid, if heated without the addition of some inflammable ingredient.—*Fourcroy*.—*Lagrange*.—*Thomson*.—*Henry*.

Acid (Benzoic). This acid was first described in 1608, by Blaise de Vigenere, in his Treatise on Fire and Salt, and has been generally known since by the name of flowers of benjamin, or benzoin, because it was obtained by sublimation from the resin of this name. As it is still most commonly procured from this substance, it has preserved the epithet of benzoic, though known to be a peculiar acid, obtainable not from benzoin alone, but from different vegetable balsams, vanello, cinnamon, ambergris, the urine of children, frequently that of adults, and always, according to Fourcroy and Vauquelin, though Giese denies this, that of quadrupeds living on grass and hay, particularly the camel, the horse, and the cow. There is reason to conjecture, that many vegetables, and among them some of the grasses, contain it; and that it passes from them into the urine. Fourcroy and Vauquelin found it combined with potash and lime in the liquor of dunghills, as well as in the urine of the quadrupeds above mentioned; and they strongly suspect it to exist in the anthoxanthum odoratum, or sweet-scented vernal-grass, from which hay principally derives its fragrant smell. Giese, however, could find none either in this grass or in oats.

The usual method of obtaining it affords a very elegant and pleasing example of the chemical process of sublimation. For this purpose a thin stratum of powdered benzoin is spread over the bottom of a glazed earthen pot, to which a tall conical paper covering is fitted: gentle heat is then to be applied to the bottom of the pot, which fuses the benzoin, and fills the apartment with a fragrant smell, arising from a portion of essential oil and acid of benzoin, which are dissipated into the air; at the same time the acid itself rises very suddenly in the paper head, which may be occasionally inspected at the top, though with some little care, because the fumes will excite coughing. This saline sublimate is condensed in the form of long needles, or straight filaments of a white colour, crossing each other in all directions, When the acid ceases to rise, the cover may be changed, a new one applied, and the heat raised: more flowers of a yellowish colour will then rise, which require a second sublimation to deprive them of the empyreumatic oil they contain.

The sublimation of the acid of benzoin may be conveniently performed by substituting an inverted earthen pan instead of the paper cone. In this case the two pans should be made to fit, by grinding on a stone with sand, and they must be luted together with paper dipped in paste. This method seems preferable to the other, where the presence of the operator is required elsewhere; but the paper head can be more easily inspected and changed. The heat applied must be very gentle, and the vessels ought not to be separated till they have become cool.

The quantity of acid obtained in these methods differs according to the management, and probably also from difference of purity, and in other respects of the resin itself. It usually amounts to no more than about one eighth part of the whole weight. Indeed Scheele says, not more than a tenth or twelfth. The whole acid of benzoin is obtained with greater certainty in the humid process of Scheele: this consists in boiling the powdered resin with lime-water, and afterwards separating the lime by the addition of muriatic acid. Twelve ounces of water are to be poured upon four ounces of slaked lime; and, after the ebullition is over, eight pounds, or ninety-six ounces, more of water are to be added: a pound of finely-powdered benzoin being then put into a tin vessel, six ounces of the lime-water are to be added, and mixed well with the powder; and afterwards the whole of the lime-water in the same gradual manner, because the benzoin would coagulate into a mass, if the whole were added at once. This mixture must be gently boiled for half an hour with constant agitation, and afterwards suffered to cool and subside during an hour. The supernatant liquor must be decanted, and the residuum boiled with eight pounds more of lime-water; after which the same process is to be once more repeated: the remaining powder must be edulcorated on the filter by affusions of hot water. Lastly, all the decoctions, being mixed together, must be evaporated to two pounds, and strained into a glass vessel.

This fluid consists of the acid of benzoin combined with lime. After it is become cold, a quantity of muriatic acid must be added, with constant stirring, until the fluid tastes a little sourish. During this time the last-mentioned acid unites with the lime, and forms a soluble salt, which remains suspended, while the less soluble acid of benzoin, being disengaged, falls to the bottom in powder. By repeated affusions of cold water upon the filter, it may be deprived of the muriat of lime and muriatic acid, with which it may happen to be mixed. If it be required to have a shining appearance, it may be dissolved in a small quantity of boiling water, from which it will separate in silky filaments by cooling. By this process the benzoic acid may be procured from other substances, in which it exists.

As an œconomical mode of obtaining this acid, Fourcroy recommends the extraction of it from the water that drains from dunghills, cowhouses, and stables, by means of the muriatic acid, which decomposes the benzoat of lime contained in them, and separates the benzoic acid, as in Scheele's process. He confesses the smell of the acid thus obtained differs a little from that of the acid extracted from benzoin: but this, he says, may be remedied, by dissolving the acid in boiling water, filtering the solution, letting it cool, and thus suffering the acid to crystallize, and repeating this operation a second time.

Mr. Accum found the benzoic acid which he obtained from vanello pods contaminated with a yellow colouring matter, from which it could not be freed by repeated solutions and crystallizations; but by boiling with charcoal powder, the acid was rendered perfectly pure.

The acid of benzoin is so inflammable that it burns with a clear yellow flame without the assistance of a wick. The sublimed flowers in their purest state, as white as ordinary writing-paper, were fused into a clear transparent yellowish fluid, at the two hundred-and-thirtieth degree of Fahrenheit's thermometer, and at the same time began to rise in sublimation. It is probable that a heat somewhat greater than this may be required to separate it from the resin. It is strongly disposed to take the crystalline form in cooling The concentrated sulphuric and nitric acids dissolve this concrete acid, and it is again separated, without alteration, by adding water. Other acids dissolve it by the assistance of heat, from which it separates by cooling, unchanged. It is plentifully soluble in ardent spirit, from which it may likewise be separated by diluting the spirit with water. It readily dissolves in oils, and in melted tallow. If it be added in a small proportion to this last fluid, part of the tallow congeals before the rest, in the form of white opake clouds. If the quantity of acid be more considerable, it separates in part by cooling, in the form of needles or feathers. It did not communicate any considerable degree of hardness to the tallow, which was the object of this experiment. When the tallow was heated nearly to ebullition, it emitted fumes which affected the respiration, like those of the acid of benzoin, but did not possess the peculiar and agreeable smell of that substance, being probably the sebacic acid. A stratum of this tallow, about one-twentieth of an inch thick, was fused upon a plate of brass, together with other fat substances, with a view to determine its relative disposition to acquire and retain the solid state. After it had cooled it was left upon the plate, and in the course of some weeks it gradually became tinged throughout of a blueish green colour If this circumstance be not supposed to have arisen from a solution of the copper during the fusion, it seems a remarkable instance of the mutual action of two bodies in the solid state, contrary to that axiom of chemistry which affirms, that bodies do not act on each other unless one or more of them be in the fluid state. Tallow itself however has the same effect.

Pure benzoic acid is in the form of a light powder, evidently crystallized in fine needles, the figure of which is difficult to be determined from their smallness. It has a white and shining appearance; but when contaminated by a portion of volatile oil, is yellow or brownish. It is not brittle as might be expected from its appearance, but has rather a kind of ductility and elasticity, and on rubbing in a mortar becomes a sort of paste. Its taste is acrid, hot, acidulous, and bitter. It reddens the infusion of litmus, but not sirup of violets. It has a peculiar aromatic smell, but not strong unless heated. This, however, appears not to belong to the acid; for Mr. Giese informs us, that on dissolving the benzoic acid in as little alcohol as possible, filtering the solution, and precipitating by water, the acid will be obtained pure, and void of smell, the odorous oil remaining dissolved in the spirit. Its specific gravity is 0·667. It is not perceptibly altered by the air, and has been kept in an open vessel twenty years without losing any of its weight. None of the combustible substances have any effect on it: but it may be refined by mixing it with charcoal powder and subliming, being thus rendered much whiter and better crystallized. It is not very soluble in water. Wenzel and Lichtenstein say four hundred parts of cold water dissolve but one, though the same quantity of boiling water dissolves twenty parts, nineteen of which separate on cooling.

The benzoic acid unites without much difficulty with the earthy and alkaline bases.

The benzoat of barytes is soluble, crystallizes tolerably well, is not affected by exposure to the air, but is decomposable by fire, and by the stronger acids. That of lime is very soluble in water, though much less in cold than in hot; and crystallizes on cooling. It is in like manner decomposable by the acids, and by barytes. The benzoat of magnesia is soluble, crystallizable, a little deliquescent, and more decomposable than the former. That of alumine is very soluble; crystallizes in dendrites; is deliquescent; has an acerb and bitter taste; and is decomposable by fire, and even by most of the vegetable acids. The benzoat of potash crystallizes on cooling in little compacted needles. All the acids decompose it, and the solution of barytes and lime form with it a precipitate. The benzoat of soda is very crystallizable, very soluble, and not deliquescent like that of potash: but it is decomposable by the same means. It is sometimes found native in the urine of graminivorous quadrupeds; but by no means so abundantly as that of lime. The benzoat of ammonia is volatile, and decomposable by all the acids and all the bases. The solutions of all the benzoats, when drying on the sides of a vessel wetted with them, form dendritical crystallizations.

Trommsdorf found in his experiments,

that benzoic acid did not act upon metals, but united with their oxides.

From the chemical properties of this acid, it appears to differ from the other vegetable acids in the nature and properties of the principles that constitute its radical. Its odour, volatility, combustibility, great solubility in alcohol, and little solubility in water, formerly occasioned it to be considered as an oily acid; and have led modern chemists to conceive, that it contains a large quantity of hidrogen in its composition, and that it is in the superabundance of this combustible principle its difference from the other vegetable acids consists. Its solubility in the powerful acids, and its subsequent separation, indicate that its principles are not easily separable from each other. Attempts have been made to decompose it by repeated abstraction of nitric acid: the nitric acid rises first, scarcely altered except toward the end of the process, when nitrous gas comes over; and the acid of benzoin is afterwards sublimed with little alteration. By repeating the process, however, it is said to become more fixed, and at length to afford a few drops of an acid resembling the oxalic in its properties.

The benzoic acid is occasionally used in medicine, but not so much as formerly; and enters into the composition of the camphorated tincture of opium of the London college, heretofore called paregoric elixir.—*Fourcroy.*—*Thomson.*—*Scherer's Allg. Journ. der Chemie.*

ACID (BOMBIC). Mr. Boissier de Sauvages observed, that the juices of the silkworm, in a certain diseased state, contained an acid. Chaussier found, that in the moth state it emits an acid liquor; and this he found to be deposited, when it spins its cocoon, in a reservoir near the anus. By bruising the animal, and infusing it in alcohol, he obtained a solution of the acid; which on evaporating the alcohol was found to be a pungent yellow fluid, capable of reddening vegetable blues, and uniting with alkalis and some of the earths. He supposed it to be a peculiar acid; but it has not yet been farther investigated, and from analogy it is probable, that like the formic acid, and some others, it is merely a compound of the acetous.

ACID (BORACIC). The neutral salt composed of this acid and soda, had long been used both in medicine and the arts under the name of borax, when Homberg first obtained the acid separate in 1702, by distilling a mixture of borax and sulphat of iron. He supposed, however, that it was a product of the latter; and gave it the name of *volatile narcotic salt of vitriol*, or *sedative salt*. Lemery the younger soon after discovered, that it could be obtained from borax equally by means of the nitric or muriatic acid; Geoffroy detected soda in borax; and at length Baron proved by a number of experiments, that borax is a compound of soda and a peculiar acid. Cadet has disputed this; but he has merely shown, that the borax of the shops is frequently contaminated with copper: and Struve and Exchaquet have endeavoured to prove that the boracic and phosphoric acids are the same; yet their experiments only show, that they resemble each other in certain respects, not in all.

To procure the acid, dissolve borax in hot water; and filter the solution: then add sulphuric acid by little and little, till the liquid has a sensibly acid taste. Lay it aside to cool, and a great number of small shining laminated crystals will form. These are the boracic acid. They are to be washed with cold water, and drained upon brown paper.

Boracic acid thus procured is in the form of thin irregular hexagonal scales, of a silvery whiteness, having some resemblance to spermaceti, and the same kind of greasy feel. It has a sourish taste at first, then makes a bitterish cooling impression, and at last leaves an agreeable sweetness. Pressed between the teeth, it is not brittle but ductile. It has no smell; but, when sulphuric acid is poured on it, a transient odour of musk is produced. Its specific gravity in the form of scales is 1·479; after it has been fused, 1·803. It is not altered by light. Exposed to the fire it swells up, from losing its water of crystallization, and in this state is called calcined boracic acid. It melts a little before it is red-hot, without perceptibly losing any water, but it does not flow freely till it is red, and then less than the borat of soda. After this fusion it is a hard transparent glass, becoming a little opake on exposure to the air, without abstracting moisture from it, and unaltered in its properties, for on being dissolved in boiling water it crystallizes as before. This glass is used in the composition of false gems.

Boiling water scarcely dissolves one fiftieth part, and cold water much less. When this solution is distilled in close vessels, part of the acid rises with the water, and crystallizes in the receiver. It is more soluble in alcohol, and alcohol containing it burns with a green flame, as does paper dipped in a solution of boracic acid.

Neither oxigen gas, nor the simple combustibles, nor the metals, produce any change upon boracic acid, as far as is at present known. If mixed with finely powdered charcoal it is nevertheless capable of vitrification; and with soot it melts into a black bitumen-like mass, which however is soluble in water, and cannot easily be burned to ashes, but sublimes in part. With the assistance of a distilling heat it dissolves in oils, especially mineral oils; and with these it yields fluid and solid products, which impart a green colour to spirit of wine. When rubbed with phosphorus it does not prevent its inflammation, but an earthy yellow matter is left behind. It is hardly capable of oxiding or dissolving any of the metals except iron and zinc, and perhaps copper; but it combines with most of the metallic oxides, as it does with the alkalis, and probably with all the earths, though the greater part of its combinations have hitherto been little or not at all examined. It is of great use in analysing stones that contain a fixed alkali.

The boracic acid has a more powerful attraction for lime, than for any other of the bases, though it does not readily form borat of lime by adding a solution of it to lime-water, or decomposing by lime-water the soluble alkaline borats. In either case an insipid white powder, nearly insoluble, which is the borat of lime, is however precipitated. The borat of barytes is likewise an insoluble, tasteless, white powder.

Bergman has observed, that magnesia, thrown by little and little into a solution of boracic acid, dissolved slowly, and the liquor on evaporation afforded granulated crystals without any regular form: that these crystals were fusible in the fire without being decomposed: but that alcohol was sufficient to separate the boracic acid from the magnesia. If however some of the soluble magnesian salts be decomposed by alkaline borats in a state of solution, an insipid and insoluble borat of magnesia is thrown down. It is probable, therefore, that Bergman's salt was a borat of magnesia dissolved in an excess of boracic acid; which acid being taken up by the alcohol, the true borat of magnesia was precipitated in a white powder, and mistaken by him for magnesia.

One of the best known combinations of this acid is the native magnesio-calcareous borat of Kalkberg, near Lunenburg: the *wurfelstein* of the Germans, *cubic quartz* of various mineralogists, and *boracite* of Kirwan. It is of a grayish white colour, sometimes passing into the greenish white, or purplish. Its figure is that of a cube, incomplete on its twelve edges, and at four of its solid angles, the complete and incomplete angles being diametrically opposite to each other. The surfaces generally appear corroded. It strikes fire with steel, and scratches glass. Its specific gravity is 2·566, as determined by M. Westrumb, who found it to be composed of boracic acid 0·68, magnesia 0·1305, lime 0·11; with alumine 0·01, silex 0·02, and oxide of iron 0·0075, all of which he considers as casual. Its most remarkable property, discovered by Haüy, is, that like the tourmalin it becomes electric by heat, though little so by friction: and it has four electric poles, the perfect angles always exhibiting negative electricity, and the truncated angles positive.

Since the component parts of this native salt have been known, attempts have been made to imitate it by art; but no chemist has been able, by mixing lime, magnesia, and boracic acid, to produce any thing but a pulverulent salt, incapable of being dissolved, or exhibited in the crystallized form, and with the hardness of the borat of Kalkberg.

It has lately been denied, however, that this compound is really a triple salt. Vauquelin, examining this substance with Mr. Smith, who had a considerable quantity, found the powder to effervesce with acids; and therefore concluded the lime to be no essential part of the compound. They attempted, by using weak acids much diluted, to separate the carbonat from the borat; but they did not succeed, because the acid attacked the borat likewise, though feebly. M. Stromager having afterwards supplied Vauquelin with some transparent crystals, which did not effervesce with acids, he mixed this powder with muriatic acid, and, when the solution was effected by means of heat, evaporated to dryness to expel the excess of acid. By solution in a small quantity of cold distilled water he separated most of the boracic acid; and, having diluted the solution, added a certain quantity of oxalat of ammonia, but no sign of the existence of lime appeared. To ascertain that the precipitation of the lime was not prevented by the presence of the small quantity of boracic acid, he mixed with the solution a very small portion of muriat of lime, and a cloudiness immediately ensued through the whole. Hence he infers, that the opacity of the magnesian borat is occasioned by carbonat of lime interposed between its particles, and that the borat in transparent crystals contains none.

The borat of potash is but little known, though it is said to be capable of supplying the place of that of soda in the arts; but more direct experiments are required to establish this effect. Like that, it is capable of existing in two states, neutral and with excess of base, but it is not so crystallizable, and assumes the form of parallelopipeds.

With soda the boracic acid forms two different salts. One, in which the alkali is more than treble the quantity necessary to saturate the acid, is of considerable use in the arts, and has long been known by the name of borax; under which its history and an account of its properties will be given. The other is a neutral salt, not changing the sirup of violets green like the borat with excess of base; differing from it in taste and solubility; crystallizing neither so readily, nor in the same manner; not efflorescent like it; but like it fusible into a glass, and capable of being employed for the same purposes. This salt may be formed, by saturating the superabundant soda in borax with some other acid, and then separating the two salts: but it is obviously more eligible, to saturate the excess of soda with an additional portion of the boracic acid itself.

Borat of ammonia forms in small rhomboidal crystals, easily decomposed by fire; or in scales, of a pungent urinous taste, which lose the crystalline form, and grow brown on exposure to the air.

It is very difficult to combine the boracic acid with alumine, at least in the direct way. It has been recommended, for this purpose, to add a solution of borax to a solution of sulphat of alumine: but for this process the neutral borat of soda is preferable, since, if borax be employed, the soda that is in excess may throw down a precipitate of alumine, which might be mistaken for an earthy borat.

The boracic acid unites with silex by fusion, and forms with it a solid and permanent vitreous compound. This borat of silex, however, is neither sapid, nor soluble, nor perceptibly alterable in the air; and cannot be formed without the assistance of a violent heat. In the same manner triple compounds may be formed with silex and borats already saturated with other bases.

The boracic acid has been found in a disengaged state in several lakes of hot mineral waters near Monte Rotondo, Berchiaio, and Castellonuovo in Tuscany, in the proportion of nearly nine grains in a hundred of water, by M. Hoeffer. M. Mascagni also found it adhering to schistus, on the borders of lakes, of an obscure white, yellow, or greenish colour, and crystallized in the form of needles. He has likewise found it in combination with ammonia.

Dr. Fabroni, an able natural philosopher of Florence, informed Fourcroy, that, from particular experiments he had made, which however are not published, he considered the boracic acid as a modification of the muriatic; that it could be completely fabricated from that acid; and that the boracic acid in the Tuscan lakes, as he conceived, was probably formed in this way.

A very curious set of experiments have been lately made on it by Crell. By digesting oxigenated muriatic acid on it for a very long time, he succeeded in decomposing it, and obtained from it a substance exactly resembling charcoal; and a volatile acid resembling the muriatic in the greater number of its properties, but differing from it in not precipitating lead from its solution. Crell considers this volatile acid as very similar to the sebacic. Its fixity in the fire too is deemed an argument in favour of its being a compound; for it has been remarked, that simple substances in general are more volatile.—*Kirwan.*—*Fourcroy.*—*Lagrange.*—*Reuss.*—*Hassenfratz.*—*Kerr.*—*Thomson.*—*Ann. de Chimie.*

Acid (Camphoric). M. Kosegarten found some years ago, that an acid with peculiar properties was obtained by distilling nitric acid eight times following from camphor. Bouillon Lagrange has since repeated his experiments, and the following is the account he gives of its preparation and properties.

One part of camphor being introduced into a glass retort, four parts of nitric acid of the strength of 36 degrees are to be poured on it, a receiver adapted to the retort, and all the joints well luted. The retort is then to be placed on a sand-heat, and gradually heated. During the process a considerable quantity of nitrous gas, and of carbonic acid gas, is evolved; and part of the camphor is volatilized, while another part seizes the oxygen of the nitric acid. When no more vapours are extricated, the vessels are to be separated, and the sublimed camphor added to the acid that remains in the retort. A like quantity of nitric acid is again to be poured on this, and the distillation repeated. This operation must be reiterated till the camphor is completely acidified. Twenty parts of nitric acid at 36 are sufficient to acidify one of camphor.

When the whole of the camphor is acidified, it crystallizes in the remaining liquor. The whole is then to be poured out upon a filter, and washed with distilled water, to carry off the nitric acid it may have retained. The most certain indication of the acidification of the camphor is its crystallizing on the cooling of the liquor remaining in the retort.

To purify this acid it must be dissolved in hot distilled water, and the solution, after being filtered, evaporated nearly to half, or till a slight pellicle forms; when the camphoric acid will be obtained in crystals on cooling.

This experiment being too long to be exhibited by the chemical lecturer, its place may be supplied by the following.

A jar is to be filled over mercury with oxigen gas from the super-oxigenated muriat of potash, and a little water passed into it. On the other hand a bit of camphor and an atom of phosphorus are to be placed in a little cupel: and then one end of a curved tube is to be conveyed under the jar, and the other end under a jar filled with water in the pneumato-chemical apparatus. The apparatus being thus arranged, the phosphorus is to be kindled by means of a red-hot iron. The phosphorus inflames, and afterwards the camphor. The flame produced by the camphor is very vivid; much heat is given out; and the jar is lined with a black substance, which gradually falls down, and covers the water standing on the quicksilver in the jar. This is oxide of carbon. At the same time a gas is collected, that has all the characters of carbonic acid. The water contained in the jar is very fragrant, and contains camphoric acid in solution.

The camphoric acid has a slightly acid,

bitter taste, and reddens infusion of litmus.

It crystallizes; and the crystals upon the whole resemble those of muriat of ammonia. [Kosegarten says they are parallelopipeds of a snowy whiteness.] It effloresces on exposure to the atmosphere: is not very soluble in cold water: when placed on burning coals, gives out a thick aromatic smoke, and is entirely dissipated: and with a gentle heat melts, and is sublimed. The mineral acids dissolve it entirely. It decomposes the sulphat and muriat of iron. The fixed and volatile oils dissolve it. It is likewise soluble in alcohol, and is not precipitated from it by water; a property that distinguishes it from the benzoic acid. It unites easily with the earths and alkalis.

To prepare the camphorats of lime, magnesia, and alumine, these earths must be diffused in water, and crystallized camphoric acid added. The mixture must then be boiled, filtered while hot, and the solution concentrated by evaporation.

The camphorat of barytes is prepared by dissolving the pure earth in water, and then adding crystallized camphoric acid.

Those of potash, soda, and ammonia, should be prepared with their carbonats dissolved in water: these solutions are to be saturated with crystallized camphoric acid, heated, filtered, evaporated, and cooled, by which means the camphorats will be obtained.

If the camphoric acid be very pure, they have no smell: if it be not, they have always a slight smell of camphor.

The camphorats of alumine and barytes leave a little acidity on the tongue; the rest have a slightly bitterish taste.

They are all decomposed by heat: the acid being separated and sublimed, and the base remaining pure; that of ammonia excepted, which is entirely volatilized.

If they be exposed to the blow-pipe, the acid burns with a blue flame: that of ammonia gives first a blue flame; but toward the end it becomes red.

The camphorats of lime and magnesia are little soluble, the others dissolve more easily.

The mineral acids decompose them all. The alkalis and earths act in the order of their affinity for the camphoric acid: which is, lime, potash, soda, barytes, ammonia, alumine, magnesia.

Several metallic solutions, and several neutral salts, decompose the camphorats: such as the nitrat of barytes, most of the calcareous salts, &c.

The camphorats of lime, magnesia, and barytes, part with their acid to alcohol.—*Lagrange's Manuel d'un Cours de Chimie.*

Acid (Carbonic). This acid, being a compound of carbon and oxigen, may be formed by burning charcoal; but as it exists in great abundance ready formed, it is not necessary to have recourse to this expedient. All that is necessary is to pour sulphuric acid, diluted with five or six times its weight of water, on common chalk, which is a compound of carbonic acid and lime. An effervescence ensues, carbonic acid is evolved in the state of gas, and may be received in the usual manner.

As the rapid progress of chemistry during the latter part of the 18th century, was in a great measure owing to the discovery of this acid, it may be worth while to trace the history of it somewhat particularly.

Paracelsus and Van Helmont were acquainted with the fact, that air is extricated from solid bodies during certain processes, and the latter gave to air thus produced the name of gas Boyle called these kinds of air artificial airs, and suspected that they might be different from the air of the atmosphere. Hales ascertained the quantity of air that could be extricated from a great variety of bodies, and showed that it formed an essential part of their composition. Dr. Black proved, that the substances then called lime, magnesia, and alkalis, were compounds, consisting of a peculiar species of air, and pure lime, magnesia, and alkali. To this species of air he gave the name of fixed air, because it existed in these bodies in a fixed state. This air or gas was afterward investigated, and a great number of its properties ascertained, by Dr. Priestley. From these properties Mr. Keir first concluded that it was an acid; and this opinion was soon confirmed by the experiments of Bergman, Fontana, and others. Dr. Priestley at first suspected that this acid entered as an element into the composition of atmospherical air; and Bergman, adopting the same opinion, gave it the name of aërial acid. Mr. Bewley called it mephitic acid, because it could not be respired without occasioning death; and this name was also adopted by Morveau. Mr. Keir called it calcareous acid: and at last M. Lavoisier, after discovering its composition, gave it the name of carbonic acid gas.

The opinions of chemists concerning the composition of carbonic acid have undergone as many revolutions as its name. Dr. Priestley and Bergman seem at first to have considered it as an element; and several celebrated chemists maintained that it was the acidifying principle. Afterward it was discovered to be a compound, and that oxigen gas was one of its component parts. Upon this discovery the prevalent opinion of chemists was, that it consisted of oxigen and phlogiston; and when hidrogen and phlogiston came, according to Mr. Kirwan's theory, to signify the same thing, it was of course maintained that carbonic acid was composed of oxigen and hidrogen: and though M. Lavoisier demonstrated that it was formed by the combination of carbon and oxigen, this did not prevent the old theory from being maintained; because carbon was itself considered as a compound, into which a very great quantity of hidrogen entered. But after M. Lavoisier had demonstrated, that the weight of the carbonic acid produced was precisely equal to the charcoal and oxigen employed; after Mr. Cavendish had discovered, that oxigen and hidrogen when combined did not form carbonic acid but water; it was no longer possible to doubt that this acid was composed of carbon and oxigen. Accordingly all farther dispute about it seems now at an end.

If any thing were still wanting, to put this conclusion beyond the reach of doubt, it was to decompose carbonic acid, and thus to exhibit its component parts by analysis as well as synthesis. This has been actually done by Mr. Tennant. Into a tube of glass he introduced a bit of phosphorus and some carbonat of lime. He then sealed the tube hermetically, and applied heat. Phosphat of lime was formed, and a quantity of charcoal deposited. Now phosphat of lime is composed of phosphoric acid and lime; and phosphoric acid is composed of phosphorus and oxigen. The substances introduced into the tube were phosphorus, lime, and carbonic acid; and the substances found in it were phosphorus, lime, oxigen, and charcoal. The carbonic acid, therefore, must have been decomposed, and it must have consisted of oxigen and charcoal. This experiment was repeated by Dr. Pearson, who ascertained, that the weight of the oxigen and charcoal together was equal to that of the carbonic acid which had been introduced: and in order to show that it was the carbonic acid which had been decomposed, he introduced pure lime and phosphorus; and, instead of phosphat of lime and carbon, he got nothing but phosphuret of lime. These experiments were also confirmed by Fourcroy, Vauquelin, Sylvestre, and Brongniart. Count Mussin-Puschkin too boiled a solution of carbonat of potash on purified phosphorus, and obtained charcoal. This he considered as an instance of the decomposition of carbonic acid, and as a confirmation of the experiments above related.

Carbonic acid abounds in great quantities in nature, and appears to be produced in a variety of circumstances. It composes about one third of the weight of lime-stone, marble, calcareous spar, and other natural specimens of calcareous earth; from which it may be extricated either by the simple application of heat, or by the superior affinity of some other acid; most acids having a stronger action on bodies than this. This last process does not require heat, because fixed air is strongly disposed to assume the elastic state. Water, under the common pressure of the atmosphere, and at a low temperature, absorbs somewhat more than its bulk of fixed air, and then constitutes a weak acid. If the pressure be greater, the absorption is augmented. It is to be observed likewise, that more gas than water will absorb should be present. Heated water absorbs less; and if water impregnated with this acid be exposed on a brisk fire, the rapid escape of the aërial bubbles affords an appearance as if the water were at the point of boiling, when the heat is not greater than the hand can bear. Congelation separates it readily and completely from water; but no degree of cold or pressure has yet exhibited this acid in a dense or concentrated state of fluidity.

Carbonic acid gas is nearly twice as heavy as common air, and for this reason occupies the lower parts of such mines or caverns as contain materials which afford it by decomposition. The miners call it choke damp. The Grotto del Cano, in the kingdom of Naples, has been famous for ages on account of the effects of a stratum of fixed air, which covers its bottom. It is a cave or hole in the side of a mountain, near the lake Agnano, measuring not more than eighteen feet from its entrance to the inner extremity; where if a dog or other animal that holds down its head be thrust, it is immediately killed by inhaling this noxious fluid.

Carbonic acid gas is emitted in large quantities by bodies in the state of the vinous fermentation (see FERMENTATION), and on account of its great weight it occupies the apparently empty space or upper part of the vessels in which the fermenting process is going on. A variety of striking experiments may be made in this stratum of elastic fluid. Lighted paper, or a candle dipped into it, is immediately extinguished; and the smoke remaining in the carbonic acid gas renders its surface visible, which may be thrown into waves by agitation like water. If a dish of water be immersed in this gas, and briskly agitated, it soon becomes impregnated, and obtains the vivid taste of Pyrmont water. In consequence of the weight of the carbonic acid gas, it may be dipped out in a pitcher, or bottle, which, if well corked, may be used to convey it to great distances: or it may be drawn out of a vessel by a cock like a liquid. The effects produced by pouring this invisible fluid from one vessel to another have a very singular appearance; if a candle or small animal be placed in a deep vessel, the former becomes extinct, and the latter expires in a few seconds, after the carbonic acid gas is poured upon them, though the eye is incapable of distinguishing any thing that is poured. If, however, it be poured into a vessel full of air, in the sunshine, its density being so much greater than that of the air, renders it slightly visible by the undulations and streaks it forms in this fluid, as it descends through it.

Carbonic acid reddens infusion of litmus;

but the redness vanishes by exposure to the air, as the acid flies off. It has a peculiar sharp taste, which may be perceived over vats in which wine or beer is fermenting; as also in sparkling Champaign, and the brisker kinds of cider. Light passing through it is refracted by it, but does not effect any sensible alteration in it; though it appears from experiment, that it favours the separation of its principles by other substance. It will not unite with an overdose of oxigen, of which it contains 72 parts in 100, the other 28 being pure carbon. It not only destroys life, but the heart and muscle of animals killed by it lose all their irritability, so as to be insensible to the stimulus of galvanism.

Carbonic acid is dilated by heat, but not otherwise altered by it. It is not acted upon by oxigen, or any of the simple combustibles. Charcoal absorbs it, but gives it out again unchanged. Phosphorus is insoluble in carbonic acid gas; but, as already observed, is capable of decomposing it by compound affinity, when assisted by sufficient heat: and Priestley and Cruickshank have shown, that iron, zinc, and several other metals, are capable of producing the same effect. If carbonic acid be mixed with sulphurated, phosphorated, or carbonated gas, it renders them less combustible, or destroys their combustibility entirely, but produces no other sensible change. Such mixtures occur in various analyses, and particularly in the products of the decomposition of vegetable and animal substances. The inflammable air of marshes is frequently carbonated hidrogen intimately mixed with carbonic acid gas; and the sulphurated hidrogen gas obtained from mineral waters is very often mixed with it.

Carbonic acid appears from various experiments of Ingenhousz to be of considerable utility in promoting vegetation. It is probably decomposed by the organs of plants, its base furnishing part at least of the carbon, that is so abundant in the vegetable kingdom, and its oxigen contributing to replenish the atmosphere with that necessary support of life, which is continually diminished by the respiration of animals and other causes.

In point of affinity for the earths and alkalis, carbonic acid stands at the bottom of the scale. Before its true nature was known, its compounds with them were not considered as salts, but as the earths and alkalis themselves, only distinguished by the names of *mild*, or *effervescent*, from their qualities of effervescing with acids, and wanting causticity.

The carbonat of barytes was formed artificially by Bergman and Scheele in 1776: but Dr. Withering first found it native at Moor Alston in Cumberland in 1783. From this circumstance it has been termed Witherite by Werner. It has been likewise called *aërated heavy spar*, *aërated baroselenite*, *aërated heavy earth* or barytes, *barolite*, &c. Its crystals have been observed to assume four different forms; double six-sided, and double four-sided pyramids; six-sided columns terminated by a pyramid with the same number of faces; and small radiated crystals, half an inch in length, and very thin, appearing to be hexagonal prisms, rounded toward the point. The hexaëdrial prism is presumed to be its primitive form. Its specific gravity, when native, is 4·331; when prepared artificially it scarcely exceeds 3·763.

It may be prepared by exposing a solution of pure barytes to the atmosphere, when it will be covered with a pellicle of this salt by absorbing carbonic acid; or carbonic acid may be received into this solution, in which it will immediately form a copious precipitate: or a solution of nitrat or muriat of barytes may be precipitated by a solution of the carbonat of potash, soda, or ammonia. The precipitate in either of these cases, being well washed, will be found to be very pure carbonat of barytes. It may likewise be procured by decomposing the native sulphat of barytes by the carbonat of potash, or of soda, in the dry way, with the assistance of fire; but in this way the sulphat of barytes is never completely decomposed, and some of it remains mixed with the carbonat.

The carbonat of barytes is soluble only in 4304 times its weight of cold water, and 2304 of boiling water, and this requires a long time; but water saturated with carbonic acid dissolves 1-830th. It is not altered by exposure to the air; but is decomposed by the application of a very violent heat either in a black lead crucible, or when formed into a paste with charcoal powder. Sulphuric acid, in a concentrated state, or diluted with three or four parts of water, does not separate the carbonic acid with effervescence, unless assisted by heat. Muriatic acid does not act upon it likewise, unless diluted with water, or assisted by heat. And nitric acid does not act upon it at all, unless diluted. It has no sensible taste; yet it is extremely poisonous.

As this salt has lately been found, in large quantities, near Murton in Cumberland, and some other places in the vicinity, it might probably be introduced into manufactures with advantage, as for extracting the bases of several salts.

Carbonat of strontian was first pointed out as distinct from the preceding species by Dr. Crawford in 1790, but Dr. Hope gave the first accurate account of it in the Edinburgh Transactions. It has been found native in Scotland, at Strontian in Argyleshire, and at Leadhills. It is usually in fine striated needles, or prisms, that appear to be hexaëdral, semitransparent, and of a white colour slightly tinged with green. It is insipid; requires 1536 parts of boiling water to dissolve it; is not altered by exposure to the air; but when strongly heated in a crucible loses part of its acid; and this decomposition is facilitated by making it into a paste with charcoal powder. When the fire is strongly urged, it attacks the crucible, and melts into a glass, resembling the colour of chrysolite, or pyramidal phosphat of lime. If thrown in powder on well kindled coals, or the flame of a candle, it exhibits red sparks. The same phænomenon occurs, if it be treated with the blow pipe, which fuses it into an opaque vitreous globule, that falls to powder in the open air. Its specific gravity is only 3·66, in which it differs strikingly from the carbonat of barytes; as it does in not being poisonous, according to the experiments made by Pelletier on various animals.

Carbonat of lime exists in great abundance in nature, variously mixed with other bodies, under the name of *marble, chalk, limestone, stalactites*, &c., in which it is of more important and extensive use than any other of the salts, except perhaps the muriat of soda. It is often found crystallized, and perfectly transparent. The primitive form of its crystals is the rhomboidal prism, with angles of 101½ and 78½. Its integrant particles have the same form. Beside this, however, forty-two varieties of its crystals have been discovered and described by mineralogists. The specific gravity of the marbles is from 2·65 to 2·85; of the crystallized carbonats, about 2·7; of the stalactites, from 2·32 to 2·47; of the limestones, from 1·39 to 2·72.

It has scarcely any taste: is insoluble in pure water, but water saturated with carbonic acid takes up 1-1500th, though as the acid flies off this is precipitated. It suffers little or no alteration on exposure to the air. When heated it decrepitates, its water flies off, and lastly its acid; but this requires a pretty strong heat. By this process it is burned into lime.

The carbonat or rather subcarbonat of potash was long known by the name of *vegetable alkali*. It was also called *fixed nitre, salt of tartar, salt of wormwood*, &c., according to the different modes in which it was procured; and was supposed to retain something of the virtues of the substance from which it was extracted. This error has been some time exploded, but the knowledge of its true nature is of more recent date.

As water at the usual temperature of the air dissolves rather more than its weight of this salt, we have thus a ready mode of detecting its adulterations in general; and as it is often of consequence in manufactures, to know how much alkali a particular specimen contains, this may be ascertained by the quantity of sulphuric acid it will saturate.

This salt is deliquescent.

The carbonat of potash crystallizes, according to Fourcroy, in square prisms, the apexes of which are quadrangular pyramids. According to Pelletier they are tetraëdral rhomboidal prisms, with diëdral summits. The complete crystal has eight faces, two hexagons, two rectangles, and four rhombs. It has a urinous but not caustic taste: changes the sirup of violets green: boiling water dissolves five-sixths of its weight, and cold water one-fourth: alcohol, even when hot, will not dissolve more than 1-1200th. Its specific gravity is 2·012.

When it is very pure and well crystallized it effloresces on exposure to a dry atmosphere, though it was formerly considered as deliquescent. The fact is, that the common salt of tartar of the shops is a compound of this carbonat and pure potash; the latter of which, being very deliquescent, attracts the moisture of the air till the whole is dissolved. From its smooth feel, and the manner in which it was prepared, the old chemists called this solution *oil of tartar per deliquium*.

The carbonat of potash melts with a gentle heat, loses its water of crystallization, amounting to 0·15, or ·17, and gives out a portion of its carbonic acid; though no degree of heat will expel the whole of the acid. Thus, as the carbonat of potash is always prepared by incineration of vegetable substances, and lixiviation, it must be in the intermediate state; or that of a carbonat with sulphur of alkali: and to obtain the true carbonat we must saturate this salt with carbonic acid, which is best done by passing the acid in the state of gas through a solution of the salt in twice its weight of water; or, if we want the potash pure, we must have recourse to lime, to separate that portion of acid which fire will not expel.

Another mode, recommended by Berthollet, and which may be of use on some occasions, is to add solid carbonat of ammonia to a solution of potash not saturated, and distil the mixture: when the ammonia may be obtained in the form of gas, or caustic liquor, while the carbonat crystallizes in the retort.

The carbonat of soda has likewise been long known, and distinguished from the preceding by the name of *mineral alkali*. In commerce it is usually called *barilla*, or *soda*; in which state, however, it always contains a mixture of earthy bodies, and usually common salt. It may be purified by dissolving it in a small portion of water, filtering the solution, evaporating at a low heat, and skimming off the crystals of muriat of soda as they form on its surface. When these cease to form, the solution may be suffered to cool, and the carbonat of soda will crystallize. To obtain this salt perfectly pure Klaproth dissolves common carbonat of soda in water, and saturates this solution with nitric acid, taking care that the acid is a little in excess. He then separates the sulphuric acid by nitrat of barytes, and the muriatic acid by nitrat of silver. The fluid thus purified he evaporates to dryness, fuses the nitrat of soda obtained, and decomposes it by detonation with charcoal. He then elixiviates the residue, and crystallizes the carbonat of soda. If it be adulterated with potash, tartarous acid will form a precipitate in a pretty strong solution of it.

It is found abundantly in nature. In Egypt, where it is collected from the surface of the earth, particularly after the desiccation of temporary lakes, it has been known from time immemorial by the name of *nitrum*, *natron*, or *natrum*. This it has been proposed to retain: and accordingly the London college has adopted the term *natron*. Dr. Bostock of Liverpool lately found, that the efflorescence, which copiously covered the decaying parts of the plaster of the salt-water baths in that town, consisted of carbonat of soda. A carbonat of soda exported from Tripoli, which is called *Trona* from the name of the place where it is found, and analysed by Klaproth, contained of soda 37 parts, carbonic acid 38, water of crystallization 22·5, sulphat of soda, 2. This does not effloresce. A great deal is prepared in Spain by incinerating the maritime plant salsola; and it is manufactured in this country, as well as in France, from different species of sea-weeds. It is likewise found in mineral waters; and also in some animal fluids.

It crystallizes in irregular or rhomboidal decaëdrons, formed by two quadrangular pyramids, truncated very near their bases. Frequently it exhibits only rhomboidal laminæ. Its specific gravity is 1·3591. Its taste is urinous, and slightly acrid, without being caustic. It changes blue vegetable colours to a green. It is soluble in less than its weight of boiling water, and twice its weight of cold. It is one of the most efflorescent salts known, falling completely to powder in no long time. On the application of heat it is soon rendered fluid from the great quantity of its water of crystallization; but is dried by a continuance of the heat, and then melts. It is somewhat more fusible than the carbonat of potash, promotes the fusion of earths in a greater degree, and forms a glass of better quality. Like that, it is very tenacious of a certain portion of its carbonic acid. See the article SODA.

The carbonat of magnesia, in a state of imperfect saturation with the acid, has been used in medicine for some time under the simple name of magnesia. It is prepared by precipitation from the sulphat of magnesia by means of carbonat of potash. Equal parts of sulphat of magnesia and carbonat of potash, each dissolved in its own weight of boiling water, are filtered and mixed together hot; the sulphat of potash is separated by copious washing with water; and the carbonat of magnesia is then left to drain, and afterward spread thin on paper, and carried to the drying stove. When once dried it will be in friable white cakes, or a fine powder.

Another mode of preparing it in the great will be found under the article AMMONIA.

To obtain carbonat of magnesia saturated with acid, a solution of sulphat of magnesia may be mixed cold with a solution of carbonat of potash; and at the expiration of a few hours, as the superfluous carbonic acid, that held it in solution, flies off, the carbonat of magnesia will crystallize in very regular transparent prisms of six equal sides. It may be equally obtained by dissolving magnesia in water impregnated with carbonic acid, and exposing the solution to the open air. Dr. Thomson says, the most regular crystals will be obtained by mixing together 125 parts of sulphat of magnesia and 136 parts of carbonat of soda, both dissolved in water, filtering the solution, and then setting it aside for two or three days.

These crystals soon lose their transparency, and become covered with a white powder. Exposed to the fire in a crucible they decrepitate slightly, lose their water and acid, fall to powder, and are reduced to one-fourth of the original weight. When the common carbonat is calcined in the great, it appears as if boiling, from the extrication of carbonic acid; a small portion ascends like a vapour, and is deposited in a white powder on the cold bodies with which it comes into contact; and in a dark place, toward the end of the operation, it shines with a blueish phosphoric light. It thus loses half its weight, and the magnesia is left quite pure.

As the magnesia of the shops is sometimes adulterated with chalk, this may be detected by the addition of a little sulphuric acid diluted with 8 or 10 times its weight of water, as this will form with the magnesia a very soluble salt, while the sulphat of lime will remain undissolved. Calcined magnesia should dissolve in this dilute acid without any effervescence.

The crystallized carbonat dissolves in forty-eight times its weight of cold water; the common carbonat requires at least ten times as much, and first forms a paste with a small quantity of the fluid.

Guyton Morveau has lately found the carbonat of magnesia native, near Castella-Monte, in a stone considered there as a clay very rich in alumine. It is amorphous, as white as ceruse, and as compact as the hardest chalk; does not sensibly adhere to the tongue; and has no argillaceous smell. Its specific gravity, when all the bubbles of air it contains have escaped, is 2·612. In the fire it lost 0·585 of its weight, and became sufficiently hard to scratch Bohemian glass slightly. On analysis it was found to contain: magnesia 26·3, silex 14·2, carbonic acid 46, water 12, iron an inappreciable quantity.

The carbonat of ammonia, once vulgarly known by the name of *volatile sal ammoniac*, and abroad by that of *English volatile salt*, because it was first prepared in this country, was commonly called *mild volatile alkali*, before its true nature was known.

When very pure it is in a crystalline form, but seldom very regular. Its crystals are so small, that it is difficult to determine their figure. Bergman describes them as acute octaëdrons, the four angles of which are truncated. Romé de Lisle had compressed *tetraëdral* prisms, terminated by a diëdral summit. Bergman obtained his by saturating warm water with the salt, stopping the bottle closely, and exposing it to great cold. The crystals commonly produced by sublimation are little bundles of needles, or very slender prisms, so arranged as to represent herborizations, fern leaves, or feathers. The taste and smell of this salt are the same with those of pure ammonia, but much weaker. It turns the colour of violets green, and that of turmeric brown. Its specific gravity is 0·966. It is soluble in rather less than twice its weight of cold water, and in its own weight of hot water; but a boiling heat volatilizes it. When pure, and thoroughly saturated, it is not perceptibly alterable in the air; but when it has an excess of ammonia, it softens and grows moist. It cannot be doubted, however, that it is soluble in air; for if left in an open vessel, it gradually diminishes in weight, and its peculiar smell is diffused to a certain distance. Heat readily sublimes, but does not decompose it.

It has been prepared by the destructive distillation of animal substances and some others, in large iron pots, with a fire increased by degrees to a strong red heat, the aqueous liquor, that first comes over, being removed, that the salt might not be dissolved in it. Thus we had the *salt of hartshorn*, *salt of soot*, *essential salt of vipers*, &c. If the salt were dissolved in the water, it was called *spirit* of the substance from which it was obtained. Thus, however, it was much contaminated by a fetid animal oil, from which it required to be subsequently purified, and is much better fabricated by mixing one part of muriat of ammonia and two of carbonat of lime, both as dry as possible, and subliming in an earthen retort.

Mr. Davy has shown, that its component parts vary exceedingly, according to the manner of preparing it. The lower the temperature at which it is formed, the greater the proportion of acid and water. Thus, if formed at the temperature of 300°, it contains more than fifty per cent. of alkali; if at 60°, not more than twenty per cent.

It is well known as a stimulant usually put into smelling-bottles, frequently with the addition of some odoriferous oil.

Fourcroy has found, that an ammoniaco-magnesian carbonat is formed on some occasions. Thus, if carbonat of ammonia be decomposed by magnesia in the moist way, leaving these two substances in contact with each other in a bottle closely stopped, a complete decomposition will not take place, but a portion of this trisall will be formed. The same will take place, if a solution of carbonat of magnesia in water impregnated with carbonic acid be precipitated by pure ammonia; or if ammoniacomagnesian sulphat, nitrat, or muriat, be precipitated by carbonat of potash or of soda.

The properties of this trisall are not yet known; but it crystallizes differently from the carbonat of either of its bases, and has its own laws of solubility and decomposition.

The carbonat of glucine has only been examined by Vauquelin, though it is among the salts of that earth of which he has most accurately ascertained the properties. It is in a white, dull, clotty, powder, never dry, but greasy and soft to the feel. It is not sweet, like the other salts of glucine, but insipid. It is very light, insoluble in water, perfectly unalterable by the air, but very readily decomposed by fire.

A saturated solution of carbonat of ammonia takes up a certain portion of this carbonat, and forms with it a triple salt. This property enabled Vauquelin to separate glucine from alumine, and was one of the means of his distinguishing that earth.

Carbonic acid does not appear to be much disposed to unite with argillaceous earth. Most clays, however, afford a small quantity of this acid by heat; and Fourcroy says, that the fat clays effervesce with acids. The snowy white substance resembling chalk, and known by the name of *lac lunæ*, is found to consist almost wholly of alumine saturated with carbonic acid. A saline substance consisting of two six-sided pyramids joined at one common base, weighing five or six grains, and of a taste somewhat resembling alum, was produced by leaving an ounce phial of water impregnated with carbonic acid, and a redundancy of alumine exposed to spontaneous evaporation for some months.

Vauquelin has found, that carbonat of zircone may be formed by evaporating muriat of zircone, redissolving it in water, and precipitating by the alkaline carbonat. He also adds, that it very readily combines so as to form a triple salt with either of the three alkaline carbonats.—*Priestley.—Keir.—Bergman.—Black.—Fourcroy.—Thomson.—Kirwan.*

Acid (Chromic). This acid is but lately known, and has only been examined in small quantities by Vauquelin, who first discovered it, and by count Mussin Puschkin; yet we are better acquainted with it, than with the metal that forms its basis. However, as the chromat of iron has lately been found in abundance in the department of Var, in France, we may expect its properties to be more amply investigated, and applied with advantage in the arts, as the chromats of lead and iron are of excellent use in painting and enamelling.

It was extracted from the red lead ore of Siberia, by treating this ore with carbonat of potash, and separating the alkali by means of a more powerful acid. In this state it is a red or orange-coloured powder, of a peculiar rough metallic taste, which is more sensible in it than in any other metallic acid. If this powder be exposed to the action of light and heat, it loses its acidity, and is converted into green oxide of chrome, giving out pure oxigen gas. The chromic acid is the first that has been found to deacidify itself easily by the action of heat, and afford oxigen gas by this simple operation. It appears that several of its properties are owing to the weak adhesion of a part at least of its oxigen. The green oxide of chrome cannot be brought back to the state of an acid, unless its oxigen be restored by treating it with some other acid.

The chromic acid is soluble in water, and crystallizes, by cooling and evaporation, in longish prisms of a ruby red.

Its action on combustible substances is little known. If it be strongly heated with charcoal, it grows black, and passes to the metallic state, without melting.

Of the acids, the action of the muriatic on it is the most remarkable. If this be distilled with the chromic acid, by a gentle heat, it is readily converted into oxigenated muriatic acid. It likewise imparts to it by mixture the property of dissolving gold; in which the chromic resembles the nitric acid. This is owing to the weak adhesion of its oxigen, and it is the only one of the metallic acids that possesses this property.

It readily unites with alkalis, and is the only acid that has the property of colouring its salts, whence the name of chromic has been given it. If two parts of the red lead ore of Siberia in fine powder be boiled with one of an alkali saturated with carbonic acid, in forty parts of water, a carbonat of lead will be precipitated, and the chromat remain dissolved. The solutions are of a lemon colour, and afford crystals of a somewhat deeper hue. Those of chromat of ammonia are in yellow laminæ, having the metallic lustre of gold.

The chromat of barytes is very little soluble, and that of lime still less. They are both of a pale yellow, and when heated give out oxigen gas, as do the alkaline chromats.

If the chromic acid be mixed with filings of tin and the muriatic acid, it becomes at first yellowish brown, and afterward assumes a blueish green colour, which preserves the same shade after desiccation. Ether alone gives it the same dark colour. With a solution of nitrat of mercury it gives a precipitate of a dark cinnabar colour. With a solution of nitrat of silver it gives a precipitate, which, the moment it is formed, appears of a beautiful carmine colour, but becomes purple by exposure to the light. This combination, exposed to the heat of the blowpipe, melts before the charcoal is inflamed, and assumes a blackish and metallic appearance. If it be then pulverised, the powder is still purple; but after the blue flame of the lamp is brought into contact with this powder, it assumes a green colour, and the silver appears in globules disseminated through its substance.

With nitrat of copper it gives a chesnut red precipitate. With the solution of sulphat of zinc, muriat of bismuth, muriat of antimony, nitrat of nickel and muriat of platina, it produces yellowish precipitates, when the solutions do not contain an excess of acid. With muriat of gold it produces a greenish precipitate.

When melted with borax, or glass, or acid of phosphorus, it communicates to it a beautiful emerald green colour.

If paper be impregnated with it, and exposed to the sun a few days, it acquires a green colour, which remains permanent in the dark.

A slip of iron, or tin, put into its solution, imparts to it the same colour.

The aqueous solution of tannin produces a flocculent precipitate of a brown fawn colour.

Sulphuric acid, when cold, produces no effect on it; but when warmed it makes it assume a blueish green colour.—*Fourcroy.*—*Lagrange.*—*Thomson.*

Acid (Citric). The juice of lemons, or limes, has all the characters of an acid of considerable strength: but on account of the mucilaginous matter with which it is mixed, it is very soon altered by spontaneous decomposition. Various methods have been contrived to prevent this effect from taking place, in order that this wholesome and agreeable acid might be preserved for use in long voyages, or other domestic occasions. The juice may be kept in bottles under a thin stratum of oil, which indeed prevents, or greatly retards, its total decomposition; though the original fresh taste soon gives place to one which is much less grateful. In the East Indies it is evaporated to the consistence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated the mucilage thickens, and separates in the form of flocks, part of which subsides, and part rises to the surface: these must be taken out. The vapours which arise are not acid. If the evaporation be not carried so far as to deprive the liquid of its fluidity, it may be long preserved in well closed bottles; in which, after some weeks standing, a farther portion of mucilage is separated without any perceptible change in the acid.

Of all the methods of preserving lemon-juice, that of concentrating it by frost appears to be the best, though in the warmer climates it cannot conveniently be practised. Lemon-juice, exposed to the air, in a temperature between 50° and 60°, deposits in a few hours a white semitransparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much less alterable than before. This mucilage is not of a gummy nature, but resembles the gluten of wheat in its properties: it is not soluble in water when dried. More mucilage is separated from lemon-juice by standing in closed vessels. If this depurated lemon-juice be exposed to a degree of cold of about seven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the process be continued until the ice begins to exhibit signs of acidity, the remaining acid will be found to be reduced to about one-eighth of its original quantity, at the same time that its acidity will be eight times as intense, as is proved by its requiring eight times the quantity of alkali to saturate an equal portion of it. This concentrated acid may be kept for use, or, if preferred, it may be made into a dry lemonade, by adding six times its weight of fine loaf sugar in powder.

The above processes may be used when the acid of lemons is wanted for domestic purposes, because they leave it in possession of the oils, or other principles, on which its flavour peculiarly depends; but in chemical researches, where the acid itself is required to be had in the utmost purity, a more elaborate process must be used. Boiling lemon-juice is to be saturated with powdered chalk, the weight of which is to be noted, and the powder must be stirred up from the bottom, or the vessel shaken from time to time. The neutral saline compound is scarcely more soluble in water than selenite; it therefore falls to the bottom, while the mucilage remains suspended in the watery fluid, which must be decanted off; the remaining precipitate must then be washed with warm water until it comes off clear. To the powder thus edulcorated, a quantity of sulphuric acid, sufficient to saturate the lime, and diluted with ten parts of water, must be added, and the mixture boiled a few minutes. The sulphuric acid combines with the earth, and forms sulphat of lime, which remains behind when the cold liquor is filtered, while the disengaged acid of lemons remains dissolved in the fluid. This last must be evaporated to the consistence of a thin sirup, and sulphuric acid must be then added in small portions, to precipitate the lime, if any should still remain in combination with the citric acid. When no more precipitate is afforded by the addition of sulphuric acid, a farther evaporation separates the pure citric acid in little needle-like crystals. It is necessary that the sulphuric acid last added should be rather in excess, because the presence of a small quantity of lime will prevent the crystallization. This excess will be found in the mother water.

M. Dize, a skilful apothecary at Paris, who has repeated this process of Scheele on a very extensive scale, asserts, that an excess of sulphuric acid is necessary, not only to obtain the citric acid pure, but to destroy the whole of the mucilage, part of which would otherwise remain, and occasion its spoiling. It is not certain, however, but the sulphuric acid may act on the citric itself, and by decomposing it produce the charcoal, that M. Dize ascribes to the decomposition of mucilage: and if so, the smaller the excess of sulphuric acid the better. He also adds, that to have it perfectly pure it must be repeatedly crystallized, and thus it forms very large and accurately defined crystals, in rhomboidal prisms, the sides of which are inclined in angles of 60° and 120°, terminated at each end by tetraëdral summits, which intercept the solid angles. These, however, will not be obtained when operating on small quantities.

Its taste is extremely sharp, so as to appear caustic. Distilled in a retort, part rises without being decomposed; it appears to give out a portion of vinegar; it then evolves carbonic acid gas, and a little carbonated hidrogen; and a light coal remains. It is among the vegetable acids that must powerfully resist decomposition by fire.

In a dry and warm air it seems to effloresce; but it absorbs moisture, when the air is damp, and at length loses its crystalline form. A hundred parts of this acid are soluble in seventy-five of water at 60° according to Vauquelin. Though it is less alterable than most other solutions of vegetable acids, it will undergo decomposition when long kept. Fourcroy thinks it probable, that it is converted into acetous acid before its final decomposition.

It is not altered by any combustible substance; charcoal alone appears to be capable of whitening it. The most powerful acids decompose it less easily than they do other vegetable acids: but the sulphuric evidently converts it into acetous acid. The nitric acid likewise, according to Fourcroy and Vauquelin, if employed in large quantity, and heated on it a long time, converts the greater part of it into acetous acid, and a small portion into oxalic. Scheele indeed could not effect this: but Westrumb supposes, that it was owing to his having used too much nitric acid; for on treating 60 grains of citric acid with 200 of nitric he obtained 30 grains of oxalic acid, with 300 grains of nitric acid he got 15, and with 600 grains no vestige of oxalic acid appeared.

If a solution of barytes be added gradually to a solution of citric acid, a flocculent precipitate is formed, soluble by agitation, till the whole of the acid is saturated. This salt at first falls down in powder, and then collects in silky tufts, and a kind of very beautiful and shining silvery bushes. It requires a large quantity of water to dissolve it.

The citrat of lime has been mentioned already, in treating of the mode of purifying the acid.

The citrat of potash is very soluble and deliquescent.

The citrat of soda has a dull saline taste; dissolves in less than twice its weight of water; crystallizes in six-sided prisms with flat summits; effloresces slightly, but does not fall to powder; boils up, swells, and is reduced to a coal on the fire. Lime-water decomposes it, but does not render the solution turbid, notwithstanding the little solubility of citrat of lime.

Citrat of ammonia is very soluble; does not crystallize unless its solution be greatly concentrated; and forms elongated prisms.

Citrat of magnesia does not crystallize. When its solution had been boiled down, and it had stood some days, on being slightly shaken it fixed in one white opake mass, which remained soft, separating from the sides of the vessel, contracting its dimensions, and rising in the middle like a kind of mushroom.

Its combination with the other earths has not yet been examined . and its action upon metals has been little studied. Scheele however found, that it did not precipitate the nitric solutions of white metals, as the malic acid does.

All the citrats are decomposed by the powerful acids, which do not form a precipitate with them, as with the oxalats and tartrits. The oxalic and tartarous acids decompose them, and form crystallized or insoluble precipitates in their solutions. All afford traces of acetous acid, or a product of the same nature, on being exposed to distillation: this character exists particularly in the metallic citrats. Placed on burning coals they melt, swell up, emit an empyreumatic smell of acetous acid, and leave a light coal. All of them, if dissolved in water, and left to stand for a time, undergo decomposition, depose a flocculent mucus which grows black, and leave their bases combined with carbonic acid, one of the products of the decomposition. Before they are completely decomposed, they appear to pass to the state of acetits.

The affinities of the citric acid are arranged by Vauquelin in the following order: barytes, lime, potash, soda, strontian, magnesia, ammonia, alumine. These for zircone, glucine, and the metallic oxides, are not ascertained.

The citric acid is found in many fruits united with the malic acid; which see for the process of separating them in this case.

Acid (Fluoric). The fusible spar, which is generally distinguished by the name of Derbyshire spar, consists of calcareous earth in combination with the acid at present under our consideration. If the pure fluor, or spar, be placed in a retort of lead, with a receiver of the same metal adapted, and half its weight of sulphuric acid be then poured upon it, the fluoric acid will be disengaged in the aërial form by the application of a moderate heat. This acid gas readily combines with water; for which purpose it is necessary that the receiver should previously be half filled with that fluid When experiments are required to be made with the acid in the elastic state, it must be received over mercury.

Mr. Accum, however, has found, by mingling the acid thus obtained with water impregnated with sulphurated hidrogen gas, that it always contains lead. Tin it acts upon less, and silver not at all: but to obtain the acid pure he recommends the following process. One part of fluor spar in fine powder is to be mixed with two of sulphuric acid, and one of water. The mixture is then to be introduced into a glass retort, to which a glass receiver has been previously luted containing two ounces of water. Heat being then applied, the distillation is to be carried on slowly. After the decomposition of the fluat of lime is effected, which may be known by the disappearance of the whitish vapours in the retort, the contents of the receiver must be filtered, and distilled water added to the filtered fluid, till, on a new admixture of water, no farther cloudiness appears. The acid thus obtained contains no silex; it is absolutely pure, and may be kept in glass bottles covered within with wax, or, in preference, with a hard varnish.

The distinguishing and most remarkable property of this acid is its power of combining with and volatilizing siliceous earth, which remains suspended with it in the permanently elastic form. The first experiments with fluor spar were made in glass vessels, and were attended with the singular phænomenon of an earthy matter being deposited at the instant that the acid air came into contact with the water in the recipient. Upon examination it was found to consist of siliceous earth; and subsequent experiments proved, that it was obtained by corrosion of the glass retort, and deposited in consequence of the acid possessing a less power of suspending siliceous earth when combined with water, than when in the elastic state.

Fluoric acid in the state of gas is as invisible as the air: yet if it come into contact with the least moisture, it becomes more or less cloudy. It has a pungent, acrid smell, pretty analogous to that of the muriatic acid, yet not exactly the same. It is much heavier than common air, but its specific gravity is not accurately determined, perhaps because we never have it pure. It extinguishes a candle, first rendering the flame green; kills animals; and reddens vegetable blues. Light is refracted by it in proportion to its density. Heat dilates it, but does not appear to alter its nature, since it retains all its properties after passing through a red-hot tube of porcelain. When placed in contact with oxigen gas, atmospheric air, or azot, it does not alter or absorb it, and remains unaltered by it. If, however, either of these gases contain water, a thick white vapour is formed, not merely from the condensation of the gas, but from the precipitation of part of the earth it contained.

From its being unaffected by any of the combustible substances, its base is unknown: but it is presumed from analogy to consist of some base united with oxigen, and having too powerful an attraction for it to yield it to any known combustible.

Mr. Henry infers, from some phænomena that occurred in his endeavours to decompose it, that it is capable of being further oxigenised like the muriatic, and, in this state of acting on mercury.

Water, either fluid or frozen, readily absorbs this acid; which melts the ice, lowering its temperature as it liquefies it, or heats the water as it condenses in it.

Most of the metallic oxides absorb this acid in the state of gas but slowly; when it is dissolved in water, it acts on them more readily, and forms peculiar metallic salts.

From the remarkable property this acid possesses of corroding glass, it has been employed for etching on it, both in the gaseous state and combined with water; and an ingenious apparatus for this purpose is given by Mr. Richard Knight in the Philosophical Magazine, vol. xvii. p. 357.

M. Kortum, of Warsaw, having found that some pieces of glass were more easily acted upon by it than others, tried its effect on various stones. Rock crystal, ruby, sapphire, lux sapphire, emerald, oriental garnet, amethyst, chrysolite, aventurine, girasol, a Saxon topaz, a Brazilian topaz burnt, and an opal, being exposed to the fluoric gas at a temperature of 122° F., were not acted upon. Diamond exposed to the vapour on a common German stove for four days was unaffected. Of polished granite neither the quartz nor mica appeared to be attacked, but the feldt-spar was rendered opake and muddy, and covered with a white powder. Chrysoprase, an opal from Hungary, onyx, a carnelian from Persia, agate, chalcedony, green Siberian jasper, and common flint, were etched by it in twenty-four hours; the chrysoprase near half a line deep, the onyx pretty deeply, the opal with the finest and most regular strokes, and all the rest more or less irregularly. The uncovered part of the brown flint had become white, but was still compact: water, alcohol, and other liquids, rendered the whiteness invisible, but as soon as the flint became dry it appeared again. The same effect was produced on carnelian, and on a dark brown jasper, if the operation of the acid were stopped as soon as it had whitened the part exposed without destroying its texture. A piece of black flint, with efflorescent white spots, and partly covered with the common white crust, being exposed five days to the gas at a heat of about 68° F., was reduced from 103 grains to 91, and rendered white throughout. Some parts of it were rendered friable. White Carara marble in twenty-four hours, at 77°, lost 1-30th of its weight, but the shining surface of its crystallized texture was distinguishable. Black marble was not affected either in weight or colour, and agate was not attacked. Transparent foliated gypsum fell into white powder on its surface in a few hours; but this powder was not soluble in dilute nitric acid,—so that the fluoric acid had not destroyed the combination of its principles, but deprived it of its water of crystallization. A striated zeolite, weighing 102 grains, was rendered friable on its surface in forty-eight hours, and weighed only 85½ grains. On being immersed in water, and then dried, it gained 2½ grains, but did not recover its lustre. Barytes of a fibrous texture remained unchanged. A thin plate of Venetian talc, weighing 124 grains, was reduced to 81 grains in forty-eight hours, and had fallen into a soft powder, which floated on water. M. Kortum poured water on the residuum in the apparatus, and the next day the sides were incrusted with small crystalline glittering flakes, adhering in detached masses, which could not be washed off with dilute nitrous acid.

Of the combination of this acid with most of the bases little is known.

The native fluat of lime, the fluor spar already mentioned, is the most common. It is rendered phosphorescent by heat, but this property gradually goes off, and cannot be produced a second time. With a strong heat it decrepitates. At a heat of 130° of Wedgwood it enters into fusion in a clay crucible. It is not acted upon by the air, and is insoluble in water. Concentrated sulphuric acid deprives it of the fluoric acid with effervescence, at the common temperature, but heat promotes its action. Besides its use for obtaining this acid, it is much employed in chimney ornaments, and as a flux for some ores and stones.

The fluoric acid takes barytes from the nitric and muriatic, and forms a salt very little soluble, that effloresces in the air.

With magnesia it precipitates, according to Scheele, in a gelatinous mass. But Bergman says, that a part remains in solution, and by spontaneous evaporation shoots on the sides of the vessel into crystalline threads resembling a transparent mass. The bottom of the vessel affords also crystals in hexagonal prisms, ending in a low pyramid of three rhombs. He adds, that no acid decomposes it in the moist way, and that it is unalterable by the most violent fire.

The fluat of potash is not crystallizable; and if it be evaporated to dryness it soon deliquesces. Its taste is somewhat acrid and saline. It melts with a strong heat, is afterward caustic, and attracts moisture.

This fluat, as well as those of soda and ammonia, are commonly obtained, as Fourcroy conceives, in the state of triple salts, being combined with siliceous earth.

The fluat of soda affords small crystals in cubes and parallelograms, of a bitterish and astringent taste, decrepitating on burning coals, and melting into semitransparent globules with the blowpipe without losing their acid. It is not deliquescent, and difficultly soluble. The concentrated acids disengage its acid with effervescence.

The fluat of ammonia may be prepared by adding carbonat of ammonia to diluted fluoric acid in a leaden vessel, observing, that there is a small excess of acid. This is a very delicate test of lime.

Fourcroy informs us, that ammonia and magnesia form a triple salt with the fluoric acid.

Scheele observed, that the fluor acid united with alumine into a salt, that could not be crystallized, but assumed a gelatinous form. Fourcroy adds, that the solution is always acid, astringent, decomposable and precipitable by all the earthy and alkaline bases, but capable of uniting with silex and the alkalis into various triple salts. A native combination of alumine and soda with fluoric acid has been found lately in a semitransparent stone from Greenland. See Cryolite.

The affinity of the fluoric acid for silex has already appeared. If the acid solution of fluat of silex, obtained by keeping the solution of the acid in glass vessels, be evaporated to dryness, the fluoric acid may be disengaged from the solid salt remaining, as Fourcroy informs us, either by the powerful acids, or by a strong heat: and if the solution be kept in a vessel that admits of a slow evaporation, small brilliant crystals, transparent, hard, and apparently of a rhomboidal figure, will form on the bottom of the vessel, as Bergman found in the course of two years' standing.

Beside the fluor spar and cryolite, in which it is abundant, fluoric acid has been detected in the topaz; in wavellite, in which, however, it is not rendered sensible by sulphuric acid; and in fossil teeth and fossil ivory, though it is not found in either of these in their natural state.—*Scheele.*—*Bergman.*—*Fourcroy.*—*Henry.*—*Phil. Journal.*—*Voigt's Mag. der Naturkunde.*

Acid (Formic). It has long been known, that ants contain a strong acid, which they occasionally emit; and which may be obtained from the ants, either by simple distillation, or by infusion of them in boiling water, and subsequent distillation of as much of the water as can be brought over without burning the residue. After this it may be purified by repeated rectifications, or by boiling to separate the impurities; or after rectification it may be concentrated by frost.

This has now lost its rank as a separate acid, as it has been shown by Fourcroy and Vauquelin to be a compound of the malic and acetic.

We have been informed, that it has been employed among quacks as a wonderful remedy for the toothach, by applying it to the tooth with the points of the forefinger and thumb.

Acid (Gallic). This acid is found in different vegetable substances possessing astringent properties, but most abundantly in the excrescences termed galls, or nutgalls, whence it derives its name. It may be obtained by macerating galls in water, filtering, and suffering the liquor to stand exposed to the air. It will grow mouldy, be covered with a thick glutinous pellicle, abundance of glutinous flocks will fall down, and in the course of two or three months the sides of the vessel will appear covered with small yellowish crystals, abundance of which will likewise be found on the under surface of the supernatant pellicle. These crystals may be purified by solution in alcohol, and evaporation to dryness.

Or muriat of tin may be added to the infusion of galls till no more precipitate falls down; the excess of oxide of tin remaining in the solution may then be precipitated by sulphurated hidrogen gas: and the liquor will yield crystals of gallic acid by evaporation.

A more simple process, however, is that of M. Fiedler. Boil an ounce of powdered galls in sixteen ounces of water to eight, and strain. Dissolve two ounces of alum in water, precipitate the alumine by carbonat of potash, and, after edulcorating it completely by repeated ablutions, add it to the decoction, frequently stirring the mixture with a glass rod. The next day filter the mixture; wash the precipitate with warm water, till this will no longer blacken sulphat of iron; mix the washings with the filtered liquor, evaporate, and the gallic acid will be obtained in fine needled crystals.

These crystals obtained in any of these ways, however, according to Mr. Davy, are contaminated with a small portion of extractive matter; and to purify them they may be placed in a glass capsule in a sand heat, and sublimed into another capsule, inverted over this and kept cool. M. Deyeux indeed recommends to procure the acid by sublimation in the first instance; putting the powdered galls into a glass retort, and applying heat slowly and cautiously; when the acid will rise, and be condensed in the neck of the retort. This process requires great care, as, if the heat be carried so far as to disengage the oil, the crystals will be dissolved immediately. The crystals thus obtained are pretty large, laminated, and brilliant.

The gallic acid, placed on a red-hot iron, burns with flame, and emits an aromatic smell not unlike that of benzoic acid. It is soluble in 24 parts of cold water, and in 3 parts at a boiling heat. It is more soluble in alcohol, which takes up an equal weight if heated, and one-fourth of its weight cold.

Concentrated sulphuric acid decomposes and carbonizes it; and the nitric acid converts it into malic and oxalic acids.

United with barytes, strontian, lime, and magnesia, it forms salts of a dull yellow colour, which are little soluble, but more so if their base be in excess. With alkalis we only know it forms salts that are not very soluble in general, and precipitate metallic solutions in coloured gallats.

Its most distinguishing characteristic is its great affinity for metallic oxides, so as to take them in general from the most powerful acids. The more readily the metallic oxides are to part with their oxigen, the more they are alterable by the gallic acid. To a solution of gold it imparts a green hue; and a brown precipitate is formed, which readily passes to the metallic state, and covers the solution with a shining golden pellicle. With nitric solution of silver it produces a similar effect. Mercury it precipitates of an orange yellow; copper, brown; bismuth, of a lemon colour; lead, white; iron, black. Platina, zinc, tin, cobalt, and manganese, are not precipitated by it.

The gallic acid is of extensive use in the art of dyeing, as it constitutes one of the principal ingredients in all the shades of black, and is employed to fix or improve several other colours. It is well known as an ingredient in ink. See GALLS, DYEING, and INK.

ACID (HYDROTHIAN). Some of the German chemists distinguish sulphuretted hidrogen by this name, on account of its properties resembling those of an acid.

ACID (LACCIC). About the year 1786, Dr. Anderson of Madras was made acquainted with a substance formed as a kind of nidus by the female of an insect of the genus coccus, of which the natives are very fond. This substance, which has a considerable resemblance to bees wax, he named white lac. In 1789 a small quantity of it was sent to Europe; and in 1793 it was analysed by Dr. Pearson, at the request of sir Joseph Banks. It is of a gray colour, opaque, rough, and in roundish pieces, weighing from three to fifteen grains, and fusible at 145°. On pressing it between the fingers, particularly when fresh gathered, a reddish fluid is squeezed out.

Two thousand grains of the white lac being exposed to a heat just sufficient to melt it, 550 grains of a reddish watery liquid, like that pressed out by the fingers, oozed out of the mass. To this Dr. Pearson gives the name of laccic acid.

This fluid reddens blue litmus paper; after being filtered has a slightly saltish taste, with bitterness, but is not at all sour; when heated smells like bread just baked; and on standing deposits a small quantity of sediment. Its specific gravity at 60° is 1·025. Having been evaporated till it grew very turbid, it afforded on standing small needle-shaped crystals in mucilaginous matter.

Two hundred and fifty grains being put into a retort, the liquor distilled over very fast at the temperature of 200°, and left a small quantity of extractive matter behind. The distilled liquor was transparent and yellowish. A strip of litmus paper, which had been put into the receiver, was not reddened, and another, previously immersed in a solution of sulphat of iron, was turned blue by solution of potash.

A hundred grains of the distilled liquor being evaporated till it grew turbid, and set by for a night, afforded a group of acicular crystals, not amounting to a quarter of a grain. These tasted only bitterish.

A similar quantity evaporated to dryness in a low temperature left a blackish residuum, which was not entirely dissipated by heating the spoon very hot in the naked fire.

Carbonat of lime dissolved in the distilled liquor with effervescence; and on adding carbonat of potash a copious precipitation ensued. A little of this mixture being evaporated to dryness, and the residuum heated red-hot, nothing remained but carbonat of lime and carbonat of potash.

This liquid did not render nitrat of lime turbid; but it did both nitrat and muriat of barytes.

The reddish liquor obtained by melting the lac excited effervescence with carbonat of soda, three grains of which were sufficient to neutralise five hundred of the liquor. A quantity of mucilaginous matter, with a little carbonat of lime, was precipitated. The saturated solution being filtered, and duly evaporated, afforded on standing deliquescent crystals, which on exposure to fire left a residuum of carbonat of soda.

Lime-water produced a light purple turbid appearance in the reddish liquor, and on standing clouds were just perceptible. Sulphat of lime occasioned a white precipitate, but no smell of sulphurated hidrogen gas was perceived. Tincture of galls gave a green precipitation. Sulphat of iron produced a purplish colour, but no precipitation: neither was any formed on adding to the mixture first a little vinegar, and then a little potash. Acetit of lead threw down a reddish precipitate, which the addition of a little nitric acid redissolved. Nitrat of mercury produced a whitish turbid mixture. Oxalic acid immediately threw down some white needly crystals. Tartrit of potash occasioned a precipitate not unlike what takes place with tartarous acid, but it did not redissolve on adding potash.

It appears, therefore, that this is either a new acid, or an acid disguised by circumstances not yet developed.—*Phil. Trans. for 1794, part ii.*

Acid (Lactic). By evaporating sour whey to one-eighth, filtering, precipitating with lime-water, and separating the lime by oxalic acid, Scheele obtained an aqueous solution of what he supposed to be a peculiar acid, which has accordingly been termed the *lactic*. To procure it separate, he evaporated the solution to the consistence of honey, poured on it alcohol, filtered this solution, and evaporated the alcohol. The residuum was an acid of a yellow colour, incapable of being crystallized, attracting the humidity of the air, and forming deliquescent salts with the earths and alkalis.

Bouillon Lagrange has since examined it more narrowly; and from a series of experiments concludes, that it consists of acetic acid, muriat of potash, a small portion of iron probably dissolved in the acetic acid, and an animal matter.—*Ann. de Chimie.*

Acid (Lithic). This was discovered about the year 1776 by Scheele, in analysing human calculi, of many of which it constitutes the greater part, and of some, particularly that which resembles wood in appearance, it forms almost the whole. It is likewise present in human urine, and in that of the camel; and Dr. Pearson found it in those arthritic concretions commonly called chalkstones, which Mr. Tennant has since confirmed.

The following are the results of Scheele's experiments on calculi, which were found to consist almost wholly of this acid:

1. Dilute sulphuric acid produced no effect on the calculus, but concentrated dissolved it; and the solution distilled to dryness left a black coal, giving off sulphurous acid fumes. 2. The muriatic acid, either diluted or concentrated, had no effect on it even with ebullition. 3. Dilute nitric acid attacked it cold; and with the assistance of heat produced an effervescence and red vapour, carbonic acid was evolved, and the calculus was entirely dissolved. The solution was acid, even when saturated with the calculus, and gave a beautiful red colour to the skin in half an hour after it was applied; when evaporated it became of a blood red, but the colour was destroyed by adding a drop of acid: it did not precipitate muriat of barytes, or metallic solutions, even with the addition of an alkali: alkalis rendered it more yellow, and, if superabundant, changed it by a strong digesting heat to a rose colour; and this mixture imparts a similar colour to the skin, and is capable of precipitating sulphat of iron black, sulphat of copper green, nitrat of silver gray, superoxigenated muriat of mercury, and solutions of lead and zinc, white. Lime-water produced in the nitric solution a white precipitate, which dissolved in the nitric and muriatic acids without effervescence, and without destroying their acidity. Oxalic acid did not precipitate it. 4. Carbonat of potash did not dissolve it, either cold or hot, but a solution of perfectly pure potash dissolved it even cold. The solution was yellow; sweetish to the taste; precipitated by all the acids, even the carbonic; did not render lime-water turbid; decomposed and precipitated solution of iron brown, of copper gray, of silver black, of zinc, mercury, and lead, white; and exhaled a smell of ammonia. 5. About 200 parts of lime-water dissolved the calculus by digestion, and lost its acrid taste. The solution was partly precipitated by acids. 6. Pure water dissolved it entirely, but it was necessary to boil for some time 360 parts with one of the calculus in powder. This solution reddened tincture of litmus, did not render lime-water turbid, and on cooling deposited in small crystals almost the whole of what it had taken up. 7. Seventy-two grains distilled in a small glass retort over an open fire, and gradually brought to a red heat, produced water of ammonia mixed with a little animal oil, and a brown sublimate weighing 28 grains, and 12 grains of coal remained, which preserved its black colour on red hot iron in the open air. The brown sublimate was rendered white by a second sublimation; was destitute of smell, even when moistened by an alkali; was acid to the taste; dissolved in boiling water, and also in alcohol, but in less quantity; did not precipitate lime-water; and appeared to resemble succinic acid.

Fourcroy has found, that this acid is almost entirely soluble in 2000 times its weight of cold water, when the powder is repeatedly treated with it. From his experiments he infers, that it contains azot, with a considerable portion of carbon, and but little hidrogen, and little oxigen.

Of its combinations with the bases we know but little. The lithiat of lime is more soluble than the acid itself; but on exposure to the air it is soon decomposed, the carbonic acid in the atmosphere combining with the lime, and precipitating both the lithic acid and new formed carbonat of lime separate from each other. The lithiat of soda appears from the analysis of Mr. Tennant to constitute the chief part of the concretions formed in the joints of gouty persons. The lithiat of potash is obtained by digesting calculi in caustic lixivium; and Fourcroy recommends the precipitation of the lithic acid from this solution by acetous acid, as a good process for obtaining the acid pure in small, white, shining, and almost pulverulent needles.—*Scheele.—Bergman.—Phil. Trans.—Ann. de Chimie.*

Acid (Malic). This acid is thus called because it was found by Scheele chiefly in the juice of apples, though few are met with in a greater variety of productions, as it has been discovered in almost all fruits, in different parts of vegetables, and in various insects, particularly the ant. Indeed all vegetable and even animal substances, that are capable of being converted into oxalic acid by the action of the nitric, appear first to acquire the properties of the malic acid; and it may perhaps be considered as the first stage of acidification, in all the natural and artificial processes, in which carbon and hidrogen are combined with oxigen to form an acid; as it contains a larger proportion of these radicals than any of its kindred acids, and retains more of the nature of the animal or vegetable substance from which it was formed. The oxigenated muriatic acid converts insipid vegetable substances into the malic acid still more readily than the nitric does, and the malic acid obtained is more permanent, not so readily passing to the state of oxalic acid. To convert gum into malic acid nothing more is requisite than to powder it, put it into oxigenated muriatic acid, and shake them together a little while.

As it is most pure and abundant in unripe apples, it may be obtained by saturating their juice with carbonat of potash, and precipitating with acetat of lead. When no more falls down, the precipitate is to be washed with water, and then decomposed by adding dilute sulphuric acid, till the supernatant fluid acquires a sour taste unmixed with any sweetness. If there be an excess of sulphuric acid, this may be remedied by the addition of a little of the malat of lead. The sulphat of lead being then separated by filtration, the liquid may be evaporated till it becomes of a thickish consistence, and a dark red colour, but it will not yield crystals.

In a great many fruits it is mixed with citric acid, as in the juice of gooseberries in particular, and the following mode may be employed to separate them. The juice being boiled down to the consistence of honey, pour on it alcohol, which dissolves both the acids, and leaves behind a large quantity of mucilage. Saturate the two acids in the alcoholic solution with carbonat of lime, and wash the precipitate with boiling water, which will take up the malat of lime, and leave the citrat. The malat of lime may then be decomposed by sulphuric acid.

The malic acid will not crystallize, but after having been boiled down to a thick consistence will desiccate in layers like a shining varnish by being exposed to a dry air. It is easily decomposed by fire, and gives out an acid liquor, a great deal of carbonic acid gas, and a little carbonated hidrogen, and leaves behind a light spongy coal. Its empyreumatic acid appears to resemble that which has been termed pyromucous. Kept in bottles, it undergoes a slow spontaneous decomposition, ferments perceptibly, becomes at first slightly vinous, and deposits a mucous, filamentous, flocculent sediment, which is ultimately carbonized. It is alterable by all the powerful acids, the sulphuric carbonizing it, and the nitric converting it into oxalic acid.

The malat of barytes is capable of solution and crystallization. That of lime affords small irregular crystals, that are not very soluble in boiling water, though they are in an excess of their own acid, or in vinegar, as is likewise the malat of barytes. The malat of lime, thus dissolved in its own acid, grows thick in the air, and forms a solid shining substance resembling varnish. This malat has been found by Vauquelin in various plants, and he observes, that, if the juice of a plant afford a copious precipitate with oxalat of ammonia, and with acetat of lead a light flocculent precipitate, easily soluble in vinegar, we may be certain it contains malat of lime. The malat of alumine is very little soluble: those of magnesia and the three alkalis are deliquescent.

The malic acid precipitates the nitrats of mercury, lead, and silver, in which it differs from the citric acid.

Acid (Mellitic). M. Klaproth has lately discovered in the melilite, or honeystone, what he conceives to be a peculiar acid of the vegetable kind combined with alumine. This acid is easily obtained by reducing the stone to powder, and boiling it in about seventy times its weight of water; when the acid will dissolve, and may be separated from the alumine by filtration. By evaporating the solution it may be obtained in the form of crystals. The following are its characters:

It crystallizes in fine needles or globules by the union of these, or small prisms. It does not seem however at first to possess this property, but gradually acquires it on exposure to the air, perhaps by absorbing oxigen. Its taste is at first a sweetish sour, which leaves a bitterness behind. On a plate of hot metal it is readily decomposed, and dissipated in copious gray fumes, which affect not the smell; leaving behind a small quantity of ashes, that do not change either red or blue tincture of litmus. Neutralized by potash it crystallizes in groups of long prisms: by soda, in cubes, or triangular laminæ, sometimes in groups, sometimes single: and by ammonia, in beautiful prisms with six planes, which soon lose their transparency, and acquire a silvery white hue. If the melitic acid be dissolved in lime-water, and a solution of calcined strontian or barytes be dropped into it, a white precipitate is thrown down, which is redissolved on adding muriatic acid. With a solution of acetit of barytes, it produces likewise a white precipitate, which nitric acid redissolves. With solution of muriat of barytes it produces no precipitate, or even cloud; but, after standing some time, fine transparent needly crystals are deposited. The melitic acid produces no change in a solution of nitrat of silver. From a solution of nitrat of mercury, either hot or cold, it throws down a copious white precipitate, which an addition of nitric acid immediately redissolves. With nitrat of iron it gives an abundant precipitate of a dun yellow colour, which may be redissolved by muriatic acid. With a solution of acetit of lead it produces an abundant precipitate, immediately redissolved on adding nitric acid. With acetit of copper it gives a grayish green precipitate; but it does not affect a solution of muriat of copper. Lime-water precipitated by it is immediately redissolved on adding nitric acid.

M. Klaproth was never able to convert this acid into the oxalic by means of nitric acid, which only changed its brownish colour to a pale yellow.

Acid (Molybdenous). Molybdena is susceptible of four different stages of oxigenation: at the lowest it is in the state of a black oxide; its next is a blue oxide; with an additional portion of oxigen it becomes green, and, beginning to assume acid properties, is termed *molybdenous acid*; and when it is saturated with as much oxigen as it can take up, it is of a yellowish white colour, and is the *molybdic acid*, an account of which is given in the succeeding article.

Acid (Molybdic). The ore of molybdena is a substance that greatly resembles plumbago or black lead; but its texture is scaly, and it is not easily pulverised, on account of a degree of flexibility which its laminæ possess. It may, however, be reduced to powder by grinding it in a mortar with some sulphat of potash; the hardness and angular figure of the particles of this salt tending greatly to facilitate the division. The salt may afterward be washed off by three or four affusions and decantations of hot water.

None of the known acids have any effect upon molybdena, except the sulphuric, arsenic, and nitric. The ore of molybdena is not attacked by the arsenic acid till the water is evaporated. If then the heat be increased a little, arsenic rises into the neck of the retort, and toward the end of the operation sulphuret of arsenic is sublimed. Sulphurous acid goes over into the receiver. The molybdic acid remains in the retort, contaminated, however, with arsenic and its sulphuret.

The concentrated nitric acid being poured upon powdered ore of molybdena in the proportion of two parts of the former to one of the latter; the mixture is scarcely warmed in the retort, before the whole mass passes over into the receiver with great heat. Scheele considers this mixture as in danger of taking fire, when the quantity is large, and therefore uses the diluted nitric acid.

Six ounces of diluted nitric acid being added to one ounce and a half of the powdered ore of molybdena in a retort, no effect takes place during the digestion; but as soon as the mixture begins to boil, red vapours are extricated with great intumescence, so that it is necessary to use a large retort. The distillation should be continued to dryness; after which the same quantity of nitric acid being again poured on the residuum, it will be distilled off with the same appearances as before. This process being again and again repeated until the fourth or fifth time, the residual powder becomes less and less in quantity, until at last it consists of six drachms and a half of white pulverulent matter resembling chalk. This substance, by edulcoration with hot water, being freed from some sulphuric acid and a small quantity of iron, is the acid of molybdena.

The ore, or sulphuret of molybdena may likewise be converted into the acid state by detonation in a red-hot crucible with three or four times its weight of purified nitre. The reddish alkaline mass which remains is to be dissolved in water, and affords both sulphat and nitrat of potash by evaporation. The remaining lixivium appears to consist of a combination of the molybdic acid with a portion of the alkali. This acid falls down, upon the addition of diluted sulphuric acid; which, however, must be cautiously added, because an excess will suspend the precipitate; and if the solution be hot, no precipitate whatever ensues. It is not easy to deprive this precipitate of the last portions of alkali.

The molybdic acid may also be obtained by powdering sulphuret of molybdena, and torrefying it in an inclined crucible, to separate the sulphur, and oxigenate the metal. The heat must be raised immediately to a very high degree; and when the molybdena has lost its brilliancy, and become gray, the process is to be finished with a more moderate heat, to prevent fusion, stirring the matter with an iron spatula continually. The acid is then to be separated, by digesting it repeatedly in a solution of ammonia, having first reduced it to a fine powder; and the ammonia is to be expelled by distillation in a glass retort, and ultimately heating the residuum to a white heat. This mode has lately been recommended by M. Bucholz; but he observes, that the ammonia must be expelled from the acid without delay, as by keeping it a little while a decomposition takes place.

The molybdic acid requires about five hundred times its weight of water to dissolve it. The solution is sour and austere to the taste, reddens litmus, coagulates solutions of soap, and precipitates alkaline sulphurets. The addition of potash forms a salt, which is much more soluble in water than the pure acid itself, and affords crystals by evaporation. This neutral salt does not rise by the action of heat, like the pure acid itself. With ammonia it forms a neutral salt, which parts with its alkali in a gentle heat. The solution of the acid expels the carbonic from chalk or magnesia, and effervesces with alumine, forming salts of difficult solution with these earths. It precipitates barytes from its nitrous or muriatic solutions, and forms a neutral compound very sparingly soluble in cold water; but it does not precipitate the solutions of other earths. It precipitates silver, mercury, and lead from the nitrous acid, and also lead from the muriatic acid. These precipitates are reducible by the blow-pipe upon charcoal. The other metals are not precipitated. The neutral alkaline molybdats precipitate all metallic solutions. Gold, muriat of mercury, zinc, and manganese are precipitated in the form of a white powder; iron and tin from their solutions in muriatic acid; of a brown colour; cobalt, of a rose colour; copper, blue; and the solutions of alum and quick lime, white. If a dilute solution of recent muriat of tin be precipitated by a dilute solution of molybdat of potash, a beautiful blue powder is obtained.

The concentrated sulphuric acid dissolves a considerable quantity of the molybdic acid, the solution becoming of a fine blue colour as it cools, at the same time that it thickens: the colour disappears again on the application of heat, but returns again by cooling. A strong heat expels the sulphuric acid. The nitric acid has no effect on it; but the muriatic dissolves it in considerable quantity, and leaves a dark blue residuum when distilled. With a strong heat it expels a portion of sulphuric acid from sulphat of potash. It also disengages the acid from nitre and common salt by distillation. It has some action upon the filings of the metals in the moist way.

The molybdic acid has not yet been employed in the arts, though experiments have lately been made for the purpose of ascertaining its useful properties. Mr. Hermbstaedt has found, that it throws down a dark violet precipitate from tincture of cochineal; and that a piece of kerseymere, boiled in a solution of the acid, acquired a colour approaching to bright green, which was converted into a bluish gray by drying in the sun. The cloth impregnated with this mordant was dyed of an agreeable violet by immersion in a hot bath of cochineal. Mr. Jaeger carried these experiments still further. He used the supermolybdat of potash. A solution of this salt being mixed with a saturated solution of tin was boiled for half an hour in a retort, and then set by for eight or ten days. The supernatant liquor, which by this time had acquired a deep blue colour, gave a bright blue colour to muslin, and a deeper blue to woollen. Mixed with infusion of quercitron bark it gave a good Saxon green. He tried it likewise with other colours, and found the results in general very satisfactory, many of the colours being extremely fixed, and unalterable by the sun, air, or acids. In particular, he obtained a black much more durable than the common by a composition of molybdat of potash, acetit of alumine, and logwood. He likewise found, that the blue tincture above mentioned, if evaporated by a gentle heat, afforded a fine blue, soluble in water, and capable of being employed either for writing or painting. Richter had long before obtained a fine blue precipitate from molybdat of potash and muriat of tin.—*Fourcroy.—Phil. Trans.—Scherer's Chem. Journ.*

ACID (MOROXYLIC). In the botanic garden at Palermo, Mr. Thompson found an uncommon saline substance on the trunk of a white mulberry-tree. It appeared as a coating on the surface of the bark in little granulous drops of a yellowish and blackish brown colour, and had likewise penetrated its substance. M. Klaproth, who analysed it, found that its taste was somewhat like that of succinic acid; on burning coals it swelled up a little, emitted a pungent vapour scarcely visible to the eye, and left a slight earthy residuum. Six hundred grains of the bark loaded with it were lixiviated with water, and afforded 320 grains of a light salt, resembling in colour a light wood, and composed of short needles united in radii. It was not deliquescent; and though the crystals did not form till the solution was greatly condensed by evaporation it is not very soluble, since 1000 parts of water dissolve but 35 with heat, and 15 cold.

This salt was found to be a compound of lime and a peculiar vegetable acid, with some extractive matter.

To obtain the acid separate, M. Klaproth decomposed the calcareous salt by acetit of lead, and separated the lead by sulphuric acid. He likewise decomposed it directly by sulphuric acid. The product was still more like succinic acid in taste; was not deliquescent; easily dissolved both in water and alcohol; and did not precipitate the metallic solutions, as it did in combination with lime. Twenty grains being slightly heated in a small glass retort, a confile of drops of an acid liquor first came over; next a concrete salt arose, that adhered flat against the top and part of the neck of the retort in the form of prismatic crystals, colourless and transparent; and a coaly residuum remained. The acid was then washed out, and crystallized by spontaneous evaporation. Thus sublimation appears to be the best mode of purifying the salt, but it adhered too strongly to the lime to be separated from it directly by heat without being decomposed.

Not having a sufficient quantity to determine its specific characters, though he conceives it to be a peculiar acid, coming nearest to the succinic both in taste and other qualities, Mr. Klaproth has provisionally given it the name of moroxylic, and the calcareous salt containing it that of moroxylat of lime.—*Scherer's Allg. Journ. der Chemie.*

Acid (Mucous). This acid has been generally known by the name of *saccholactic*, because it was first obtained from sugar of milk; but as all the gums appear to afford it, and the principal acid in sugar of milk is the oxalic, the French chemists in general now distinguish it by the name of *mucous* acid. Hermbstaedt indeed supposes, that it is merely an oxalat of lime combined with a fatty matter; but experiments seem to show the contrary.

It was discovered by Scheele. Having poured twelve ounces of diluted nitric acid on four ounces of powdered sugar of milk in a glass retort on a sand bath, the mixture became gradually hot, and at length effervesced violently, and continued to do so for a considerable time after the retort was taken from the fire. It is necessary therefore to use a large retort, and not to lute the receiver too tight. The effervescence having nearly subsided, the retort was again placed on the sand heat, and the nitric acid distilled off, till the mass had acquired a yellowish colour. This exhibiting no crystals, eight ounces more of the same acid were added, and the distillation repeated, till the yellow colour of the fluid disappeared. As the fluid was inspissated by cooling, it was redissolved in eight ounces of water, and filtered. The filtered liquor held oxalic acid in solution, and seven drams and a half of a white powder remained on the filter. This powder was the acid under consideration.

If one part of gum be heated gently with two of nitric acid, till a small quantity of nitrous gas and of carbonic acid is disengaged, the dissolved mass will deposit on cooling the mucous acid. According to Fourcroy and Vauquelin, different gums yield from 14 to 26 hundredths of this acid.

This pulverulent acid is soluble in about 60 parts of hot water, and by cooling a fourth part separates in small shining scales, that grow white in the air. It decomposes the muriat of barytes, and both the nitrat and muriat of lime. It acts very little on the metals, but forms with their oxides salts scarcely soluble. It precipitates the nitrats of silver, lead, and mercury. With potash it forms a salt soluble in eight parts of boiling water, and crystallizable by cooling. The mucit of soda requires but five parts of water, and is equally crystallizable. Both these salts are still more soluble when the acid is in excess. The mucit of ammonia is deprived of its base by heat. The mucits of barytes, lime, and magnesia, are nearly insoluble.—*Scheele's Essays.—Fourcroy.*

Acid (Muriatic), known in commerce by the name of spirit of salt. As common salt consists of this peculiar acid united with soda by so strong an affinity that both substances may be driven up by heat, instead of any separation taking place, the acid itself cannot be obtained alone, but by means of processes in which a third substance is presented to combine with the alkali. Various methods were formerly used, in which the common salt was ground with earthy substances, and then exposed to distillation. These methods have been discontinued in England since the sulphuric acid has been obtained at an easy rate. In the antient method, common salt was previously decrepitated, then ground with dried clay, and kneaded or wrought with water to a moderately stiff consistence, after which it was divided into balls of the size of a pigeon's egg: these balls, being previously well dried, were put into a retort, so as to fill the vessel two-thirds full; distillation being then proceeded upon, the muriatic acid came over when the heat was raised to ignition. In this process eight or ten parts of clay to one of salt are to be used. The retort must be of stone-ware well coated, and the furnace must be of that kind called reverberatory.

It was formerly thought, that the salt was merely divided in this operation by the clay, and on this account more readily gave out its acid: but there can be little doubt, that the effect is produced by the siliceous earth, which abounds in large proportions in all natural clays, and detains the alkali of the salt by combining with it.

The extrication of muriatic acid from common salt by means of the sulphuric is much the most elegant and effectual. The English manufacturers use iron stills for this distillation, with earthen heads: the philosophical chemist will doubtless prefer glass. One part, by weight, of strong sulphuric acid is to be added to three of decrepitated sea salt, in a retort, the upper part of which is furnished with a tube or neck, through which the acid is to be poured upon the salt. The aperture of this tube must be closed with a ground stopper immediately after the pouring. The sulphuric acid immediately combines with the alkali, and expels the muriatic acid in the form of a peculiar air, which is rapidly absorbed by water, but may be confined by mercury. As this combination and disengagement take place without the application of heat, and the aërial fluid escapes very readily, it is necessary to arrange and lute the vessels together before the vitriolic acid is added, and not to make any fire in the furnace until the disengagement begins to slacken; at which time it must be very gradually raised. Before the modern improvements in chemistry were made, a great part of the acid escaped for want of water to combine with; but by the use of Woulfe's apparatus (See LABORATORY), the acid air is made to pass through water, in which it is condensed, and forms muriatic acid of double the weight of the water, though the bulk of this fluid is increased one half only. The acid condensed in the first receiver, which contains no water, is of a yellow colour, arising from the impurities of the salt.

The marine acid in commerce has a straw colour: but this is owing to accidental impurity; for it does not obtain in the acid produced by the impregnation of water with the aëriform acid.

The base of the muriatic acid has never yet been ascertained. Some years ago Dr. Girtanner peremptorily announced that it was a compound of hidrogen and oxigen, because he conceived it to have been decomposed in some experiments in which hidrogen was produced. In all of these, however, water was present; for Girtanner was so unacquainted with the nature of this acid, as to conceive what he used in a fluid state to be free from water: and in several experiments, both analytical and synthetical, made by Van Mons with a view to ascertain this point, he could obtain nothing decisive, either to confirm or refute this hypothesis; for though hidrogen was sometimes produced, it could never be unequivocally ascertained to have proceeded from the muriatic acid, and in all his attempts at synthesis he was unsuccessful. Of the experiments of Tassaert, and of those of Mr. Henry, both of whom pursued the investigation, the same may be said. Berthollet has inferred, chiefly from a fact observed by Humboldt, that a portion of muriat of iron was formed by exposing sulphat of iron to the action of oxide of nitrogen; and from those of Cavendish, who observed, that nitric acid formed from oxigen and nitrogen by the electric spark precipitated nitrat of silver, and that nitrat of potash, from which part of its oxigen was expelled by heat, did the same; that the muriatic acid is a compound of both hidrogen and nitrogen with oxigen. The discovery of galvanism has opened a new field of inquiry. Professor Pacchioni of Pisa, and Mr. Peele of Cambridge, both profess to have found muriatic acid formed in water by its agency; and Mr. Henry obtained a similar result, though he was not perfectly satisfied that no source of fallacy was present. The experiment was attempted by the Galvanic Society at Paris without success: but more lately Mr. Sylvester has tried it with great care, and found that muriatic acid is generally formed; though sometimes the acid produced is found to be the nitric, with little or none of the muriatic. But in all these instances the quantity produced was so very small, that nothing conclusive can be affirmed, at least with respect to the base. We must not omit to mention here too the experiments of Mr. Lambe, who found, that when pure iron filings were subjected to the action of a solution of sulphurated hidrogen, a muriat of iron was obtained; and those of M. Biot, who infers, from his curious researches on refraction, that muriatic acid can neither be an oxide of hidrogen with less oxigen than water, as some have supposed, nor have nitrogen for its base.

Whatever this base may be, it appears to be capable of existing in three different states of combination distinguished by the terms *muriatic*, *oxigenised*, and *hyperoxigenised muriatic* acid. Mr. Chenevix indeed has suggested, that the first is the radical, and the other two might be termed *muriatous* and *muriatic* acids: but his radical is possessed of the characters of an acid in too decisive and potent a manner to be easily dismissed from its rank.

The muriatic acid is one of those longest known, and some of its compounds are among those salts with which we are most familiar. They are all soluble in water.

The muriat of barytes crystallizes in tables bevelled at the edges, or in octaëdral pyramids applied base to base. It is soluble in five parts of water at 60°, in still less at a boiling heat, and also in alcohol. It is not altered in the air, and but partially decomposable by heat. The sulphuric acid separates its base; and the alkaline carbonats and sulphats decompose it by double affinity. It is best prepared by dissolving the carbonat in dilute muriatic acid: and if contaminated with iron or lead, which occasionally happens, these may be separated by the addition of a small quantity of liquid ammonia, or by boiling and stirring the solution with a little lime. Mr. Goettling recommends to prepare it from the sulphat of barytes: eight parts of which in fine powder are to be mixed with two of muriat of soda, and one of charcoal powder. This is to be pressed hard into a Hessian crucible, and exposed for an hour and a half to a red heat in a wind furnace. The cold mass, being powdered, is to be boiled a minute or two in sixteen parts of water, and then filtered. To this liquor muriatic acid is to be added by little and little, till sulphurated hidrogen ceases to be evolved; it is then to be filtered, a little hot water to be poured on the residuum, the liquor evaporated to a pellicle, filtered again, and then set to crystallize. As the muriat of soda is much more soluble than the muriat of barytes, and does not separate by cooling, the muriat of barytes will crystallize into a perfectly white salt, and leave the muriat of soda in the mother water, which may be evaporated repeatedly till no more muriat of barytes is obtained. This salt was first employed in medicine by Dr. Crawford, chiefly in scrofulous complaints and cancer, beginning with doses of a few drops of the saturated solution twice a day, and increasing it gradually, as far as forty or fifty drops in some instances. In large doses it excites nausea, and has deleterious effects. Fourcroy says it has been found very successful in scrofula in France. It has likewise been recommended as a vermifuge; and we have given it with much apparent advantage, even to very young children, where the usual symptoms of worms occurred, though none were ascertained to be present. As a test of sulphuric acid it is of great use.

The muriat of potash, formerly known by the names of *febrifuge salt of Sylvius*, *digestive salt*, and *regenerated sea salt*, crystallizes in regular cubes, or in rectangular parallelopipedons; decrepitating on the fire, without losing much of their acid, and acquiring a little moisture from damp air, and giving it out again in dry. Their taste is saline and bitter. They are soluble in thrice their weight of cold water, and in but little less of boiling water, so as to require spontaneous evaporation for crystallizing. Fourcroy recommends, to cover the vessel with gauze, and suspend hairs in it, for the purpose of obtaining regular crystals.

It is sometimes prepared in decomposing sea salt by common potash for the purpose of obtaining soda; and may be formed by the direct combination of its constituent parts.

It is decomposable by the sulphuric and nitric acids, and in the dry way by the phosphoric. Barytes decomposes it, though not completely. And both silex and alumine decompose it partially in the dry way. It decomposes the earthy nitrats, so that it might be used in saltpetre manufactories to decompose the nitrat of lime.

Muriat of soda, or *common salt*, is of considerable use in the arts, as well as a necessary ingredient in our food. It crystallizes in cubes, which are sometimes grouped together in various ways, and not unfrequently form hollow quadrangular pyramids. In the fire it decrepitates, melts, and is at length volatilized. When pure, it is not deliquescent. One part is soluble in 2½ of cold water, and in little less of hot, so that it cannot be crystallized but by evaporation. According to M. Chenevix it is soluble in alcohol also, particularly when it is mixed with the hyperoxymuriat.

Common salt is found in large masses, or in rocks under the earth, in England and elsewhere. In the solid form it is called *sal gem* or *rock salt*. If it be pure and transparent, it may be immediately used in the state in which it is found; but if it contain any impure earthy particles, it should be previously freed from them. In some countries it is found in incredible quantities, and dug up like metals from the bowels of the earth. In this manner has this salt been dug out of the celebrated salt mines near Bochnia and Wieliczka, in Poland, ever since the middle of the 13th century, consequently above these 500 years, in such amazing quantities, that sometimes there have been 20000 tons ready for sale. In these mines, which are said to reach to the depth of several hundred fathoms, 500 men are constantly employed. The pure and transparent salt needs no other preparation than to be beaten to small pieces, or ground in a mill. But that which is more impure must be elutriated, purified, and boiled. That which is quite impure, and full of small stones, is sold under the name of rock salt, and is applied to ordinary uses; it may likewise be used for strengthening weak and poor brine-springs.

Though the salt mines of Wieliczka, near Cracow in Poland, have long astonished the philosopher and traveller, yet it deserves to be remarked, that the quantity of rock salt obtained from the mines of Northwich is greatly superior to that obtained at Cracow. The bishop of Llandaff affirms, that a single pit, into which he descended, yielded at a medium 4000 tons of salt in a year, which alone is about two-thirds of that raised in the Polish mines. This rock salt is never used on our tables in its crude state, as the Polish rock salt is; and though the pure transparent salt might be used with our food, without any danger, yet it is prohibited under a penalty of 40s. for every pound of rock salt so applied. It is partly purified in water, and a great part of it is sent coastwise to Liverpool and other places, where it is used either for strengthening brine-springs or sea-water.

Beside the salt mines here mentioned, where the common salt is found in a concrete state, under the name of rock salt, there is at Cordova, in the province of Catalonia in Spain, a remarkable solid mountain of rock salt: this mountain is between four and five hundred feet in height, and a league in circuit; its depth below the surface of the earth is not known. This mountain contains the rock salt without the least admixture of any other matter.

The waters of the ocean every where abound with common salt, though in different proportions. The water of the Baltic sea is said to contain one sixty-fourth of its weight of salt; that of the sea between England and Flanders contains one thirty-second part; that on the coasts of Spain, one sixteenth part; and between the tropics it is said, perhaps erroneously, to contain from an eleventh to an eighth part.

The water of the sea contains, beside the common salt, a considerable proportion of muriat of magnesia, and some sulphat of lime. The former is the chief ingredient of the remaining liquid which is left after the extraction of the common salt, and is called the mother water. Sea-water, if taken up near the surface, contains also the putrid remains of animal substances, which render it nauseous, and in a long continued calm cause the sea to stink.

The whole art of extracting salt from waters which contain it consists in evaporating the water in the cheapest and most convenient manner. In England, a brine composed of sea water, with the addition of rock salt, is evaporated in large shallow iron boilers; and the crystals of salt are taken out in baskets. In Russia, and probably in other northern countries, the sea water is exposed to freeze; and the ice, which is almost entirely fresh, being taken out, the remaining brine is much stronger, and is evaporated by boiling. In the southern parts of Europe the salt-makers take advantage of spontaneous evaporation. A flat piece of ground near the sea is chosen, and banked round, to prevent its being overflowed at high water. The space within the banks is divided by low walls into several compartments, which successively communicate with each other. At flood tide, the first of these is filled with sea water; which, by remaining a certain time, deposits its impurities, and loses part of its aqueous fluid. The residue is then suffered to run into the next compartment; and the former is again filled as before. From the second compartment, after a due time, the water is transferred into a third, which is lined with clay well rammed and levelled. At this period the evaporation is usually brought to that degree, that a crust of salt is formed on the surface of the water, which the workmen break, and it immediately falls to the bottom. They continue to do this, until the quantity is sufficient to be raked out, and dried in heaps. This is called *bay salt.*

In some parts of France, and also on the coasts of China, they wash the dried sands of the sea with a small proportion of water, and evaporate this brine in leaden boilers.

There is no difference between this salt and the lake salt extracted from different lakes, excepting such as may be occasioned by the casual intervention of some substances. In this respect the Jeltonic salt-water lake, in the Russian dominions near Saratow and Dmitrewsk, deserves our attention. In the year 1748, when the Russians first fetched salt thence, the lake was almost solid with salt; and that to such a degree, that they drove their heavy waggons over it, as over a frozen river, and broke up the salt. But since the year 1757 the water has increased so much, that at this time it is nothing more than a lake very strongly impregnated with salt. The Jeltonic lake salt contains at the same time alum and sulphat of magnesia.

At several places in Germany, and at Montmarot in France, the waters of salt springs are pumped up to a large reservoir at the top of a building or shed; from which it drops or trickles through small apertures upon boards covered with brushwood. The large surface of the water thus exposed to the air causes a very considerable evaporation; and the brine is afterward conveyed to the boilers for the perfect separation of the salt.

To free common salt from those mixtures, that render it deliquescent and less fit for the purposes to which it is applied, it may be put into a conical vessel with a small aperture at the point, and a saturated solution of the muriat of soda boiling hot be poured on it. This solution will dissolve and carry off any other salts mixed with the soda, and leave it quite pure by repeating the process three or four times.

From this salt, as already observed, the muriatic acid is extracted; and of late years to obtain its base separate, in the most œconomical mode, for the purposes of the arts, has been an object of research. The process of Scheele, which consists in mixing the muriat of soda with red oxide of lead, making this into a soft paste with water, and allowing it to stand thus for some time, moistening it with water as it gets dry, and then separating the soda from the muriat of lead by lixiviation, has been resorted to in this country. A Mr. Turner some years ago had a patent for it; converting the muriat of lead into a pigment, which was termed *mineral* or *patent yellow,* by heating it to fusion. The oxide of lead should be at least twice the weight of the salt. This would have answered extremely well, had there been an adequate and regular demand for the pigment. At present, we understand, the greater part of the carbonat of soda in the market is furnished by decomposing the sulphat of soda, left after the muriatic acid is expelled in the usual way of manufacturing it from common salt. Various processes for this purpose were tried in France and made public by the French government, all depending on the principle of decomposing the acid of the sulphat by charcoal, and at the same time adding some other material to prevent the soda from forming a sulphuret. What they consider as the best, is to mix the sulphat of soda with an equal weight of chalk and rather more than half its weight of charcoal powder, and to expose the mixture in a reverberatory furnace to a heat sufficient to bring them to a state of imperfect liquefaction. Much of the sulphur formed will be expelled in vapour and burned, the mixture being frequently stirred to promote this; and this is continued till the mass on cooling assumes a fine grain. It is then left exposed to a humid atmosphere, and the carbonat of soda may be extracted by lixiviation, the sulphur not consumed having united with the lime. Tinmen's shreds, or old iron, may be employed instead of chalk, in the proportion of 65 parts to 200 of sulphat of soda and 62 of charcoal; or chalk and iron may be used at the same time in different proportions. The muriat of soda might be decomposed in the first instance by the sulphat of iron, instead of the sulphuric acid. The carbonat of soda thus prepared, however, is not free from sulphur, and Dizé recommends the abstraction of it by adding litharge to the lixivium in a state of ebullition, which will render the alkali pure. Oxide of manganese was substituted in the same way with equal success; and this may be used repeatedly, merely by calcining it after each time to expel the sulphur.

Mr. Accum gives us the following method, as having answered extremely well in a soda manufactory, in which he was employed:—Five hundred pounds of sulphat of soda, procured from the bleachers who make a large quantity in preparing their muriatic acid from common salt, were put into an iron boiler with a sufficient quantity of soft water. Into another boiler were put 560lbs. of good American potash, or 570 if the potash were indifferent, dissolved in about 30 pails of water, or as little as possible. When both were brought to boil, the solution of potash was ladled into that of sulphat of soda, agitating the mixture, and raising the fire as quickly as possible. When the whole boiled it was ladled into a wooden gutter, that conveyed it to a wooden cistern lined with lead near half an inch thick, in a cool place. Sticks were placed across the cistern, from which slips of sheet lead two or three inches wide hung down into the fluid about four inches distant from each other. When the whole was cold, which in winter was in about three days, the fluid was drawn off, the crystallized salt was detached from the slips of lead, and the rock of salt fixed to the bottom was separated by a chisel and mallet. The salt being washed in the same cistern, to free it from impurities, was then returned to the boiler, dissolved in clear water, and evaporated till a strong pellicle formed. Letting it cool till the hand could be dipped into it, it was kept at this temperature as long as pellicles would form over the whole surface and fall to the bottom. When no more pellicles appeared without blowing on the surface, the fire was put out, and the solution returned into the cistern to crystallize. If the solution be suffered to cool pretty low, very little sulphat of potash will be found mixed with the soda; but the rocky masses met with in the market generally contain a pretty large quantity. In the process above described the produce of the mixed salt from 100lbs. of sulphat of soda was in general from 136 to 139lbs.

Beside its use in seasoning our food, and preserving meat both for domestic consumption and during the longest voyages; and in furnishing us with the muriatic acid and soda; salt forms a glaze for coarse pottery by being thrown into the oven, where it is baked; it improves the whiteness and clearness of glass; it gives greater hardness to soap; in melting metals it preserves their surface from calcination by defending them from the air, and is employed with advantage in some assays; it is used as a mordant, and for improving certain colours; and enters more or less into many other processes of the arts.

The muriat of strontian has not long been known. M. Klaproth first distinguished it from muriat of barytes. It crystallizes in very slender hexagonal prisms; has a cool pungent taste, without the austerity of the muriat of barytes, or the bitterness of the muriat of lime; is soluble in 0·75 of water at 60°, and to almost any amount in boiling water; is likewise soluble in alcohol, and gives a blood red colour to its flame.

It has never been found in nature, but may be prepared in the same way as the muriat of barytes.

The muriat of lime has been known by the names of *marine selenite*, *calcareous marine salt*, *muria*, and *fixed sal ammoniac*. It crystallizes in hexaëdral prisms terminated by acute pyramids; but if the solution be greatly concentrated, and exposed to a low temperature, it is condensed in confused bundles of needly crystals. Its taste is acrid, bitter, and very disagreeable. It is soluble in half its weight of cold water, and by heat in its own water of crystallization. It is one of the most deliquescent salts known, and when deliquesced has been called *oil of lime*. It exists in nature, but neither very abundantly nor very pure. It is formed in chemical laboratories in the decomposition of muriat of ammonia; and Homberg found, that, if it were urged by a violent heat till it condensed on cooling into a vitreous mass, it emitted a phosphoric light upon being struck by any hard body, in which state it was called *Homberg's phosphorus*.

Hitherto it has been little used except for frigorific mixtures; and with snow it produces a very great degree of cold. Fourcroy, indeed, says he has found it of great utility in obstructions of the lymphatics, and in scrofulous affections; but we do not know that any trial of it has been made in this country.

The muriat of ammonia has long been known by the name of *sal ammonia* or *ammoniac*. It is found native in the neighbourhood of volcanoes, where it is sublimed sometimes nearly pure; and in different parts of Asia and Africa. A great deal is carried annually to Russia and Siberia from Bucharian Tartary; and we formerly imported large quantities from Egypt, but now manufacture it at home. See AMMONIA.

This salt is usually in the form of cakes, with a convex surface on one side, and concave on the other, from being sublimed into large globular vessels; but by solution it may be obtained in regular quadrangular crystals. It is remarkable for possessing a certain degree of ductility, so that it is not easily pulverable. It is soluble in 3½ parts of water at 60°, and in little more than its own weight of boiling water. Its taste is cool, acrid, and bitterish. Its specific gravity is 1·42. It attracts moisture from the air but very slightly.

Muriat of ammonia has been more employed in medicine than it is at present. It is sometimes useful as an auxiliary to the bark in intermittents: in gargles it is beneficial; and externally it is a good discutient. In dyeing it improves or heightens different colours. In tinning and soldering it is employed to preserve the surface of the metals from oxidation. In assaying it discovers iron, and separates it from some of its combinations.

The muriat of magnesia is extremely deliquescent, soluble in an equal weight of water, and difficultly crystallizable. It dissolves also in five parts of alcohol. It is decomposable by heat, which expels its acid. Its taste is intensely bitter.

With ammonia this muriat forms a triple salt, crystallizable in little polyedrons, which separate quickly from the water, but are not very regularly formed. Its taste partakes of that of both the preceding salts. The best mode of preparing it is by mixing a solution of 27 parts of muriat of ammonia with a solution of 73 of muriat of magnesia; but it may be formed by a semidecomposition of either of these muriats by the base of the other. It is decomposable by heat, and requires six or seven times its weight of water to dissolve it.

Of the muriat of glucine we know but little. It appears to crystallize in very small crystals; to be decomposable by heat; and, dissolved in alcohol and diluted with water, to form a pleasant saccharine liquor.

Muriat of alumine is scarcely crystallizable, as on evaporation it assumes the state of a thick jelly. It has an acid, styptic, acrid taste. It is extremely soluble in water, and deliquescent. Fire decomposes it. It may be prepared by directly combining the muriatic acid with alumine, but the acid always remains in excess.

The muriat of zircon crystallizes in small needles, which are very soluble, attract moisture, and lose their transparency in the air. It has an austere taste, with somewhat of acrimony. It is decomposable by heat. The gallic acid precipitates from its solution, if it be free from iron, a white powder. Carbonat of ammonia, if added in excess, redissolves the precipitate it had before thrown down.

Muriat of yttria does not crystallize when evaporated, but forms a jelly: it dries with difficulty, and deliquesces.

Fourcroy observes, that when siliceous stones, previously fused with potash, are treated with muriatic acid, a limpid solution is formed, which may be reduced to a transparent jelly by slow evaporation. But a boiling heat decomposes the siliceous muriat, and the earth is deposited. The solution is always acid.—*Murray.—Fourcroy.—Henry.—Watson.—Klaproth.—Kirwan.—Phil. Trans.—Mem. de l'Instit. Nat.—Ann. de Chim.—Philos. Journal.—Phil. Mag.—Hist. Nat. de l'Espagne.*

ACID (MURIATIC, OXIGENISED). This acid, to which some of the moderns give the name of *oxi-muriatic*, and termed *dephlogisticated* by its discoverer Scheele, conformably to the theory of that time, consists of 84 parts of the preceding acid united with 16 of oxigen. It may be made by adding two parts of muriatic acid to one of finely powdered manganese, in a retort connected with Woulfe's apparatus, and applying a gentle heat to it, while the receivers are surrounded by water as near as possible to the freezing point; or by mixing eight parts of muriat of soda with three of powdered manganese, putting them into a retort, pouring on them four parts of sulphuric acid, previously diluted with an equal weight of water, and proceeding as above. The operator should be very careful, that none of the acid escapes into the air in the state of gas, as it is very injurious when respired, occasioning all the symptoms of violent catarrh by coming into contact with the membrane that lines the nostrils, and severe stricture and oppression of the chest if it enter the lungs. The best preventative of its mischievous effects, when it does thus escape, is the vapour of volatile alkali, for which it has a powerful affinity.

When the water in the receivers is kept at a temperature below 40°, the water not only saturates itself with the gas, but crystals, of a shining greenish white, form in hexaëdral scales on the surface, and round the sides, enclosing the fluid, till the whole assumes a gelatinous appearance. A very moderate heat melts the concrete matter, and even converts it into a gas, that rises in bubbles through the saturated fluid, and floats on its surface. By increasing the heat, the whole of the gas may be expelled with very little alteration; but light decomposes it, and reduces it to the state of common muriatic acid, by liberating the oxigen.

It is a singular circumstance, that one of the powerful mineral acids should be deprived of what are considered as characteristic properties of an acid by the addition of oxigen, which is deemed the acidifying principle. Its taste, instead of being sour, is harsh and styptic; and instead of reddening blue vegetable colours it destroys them, as it does most others, yellow excepted. From this property, it is of use for removing stains and discolorations from old books and prints; though it is destructive to manuscripts, as it discharges writing ink; and it is very extensively employed in bleaching, as will be seen more at large under that article. In medicine too it has been tried. Van Deiman recommends it in a dilute state against the itch and scald-head, and as a wash for the gums when scorbutic: Fourcroy mentions it as a powerful tonic: and Mr. Brathwaite of Lancaster extols it highly in doses of 10 or 15 drops against scarlet fever. But we are not inclined to give it credit for any decided superiority over other acids, that can be obtained and administered more commodiously.

Another singularity attending this acid is, that when an alkaline or earthy base is added to it, for the purpose of forming an oxi-muriat, the acid is decomposed, and two different salts are formed, one the simple muriat and the other a hyperoxi-muriat. It appears, however, that oximuriats are actually formed, though not obtainable separate by crystallization; since a solution of alkali into which oxigenised muriatic acid gas has been passed, is capable of destroying vegetable colours, and is decomposable by light alone, which neither the simple nor hyperoxigenized muriat is.

Acid (Muriatic, Hyperoxigenised). This acid, which, just the reverse of the preceding, has been obtained only in combination with some base, and never separate, appears to consist of 65 parts of oxigen to 35 of muriatic acid. To its compounds therefore we shall proceed, first premising, that we are indebted to M. Chenevix for an accurate knowledge of it, though it was discovered by Berthollet.

Hyperoximuriat of potash may be procured by receiving the oximuriatic acid, as it is formed, into a solution of potash. When the solution is saturated, it may be evaporated gently, and the first crystals produced will be the salt desired, this crystallizing before the simple muriat, which is produced at the same time with it. Its crystals are in shining hexaëdral laminæ or rhomboidal plates. It is soluble in 17 parts of cold water; and, but very sparingly, in alcohol. It is not decomposed by the direct rays of the sun. Subjected to distillation in a coated retort it first fuses, and on increasing the heat gives out oxigen gas. A hundred grains yield 75 cubic inches of this gas with about two only of azote. It is incapable of discharging vegetable colours; but the addition of a little sulphuric acid develops this property, by setting at liberty oxigenised muriatic acid. So likewise a few grains of it added to an ounce of muriatic acid give it this property. It is decomposed by the sulphuric and nitric acid. If a few grains be dropped into strong sulphuric acid, an offensive smell is produced, resembling that of a brick-kiln mixed with that of nitrous gas; and if the quantity be large enough an explosion will ensue. If the vessel be deep, it will be filled with a thick, heavy vapour, of a greenish yellow colour, but not producing the symptoms of catarrh, at least in so violent a degree as the fumes of oxigenised muriatic acid. Underneath this vapour is a bright orange-coloured fluid. This vapour inflames alcohol, oil of turpentine, camphor, resin, tallow, elastic gum, and some other inflammable substances, if thrown into it. If the sulphuric acid be poured upon the salt, a violent decrepitation takes place, sometimes, though rarely, accompanied by a flash. M. Chenevix attempted to disengage the hyperoxigenised acid from this muriat by adding sulphuric acid to it in a retort; but almost as soon as the fire was kindled an explosion took place, by which a French gentleman present was severely wounded, and narrowly escaped the loss of an eye.

The effects of this hyperoximuriat on inflammable bodies are very powerful. Rub two grains into powder in a mortar, add a grain of sulphur, mix them well by gentle trituration, then collect the powder into a heap, and press upon it suddenly and forcibly with the pestle, a loud detonation will ensue. If the mixture be wrapped in strong paper, and struck with a hammer, the report will be still louder. Five grains of the salt mixed in the same manner with two and a half of charcoal, will be inflamed by strong trituration, especially if a grain or two of sulphur be added, but without much noise. If a little sugar be mixed with half its weight of the muriat, and a little strong sulphuric acid poured on it, a sudden and vehement inflammation will ensue: but this experiment requires caution, as well as the following. To one grain of the powdered salt in a mortar add half a grain of phosphorus, it will detonate, with a loud report, on the gentlest trituration. In this experiment the hand should be defended by a glove, and great care should be taken, that none of the phosphorus get into the eyes. Phosphorus may be inflamed by it under water, putting into a wine-glass one part of phosphorus and two of the muriat, nearly filling the glass with water, and then pouring in through a glass tube reaching to the bottom three or four parts of sulphuric acid. This experiment too is very hazardous to the eyes. If olive or linseed oil be taken instead of phosphorus, it may be inflamed by similar means on the surface of the water. This salt should not be kept mixed with sulphur, or perhaps any inflammable substance, as in this state it has been known to detonate spontaneously. As it is the common effect of mixtures of this salt with inflammable substances of every kind to take fire on being projected into the stronger acids, M. Chenevix tried the experiment with it mixed with diamond powder in various proportions, but without success.

Hyperoximuriat of soda may be prepared in the same manner as the preceding, by substituting soda for potash; but it is not easy to obtain it separate, as it is nearly as soluble as the muriat of soda, requiring only 3 parts of cold water. Neither is the solubility of this salt in alcohol sufficient to separate it from the common muriat, since this also, according to M. Chenevix, is soluble in alcohol, and more especially so when accompanied by the hyperoximuriat. This gentleman, however, succeeded in obtaining a little pure hyperoximuriat of soda, by sending a current of oxigenised muriatic acid through a solution of carbonat of soda, and repeatedly crystallizing in alcohol a large quantity of the mixed salt thus formed. It crystallizes in cubes, or rhomboids little different from cubes; produces a sensation of cold in the mouth and a saline taste; is slightly deliquescent; and in its other properties resembles the hyperoximuriat of potash.

Barytes appears to be the next base in order of affinity for this acid, though its force of attraction for it is greatly inferior. The best method of forming it is to pour hot water on a large quantity of this earth, and to pass a current of oxigenised muriatic acid gas through the liquid kept warm, so that a fresh portion of barytes may be taken up as the former is saturated. This salt is soluble in about four parts of cold water, and less of warm; and crystallizes like the simple muriat. It may be obtained, however, by the agency of double affinity; for phosphat of silver boiled in the solution will decompose the simple muriat, and the muriat of silver and phosphat of barytes, being insoluble, will both fall down and leave the hyperoximuriat in solution alone. The phosphat of silver employed in this process must be perfectly pure, and not the least contaminated with copper.

The hyperoximuriat of strontian may be obtained in the same manner. It is deliquescent, melts immediately in the mouth and produces cold, is more soluble in alcohol than the simple muriat, and crystallizes in needles.

The hyperoximuriat of lime, obtained in a similar way, is extremely deliquescent; liquefies at a low heat; is very soluble in alcohol; produces much cold in solution; and has a sharp bitter taste. This salt, when perfectly saturated, possesses bleaching properties, producing whiteness in the unbleached part of printed goods, without injuring their colours; for which purpose it is made by passing the oxigenated muriatic acid gas into water, through which lime is diffused by agitation.

As the oxigenised muriatic acid decomposes ammonia, it might be supposed, that a hyperoximuriat of this base could not exist: but though for this reason it cannot be formed as the preceding salts, it may by double affinity, the carbonat of ammonia decomposing the earthy salts of this genus, giving up its carbonic acid to their base, and combining with their acid into hyperoximuriat of ammonia, which may be obtained by evaporation. It is very soluble both in water and alcohol, and decomposed by a moderate heat.

The hyperoximuriat of magnesia much resembles that of lime.

To obtain hyperoximuriat of alumine, M. Chenevix put some alumine, precipitated from the muriat, and well washed but still moist, into a Woulfe's apparatus, and treated it as the other earths. The alumine shortly disappeared; and on pouring sulphuric acid into the liquor a strong smell of hyperoxigenised muriatic acid was perceivable: but on attempting to obtain the salt pure by means of phosphat of silver, the whole was decomposed, and nothing but hyperoximuriat of silver was found in the solution. M. Chenevix adds, however, that the aluminous salt appears to be very deliquescent, and soluble in alcohol.—*Phil. Trans.*—*Henry.*—*Davy.*

ACID (MURIATIC, SULPHURETTED). By this name Dr. T. Thomson of Edinburgh has distinguished a compound of muriatic acid and oxide of sulphur, which he discovered, and which will be more fully noticed under the article SULPHUR.

ACID (NITRIC). The two principal constituent parts of our atmosphere, when in certain proportions, are capable, under particular circumstances, of combining chemically into one of the most powerful acids, the nitric, which consists, according to Mr. Davy, of 70·5 of oxigen, and 29·5 of azot, or nitrogen. If these gases be mixed in this proportion in a glass tube about a line in diameter over mercury, and a series of electric shocks be passed through them for some hours, they will form nitric acid; or, if a solution of potash be present with them, nitrat of potash will be obtained. The constitution of this acid may be further proved, analytically, by driving it through a redhot porcelain tube, as thus it will be decomposed into oxigen and nitrogen gases. For all practical purposes, however, the nitric acid is obtained from nitrat of potash, from which it is expelled by sulphuric acid.

Four parts of pure nitrat of potash coarsely powdered are to be put into a glass retort, and three parts of concentrated sulphuric acid cautiously added, taking care to avoid the fumes that arise, which is best done by standing in a current of air to convey them up the chimney. Join to the retort a tubulated receiver of large capacity, with an adopter interposed, and lute the junctures with a mixture of pipeclay, sifted sand, and cut tow. In the tubulure fix with fat lute a glass tube terminating in another large receiver, in which is a small quantity of water; and, if you wish to collect the gaseous products, let a bent glass tube from this receiver communicate with a pneumatic trough. Apply heat to the receiver by means of a sand bath. The first product that passes into the receiver is generally red and fuming; but the appearances gradually diminish, till the acid comes over pale, and even colourless, if the materials used were clean. After this it again becomes more and more red and fuming, till the end of the operation; and the whole mingled together will be of a yellow or orange colour.

In the large way, and for the purposes of the arts, extremely thick cast iron or earthen retorts are usually employed, to which an earthen head is adapted, and connected with a range of proper condensers. The strength of the acid too is varied, by putting more or less water in the receivers. The nitric acid thus made generally contains sulphuric acid, and also muriatic from the impurity of the nitrat employed. If the former, a solution of nitrat of barytes will occasion a white precipitate; if the latter, nitrat of silver will render it milky. The sulphuric acid may be separated by a second distillation from very pure nitre, equal in weight to an eighth of that originally employed; or by precipitating with nitrat of barytes, decanting the clear liquid, and distilling it. The muriatic acid may be separated by proceeding in the same way with nitrat of siver, or with litharge, decanting the clear liquor, and redistilling it; leaving an eighth or tenth part in the retort. The acid for the last process should be condensed as much as possible, and the redistillation conducted very slowly; and if it be stopped when half is come over, beautiful crystals of muriat of lead will be obtained on cooling the remainder, if litharge be used, as M. Steinacher informs us; who also adds, that the vessels should be made to fit tight by grinding, as any lute is liable to contaminate the product.

As this acid still holds in solution more or less nitrous gas, it is not in fact nitric acid, but a kind of nitrous: it is therefore necessary, to put it into a retort to which a receiver is added, the two vessels not being luted, but merely joined by paper; and to apply a very gentle heat for several hours, changing the receiver as soon as it is filled with red vapours. The nitrous gas will thus be expelled, and the nitric acid will remain in the retort as limpid and colourless as water. It should be kept in a bottle secluded from the light, otherwise it will lose part of its oxigen.

According to Lagrange, a hundred parts of the nitrat of potash afford but 43 of acid by this process; but Mr. Henry informs us that it yields above 50. He adds too, that a part is decomposed by the heat employed, and a large quantity of oxigen gas evolved, that may easily be collected. What remains in the retort is a supersulphat of potash, from which the superfluous acid may be expelled by a pretty strong heat, and the residuum, being dissolved and crystallized, will be sulphat of potash.

As nitric acid in a fluid state is always mixed with water, different attempts have been made to ascertain its strength, or the quantity of real acid contained in it. Mr. Kirwan supposed, that the nitrat of soda contained the pure acid undiluted with water, and thus calculated its strength from the quantity requisite to saturate a given portion of soda. Mr. Davy has more recently taken the acid in the form of gas as the standard, and found how much of this is contained in an acid of a given specific gravity in the liquid state. We shall merely annex to Mr. Davy's table those numbers of Mr. Kirwan's, which is much more extensive, that relate to nearly similar gravities.

NITRIC ACID OF SPECIFIC GRAVITY.		CONTAINS.		
KIRWAN.	DAVY.	OF REAL ACID, KIRWAN.	DAVY.	
			OF REAL ACID.	OF WATER.
1·5070	1·5040	·6839	·9155	·0845
1·4471	1·4475	·5809	·8039	·1961
1·4275	1·4285	·5515	·7165	·2835
1·3925	1·3906	·5000	·6296	·3704
1·3571	1·3551	·4486 +	·5688	·4312
1·3160	1·3186	·3897	·5203	·4797
1·3056	1·3042	·3750	·4904	·5096
1·2812	1·2831	·3530 +	·4603	·5397
1·2033	1·2090	·2574 +	·4527	·5473

The strongest acid that Mr. Kirwan could procure at 60° was 1·5543, which by his calculation contained ·7354 of real acid; but Rouelle professes to have obtained it of 1·583. It is observable, that, on comparing the tables of Kirwan and Davy, the aëriform acid appears to contain a considerable portion of water more than that which is combined with soda to form the nitrat.

Nitric acid should be of the specific gravity of 1·5, or a little more, and colourless. It boils at 248°, and may be distilled without any essential alteration. Exposed to the air it absorbs moisture. If two parts be suddenly diluted with one of water, the temperature will rise to about 112°; but the addition of more water to this diluted acid will lower its temperature. It retains its oxigen with little force, so that it is decomposed by all combustible bodies. Brought into contact with hidrogen gas at a high temperature, a violent detonation ensues, so that this must not be done without great caution. It inflames essential oils, as those of turpentine and cloves, when suddenly poured on them: but, to perform this experiment with safety, the acid must be poured out of a bottle tied to the end of a long stick, otherwise the operator's face and eyes will be greatly endangered. If it be poured on perfectly dry charcoal powder, it excites combustion, with the emission of copious fumes. By boiling it with sulphur it is decomposed, and its oxigen, uniting with the sulphur, forms sulphuric acid. Chemists in general agree, that it acts very powerfully on almost all the metals: but Baumé has asserted, that it will not dissolve tin; and Dr. Woodhouse of Pennsylvania affirms, that in a highly concentrated and pure state it acts not at all on silver, copper, or tin, though with the addition of a little water its action on them is very powerful. He does not mention the specific gravity of this acid: he only says, that it was prepared by first expelling the water of crystallization from nitre by heat, and then decomposing this nitre by means of strong sulphuric acid.

It has already been observed, that the nitric acid when first distilled over holds in solution a portion of nitric oxide, which is greater in proportion as the heat has been urged toward the end, and much increased by even a small portion of inflammable matter, should any have been present. The colour of the acid too is affected by the quantity of nitric oxide it holds, and Mr. Davy has given us the following table of proportions answering to its different hues.

COLOUR.	REAL ACID.	NITRIC OXIDE.	WATER.
Pale yellow	90·5	1·2	8·3
Bright yellow	88·94	2·96	8·10
Dark orange	86·84	5·56	7·6
Light olive	86·0	6·45	7·55
Dark olive	85·4	7·1	7·5
Bright green	84·8	7·76	7·44
Blue green	84·6	8·	7·4

But these colours are not exact indications of the state of the acid, for an addition of water will change the colour into one lower in the scale, so that a considerable portion of water will change the dark orange to a blue green.

The nitric acid is of considerable use in the arts. It is employed for etching on copper; as a solvent of tin to form with that metal a mordant for some of the finest dyes; in metallurgy and assaying; in various chemical processes, on account of the facility with which it parts with oxigen and dissolves metals; in medicine as a tonic, and as a substitute for mercurial preparations in siphylis and affections of the liver; as also in the form of vapour to destroy contagion. For the purposes of the arts it is commonly used in a diluted state, and contaminated with the sulphuric and muriatic acids, by the name of *aqua fortis*. This is generally prepared by mixing common nitre with an equal weight of sulphat of iron, and half its weight of the same sulphat calcined, and distilling the mixture: or by mixing nitre with twice its weight of dry powdered clay, and distilling in a reverberatory furnace. Two kinds are found in the shops, one called *double aqua fortis*, which is about half the strength of nitric acid; the other simply *aqua fortis*, which is half the strength of the double.

A compound made by mixing two parts of the nitric acid with one of muriatic, known formerly by the name of *aqua regia*, and now by that of *nitro-muriatic acid*, has the property of dissolving gold and platina. On mixing the two acids heat is given out, an effervescence takes place, oxigenated muriatic acid gas is evolved, and the mixture acquires an orange colour. This is likewise made by adding gradually to an ounce of powdered muriat of ammonia, four ounces of double aqua fortis, and keeping the mixture in a sand-heat till the salt is dissolved; taking care to avoid the fumes, as the vessel must be left open: or by distilling nitric acid with an equal weight, or rather more, of common salt.

With the different bases the nitric acid forms nitrats.

The nitrat of barytes, when perfectly pure, is in regular octaëdral crystals, though it is sometimes obtained in small shining scales. It may be prepared by uniting barytes directly with nitric acid, or by decomposing the carbonat of sulphuret of barytes with this acid. Exposed to heat it decrepitates, and at length gives out its acid, which is decomposed; but if the heat be urged too far the barytes is apt to vitrify with the earth of the crucible. It is soluble in 12 parts of cold, and 3 or 4 of boiling water. It is said to exist in some mineral waters.

The nitrat of potash is the salt well known by the name of *nitre*, or *saltpetre*. It is found ready formed in the East Indies, in Spain, in the kingdom of Naples, and elsewhere, in considerable quantities; but nitrat of lime is still more abundant. Far the greater part of the nitrat made use of is produced by a combination of circumstances which tend to compose and condense nitric acid. This acid appears to be produced in all situations, where animal matters are completely decomposed with access of air, and of proper substances with which it can readily combine. Grounds frequently trodden by cattle and impregnated with their excrements, or the walls of inhabited places where putrid animal vapours abound, such as slaughter-houses, drains, or the like, afford nitre by long exposure to the air. Artificial nitre beds are made by an attention to the circumstances in which this salt is produced by nature. Dry ditches are dug, and covered with sheds, open at the sides, to keep off the rain: these are filled with animal substances—such as dung, or other excrements, with the remains of vegetables, and old mortar, or other loose calcareous earth; this substance being found to be the best and most convenient receptacle for the acid to combine with. Occasional watering, and turning up from time to time, are necessary, to accelerate the process, and increase the surfaces to which the air may apply; but too much moisture is hurtful. When a certain portion of nitrat is formed, the process appears to go on more quickly: but a certain quantity stops it altogether, and after this cessation the materials will go on to furnish more, if what is formed be extracted by lixiviation. After a succession of many months, more or less, according to the management of the operation, in which the action of a regular current of fresh air is of the greatest importance, nitre is found in the mass. If the beds contained much vegetable matter, a considerable portion of the nitrous salt will be common saltpetre; but, if otherwise, the acid will, for the most part, be combined with the calcareous earth.

To extract the saltpetre from the mass of earthy matter, a number of large casks are prepared, with a cock at the bottom of each, and a quantity of straw within, to prevent its being stopped up. Into these the matter is put, together with wood-ashes, either strewed at top, or added during the filling. Boiling water is then poured on, and suffered to stand for some time; after which it is drawn off, and other water added in the same manner, as long as any saline matter can be thus extracted. The weak brine is heated, and passed through other tubs, until it becomes of considerable strength. It is then carried to the boiler, and contains nitre and other salts; the chief of which is common culinary salt, and sometimes muriat of magnesia. It is the property of nitre to be much more soluble in hot than cold water; but common salt is very nearly as soluble in cold as in hot water. Whenever, therefore, the evaporation is carried by boiling to a certain point, much of the common salt will fall to the bottom, for want of water to hold it in solution, though the nitre will remain suspended by virtue of the heat. The common salt thus separated is taken out with a perforated ladle, and a small quantity of the fluid is cooled, from time to time, that its concentration may be known by the nitre which crystallizes in it. When the fluid is sufficiently evaporated, it is taken out and cooled, and great part of the nitre separates in crystals; while the remaining common salt continues dissolved, because equally soluble in cold and in hot water. Subsequent evaporation of the residue will separate more nitre in the same manner.

This nitre, which is called nitre of the first boiling, contains some common salt; from which it may be purified by solution in a small quantity of water, and subsequent evaporation: for the crystals thus obtained are much less contaminated with common salt than before: because the proportion of water is so much larger, with respect to the small quantity contained by the nitre, that very little of it will crystallize. For nice purposes, the solution and crystallization of nitre are repeated four times. The crystals of nitre are usually of the form of six-sided flattened prisms, with diedral summits. Its taste is penetrating; but the cold produced by placing the salt to dissolve in the mouth is such as to predominate over the real taste at first. Seven parts of water dissolve two of nitre, at the temperature of sixty degrees: but boiling water dissolves its own weight. 100 parts of alcohol, at a heat of 176°, dissolve only 2·9.

On being exposed to a gentle heat nitre fuses; and in this state being poured into moulds, so as to form little round cakes, or balls, it is called *sal prunella*, or *crystal mineral*. This at least is the way in which this salt is now usually prepared, conformably to the directions of Boerhaave; though in most dispensatories a twenty-fourth part of sulphur was directed to be deflagrated on the nitre, before it was poured out. This salt should not be left on the fire after it has entered into fusion, otherwise it will be converted into a *nitrit* of potash. If the heat be increased to redness, the acid itself is decomposed, and a considerable quantity of tolerably pure oxigen gas is evolved, succeeded by nitrogen.

This salt powerfully promotes the combustion of inflammable substances. Two or three parts mixed with one of charcoal, and set on fire, burn rapidly; azot and carbonic acid gas are given out, and a small portion of the latter is retained by the alkaline residuum, which was formerly called *clyssus of nitre*. Three parts of nitre, two of subcarbonat of potash, and one of sulphur, mixed together in a warm mortar, form the *fulminating powder*; a small quantity of which, laid on a fire-shovel, and held over the fire till it begins to melt, explodes with a loud sharp noise. Mixed with sulphur and charcoal it forms *gunpowder*. See GUNPOWDER.

Three parts of nitre, one of sulphur, and one of fine sawdust, well mixed, constitute what is called the powder of fusion. If a bit of base copper be folded up and covered with this powder in a walnut shell, and the powder be set on fire with a lighted paper, it will detonate rapidly, and fuse the metal into a globule of sulphuret, without burning the shell.

If nitrat of potash be heated in a retort with half its weight of solid phosphoric or boracic acid, as soon as this acid begins to enter into fusion it combines with the potash, and the nitric acid is expelled, accompanied with a small portion of oxigen gas and nitric oxide.

Silex, alumine, and barytes, decompose this salt in a high temperature by uniting with its base, as was observed when speaking of aqua fortis. The alumine will effect this even after it has been made into pottery.

The uses of nitre are various. Beside those already indicated, it enters into the composition of fluxes, and is extensively employed in metallurgy; it serves to promote the combustion of sulphur in fabricating its acid; it is used in the art of dyeing; it is added to common salt for preserving meat, to which it gives a red hue; it is an ingredient in some frigorific mixtures; and it is prescribed in medicine, as cooling, febrifuge, and diuretic, and some have recommended it mixed with vinegar as a very powerful remedy for the sea scurvy.

Nitrat of soda, formerly called *cubic* or *quadrangular nitre*, approaches in its properties the nitrat of potash; but differs from it in being somewhat more soluble in cold water, though less in hot, which takes up little more than its own weight; in being inclined to attract moisture from the atmosphere;* and in crystallizing in rhombs, or rhomboidal prisms. It may be prepared by saturating soda with the nitric acid, by precipitating nitric solutions of the metals, or of the earths, except barytes, by soda: by lixiviating and crystallizing the residuum of common salt distilled with three-fourths its weight of nitric acid; or by saturating the mother waters of nitre with soda instead of potash.

This salt has been considered as useless; but professor Proust says, that five parts of it, with one of charcoal and one of sulphur, will burn three times as long as common powder, so as to form an œconomical composition for fire-works.

Nitrat of strontian may be obtained in the same manner as that of barytes, with which it agrees in the shape of its crystals, and most of its properties. It is much more soluble, however, requiring but four or five parts of water according to Vauquelin, and only an equal weight according to Mr. Henry. Boiling water dissolves nearly twice as much as cold. Applied to the wick of a candle, or added to burning alcohol, it gives a deep red colour to the flame. On this account it might be useful, perhaps, in the art of pyrotechny.

Nitrat of lime, the *calcareous nitre* of older writers, abounds in the mortar of old buildings, particularly those that have been much exposed to animal effluvia, or processes in which azot is set free. Hence it abounds in nitre beds, as was observed when treating of the nitrat of potash. It may also be prepared artificially by pouring dilute nitric acid on carbonat of lime. If the solution be boiled down to a sirupy consistence, and exposed in a cool place, it crystallizes in long prisms, resembling bundles of needles diverging from a centre. These are soluble, according to Henry, in an equal weight of boiling water, and twice their weight of cold; soon deliquesce on exposure to the air; and are decomposed at a red heat. Fourcroy says, that cold water dissolves four times its weight, and that its own water of crystallization is sufficient to dissolve it at a boiling heat. It is likewise soluble in less than its weight of alcohol. By evaporating the aqueous solution to dryness, continuing the heat till the nitrat fuses, keeping it in this state five or ten minutes, and then pouring it into an iron pot previously heated, we obtain *Baldwin's phosphorus*. This, which is perhaps more properly *nitrit of lime*, being broken to pieces, and kept in a phial closely stopped, will emit a beautiful white light in the dark, after having been exposed some time to the rays of the sun. At present no use is made of this salt, except for drying some of the gases by attracting their moisture; but it might be employed instead of the nitrat of potash for manufacturing aqua fortis.

The nitrat of ammonia possesses the property of exploding, and being totally decomposed, at the temperature of 600°; whence it acquired the name of *nitrum flammans*. The readiest mode of preparing it is by adding carbonat of ammonia to dilute nitric acid till saturation takes place.

If this solution be evaporated in a heat between 70° and 100°, and the evaporation not carried too far, it crystallizes in hexaëdral prisms terminating in very acute pyramids: if the heat rise to 212°, it will afford, on cooling long fibrous silky crystals: if the evaporation be carried so far as for the salt to concrete immediately on a glass rod by cooling, it will form a compact mass. According to Mr. Davy, these differ but little from each other, except in the water they contain, their component parts being as follows:

	contains of acid	ammonia	water
Prismatic	69·5	18·4	12·1
Fibrous	72·5	19·3	8·2
Compact	74·5	19·8	5·7

All these are completely deliquescent, but they differ a little in solubility. Alcohol at 176° dissolves nearly 90·9 of its own weight.

The chief use of this salt is for affording nitrous oxide on being decomposed by heat. See Gas, Nitrous Oxide.

Nitrat of magnesia, *magnesian nitre*, crystallizes in four-sided rhomboidal prisms, with oblique or truncated summits, and sometimes in bundles of small needles. Its taste is bitter, and very similar to that of nitrat of lime, but less pungent. It is fusible, and decomposable by heat, giving out first a little oxigen gas, then nitrous oxide, and lastly nitric acid. It deliquesces slowly. It is soluble in an equal weight of cold water, and in but little more hot, so that it is scarcely crystallizable but by spontaneous evaporation.

The two preceding species are capable of combining into a triple salt, an ammoniaco-magnesian nitrat, either by uniting the two in solution, or by a partial decomposition of either by means of the base of the other. This is slightly inflammable when suddenly heated: and by a lower heat is decomposed, giving out oxigen, azot, more water than it contained, nitrous oxide, and nitric acid. The residuum is pure magnesia. It is disposed to attract moisture from the air, but is much less deliquescent than either of the salts that compose it; and requires eleven parts of water at 60° to dissolve it. Boiling water takes up more, so that it will crystallize by cooling. It consists of 78 parts of nitrat of magnesia, and 22 of nitrat of ammonia.

From the activity of the nitric acid as a solvent of earths in analyzation the nitrat of glucine is better known than any other of the salts of this new earth. Its form is either pulverulent, or a tenacious or ductile mass. Its taste is at first saccharine, and afterward astringent. It grows soft by exposure to heat, soon melts, its acid is decomposed into oxigen and azot, and its base alone is left behind. It is very soluble and very deliquescent.

Nitrat, or rather supernitrat, of alumine crystallizes, though with difficulty, in thin, soft, pliable flakes. It is of an austere and acid taste, and reddens blue vegetable colours. It may be formed by dissolving in diluted nitric acid, with the assistance of heat, fresh precipitated alumine, well washed but not dried. It is deliquescent, and soluble in a very small portion of water. Alcohol dissolves its own weight. It is easily decomposed by heat.

Nitrat of zircone was first discovered by Klaproth, and has since been examined by Guyton-Morveau and Vauquelin. Its crystals are small, capillary, silky needles. Its taste is astringent. It is easily decomposed by fire, very soluble in water, and deliquescent. It may be prepared by dissolving zircone in strong nitric acid; but, like the preceding species, the acid is always in excess.

Nitrat of yttria may be prepared in a similar manner. Its taste is sweetish, and astringent. It is scarcely to be obtained in crystals; and if it be evaporated by too strong a heat, the salt becomes soft like honey, and on cooling concretes into a stony mass. Exposed to the air it deliquesces.—*Fourcroy.*—*Henry.*—*Murray.*—*Davy.*—*Van Mons's Journal.*—*Journ. de Phys.*—*Philos. Trans.*

Acid (Nitrous). It has already been observed, that there is no such thing, properly speaking, as *nitrous* acid, or the nitric base acidified with a minimum dose of oxigen; but that the nitric acid is capable of absorbing various portions of nitric oxide, with which it parts very readily, so that when in considerable quantity it gives it out in the ordinary state of the air, on mixing with which it assumes the appearance of a very red vapour. Hence it was formerly called *fuming nitrous acid.* It appears, however, to be capable of combining with some at least of the salifiable bases, so as to form a distinct genus of salts, that may be termed *nitrits.* But these cannot be formed by a direct union of their component parts; being obtainable only by exposing a nitrat to a high temperature, which expels a portion of its oxigen in the state of gas, and leaves the remainder in the state of a nitrit, if the heat be not urged so far, or continued so long, as to effect a complete decomposition of the salt. In this way the nitrits of potash and soda may be obtained, and perhaps those of barytes, strontian, lime, and magnesia. The nitrits are particularly characterized by being decomposable by all the acids except the carbonic, even by the nitric acid itself, all of which expel from it nitrous acid. We are little acquainted with any one except that of potash, which attracts moisture from the air, changes blue vegetable colours to green, is somewhat acrid to the taste, and when powdered emits a smell of nitric oxide.

Acid (Oxalic). This acid, which abounds in wood sorrel, and which, combined with a small portion of potash as it exists in that plant, has been sold under the name of *salt of lemons,* to be used as a substitute for the juice of that fruit, particularly for discharging ink spots and iron-moulds, was long supposed to be analogous to that of tartar. In the year 1776, however, Bergman discovered, that a powerful acid might be extracted from sugar by means of the *nitric*; and a few years afterward Scheele found this to be identical with the acid existing naturally in sorrel. Hence the acid began to be distinguished by the name of *saccharine,* but has since been known in the new nomenclature by that of oxalic.

Scheele extracted this acid from the salt of sorrel, or acidulous oxalat of potash as it exists in the juice of that plant, by saturating it with ammonia, when it becomes a very soluble triple salt, and adding to the solution nitrat of barytes dissolved in water. Having well washed the oxalat of barytes, which is precipitated, he dissolved it in boiling water, and precipitated its base by sulphuric acid. To ascertain that no sulphuric acid remained in the supernatant liquor, he added a little of a boiling solution of oxalat of barytes till no precipitate took place, and then filtered the liquor, which contained nothing but pure oxalic acid, which he crystallized by evaporation and cooling.

It may be obtained, however, much more readily and œconomically from sugar in the following way: To six ounces of nitric acid in a stoppered retort, to which a large receiver is luted, add by degrees one ounce of lump sugar coarsely powdered. A gentle heat may be applied during the solution, and nitric oxide will be evolved in abundance. When the whole of the sugar is dissolved, distil off a part of the acid, till what remains in the retort has a sirupy consistence, and this will form regular crystals, amounting to 58 parts from 100 of sugar. These crystals must be dissolved in water, recrystallized, and dried on blotting paper.

A variety of other substances afford the oxalic acid when treated by distillation with the nitric. Bergman procured it from honey, gum arabic, alcohol, and the calculous concretions in the kidneys and bladders of animals; Scheele and Hermbstadt from sugar of milk. Scheele from a sweet matter contained in fat oils, and also from the uncrystallizable part of the juice of lemons. Hermbstadt from the acid of cherries, and the acid of tartar. Goetling from beech wood. Kohl from the residuum in the distillation of ardent spirits. Westrumb not only from the crystallized acids of currants, cherries, citrons, raspberries, but also from the saccharine matter of these fruits, and from the uncrystallizable parts of the acid juices. Hoffmann from the juice of the barberry; and Berthollet from silk, hair, tendons, wool; also from other animal substances, especially from the coagulum of blood, whites of eggs, and likewise from the amylaceous and glutinous parts of flour. M. Berthollet observes, that the quantity of the oxalic acid obtained by treating wool with nitric acid was very considerable, being above half the weight of the wool employed. He mentions a difference which he observed between animal and vegetable substances thus treated with nitric acid, namely, that the former yielded, beside ammonia, a large quantity of an oil which the nitric acid could not decompose; whereas the oily parts of vegetables were totally destroyed by the action of this acid: and he remarks, that in this instance the glutinous part of flour resembled animal substances, whereas the amylaceous part of the flour retained its vegetable properties. He further remarks, that the quantity of oxalic acid furnished by vegetable matters, thus treated is proportionable to their nutritive quality, and particularly that from cotton he could not obtain any sensible quantity. Deyeux, having cut with scissars the hairs of the chick pea, found they gave out an acid liquor, which on examination proved to be an aqueous solution of pure oxalic acid. Proust and other chemists had before observed, that the shoes of persons walking through a field of chick pease were corroded.

Oxalic acid crystallizes in quadrilateral prisms, the sides of which are alternately broad and narrow, and summits diëdral; or, if crystallized rapidly, in small irregular needles. They are efflorescent in dry air, but attract a little humidity if it be damp; are soluble in one part of hot and two of cold water; and are decomposable by a red heat, leaving a small quantity of coaly residuum.—100 parts of alcohol take up near 56 at a boiling heat, but not above 40 cold. Their acidity is so great, that when dissolved in 3600 times their weight of water the solution reddens litmus paper, and is perceptibly acid to the taste.

The oxalic acid is a good test for detecting lime, which it separates from all the other acids, unless they are present in excess. It has likewise a greater affinity for lime than for any other of the bases, and forms with it a pulverulent, insoluble salt, not decomposable except by fire, and turning sirup of violets green.

With barytes it forms an insoluble salt; but this salt will dissolve in water acidulated with oxalic acid, and afford angular crystals. If, however, we attempt to dissolve these crystals in boiling water, the excess of acid will unite with the water, and leave the oxalat, which will be precipitated.

The oxalat of strontian too is a nearly insoluble compound.

Oxalat of magnesia too is insoluble, unless the acid be in excess.

The oxalat of potash exists in two states, that of a neutral salt, and that of an acidule. The latter is generally obtained from the juice of the leaves of the *oxalis acetosella*, wood sorrel, or *rumex acetosa*, common sorrel. The expressed juice, being diluted with water, should be set by for a few days, till the feculent parts have subsided, and the supernatant fluid is become clear; or it may be clarified, when expressed, with the whites of eggs. It is then to be strained off, evaporated to a pellicle, and set in a cool place to crystallize. The first product of crystals being taken out, the liquor may be further evaporated, and crystallized; and the same process repeated till no more can be obtained. In this way Schlereth informs us about nine drachms of crystals may be obtained from two pounds of juice, which are generally afforded by ten pounds of wood sorrel. Savary, however, says, that ten parts of wood sorrel in full vegetation yield five parts of juice, which give little more than a two-hundredth of tolerably pure salt. He boiled down the juice, however, in the first instance without clarifying it; and was obliged repeatedly to dissolve and recrystallize the salt to obtain it white.

This salt is in small, white, needly, or lamellar crystals, not alterable in the air. It unites with barytes, magnesia, soda, ammonia, and most of the metallic oxides, into triple salts. Yet its solution precipitates the nitric solutions of mercury and silver in the state of insoluble oxalats of these metals, the nitric acid in this case combining with the potash. It attacks iron, lead, tin, zinc, and antimony.

This salt, beside its use in taking out ink spots, and as a test of lime, forms with sugar and water a pleasant cooling beverage: and according to Berthollet it possesses considerable powers as an antiseptic.

The neutral oxalat of potash is very soluble, and assumes a gelatinous form, but may be brought to crystallize in hexaëdral prisms with diëdral summits, by adding more potash to the liquor than is sufficient to saturate the acid.

Oxalat of soda likewise exists in two different states, those of an acidulous and a neutral salt, which in their properties are analogous to those of potash.

The acidulous oxalat of ammonia is crystallizable, not very soluble, and capable like the preceding acidules of combining with other bases, so as to form triple salts. But if the acid be saturated with ammonia we obtain a neutral oxalat, which on evaporation yields very fine crystals in tetraëdral prisms with diëdral summits, one of the planes of which cuts off three sides of the prism. This salt is decomposable by fire, which raises from it carbonat of ammonia, and leaves only some slight traces of a coaly residuum. Lime, barytes, and strontian unite with its acid, and the ammonia flies off in the form of gas.

The oxalic acid readily dissolves alumine, and the solution gives on evaporation a yellowish transparent mass, sweet and a little astringent to the taste, deliquescent, and reddening tincture of litmus, but not sirup of violets. This salt swells up in the fire, loses its acid, and leaves the alumine a little coloured.—*Bergman.—Scheele.—Fourcroy.—Henry.—Murray.*

Acid (Perlate). This name was given by Bergman to the acidulous phosphat of soda, Haupt having called the phosphat of soda *sal mirabile perlatum.*

Acid (Phosphoric). The base of this acid, or the acid itself, abounds in the mineral, vegetable, and animal kingdoms. In the mineral kingdom it is found in combination with lead, in the green lead ore; with iron, in the bog ores which afford cold short iron; and more especially with calcareous earth in several kinds of stone. Whole mountains in the province of Estramadura in Spain are composed of this combination of phosphoric acid and lime. Mr. Bowles affirms, that the stone is whitish, and tasteless, and affords a blue flame without smell when thrown upon burning coals. Mr. Proust describes it as a dense stone, not hard enough to strike fire with steel; and says that it is found in strata, which always lie horizontally upon quartz, and which are intersected with veins of quartz. When this stone is scattered upon burning coals, it does not decrepitate, but burns with a beautiful green light, which lasts a considerable time. It melts into a white enamel by the blowpipe; is soluble with heat, and some effervescence in the nitric acid, and forms sulphat of lime with the sulphuric acid, while the phosphoric acid is set at liberty in the fluid.

The vegetable kingdom abounds with phosphorus, or its acid. It is principally found in plants that grow in marshy places, in turf, and several species of the white woods. Various seeds, potatoes, agaric, soot, and charcoal afford phosphoric acid*, by abstracting the nitric acid from them, and lixiviating the residue. The lixivium contains the phosphoric acid, which may either be saturated with lime by the addition of lime water, in which case it forms a solid compound, or it may be tried by examination of its leading properties by other chemical methods.

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* To this prof. Bartholdi ascribes two accidents at the powder-mills at Elsone, where spontaneous combustion appeared to have taken place in one instance in the charcoal store-room, in the other in the box into which the charcoal was sifted; as well as three successive explosions at the powder-mills of Vosges. This certainly merits the attention of gunpowder manufacturers.

In the animal kingdom it is found in almost every part of the bodies of animals which are not considerably volatile. There is not, in all probability, any part of these organised beings which is free from it. It has been obtained from blood, flesh, both of land and water animals; from cheese; and it exists in large quantities in bones, combined with calcareous earth. Urine contains it, not only in a disengaged state, but also combined with ammonia, soda, and lime. It was by the evaporation and distillation of this excrementitious fluid with charcoal that phosphorus was first made; the charcoal decomposing the disengaged acid, and the ammoniacal salt. See PHOSPHORUS. But it is more cheaply obtained by the process of Scheele, from bones, by the application of an acid to their earthy residue after calcination.

In this process the sulphuric acid appears to be the most convenient, because it forms a nearly insoluble compound with the lime of the bones. Bones of beef, mutton, or veal, being calcined to whiteness in an open fire, lose almost half of their weight. This must be pounded, and sifted, or the trouble may be spared by buying the powder that is sold to make cupels for the assayers, and is, in fact, the powder of burned bones ready sifted. To three pounds of the powder there may be added about two pounds of concentrated sulphuric acid. Four or five pounds of water must be afterward added to assist the action of the acid; and during the whole process the operator must remember to place himself and his vessels so that the fumes may be blown from him. The whole may be then left on a gentle sand bath for twelve hours or more, taking care to supply the loss of water which happens by evaporation. The next day a large quantity of water must be added, the whole strained through a sieve, and the residual matter, which is sulphat of lime, must be edulcorated by repeated affusions of hot water, till it passes tasteless. The waters contain phosphoric acid nearly free from lime, and by evaporation, first in glazed earthen, and then in glass vessels, or rather in vessels of platina or silver, for the hot acid acts upon glass, afford the acid in a concentrated state, which, by the force of a strong heat in a crucible, may be made to acquire the form of a transparent consistent glass, though indeed it is usually of a milky, opake appearance.

For making phosphorus, it is not necessary to evaporate the water further than to bring it to the consistence of sirup; and the small portion of lime it contains is not an impediment worth the trouble of removing, as it affects the produce very little. But when the acid is required in a purer state, it is proper to add a quantity of carbonat of ammonia, which, by double elective attraction, precipitates the lime that was held in solution by the phosphoric acid. The fluid being then evaporated, affords a crystallized ammoniacal salt, which may be melted in a silver vessel, as the acid acts upon glass or earthen vessels. The ammonia is driven off by the heat, and the acid acquires the form of a compact glass as transparent as rock crystal, acid to the taste, soluble in water, and deliquescent in the air.

This acid is commonly pure, but nevertheless may contain a small quantity of soda, originally existing in the bones, and not capable of being taken away by this process, ingenious as it is. The only unequivocal method of obtaining a pure acid appears to consist in first converting it into phosphorus by distillation of the materials with charcoal, and then converting it again into acid by rapid combustion, at a high temperature, either in oxigen or atmospheric air, or some other equivalent process.

Phosphorus may also be converted into the acid state by treating it with nitric acid. In this operation, a tubulated retort with a ground stopper, must be half filled with nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tube will be dissolved with effervescence, produced by the escape of a large quantity of nitric oxide. The addition of phosphorus must be continued until the last piece remains undissolved. The fire being then raised to drive over the remainder of the nitric acid, the phosphoric acid will be found in the retort, partly in the concrete and partly in the liquid form.

Sulphuric acid produces nearly the same effect as the nitric; a large quantity of sulphurous acid flying off. But as it requires a stronger heat to drive off the last portions of this acid, it is not so well adapted to the purpose. The liquid oximuriatic acid likewise acidifies it: and if phosphorus be put into this acid in a state of gas, it takes fire spontaneously, and burns vehemently.

When phosphorus is burned by a strong heat, sufficient to cause it to flame rapidly, it is almost perfectly converted into dry acid, some of which is thrown up by the force of the combustion, and the rest remains upon the supporter.

This substance has also been acidified by the direct application of oxigen gas passed through hot water, in which the phosphorus was liquefied or fused.

The general characters of phosphoric acid, are: 1. It is soluble in water in all proportions, producing a specific gravity, which increases as the quantity of acid is greater, but does not exceed 2·687, which is that of the glacial acid. 2. It produces heat when mixed with water, though not very considerable. 3. It has no smell when pure, and its taste is sour, but not corrosive. 4. When perfectly dry, it sublimes in close vessels; but loses this property by the addition of water; in which circumstance it greatly differs from the boracic acid, which is fixed when dry, but rises by the help of water. 5. When considerably diluted with water, and evaporated, the aqueous vapour carries up a small portion of the acid. 6. With charcoal or inflammable matter, in a strong heat, it loses its oxigen, and becomes converted into phosphorus.

It has been supposed that the phosphoric acid was incapable of crystallizing. Goettling, however, found sharp-pointed crystals of this acid on the sides of a glass vessel in a cellar, in which phosphorus had stood three months covered with carbonic acid gas. Mr. Guezsen of Kiel having kept some of the specific gravity of 2·1 for a few weeks in a temperature between 30° and 36° perceived that it shot into feathery crystals: on being exposed several days to a temperature varying from 28° to 14°, it curdled into an opake mass like tallow, without crystallization. This mass being rendered fluid by heat, and then exposed in a small glass tube in a freezing mixture to 49° below 0 of F. for fifteen minutes, continued fluid; though it again congealed on being kept some days at 27½°. By rest even in a temperature ranging from 54° to 68° it will crystallize when of this strength; but if diluted with more water it only curdles into an irregular mass. M. Steinacher of Paris, and M. Vitalis of Rouen, likewise confirm its crystallization; but the latter says, that the crystals become deliquescent in a heat from 77° to 88°, though Guersen found no alteration in his in the hottest days of summer.

Though the phosphoric acid is scarcely corrosive, yet, when concentrated, it acts upon oils, which it discolours, and at length blackens, producing heat, and a strong smell like that of ether and oil of turpentine; but does not form a true acid soap. It has most effect on essential oils, less on drying oils, and least of all on fat oils. Spirit of wine and phosphoric acid have a weak action on each other. Some heat is excited by this mixture, and the product which comes over in distillation of the mixture is strongly acid, of a pungent arsenical smell, inflammable with smoke, miscible in all proportions with water, precipitating silver and mercury from their solutions, but not gold; and although not an ether, yet it seems to be an approximation to that kind of combination.

Phosphoric acid united with barytes produces an insoluble salt, in the form of a heavy white powder, fusible at a high temperature into a gray enamel. The best mode of preparing it is by adding an alkaline phosphat to the nitrat or muriat of barytes.

The phosphat of strontian differs from the preceding in being soluble in an excess of its acid.

Phosphat of lime is very abundant in the native state. At Marmarosch in Hungary, it is found in a pulverulent form mixed with fluat of lime: in the province of Estramadura in Spain, it is in such large masses that walls of enclosures and even houses are built with it; and it is frequently crystallized, as in the apatite of Werner, when it assumes different tints of gray, brown, purple, blue, olive, and green. In the latter state it has been confounded with the chrysolite, and sometimes with the beryl and aqua marine, as in the stone called the Saxon beryl. It likewise constitutes the chief part of the bones of all animals.

The phosphat of lime is very difficult to fuse, but in a glasshouse furnace it softens, and acquires the semitransparency and grain of porcelain. It is insoluble in water, but when well calcined forms a kind of paste with it, as in making cupels. Beside this use of it, it is employed for polishing gems and metals, for absorbing grease from cloth, linen, or paper, and for preparing phosphorus. In medicine it has been strongly recommended against the rickets by Dr. Bonhomme of Avignon, either alone or combined with phosphat of soda. The *burnt hartshorn* of the shops is a phosphat of lime.

An acidulous phosphat of lime is found in human urine, and may be crystallized in small silky filaments, or shining scales, which unite together into something like the consistence of honey, and have a perceptibly acid taste. It may be prepared by partially decomposing the calcareous phosphat of bones by the sulphuric, nitric, or muriatic acid, or by dissolving that phosphat in phosphoric acid. It is soluble in water, and crystallizable. Exposed to the action of heat it softens, liquefies, swells up, becomes dry, and may be fused into a transparent glass, which is insipid, insoluble, and unalterable in the air. In these characters it differs from the glacial acid of phosphorus. It is partly decomposable by charcoal, so as to afford phosphorus. According to Fourcroy and Vauquelin this salt contains 54 parts of acid, and 46 of lime, while the neutral phosphat contains but 41 of acid to 59 of lime.

The phosphat of potash is very deliquescent, and not crystallizable, but condensing into a kind of jelly. Like the preceding species it first undergoes the aqueous fusion, swells, dries, and may be fused into a glass; but this glass deliquesces. It has a sweetish saline taste.

The phosphat of soda was first discovered combined with ammonia in urine by Schockwitz; and was called *fusible* or *microcosmic salt*. Margraff obtained it alone by lixiviating the residuum left after preparing phosphorus from this triple salt and charcoal. Haupt, who first discriminated the two, gave the phosphat of soda the name of *sal mirabile perlatum*. Rouelle very properly announced it to be a compound of soda and phosphoric acid. Bergman considered it, or rather the acidulous phosphat, as a peculiar acid, and gave it the name of *perlate acid*: Guyton-Morveau did the same, but distinguished it by the name of *ouretic*: at length Klaproth ascertained its real nature to be as Rouelle had affirmed.

This phosphat is now commonly prepared by adding to the acidulous phosphat of lime as much carbonat of soda in solution as will fully saturate the acid. The carbonat of lime, which precipitates, being separated by filtration, the liquid is duly evaporated so as to crystallize the phosphat of soda; but if there be not a slight excess of alkali, the crystals will not be large and regular. M. Funcke, of Linz, recommends, as a more economical and expeditious mode, to saturate the excess of lime in calcined bones by dilute sulphuric acid, and dissolve the phosphat of lime that remains in nitric acid. To this solution he adds an equal quantity of sulphat of soda, and recovers the nitric acid by distillation. He then separates the phosphat of soda from the sulphat of lime by elutriation and crystallization as usual. The crystals are rhomboidal prisms of different shapes; efflorescent; soluble in 3 parts of cold and 1½ of hot water. They are capable of being fused into an opake white glass, which may be again dissolved and crystallized. It may be converted into an acidulous phosphat by an addition of acid, or by either of the strong acids, which partially, but not wholly, decompose it. As its taste is simply saline, without any thing disagreeable, it is much used as a purgative, chiefly in broth, in which it is not distinguishable from common salt. For this elegant addition to our pharmaceutical preparations we are indebted to Dr. Pearson. In assays with the blowpipe it is of great utility; and it has been used instead of borax for soldering.

The phosphat of ammonia crystallizes in prisms with four regular sides terminating in pyramids, and sometimes in bundles of small needles. Its taste is cool, saline, pungent, and urinous. On the fire it comports itself like the preceding species, except that the whole of its base may be driven off by a continuance of the heat, leaving only the acid behind. It is the only phosphoric salt decomposable by charcoal, so as to afford phosphorus. It is but little more soluble in hot water than in cold, which takes up a fourth of its weight. It is pretty abundant in human urine, particularly after it is become putrid. It is an excellent flux both for assays with the blowpipe, and in the fabrication of coloured glass and artificial gems.

Phosphat of magnesia crystallizes in irregular hexaëdral prisms, obliquely truncated; but is commonly pulverulent, as it effloresces very quickly. It requires fifty parts of water to dissolve it. Its taste is cool and sweetish. This salt too is found in urine. Fourcroy and Vauquelin have discovered it likewise in small quantity in the bones of various animals, though not in those of man. The best way of preparing it is by mixing equal parts of the solutions of phosphat of soda and sulphat of magnesia, and leaving them some time at rest, when the phosphat of magnesia will crystallize, and leave the sulphat of soda dissolved.

An ammoniaco-magnesian phosphat has been discovered in an intestinal calculus of a horse by Fourcroy, and since by Bartholdi; and likewise by the former in some human urinary calculi. Notwithstanding the solubility of the phosphat of ammonia, this triple salt is far less soluble than the phosphat of magnesia. It is partially decomposable into phosphorus by charcoal, in consequence of its ammonia.

The phosphat of glucine has been examined by Vauquelin, who informs us, that it is a white powder, or mucilaginous mass, without any perceptible taste; fusible, but not decomposable by heat; unalterable in the air; and insoluble unless in an excess of its acid.

It has been observed, that the phosphoric acid aided by heat acts upon silex; and we may add, that it enters into many artificial gems in the state of a siliceous phosphat.—*Scheele.—Bergman.—Fourcroy.—An. de Chim.—Journ. de Med.—Chimie de Dijon.—Scherer's Journ.*

Acid (Phosphorous). This acid is prepared by the slow combustion of phosphorus, for which Pelletier gives the following instructions: Place sticks of phosphorus upright in a glass funnel, keeping them separate by putting each into a glass tube open at both ends and large enough for the phosphorus to lie loose in it. This is necessary, as they would be in danger of taking fire, and burning rapidly, if in contact. Let the pipe of the funnel be inserted into the neck of an empty bottle standing on a dish in which there is a little water. Cover the bottle and funnel with a glass jar, in the sides of which are two small tubulures, that may be left open to admit air, or stopped with a cork whenever the combustion is going on too rapidly. The acid thus obtained, which will be about three times the weight of the phosphorus employed, is a white fluid of a sirupy consistence, and slightly fetid smell. It refracts light more powerfully than phosphoric acid of equal density. On exposure to heat in a glass retort, it first loses part of its water, and at length bubbles are formed at the bottom of the vessel, which give out a dense white vapour as they burst on the surface, or take fire if there be a sufficient quantity of air present. These bubbles continue to form a long time, but at length the acid will be reduced to the state of phosphoric.

As the antient chemists had not distinguished the different states of the acid of phosphorus, the salts they had formed with it were commonly phosphites, but their properties were not known with any precision, till they were examined by Fourcroy and Vauquelin. They differ from the phosphats both in figure and taste, emit a smell of phosphorus, yield a phosphorescent light when exposed to heat, and with the oxymuriat of potash detonate by mere percussion. The affinities of the phosphorous acid for the bases differ too in their order from those of the phosphoric.

The phosphit of lime, which is incapable of being decomposed by any of the bases, is a white, insipid powder, insoluble in water, but capable of being dissolved even in acids that do not decompose it.

The acidulous phosphit of lime is a little soluble, and crystallizes in small prisms or needles of no determinate figure.

The phosphit of barytes is likewise an insipid white powder, a little soluble in water, however, and like the preceding somewhat more soluble, and crystallizing in a similar manner, when supersaturated with acid. The light it emits when fused by the blowpipe is so bright as to dazzle the eyes.

The phosphit of magnesia has no perceptible taste, is often in a soft flocculent form, but sometimes crystallized; effloresces in the air; and is soluble in 400 parts of water.

The phosphit of potash forms quadrilateral prismatic crystals with diëdral summits. It has a pungent saline taste; decrepitates in the fire; and is soluble in three parts of cold, and less of hot water.

The phosphat of soda has a cool, sweet taste. It crystallizes in elongated rhomboids, square plates, or a feathery form. It is efflorescent, but much less so than phosphat of soda, and requires only two parts of cold water to dissolve it. Hot water dissolves very little more.

The phosphit of ammonia has a very pungent taste, crystallizes frequently in very slender needles, but sometimes in quadrilateral prisms terminated by tetraëdral pyramids. If subjected to distillation in a retort it is decomposed; and the ammonia is volatilized, partly in a liquid state, partly in that of gas holding phosphorus in solution, without however taking fire spontaneously in the air. This gas emits a phosphoric light when mixed with oxigen gas. What remains in the retort is glacial phosphoric acid. If this phosphit be heated on charcoal with the blowpipe, it boils in its water of crystallization; a beautiful phosphoric light is diffused over its surface; and presently bubbles of gas burst from the middle of the vitrifying salt, which burn in the air with a bright flame, and form in the ring of white vapour of phosphoric acid. The vitreous globule left is pure phosphoric acid. Phosphit of ammonia is slightly deliquescent, soluble in two parts of water at 50°, and its solubility increases with the temperature.

A triple salt may be formed by the union of phosphorous acid with ammonia and magnesia at the same time.

The phosphit of alumine has a styptic taste, easily dissolves in water, but is not crystallizable.

Acid (Prussic). The combination of this acid with iron was long known and used as a pigment by the name of Prussian blue, before its nature was understood. Macquer first found, that alkalis would decompose Prussian blue by separating the iron from the principle with which it was combined in it, and which he supposed to be phlogiston. In consequence the prussiat of potash was long called *phlogisticated alkali*. Bergman, however, from a more scientific consideration of its properties, ranked it among the acids; and as early as 1772 Sage announced, that this animal acid, as he called it, formed with the alkalis neutral salts, that with potash forming octaëdral crystals, and that with soda rhomboids or hexagonal laminæ. About the same time Scheele instituted a series of sagacious experiments, not only to obtain the acid separate, which he effected, but also to ascertain its constituent principles. These, according to him, are ammonia and carbon; and Berthollet has only added, that its triple base consists of hidrogen and azot, nearly if not precisely in the proportions that form ammonia and carbon. Berthollet could find no oxigen in any of his experiments for decomposing this acid, as chemists are still agreed to call it; and hence he thinks himself authorised to conclude, that it contains no acidifying principle. He likewise mentions another anomaly it possesses, which is, that it cannot alone take away from other acids the metallic oxides dissolved in them, though none of them can dispossess it of an oxide with which it is united. This Berthollet ascribes to its specific heat, and tendency to assume the gaseous form. Fourcroy however infers, that it does contain oxigen, because Vauquelin obtained six times as much prussic acid in decomposing muriat of ammonia mixed with charcoal by oxide of lead, as he did when using lime instead of this oxide. Fourcroy found too, that on treating the coagulated serum of blood by nitric acid, in order to obtain oxalic acid, a vaporous product was disengaged, which being collected proved to be pure prussic acid: but azotic gas was previously evolved; whence he infers, that the prussic acid contains less azot than ammonia, as in the formation of ammonia this does not take place. Carbonic acid gas too was formed in this process. Another fact corroborates the opinion that prussic acid contains less azot than ammonia. When prussic acid is decomposed by fire, a portion of carbonated hidrogen gas is evolved during the formation of the carbonat of ammonia which is produced.

Curaudau has since attempted to establish a new theory on this head. According to him, what has been called prussic acid is merely its base, which is converted into an acid by acquiring oxigen from a metallic oxide. The calcination of the animal matter produces only two of the elements of the basis, forming with the alkali a carbonated azot of potash; and this combination has the property of decomposing water instantly, so as to form the prussic radical, by the addition of hidrogen, from it. Its attraction for the hidrogen of the water however is so great, that, if its action on the water be allowed to continue after the prussic radical is formed, it will absorb sufficient to convert the azot gradually into ammonia, which will fly off. This loss, however, he adds, may be prevented, by never moistening the calcined materials for making prussiat of potash but with a solution of sulphat of iron at the maximum of oxidation. Agreeably to this theory, Curaudau would distinguish by the name of *prussire* what is commonly called the prussic acid; the combinations of this with alkalis he would call *prussirrets*; and to those in which it has been acidified by the oxigen of some oxide, he would confine the name of prussiats.

The prussic acid is usually obtained by Scheele's method, which is this: Mix four ounces of Prussian blue with two of red oxide of mercury prepared by nitric acid, and boil them in twelve ounces by weight of water, till the whole becomes colourless; filter the liquor, and add to it one ounce of clean iron filings, and six or seven drams of sulphuric acid. Draw off by distillation about a fourth of the liquor, which will be prussic acid; though, as it is liable to be contaminated with a portion of sulphuric, to render it pure it may be rectified by redistilling it from carbonat of lime. Dr. Schaub of Cassel recommends a shorter way, which is, to pour on two parts of Prussian blue one part of sulphuric acid, diluted with an equal quantity of water, and then to distil off the prussic acid.

The prussic acid has a strong smell of peach blossoms, or bitter almonds: its taste is at first sweetish, then acrid, hot, and virulent, and excites coughing; it has a strong tendency to assume the form of gas: it has been decomposed in a high temperature, and by the contact of light, into carbonic acid, ammonia, and carbonated hidrogen: it does not readily unite with the earths and alkalis, does not destroy their alkaline properties, and is displaced even by the carbonic acid: it has no action upon metals, but unites with their oxides, and forms salts for the most part insoluble: it likewise unites into triple salts with these oxides and alkalis: the oxigenated muriatic acid decomposes it.

The peculiar smell of the prussic acid could scarcely fail to suggest its affinity with the deleterious principle that rises in the distillation of the leaves of the lauro-cerasus, bitter kernels of fruits, and some other vegetable productions; and M. Schrader of Berlin has ascertained the fact, that these vegetable substances do contain a principle capable of forming a blue precipitate with iron; and that with lime they afford a test of the presence of iron equal to the prussiat of that earth. Dr Bucholtz of Weimar, and Mr. Roloff of Magdeburg, confirm this fact. The prussic acid appears to come over in the distilled oil.

Prussiat of barytes may be formed by adding Prussian blue to a boiling solution of pure barytes, till its colour ceases to be extracted, and then filtering. The filtered liquor sometimes becomes turbid by cooling, and deposits a little oxide of iron. Being again filtered, after the expiration of some hours small yellowish crystals will form, which are prussiat of barytes. More may be obtained after this by evaporation.

The most important of the prussiats however, for its use in making Prussian blue, and as a test, is the prussiat of potash. This is commonly prepared by calcining dried bullock's blood with the common subcarbonat of potash, and lixiviating. Equal parts are very commonly used; but Dr. Bucholtz recommends two parts of blood to one of potash, as equally affording the largest possible quantity, and being less apt to act upon the oxide of iron in the blood, as well as on the crucible. These should be gradually heated to ignition, in a covered crucible with a hole in the lid: but the heat must neither be applied too suddenly, nor raised too high; and must be discontinued as soon as the small blue flame ceases. The matter should be lixiviated with as little water as possible, and without heat. This alkali is employed for making Prussian blue (see IRON, PRUSSIAT OF); but it is not sufficiently pure to be used as a test. To obtain this the following process is recommended by Mr. Henry. To a solution of potash, deprived of its carbonic acid by quicklime, and heated nearly to the boiling point, add by degrees powdered Prussian blue till its colour ceases to be discharged. Filter the liquor, wash the sediment with water till it ceases to extract any thing, mix the washings together, and pour the mixture into an earthen dish in a sand-heat. When the solution has become hot, add a little dilute sulphuric acid, and continue the heat about an hour. A copious precipitate of Prussian blue will be formed, which must be separated by filtration, and assay a small quantity of the filtered liquor in a wine glass with a little dilute sulphuric acid. If an abundant production of Prussian blue still take place, the whole liquor must be again exposed

exposed to heat with a little dilute sulphuric acid, and this must be repeated as often as necessary. Into the liquor thus far purified pour a solution of sulphat of copper in four or six times its weight of warm water, as long as a reddish brown precipitate continues to appear. Wash this precipitate, which is a prussiat of copper, with repeated affusions of warm water; and when these come off colourless lay the precipitate on a linen filter to drain, after which it may be dried on a chalk stone. When the precipitate is dry, powder it, and add it by degrees to a solution of pure potash, which will take the prussic acid from the oxide of copper. This prussiat of potash, however, will be contaminated by some portion of sulphat of potash, from part of which it may be freed by gentle evaporation, as the sulphat crystallizes first. To the remaining liquor add a solution of barytes in warm water, as long as a white precipitate ensues, observing not to add more after its cessation. The solution of prussiat of potash will now be freed in a great measure from iron, and entirely from sulphats, and by gentle evaporation will form on cooling beautiful crystals. These dissolved in cold water afford the purest prussiat of potash that can be prepared. If pure barytes be not at hand, acetat of barytes may be used instead; as the acetat of potash formed, not being crystallizable, will remain in the mother-water.

Prussiats of soda and of ammonia may be prepared in a similar manner.

The prussiat of lime too has been recommended as a test by Scheele and some other chemists.—*Mem. of the Ac. of Berlin and Stockholm.—Journ. de Phys.—Hermbstaedt's Allg.—Journ. der Chem.—Ann. de Chim.—Nicholson's Journal.*

Acid (Pyroligneous). In the destructive distillation of any kind of wood an acid is obtained, which was formerly called *acid spirit of wood*, and since pyroligneous acid. In distilling cork, however, it appeared to Fourcroy and Vauquelin, that the acid obtained resembled the acetous; and on pursuing the investigation they ascertained, both analytically and synthetically, that the pyroligneous acid is nothing more than the acetous contaminated with an empyreumatic oil produced from the wood.

Acid (Pyromucous). This acid, like the pyroligneous, was proved by the same chemists to be merely the acetous, impregnated with an aromatic oil. It was formerly distinguished by the names *spirit of honey, of sugar, of manna, of gum*, &c., according to the substance from which it was obtained. In the chemical dictionary of the French Encyclopædia it was named by Guyton-Morveau *sirupous acid*, being generally procured from sugar. But as mucilage appeared to be the substance that afforded it, it was lastly called *pyromucous*.

Acid (Pyrotartarous). This acid, obtained in a similar manner from the supertartrit of potash, proves, like the two preceding, to be acetous acid united with an empyreumatic oil.

Acid (Rosacic). The sediment known to physicians by the name of *lateritious*, that is deposited from the urine of persons labouring under febrile diseases, when these diseases take a favourable turn, has long been known to consist chiefly of an acid. According to Scheele it is the uric, which is much more abundant in this critical urine as it is called, than in urine in the ordinary state. Professor Proust, however, says that it differs from the uric in being very soluble in hot water, in having little tendency to crystallize, and in precipitating muriat of gold of a violet colour. Accordingly he distinguishes it by the name of rosacic, but it remains to be determined whether it must retain its separate rank.

Acid (Saccharine). See Acid (Oxalic).

Acid (Saccholactic). See Acid (Mucous).

Acid (Sebacic). The fat of animals is a substance nearly of the same nature as those oils called fat oils in the vegetable kingdom. It affords an acid by distillation, which may be rendered purer by rectifying. But the most elegant method of obtaining this acid consists in mixing a quantity of melted suet with quicklime, suffering the mixture to cool, and afterward boiling it with a large quantity of water. After filtration and evaporation the calcareous salt, formed by the combination of the sebacic acid with the earth, is obtained of a brown colour. A slight calcination renders it purer by the destruction of a portion of inflammable matter; and by solution, filtration, and the addition of a certain quantity of carbonic acid, to precipitate the superfluous lime, a clear solution of the sebat of lime is obtained. Evaporation of the fluid affords the pure white salt; and this, when distilled with the addition of one third of its weight of sulphuric acid, diluted with water, affords the sebacic acid, which comes over into the receiver, while the sulphat of lime remains in the retort.

The sebacic acid is liquid, fuming, and of a penetrating odour; decomposable by heat, which turns it yellow, and reduces it to a coal, after having evolved carbonic acid and carbonated hidrogen gas. Blue colours are strongly reddened by it: water dissolves it in all proportions. With lime, and also with the fixed alkalis, it forms crystallizable salts, which are not decomposed in a moderate heat. With magnesia it forms an uncrystallizable saline mass, which may be reduced to a gummy consistence. With clay, or pure argillaceous earth, it unites with difficulty, forming an astringent uncrystallizable mass. Siliceous earth is thought to be corroded by this acid, probably from its action on glass, in which it may act on the alkali and not on the earth, for it has no action upon siliceous earth precipitated from liquor of flints. Mixed with nitric acid it dissolves gold.

The acid of fat produces an ether by distillation in the usual method with alcohol: it expels the acid from the alkaline sulphats, and the nitrat and acetat of potash, and is itself decomposed by distillation. It likewise precipitates supertartrit of potash from a solution of the neutral tartrit.

When nitrous acid is abstracted from tallow, there is a production of oxalic acid, and not the sebacic. Hence it has been concluded, that this acid is nearly of the same nature as the other acids obtained from organized substances. M. Thenard has lately asserted, that the acid hitherto obtained from fat has been commonly the acetous, perhaps contaminated with the sulphurous; and sometimes, when the common potash of commerce, which is mixed with more or less muriat of soda, was used, as in Crell's process, instead of the quicklime recommended above, the muriatic. He adds, however, that he has obtained a peculiar acid, which is the true sebacic, by distilling fat, washing the product repeatedly with hot water, and filtering, evaporating, and crystallizing the liquor; or precipitating the liquor with acetit of lead, and heating the precipitate, first dried in a retort with sulphuric acid. In the latter case no acid came over into the receiver, but a melted substance like fat floated on the matter in the retort, which M. Thenard first washed well, and then dissolved in boiling water, from which it separated in small crystalline needles on cooling. These crystals were slightly acid to the taste; totally void of smell; melted like fat; were very soluble in boiling water, so as to congeal with it into a mass on cooling; dissolved freely in alcohol; precipitated the nitrats of lead, silver, and mercury, and acetits of mercury and lead; formed soluble salts with the alkalis; were precipitated from their union with potash, without being decomposed, by the sulphuric, nitric, and muriatic acid. *Crell.—Journ. de Phys.—Ann. de Chim.*

Acid (Suberic). This acid was discovered by Brugnatelli in cork, and afterward more fully examined by Bouillon la Grange. To obtain it, pour on cork grated to powder six times its weight of nitric acid, of the specific gravity of 1·26, in a tubulated retort; and distil the mixture with a gentle heat, as long as any red fumes arise. As the distillation advances, a yellow matter, like wax, appears on the surface of the liquid in the retort. While its contents continue hot, pour them into a glass vessel, placed on a sand-heat, and keep them continually stirring with a glass rod; by which means the liquid will gradually grow thick. As soon as white penetrating vapours appear, let it be removed from the sand-heat, and kept stirring till cold. Thus an orange-coloured mass will be obtained, of the consistence of honey, of a strong sharp smell while hot, and a peculiar aromatic smell when cold. On this pour twice its weight of boiling water, apply heat till it liquefies, and filter. As the filtered liquor cools it deposits a powdery sediment, and acquires a thin pellicle. Separate the sediment by filtration, and evaporate the fluid nearly to dryness. The mass thus obtained is the suberic acid; which may be purified by saturating with an alkali, and precipitating by an acid, or by boiling it with charcoal powder.

Suberic acid has a rough acerb taste, and when dissolved in boiling water excites coughing: it reddens vegetable blues, and turns the blue solution of indigo in sulphuric acid green: it is soluble in two parts of boiling water, and in about one hundred and fifty of cold: it attracts moisture from the air, and is turned brown by the action of light: it sublimes in a moderate heat without being decomposed. Its base is presumed to consist of carbon and hidrogen, though Mr. Jameson would reject the hidrogen, because he obtained it by treating charcoal with nitric acid; but this is not a sufficient proof. He likewise observes, that the acid existing ready formed in peat has the properties of the suberic. Brugnatelli has obtained a large quantity of suberic acid, mixed with oxalic, from paper.

Most of the alkaline and earthy suberats have an excess of acid, and are decomposed by heat. Those of potash and ammonia are the only ones that crystallize. The alkaline are very soluble, the earthy dissolve but sparingly.—*Crell's Annals.—Ann. de Chim.—Gehlen's Journal.—Jameson's Min. of Shetland.*

Acid (Succinic). It has long been known that amber, when exposed to distillation, affords a crystallized substance, which sublimes into the upper part of the vessel. Before its nature was understood it was called *salt of amber*, a name not yet banished from our Pharmacopœias; but it is now known to be a peculiar acid, as Boyle first discovered. The crystals are at first contaminated with a little oil, which gives them a brownish colour; but they may be purified by solution and crystallization, repeated as often as necessary; when they will become transparent and shining. Pott recommends to put on the filter, through which the solution is passed, a little cotton previously wetted with oil of amber. Their figure is that of a triangular prism. Their taste is acid, and they redden the blue colour of litmus, but not that of violets. They are soluble in less than two parts of boiling alcohol, in two parts of boiling water, and in twenty-five of cold water.

M. Planche, of Paris, observes, that a considerable quantity might be collected in making amber varnish, as it sublimes while the amber is melting for this purpose, and is wasted.

It has been prescribed in nervous and catarrhal complaints, and as a diuretic.

With barytes and lime the succinic acid forms salts but little soluble; and with magnesia it unites into a thick gummy substance. The succinats of potash and ammonia are crystallizable, and deliquescent; that of soda does not attract moisture. The succinat of ammonia is useful in analysis to separate oxide of iron.

Acid (Sulphuric). When sulphur is heated to 180° or 190° in an open vessel, it melts, and soon afterward emits a blueish flame, visible in the dark, but which, in open day-light, has the appearance of a white fume. This flame has a suffocating smell, and has so little heat that it will not set fire to flax, or even gunpowder, so that in this way the sulphur may be entirely consumed out of it. If the heat be still augmented, the sulphur boils, and suddenly bursts into a much more luminous flame, the same suffocating vapour still continuing to be emitted.

The suffocating vapour of sulphur is imbibed by water, with which it forms the fluid formerly called *volatile vitriolic*, now sulphurous acid. If this fluid be exposed for a time to the air, it loses the sulphureous smell it had at first, and the acid becomes more fixed. It is then the fluid which was formerly called the *spirit of vitriol*. Much of the water may be driven off by heat, and the dense acid which remains is the sulphuric acid, commonly called *oil of vitriol*; a name which was probably given to it from the little noise it makes when poured out, and the unctuous feel it has when rubbed between the fingers, produced by its corroding and destroying the skin, with which it forms a soapy compound.

The stone or mineral called martial pyrites, which consists for the most part of sulphur and iron, is found to be converted into the salt vulgarly called *green vitriol*, but more properly sulphat of iron, by exposure to air and moisture. In this natural process the pyrites breaks and falls in pieces; and if the change take place rapidly, a considerable increase of temperature follows, which is sometimes sufficient to set the mass on fire. By conducting this operation in an accurate way, it is found that oxigen is absorbed. The sulphat is obtained by solution in water, and subsequent evaporation; by which the crystals of the salt are separated from the earthy impurities, which were not suspended in the water.

The sulphuric acid was formerly obtained in this country by distillation from sulphat of iron, as it still is in many parts abroad: the common green vitriol is made use of for this purpose, as it is to be met with at a low price, and the acid is more easily to be extracted from it. With respect to the operation itself, the following particulars should be attended to: First, the vitriol must be calcined in an iron or earthen vessel, till it appears of a yellowish red colour: by this operation it will lose half its weight. This is done in order to deprive it of the greater part of the water which it has attracted into its crystals during the crystallization, and which would otherwise in the ensuing distillation greatly weaken the acid. As soon as the calcination is finished, the vitriol is to be put immediately, while it is warm, into a coated earthen retort, which is to be filled two thirds with it, so that the ingredients may have sufficient room upon being distended by the heat, and thus the bursting of the retort be prevented. It will be most advisable to have the retort immediately enclosed in brick-work in a reverberatory furnace, and to stop up the neck of it till the distillation begins, in order to prevent the materials from attracting fresh humidity from the air. At the beginning of the distillation the retort must be opened, and a moderate fire is to be applied to it, in order to expel from the vitriol all that part of the phlegm which does not taste strongly of the acid, and which may be received in an open vessel placed under the retort. But as soon as there appear any acid drops, a receiver is to be added, into which has been previously poured a quantity of the acidulous fluid which has come over, in the proportion of half a pound of it to twelve pounds of the calcined vitriol; when the receiver is to be secured with a proper luting. The fire is now to be raised by little and little to the most intense degree of heat, and the receiver carefully covered with wet cloths, and, in winter time, with snow or ice, as the acid rises in the form of a thick white vapour, which toward the end of the operation becomes hot, and heats the receiver to a great degree. The fire must be continued at this high pitch for several days, till no vapour issues from the retort, nor any drops are seen trickling down its sides. In the case of a great quantity of vitriol being distilled, M. Bernhardt has observed it to continue emitting vapours in this manner for the space of ten days. When the vessels are quite cold, the receiver must be opened carefully, so that none of the luting may fall into it; after which the fluid contained in it is to be poured into a bottle, and the air carefully excluded. The fluid that is thus obtained is the ordinary sulphuric acid, of which Bernhardt got sixty-four pounds from six hundred weight of vitriol; and on the other hand, when no water had been previously poured into the receiver, fifty-two pounds only of a dry concrete acid. This acid was formerly called *glacial oil of vitriol*, and its consistence is owing to a mixture of sulphurous acid, which occasions it to become solid at a moderate temperature.

The sulphuric acid made in these kingdoms is produced by the combustion of sulphur. There are three conditions requisite in this operation. Oxigen must be present to maintain the combustion; the vessel must be close, to prevent the escape of the volatile matter which rises; and water must be present to imbibe it. For these purposes, a mixture of eight parts of sulphur with one of nitre is placed in a proper vessel, enclosed within a chamber of considerable size, lined on all sides with lead, and covered at bottom with a shallow stratum of water. The mixture being set on fire, and shut up, will burn for a considerable time, by virtue of the supply of oxigen which nitre gives out when heated; and the water imbibing the sulphureous vapours, becomes gradually more and more acid after repeated combustions, and the acid is afterward concentrated by distillation. The common sulphuric acid of the shops, if diluted with an equal weight of water, frequently deposits a white sediment, consisting of various impurities; and the clear fluid poured off, and then concentrated by evaporation, will be a much purer acid. To have it as pure as possible, however, it should be rectified by distillation, which is a difficult process, requiring considerable skill and experience. For this purpose a glass retort, very carefully annealed, must be taken, and coated all over the body, and as much of the neck as is exposed to the fire, with clay and sand. This being dry, it is to be half filled with the acid, and placed on a sand-bath in a reverberatory furnace, which has an opening in the side for the neck of the retort. A receiver being applied without luting, the fire must be kindled, and raised with extreme caution. The first portion that comes over, about a sixth of the whole, may be rejected, as it is chiefly water. The concentrated acid now rises, and great care must be taken to regulate the fire, so that several seconds may elapse between the fall of the drops, as at this period the neck of the retort is very liable to be broken. The process may be continued as long as any acid is condensed.

The sulphuric acid is considerably denser than any other acid or transparent fluid, and in general its affinities are stronger. It strongly attracts water, which it takes from the atmosphere very rapidly, and in larger quantities, if suffered to remain in an open vessel, imbibing one third of its weight in twenty-four hours, and more than six times its weight in a twelvemonth. If four parts by weight be mixed with one of water at 50° they produce an instantaneous heat of 300° F.; and four parts raise one of ice to 212°; on the contrary, four parts of ice mixed with one of acid sink the thermometer to 4° below 0. When pure it is colourless, and emits no fumes. If it be heated, it becomes more and more concentrated by the loss of a portion of water, which rises before the acid itself. Its specific gravity ought to be 1·85, at which it is taken by the London college; but it may be brought, by evaporation in a sand-heat, to 2 or upward. At this strength it requires a great degree of cold to freeze it; and if diluted with half a part or more of water, unless the dilution be carried very far, it becomes more and more difficult to congeal: yet at the specific gravity of 1·78, or a few hundredths above or below this, it may be frozen by surrounding it with melting snow. Its congelation forms regular prismatic crystals with six sides. Its boiling point, according to Bergman, is 540°; according to Dalton, 590°.

Attempts have been made to ascertain the proportions of the constituent principles in this acid, but chemists have differed considerably on this head. Tromsdorf carries the sulphur as high as 70 per cent., and Berthollet even to 72; while Klaproth, Richter, and Bucholz make it little more than 42. Lately Mr. Chenevix has made some very careful experiments on the subject, which give 51·5 for the proportion of sulphur, and their accuracy is strengthened by others made by Dr. Thomson of Edinburgh; and it is probable the other chemists may have erred from mistaken calculations of the component parts of the salts employed in the analysis.

The sulphuric acid is of very extensive use in the art of chemistry, as well as in metallurgy, bleaching, and some of the processes for dyeing: in medicine it is given as a tonic, stimulant, and lithontriptic, and sometimes used externally as a caustic.

The combinations of this acid with the various bases are called sulphats, and most of them have long been known by various names. With barytes it is found native and nearly pure in various forms, in coarse powder, rounded masses, stalactites, and regular crystallizations, which are in some lamellar, in others needly, in others prismatic or pyramidal. The cawks of our country and the *Bolognian stone* (which see) are native sulphats of barytes. Their colour varies considerably as well as their figure, but their specific gravity is great, that of a very impure kind being 3·89, and the pure sorts varying from 4 to 4·865; hence it has been distinguished by the names of *marmor metallicum* and *ponderous spar*. The native sulphat of barytes according to Bergman consists of 84 barytes with 16 sulphuric acid and water, the water of crystallization being 3. According to Klaproth, however, the earth is to the acid as 2 to 1 only: and Dr. Withering, who has analysed different specimens with great care, gives nearly similar proportions, or 67·2 to 33·8: and some white rhomboidal lamellar crystals, from Kilpatrick hills near Glasgow, afforded him these proportions without any foreign admixture. The artificial sulphat has generally been estimated to contain also about 67 to 33 after having been ignited; but Mr. Chenevix, who has lately made many experiments on it with a view to ascertain the proportion of sulphur in sulphuric acid, calculates the acid in artificial sulphat of barytes to be only 23·5 or 24 per cent. This salt, though deleterious, is less so than the carbonat of barytes, and therefore perhaps preferable for preparing the muriat for medicinal purposes. It requires 43000 parts of water to dissolve it at 60°.

Sulphat of strontian has a considerable resemblance to that of barytes in its properties. It is found native in considerable quantities at Aust Passage and other places in the neighbourhood of Bristol. It requires 3840 parts of boiling water to dissolve it.

The sulphat of potash, *vitriolated kali* of the London college, formerly *vitriolated tartar*, *sal de duobus*, and *arcanum duplicatum*, crystallizes in hexaëdral prisms, terminated by hexagonal pyramids, but susceptible of several variations. Its crystallization by cooling is confused. Its taste is bitter, acrid, and a little saline. It is soluble in 5 parts of boiling water, and 16 parts at 60°. In the fire it decrepitates, and is fusible by a strong heat. It is decomposable by charcoal at a high temperature. It may be prepared by direct mixture of its component parts; but the usual and cheapest mode is to neutralize the acidulous sulphat left after distilling nitric acid, the *sal enixus* of the old chemists, by the addition of carbonat of potash. The *sal polychrest* of old dispensatories, made by deflagrating sulphur and nitre in a crucible, was a compound of the sulphat and sulphit of potash. The acidulous sulphat is sometimes employed as a flux, and likewise in the manufacture of alum. In medicine the neutral salt is sometimes used as a deobstruent, and in large doses as a mild cathartic: dissolved in a considerable portion of water, and taken daily in such quantity as to be gently aperient, it has been found serviceable in cutaneous affections, and is sold in London for this purpose as a nostrum; and certainly it deserves to be distinguished from the generality of quack medicines, very few indeed of which can be taken without imminent hazard.

The sulphat of soda is the *vitriolated natron* of the college, the well known *Glauber's salt*, or *sal mirabile*. It is commonly prepared from the residuum left after distilling muriatic acid, the superfluous acid of which may be saturated by the addition of soda, or precipitated by lime; and is likewise obtained in the manufacture of the muriat of ammonia. (See AMMONIA.) Schefer mentions another mode by Mr. Funcke, which is, making 8 parts of calcined sulphat of lime, 6 of clay, and 5 of common salt, into a paste with water; burning this in a kiln; and then powdering, lixiviating, and crystallizing. It exists in large quantities under the surface of the earth in some countries, as Persia, Bohemia, and Switzerland; is found mixed with other substances in mineral springs and sea water; and sometimes effloresces on walls. Sulphat of soda is bitter and saline to the taste: is soluble in 2·85 parts of cold water, and 0·8 at a boiling heat: it crystallizes in hexagonal prisms bevelled at the extremities, sometimes grooved longitudinally, and of very large size, when the quantity is great: these effloresce completely into a white powder, if exposed to a dry air, or even if kept wrapped up in paper in a dry place, yet they retain sufficient water of crystallization to undergo the aqueous fusion on exposure to heat, but by urging the fire melt. Barytes and strontian take its acid from it entirely, and potash partially: the nitric and muriatic acids, though they have a weaker affinity for its base, combine with a part of it when digested on it. Heated with charcoal its acid is decomposed. As a purgative its use is very general: and it has been employed to furnish soda. Pajot des Charmes has made some experiments on it in fabricating glass: with sand alone it would not succeed, but equal parts of carbonat of lime, sand, and dried sulphat of soda, produced a clear, solid, pale yellow glass.

Sulphat of soda and sulphat of ammonia form together a triple salt.

Sulphat of lime, *selenite*, *gypsum*, *plaster of Paris*, and sometimes *alabaster*, form extensive strata in various mountains. The *specular gypsum*, or *glacies Mariæ*, is a species of this salt, and affirmed by some French travellers to be employed in Russia, where it abounds, as a substitute for glass in windows. Its specific gravity is from 1·872 to 2·311. It requires 500 parts of cold water, and 450 of hot, to dissolve it. When calcined it decrepitates, becomes very friable and white, and heats a little with water, with which it forms a solid mass. In this process it loses its water of crystallization, which, according to Fourcroy, is 22 per cent. In this state it is found native in Tyrol, crystallized in rectangular parallelopipeds, or octaëdral or hexaëdral prisms, and is called *anhydrous* sulphat of lime. Both the natural and artificial anhydrous sulphat consists of 56·3 lime and 43·6 acid, according to Mr. Chenevix. The calcined sulphat is much employed for making casts of anatomical and ornamental figures; as one of the bases of stucco; as a fine cement for making close and strong joints between stone, and joining rims or tops of metal to glass; for making moulds for the Staffordshire potteries; for cornices, mouldings, and other ornaments in building. For these purposes, and for being wrought into columns, chimney-pieces, and various ornaments, about eight hundred tons are raised annually in Derbyshire, where it is called alabaster. In America it is laid on grass land as a manure.

Sulphat of magnesia, the *vitriolated magnesia* of the present, and *sal catharticus amarus* of former London Pharmacopœias, is commonly known by the name of *Epsom salt*, as it was furnished in considerable quantity by the mineral water at that place, mixed however with a considerable portion of sulphat of soda. It is afforded however in greater abundance and more pure from the bittern left after the extraction of salt from sea water. It has likewise been found efflorescing on brick walls, both old and recently erected, and in small quantity in the ashes of coals. The capillary salt of Idria, found in silvery crystals mixed withthe aluminous schist in the mines of that place, and hitherto considered as a feathery alum, has been ascertained by Klaproth to consist of sulphat of magnesia, mixed with a small portion of sulphat of iron. When pure it crystallizes in small quadrangular prisms terminated by quadrangular pyramids or diedral summits. Its taste is cool and bitter. It is very soluble, requiring only an equal weight of cold water, and three-fourths its weight of hot. It effloresces in the air, though but slowly. If it attract moisture, it contains muriat of magnesia or of lime. Exposed to heat it dissolves in its own water of crystallization, and dries but is not decomposed, nor fused but with extreme difficulty. It consists, according to Bergman, of 33 acid, 19 magnesia, 48 water. A very pure sulphat is said to be prepared in the neighbourhood of Genoa by roasting a pyrites found there; exposing it to the air in a covered place for six months, watering it occasionally; and then lixiviating. The lixivium contains the sulphats of iron, copper, and magnesia. If that of copper be abundant, it is first precipitated by iron; and the remainder of the metallic sulphats is separated by adding lime diffused in water in the proportion of about one per cent. of the ore. This lime, however, contains about 16 per cent. of magnesia. On comparing this sulphat with others, 100 parts of it were found to yield 46 of carbonat of magnesia, while French sulphat of magnesia gave but 22, Spanish 37, and English 38. This is the best mode of ascertaining its purity. Sulphat of magnesia is one of our most valuable purgatives; for which purpose only it is used, and for furnishing the carbonat of magnesia. See Acid (Carbonic).

Sulphat of ammonia crystallizes in slender, flattened, hexaëdral prisms, terminated by hexagonal pyramids: it attracts a little moisture from very damp air, particularly if the acid be in excess: it dissolves in two parts of cold and one of boiling water. It is not used, though Glauber, who called it his *secret ammoniacal salt*, vaunted its excellence in assaying.

If sulphat of ammonia and sulphat of magnesia be added together in solution, they combine into a triple salt, of an octaedral figure, but varying much; less soluble than either of its component parts; unalterable in the air; undergoing on the fire the watery fusion; after which it is decomposed, part of the ammonia flying off, and the remainder subliming with an excess of acid. It contains according to Fourcroy 68 sulphat of magnesia, and 32 sulphat of ammonia.

Sulphat of glucine crystallizes with difficulty, its solution readily acquiring and retaining a sirupy consistence; its taste is sweet, and slightly astringent; it is not alterable in the air; a strong heat expels its acid, and leaves the earth pure; heated with charcoal it forms a sulphuret; infusion of galls forms a yellowish white precipitate with its solution.

Yttria is readily dissolved by sulphuric acid; and as the solution goes on the sulphat crystallizes in small brilliant grains, which have a sweetish taste, but less so than sulphat of glucine, and are of a light amethyst red colour. They require 30 parts of cold water to dissolve them, and give up their acid when exposed to a high temperature. They are decomposed by oxalic acid, prussiat of potash, infusion of galls, and phosphat of soda.

Sulphat of alumine in its pure state is but recently known, and it was first attentively examined by Vauquelin. It may be made by dissolving pure alumine in pure sulphuric acid, heating them for some time, evaporating the solution to dryness, drying the residuum with a pretty strong heat, redissolving it, and crystallizing. Its crystals are soft, foliaceous, shining, and pearly; but these are not easily obtained without cautious evaporation and refrigeration. They have an astringent taste; are little alterable in the air; are pretty soluble, particularly in hot water; give out their acid on exposure to a high temperature; are decomposable by combustible substances, though not readily, and do not form a pyrophorus like alum.

If the evaporation and desiccation directed above be omitted, the alumine will remain supersaturated with acid, as may be known by its taste, and by its reddening vegetable blue. This is still more difficult to crystallize than the neutral salt, and frequently thickens into a gelatinous mass.

A compound of acidulous sulphat of alumine with potash or ammonia has long been known by the name of Alum; which see.

If this acidulous sulphat, or alum, be dissolved in water, and boiled with pure alumine, the alumine will become saturated with its base, and fall down an insipid white powder. This salt is completely insoluble, and is not deprived of its acid by heat but at a very high temperature. It may be decomposed by long boiling with the alkaline or earth bases; and several acids convert it into common alum, but slowly.

Sulphat of zircon may be prepared by adding sulphuric acid to the earth recently precipitated, and not yet dry. It is sometimes in small needles, but commonly pulverulent; very friable; insipid; insoluble in water, unless it contain some acid; and easily decomposed by heat.

M. Giobert imagined, that sulphuric acid was capable of absorbing an additional dose of oxigen, so that there existed an *oxisulphuric* acid; but Vauquelin has refuted this, and Chenevix found the experiments of Giobert inaccurate.

On the other hand, Mr. Dabit supposes that there is an intermediate state of acidity between the sulphuric and sulphurous, producing what he calls the oxigenated sulphurous acid. His opinion is founded on the salts produced by saturating the residuum of ether diluted in water with different bases, as according to him they differ both from the sulphats and sulphits: but this requires confirmation.—*Phil. Trans.—Irish Trans.—Journ. de Phys.—Scherer's Journ.—Mem. de l'Instit. Nat.—Nicholson's Journ.—Klaproth's Analyses.—Ann. de Chim.—Henry's Chem.*

Acid (Sulphurous). It has already been observed, that sulphur burned at a low temperature absorbs less oxigen than it does when exposed to greater heat, and is consequently acidified in a slighter degree, so as to form sulphurous acid. This in the ordinary state of the atmosphere is a gas; but on reducing its temperature very low by artificial cold, and exposing it to strong compression, it becomes a liquid. To obtain it in the liquid state, however, for practical purposes, it is received into water, by which it is absorbed.

As the acid obtained by burning sulphur in this way is commonly mixed with more or less sulphuric acid, when sulphurous acid is wanted it is commonly made by abstracting part of the oxigen from sulphuric acid by means of some combustible substance. Mercury or tin is usually preferred. For the purposes of manufactures, however, chopped straw or sawdust may be employed. If one part of mercury and two of concentrated sulphuric acid be put into a glass retort with a long neck, and heat applied till an effervescence is produced, the sulphurous acid will arise in the form of gas, and may be collected over quicksilver, or received into water, which at the temperature of 61° will absorb 33 times its bulk, or nearly an eleventh of its weight.

Water thus saturated is intensely acid to the taste, and has the smell of sulphur burning slowly. It destroys most vegetable colours, but the blues are reddened by it previous to their being discharged. A pleasing instance of its effect on colours may be exhibited by holding a red rose over the blue flame of a common match, by which the colour will be discharged wherever the sulphurous acid comes into contact with it, so as to render it beautifully variegated, or entirely white. If it be then dipped into water, the redness after a time will be restored. According to Dr. Thomson, sulphurous acid consists of 68 parts sulphur and 32 oxigen.

Sulphurous acid is used in bleaching, particularly for silks. It likewise discharges vegetable stains, and ironmoulds from linen.

In combination with the salifiable bases it forms sulphits, which differ from the sulphats in their properties. The alkaline sulphits are more soluble than the sulphats, the earthy less. They are converted into sulphats by an addition of oxigen, which they acquire even by exposure to the air. The sulphit of lime is the slowest to undergo this change. A strong heat either expels their acid entirely, or converts them into sulphats. They have all a sharp, disagreeable, sulphurous taste. The best mode of obtaining them is by receiving the sulphurous acid gas into water holding the base, or its carbonat, in solution, or diffused in it in fine powder. None of them have yet been applied to any use.

Acid (Tartarous). The casks in which some kinds of wine are kept become incrusted with a hard substance, tinged with the colouring matter of the wine, and otherwise impure, which has long been known by the name of *argal*, or tartar, and distinguished into red and white according to its colour. This being purified by solution, filtration, and crystallization, was termed *cream* or *crystals of tartar*. It was afterward discovered, that it consisted of a peculiar acid combined with potash: and the supposition that it was formed during the fermentation of the wine, was disproved by Boerhaave, Neumann and others, who showed that it existed ready formed in the juice of the grape. It has likewise been found in other fruits, particularly before they are too ripe; and in the tamarisk, sumac, balm, carduus benedictus, and the roots of rest-harrow, germander, and sage. The separation of tartarous acid from this acidulous salt, is the first discovery of Scheele that is known. He saturated the superfluous acid by adding chalk to a solution of the supertartrit in boiling water as long as any effervescence ensued, and expelled the acid from the precipitated tartrit of lime by means of the sulphuric. Fourcroy observes, that by using lime instead of its carbonat, the whole of the tartarous acid may be obtained; and the supernatant liquor will then contain pure potash, instead of the neutral tartrit of potash, which it holds in solution when chalk is used. Or four parts of tartar may be boiled in twenty or twenty-four of water, and one part of sulphuric acid added gradually. By continuing the boiling the sulphat of potash will fall down. When the liquor is reduced to one half, it is to be filtered, and if any more sulphat be deposited by continuing the boiling, the filtering must be repeated. When no more is thrown down, the liquor is to be evaporated to the consistence of a sirup, and thus crystals of tartarous acid equal to half the weight of the tartar employed will be obtained.

The tartarous acid may be procured in needly or laminated crystals by evaporating a solution of it. Its taste is very acid and agreeable, so that it may supply the place of lemon-juice. It is very soluble in water. Burnt in an open fire it leaves a coaly residuum generally containing a little lime; in close vessels it gives out carbonic acid and hidrogen gas, so that its base is a compound of hidrogen and carbon. By distilling nitric acid off the crystals they may be converted into oxalic acid, and the nitric acid passes to the state of nitrous.

The tartrits of lime and barytes are white, pulverulent, and insoluble, unless in an excess of their acid.

Tartrit of strontian, formed by the double decomposition of muriat of strontian and tartrit of potash, according to Vauquelin is soluble, crystallizable, and consists of 52·88 strontian and 47·12 acid.

That of magnesia forms a gelatinous or gummy mass.

Tartrit of potash, the *tartarised kali* of the London college, and *vegetable salt* of some, formerly called *soluble tartar*, because much more so than the supertartrit, crystallizes in oblong squares, bevelled at the extremities. It has a bitterish taste, and is decomposed by heat, as its solution is even by standing some time. It is used as a mild purgative.

The supertartrit of potash, already mentioned at the beginning of this article, is much used as a cooling and gently opening medicine, as well as in several chemical and pharmaceutical preparations. Dissolved in water, with the addition of a little sugar and a slice or two of lemon peel, it forms an agreeable cooling drink by the name of *imperial*; and if an infusion of green balm be used instead of water, it makes one of the pleasantest liquors of the kind with which we are acquainted. Mixed with an equal weight of nitre, and projected into a red-hot crucible, it detonates, and forms the *white flux*; treated in the same way with half its weight of nitre, it forms the *black flux*; and simply mixed with nitre in various proportions it is called *raw flux*. It is likewise used in dyeing, in hat-making, in gilding, and in other arts.

By saturating the superfluous acid in this supertartrit with soda a triple salt is formed, which crystallizes in large regular prisms of eight nearly equal sides, of a bitter taste, efflorescent, and soluble in about five parts of water. It consists according to Vauquelin of 54 parts tartrit of potash and 46 tartrit of soda; and was once in much repute as a purgative, by the name of *Rochelle salt*, or *sel de Seignette*.

The tartrit of soda is much less soluble than this triple salt, and crystallizes in slender needles or thin plates.

The tartrit of ammonia is a very soluble, bitter salt, and crystallizes easily. Its solution is spontaneously decomposable.

This too forms with tartrit of potash a triple salt, the solution of which yields by cooling fine pyramidal or prismatic efflorescent crystals. Though both the neutral salts that compose it are bitter, this is not, but has a cool taste.

Acid (Tungstic). What has been thus called appears to be only an oxide of Tungsten; which see.

Acid (Uric). The same with Lithic acid; which see.

Acid (Zoonic). In the liquid procured by distillation from animal substances, which had been supposed to contain only carbonat of ammonia and an oil, Berthollet imagined he had discovered a peculiar acid, to which he gave the name of zoonic. Thenard, however, has demonstrated that it is merely acetous acid combined with an animal matter.

Acidifiable. Capable of being converted into an acid by the acidifying principle. (See Acid.) Substances possessing this property are called *radicals*, or *acidifiable bases*.

Acidule. A term applied by the French chemists to those salts, in which the base is combined with such an excess of acid, that they manifestly exhibit acid properties; such as the supertartrit of potash.

Adamant. See Diamond.

Adamantine Spar. This stone, which comes to us from the peninsula of hither India, and also from China, has not engaged the attention of the chemical world till within a few years past. It is remarkable for its extreme hardness, which approaches to that of the diamond, and by virtue of which property it is used for polishing gems.

Two varieties of this stone are known in Europe. The first comes from China. It is crystallized, in six-sided prisms, without pyramids, the length of which varies from half an inch to an inch, and their thickness is about three quarters of an inch. Its colour is gray of different shades. The larger pieces are opake; but thin pieces and the edges of the prisms are transparent. Its fracture is brilliant, and its texture spathose; which causes its surface to appear lightly striated. Its crystals are covered with a very fine and strongly adherent crust of plates of silvery mica mixed with particles of red felt-spar. A yellow superficial covering of sulphate of iron was observed upon one specimen.

This stone is so hard that it not only cuts glass as easily as a diamond, but likewise marks rock crystal and several other hard stones. Its specific gravity is 3710.

Small crystalline grains of magnetical ferruginous calx are occasionally found in the adamantine spar of China, which may be separated by the magnet when the stone is pulverized.

The second variety, which comes from India, is called Corundum by the inhabitants of Bombay. It differs from the former by a white colour, a texture more evidently spathose, and lastly, because the grains of magnetical iron are smaller than in the former specimens, and are not interspersed through its substance, but only at its surface.

From its hardness it is extremely difficult to analyse. Mr. Chenevix, by repeatedly heating it red-hot, and then plunging it into cold water, caused it to appear fissured in every direction. He then put it into a steel mortar, about three quarters of an inch in diameter, and three inches deep, to which a steel pestle was closely fitted. A few blows on the pestle caused it to crumble, and the fragments were then easily reduced to an impalpable powder by an agate pestle and mortar. This powder was fused in a crucible of platina with twice its weight of calcined borax, and the glass was dissolved by boiling in muriatic acid about twelve hours. The precipitates from this solution being examined, a specimen from China was found to give from 100 parts 86·50 of alumine, 5·25 of silex, 6·50 of iron: one from Ava, alumine 87, silex 6·5, iron 4·5: one from Malabar, alumine 86·5, silex 7, iron 4: one from the Carnatic, alumine 91, silex 5, iron 1·5.

The rev Mr. W. Gregor analysed a specimen from Thibet, in the collection of Mr. Rashleigh, which gave him alumine 81·75, silex 12·125, oxide of titanium 4, water 0·937, but no iron.

This stone has been said to have been found in different parts of Europe, and near Philadelphia in America; but most, if not all of the specimens have proved not to be the adamantine spar. Lately, however, prof. Pini has discovered a stone in Italy, the characters of which, as given by him, certainly agree with those of the adamantine spar, and of their identity he has no doubt.

Adipocere. The attention of chemists has been much excited by the spontaneous conversion of animal matter into a substance considerably resembling spermaceti. The fact has long been well known, and is said to have been mentioned in the works of Lord Bacon, though I have not seen the passage. On the occasion of the removal of a very great number of human bodies from the ancient burying-place des Innocens at Paris, facts of this nature were observed in the most striking manner. Fourcroy may be called the scientific discoverer of this peculiar matter, as well as the saponaceous ammoniacal substance contained in bodies abandoned to spontaneous destruction in large masses. This chemist read a memoir on the subject in the year 1789 to the Royal Academy of Sciences, from which I shall abstract the general contents.

At the time of clearing the before mentioned burying-place, certain philosophers were specially charged to direct the precautions requisite for securing the health of the workmen. A new and singular object of research presented itself, which had been necessarily unknown to preceding chemists. It was impossible to foretel what might be the contents of a soil overloaded for successive ages with bodies resigned to the putrefactive process. This spot differed from common burying-grounds, where each individual object is surrounded by a portion of the soil. It was the burying-ground of a large district, wherein successive generations of the inhabitants had been deposited for upwards of three centuries. It could not be foreseen that the entire decomposition might be retarded for more than forty years; neither was there any reason to suspect that any remarkable difference would arise from the singularity of situation.

The remains of the human bodies immersed in this mass of putrescence were found in three different states, according to the time they had been buried, the place they occupied, and their relative situations with regard to each other. The most ancient were simply portions of bones, irregularly dispersed in the soil, which had been frequently disturbed. A second state, in certain bodies which had always been insulated, exhibited the skin, the muscles, tendons, and aponeuroses, dry, brittle, hard, more or less gray, and similar to what are called mummies in certain caverns where this change has been observed, as in the catacombs at Rome, and the vault of the Cordeliers at Toulouse.

The third and most singular state of these soft parts was observed in the bodies which fill the common graves or repositories. By this appellation are understood cavities of thirty feet in depth and twenty on each side, which were dug in the burying-ground of the Innocents, and were appropriated to contain the bodies of the poor; which were placed in very close rows, each in its proper wooden bier. The necessity for disposing a great number obliged the men charged with this employment to arrange them so near each other, that these cavities might be considered when filled as an entire mass of human bodies, separated only by two planks of about half an inch thick. Each cavity contained between one thousand and fifteen hundred. When one common grave of this magnitude was filled, a covering of about one foot deep of earth was laid upon it, and another excavation of the same sort was made at some distance. Each grave remained open about three years, which was the time required to fill it. According to the urgency of circumstances, the graves were again made on the same spot after an interval of time not less than fifteen years, nor more than thirty. Experience had taught the workmen, that this time was not sufficient for the entire destruction of the bodies, and had shown them the progressive changes which form the object of Mr. Fourcroy's memoir.

The first of these large graves opened in the presence of this chemist had been closed for fifteen years. The coffins were in good preservation, but a little settled, and the wood (I suppose deal) had a yellow tinge. When the covers of several were taken off, the bodies were observed at the bottom, leaving a considerable distance between their surface and the cover, and flattened as if they had suffered a strong compression. The linen which had covered them was slightly adherent to the bodies; and, with the form of the different regions, exhibited on removing the linen nothing but irregular masses of a soft ductile matter of a gray white colour. These masses environed the bones on all sides, which had no solidity, but broke by any sudden pressure. The appearance of this matter, its obvious composition and its softness, resembled common white cheese; and the resemblance was more striking from the print which the threads of the linen had made upon its surface. This white substance yielded to the touch, and became soft when rubbed for a time between the fingers.

No very offensive smell was emitted from these bodies. The novelty and singularity of the spectacle, and the example of the grave-diggers, dispelled every idea either of disgust or apprehension. These men asserted that they never found this matter, by them called *gras* (fat), in bodies interred alone; but that the accumulated bodies of the common graves only were subject to this change. On a very attentive examination of a number of bodies passed to this state, Mr. Fourcroy remarked, that the conversion appeared in different stages of advancement, so that, in various bodies, the fibrous texture and colour, more or less red, were discernible within the fatty matter; that the masses covering the bones were entirely of the same nature, offering indistinctly in all the regions a gray substance for the most part soft and ductile, sometimes dry, always easy to be separated in porous fragments, penetrated with cavities, and no longer exhibiting any traces of membranes, muscles, tendons, vessels, or nerves. On the first inspection of these white masses, it might have been concluded that they were simply the cellular tissue, the compartments and vesicles of which they very well represented.

By examining this substance in the different regions of the body, it was found that the skin is particularly disposed to this remarkable alteration. It was afterwards perceived that the ligaments and tendons no longer existed, or at least had lost their tenacity; so that the bones were entirely unsupported, and left to the action of their own weight. Whence their relative places were preserved in a certain degree by mere juxta-position; the least effort being sufficient to separate them. The grave-diggers availed themselves of this circumstance in the removal of the bodies. For they rolled them up from head to feet, and by that means separated from each other the extremities of the bones which had formerly been articulated. In all these bodies which were changed into the fatty matter the abdominal cavity had disappeared. The teguments and muscles of this region being converted into the white matter like the other soft parts, had subsided upon the vertebral column, and were so flattened as to leave no place for the viscera, and accordingly there was scarcely ever any trace observed in the almost obliterated cavity. This observation was for a long time matter of astonishment to the investigators. In vain did they seek in the greater number of bodies the place and substance of the stomach, the intestines, the bladder, and even the liver, the spleen, the kidneys, and the matrix in females. All these viscera were confounded together, and for the most part no traces of them were left. Sometimes only certain irregular masses were found, of the same nature as the white matter, of different bulks, from that of a nut to two or three inches in diameter, in the regions of the liver or of the spleen.

The thorax likewise offered an assemblage of facts no less singular and interesting. The external part of this cavity was flattened and compressed like the rest of the organs; the ribs, spontaneously luxated in their articulations with the vertebræ, were settled upon the dorsal column; their arched part left only a small space on each side between them and the vertebræ. The pleura, the mediastines, the large vessels, the aspera arteria, and even the lungs and the heart, were no longer distinguishable; but for the most part had entirely disappeared, and in their place nothing was seen but some parcels of the fatty substance. In this case, the matter which was the product of decomposition of the viscera, charged with blood and various humours, differs from that of the surface of the body, and the long bones, in the red or brown colour possessed by the former. Sometimes the observers found in the thorax a mass irregularly rounded of the same nature as the latter, which appeared to them to have arisen from the fat and fibrous substance of the heart. They supposed that this mass, not constantly found in all the subjects, owed its existence to a superabundance of fat in this viscus, where it was found. For the general observation presented itself, that in similar circumstances, the fat parts undergo this conversion more evidently than the others, and afford a larger quantity of the white matter.

The external region in females exhibited the glandular and adipose mass of the breasts converted into the fatty matter very white and very homogeneous.

The head was, as has already been remarked, environed with the fatty matter; the face was no longer distinguishable in the greatest number of subjects; the mouth disorganized exhibited neither tongue nor palate; and the jaws, luxated and more or less displaced, were environed with irregular layers of the white matter. Some pieces of the same matter usually occupied the place of the parts situated in the mouth; the cartilages of the nose participated in the general alteration of the skin; the orbits instead of eyes contained white masses; the ears were equally disorganized; and the hairy scalp, having undergone a similar alteration to that of the other organs, still retained the hair. Mr. Fourcroy remarks incidentally, that the hair appears to resist every alteration much longer than any other part of the body. The cranium constantly contained the brain contracted in bulk; blackish at the surface, and absolutely changed like the other organs. In a great number of subjects which were examined this viscus was never found wanting, and it was always in the above-mentioned state; which proves that the substance of the brain is greatly disposed to be converted into the fat matter.

Such was the state of the bodies found in the burial-ground des Innocens. Its modifications were also various. Its consistence in bodies lately changed, that is to say, from three to five years, was soft and very ductile; containing a great quantity of water. In other subjects converted into this matter for a long time, such as those which occupied the cavities which had been closed thirty or forty years, this matter is drier, more brittle, and in denser flakes. In several which were deposited in dry earth, various portions of the fatty matter had become semi-transparent. The aspect, the granulated texture, and brittleness of this dried matter bore a considerable resemblance to wax.

The period of the formation of this substance had likewise an influence on its properties. In general, all that which had been formed for a long time was white, uniform, and contained no foreign substance, or fibrous remains; such, in particular, was that afforded by the skin of the extremities. On the contrary, in bodies recently changed, the fatty matter was neither so uniform nor so pure as in the former; but it was still found to contain portions of muscles, tendons, and ligaments, the texture of which, though already altered and changed in its colour, was still distinguishable. Accordingly, as the conversion was more or less advanced, these fibrous remains were more or less penetrated with the fatty matter, interposed as it were between the interstices of the fibres. This observation shows, that it is not merely the fat which is thus changed, as was natural enough to think at first sight. Other facts confirm this assertion. The skin, as has been remarked, becomes easily converted into very pure white matter, as does likewise the brain, neither of which has been considered by anatomists to be fat. It is true, nevertheless, that the unguinous parts, and bodies charged with fat, appear more easily and speedily to pass to the state under consideration. This was seen in the marrow, which occupied the cavities of the longer bones. And again, it is not to be supposed, but that the greater part of these bodies had been emaciated by the illness which terminated their lives; notwithstanding which they were all absolutely turned into this fatty substance.

An experiment made by Mr. Poulletier de la Salle, and Fourcroy likewise, evinced that a conversion does not take place in the fat alone. Mr. Poulletier had suspended in his laboratory a small piece of the human liver, to observe what would arise to it by the contact of the air. It partly putrefied, without however emitting any very noisome smell. Larvæ of the dermestes and bruchus attacked and penetrated it in various directions; at last it became dry, and after more than ten years suspension, it was converted into a white friable substance resembling dried agaric, which might have been taken for an earthy substance. In this state it had no perceptible smell. Mr. Poulletier was desirous of knowing the state of this animal matter, and experiment soon convinced him and Mr. F., that it was very far from being in the state of an earth. It melted by heat, and exhaled in the form of vapour, which had the smell of a very fetid fat; spirit of wine separated a concrescible oil, which appeared to possess all the properties of spermaceti. Each of the three alkalis converted it into soap, and in a word it exhibited all the properties of the fatty matter of the burial-ground of the Innocents exposed for several months to the air. Here then was a glandular organ, which in the midst of the atmosphere had undergone a change similar to that of the bodies in the burying-place; and this fact sufficiently shows, that an animal substance which is very far from being of the nature of grease may be totally converted into this fatty substance.

Among the modifications of this femarkable substance in the burying-ground before mentioned, it was observed that the dry, friable, and brittle matter was most commonly found near the surface of the earth, and the soft ductile matter at a greater depth. Mr. Fourcroy remarks, that this dry matter did not differ from the other merely in containing less water, but likewise by the volatilization of one of its principles.

The grave diggers assert, that near three years are required to convert a body into this fatty substance. But Dr. Gibbes of Oxford found, that lean beef secured in a running stream was converted into this fatty matter at the end of a month. He judges from facts, that running water is most favourable to this process. He took three lean pieces of mutton, and poured on each a quantity of the three ancient mineral acids. At the end of three days, each was much changed: that in the nitric acid was very soft, and converted into the fatty matter; that in the muriatic acid was not in that time so much altered; the sulphuric acid had turned the other black. Mr. Lavoisier thinks that this process may hereafter prove of great use in society. It is not easy to point out what animal substance, or what situation, might be the best adapted for an undertaking of this kind. Mr. L. points out fecal matters; but I have not heard of any conversion having taken place in these animal remains, similar to that of the foregoing.

The result of Mr. Fourcroy's inquiries into the ordinary changes of bodies recently deposited in the earth was not very extensive. The grave-diggers informed him, that these bodies interred do not perceptibly change colour for the first seven or eight days; that the putrid process disengages elastic fluid, which inflates the abdomen, and at length bursts it; that this event instantly causes vertigo, faintness, and nausea in such persons as unfortunately are within a certain distance of the scene where it takes place; but that when the object of its action is nearer, a sudden privation of sense, and frequently death, is the consequence. These men are taught by experience, that no immediate danger is to be feared from the disgusting business they are engaged in, excepting at this period, which they regard with the utmost terror. They resisted every inducement and persuasion, which these philosophers made use of, to prevail on them to assist their researches into the nature of this active and pernicious vapour. Mr. Fourcroy takes occasion from these facts, as well as from the pallid and unwholesome appearance of the grave-diggers, to reprobate burials in great towns or their vicinity.

Such bodies as are interred alone in the midst of a great quantity of humid earth are totally destroyed by passing through the successive degrees of the ordinary putrefaction; and this destruction is more speedy, the warmer the temperature. But if these insulated bodies be dry and emaciated; if the place of deposition be likewise dry, and the locality and other circumstances such, that the earth, so far from receiving moisture from the atmosphere, becomes still more effectually parched by the solar rays;—the animal juices are volatilized and absorbed, the solids contract and harden, and a peculiar species of mummy is produced. But every circumstance is very different in the common burying-grounds. Heaped together almost in contact, the influence of external bodies affects them scarcely at all, and they become abandoned to a peculiar disorganization which destroys their texture, and produces the new and most permanent state of combination here described. From various observations which I do not here abridge, it was found, that this fatty matter was capable of enduring in these burying-places for thirty or forty years, and is at length corroded and carried off by the aqueous putrid humidity which there abounds.

Among other interesting facts afforded by the chemical examination of this substance, are the following from experiments by Mr. Fourcroy:

1. This substance is fused at a less degree of heat than that of boiling water, and may be purified by pressure through a cloth, which disengages a portion of fibrous and bony matter. 2. The process of destructive distillation by a very graduated heat was begun, but not completed on account of its tediousness, and the little promise of advantage it afforded. The products which came over were water charged with volatile alkali, a fat oil, concrete volatile alkali, and no elastic fluid during the time the operation was continued. 3. Fragments of the fatty matter exposed to the air during the hot and dry summer of 1786 became dry, brittle, and almost pulverulent at the surface. On a careful examination, certain portions were observed to be semi-transparent and more brittle than the rest. These possessed all the apparent properties of wax, and did not afford volatile alkali by distillation. 4. With water this fatty matter exhibited all the appearances of soap, and afforded a strong lather. The dried substance did not form the saponaceous combination with the same facility or perfection as that which was recent. About two thirds of this dried matter separated from the water by cooling, and proved to be the semi-transparent substance resembling wax. This was taken from the surface of the soapy liquor, which being then passed through the filter left a white soft shining matter, which was fusible and combustible. 5. Attempts were made to ascertain the quantity of volatile alkali in

this substance by the application of lime, and of the fixed alkalis, but without success. For it was difficult to collect and appretiate the first portions which escaped, and likewise to disengage the last portions. The caustic volatile alkali, with the assistance of a gentle heat, dissolved the fatty matter, and the solution became perfectly clear and transparent at the boiling temperature of the mixture, which was at 18 .° F. 6. Sulphuric acid, of the specific gravity of 2·0, was poured upon six times its weight of the fatty matter, and mixed by agitation. Heat was produced, and a gas or effluvium of the most insupportable putrescence was emitted, which infected the air of an extensive laboratory for several days. Mr. Fourcroy says that the smell cannot be described, but that it is one of the most horrid and repulsive that can be imagined. It did not, however, produce any indisposition either in himself or his assistants. By dilution with water, and the ordinary processes of evaporation and cooling properly repeated, the sulphats of ammonia and of lime were obtained. A substance was separated from the liquor, which appeared to be the waxy matter somewhat altered by the action of the acid. 7. The nitrous and muriatic acids were also applied, and afforded phænomena worthy of remark, but which for the sake of conciseness are here omitted. 8. Alcohol does not act on this matter at the ordinary temperature of the air. But by boiling it dissolves one third of its own weight, which is almost totally separable by cooling as low as 55°. The alcohol, after this process, affords by evaporation a portion of that waxy matter which is separable by acids, and is therefore the only portion soluble in cold alcohol. The quantity of fatty matter operated on, was four ounces, or 2304 grains, of which the boiling spirit took up the whole except 26 grains, which proved to be a mixture of 20 grains of ammoniacal soap, and six or eight grains of the phosphats of soda and of lime. From this experiment, which was three times repeated with similar results, it appears that alcohol is well suited to afford an analysis of the fatty matter. It does not dissolve the neutral salts; when cold it dissolves that portion of concrete animal oil from which the volatile alkali had flown off, and when heated it dissolves the whole of the truly saponaceous matter, which is afterwards completely separated by cooling. And accordingly it was found, that a thin plate of the fatty matter, which had lost nearly the whole of its volatile alkali, by exposure to the air for three years, was almost totally dissolved by the cold alcohol.

The concrete oily or waxy substance obtained in these experiments constitutes the leading object of research, as being the peculiar substance with which the other well known matters are combined. It separates spontaneously by the action of the air, as well as by that of acids. These last separate it in a state of greater purity, the less disposed the acid may be to operate in the way of combustion. It is requisite, therefore, for this purpose, that the fatty matter should be previously diffused in 12 times its weight of hot water; and the muriatic or acetous acid is preferable to the sulphuric or the nitrous. The colour of the waxy matter is grayish; and though exposure to the air, and also the action of the oxigenated muriatic acid did produce an apparent whiteness, it nevertheless disappeared by subsequent fusion. No method was discovered by which it could be permanently bleached.

The nature of this wax or fat is different from that of any other known substance of the like kind. When slowly cooled after fusion, its texture appears crystalline or shivery, like spermaceti; but a speedy cooling gives it a semitransparency resembling wax. Upon the whole, nevertheless, it seems to approach more nearly to the former than to the latter of these bodies. It has less smell than spermaceti, and melts at 127° F.; Dr. Bostock says 92°. Spermaceti requires 6° more of heat to fuse it (according to Dr. Bostock 20°). The spermaceti did not so speedily become brittle by cooling as the adipocere. One ounce of alcohol of the strength between 39 and 40 degrees of Baumé's areometer, dissolved when boiling hot 12 gros of this substance, but the same quantity in like circumstances dissolved only 30 or 36 grains of spermaceti. The separation of these matters was also remarkably different, the spermaceti being more speedily deposited, and in a much more regular and crystalline form. Ammonia dissolves with singular facility, and even in the cold, this concrete oil separated from the fatty matter; and by heat it forms a transparent solution, which is a true soap. But no excess of ammonia can produce such an effect with spermaceti.

Mr. Fourcroy concludes his memoir with some speculations on this change to which animal substances in peculiar circumstances are subject. In the modern chemistry, soft animal matters are considered as a composition of the oxides of hidrogen and carbonated azot, more complicated than those of vegetable matters, and therefore more incessantly tending to alteration. If then the carbon be conceived to unite with the oxigen, either of the water which is present, or of the other animal matters, and thus escape in large quantities in the form of carbonic acid gas, we shall perceive the reason why this conversion is attended with so great a loss of weight, namely, about nine tenths of the whole. The azot, a principle so abundant in animal matters, will form ammonia by combining with the hidrogen; part of this will escape in the vaporous form, and the rest will remain fixed in the fatty matter. The residue of the animal matters deprived of a great part of their carbon, of their oxigen, and the whole of their azot, will consist of a much greater proportion of hidrogen, together with carbon and a minute quantity of oxigen. This, according to the theory of Mr. Fourcroy, constitutes the waxy matter, or adipocere, which in combination with ammonia forms the animal soap, into which the dead bodies are thus converted.

Muscular fibre macerated in dilute nitric acid, and afterward well washed in warm water, affords pure adipocere, of a light yellow colour, nearly of the consistence of tallow, of a homogeneous texture, and of course free from ammonia. This is the mode in which it is now commonly procured for chemical experiment.

Ambergris appears to contain adipocere in large quantity, rather more than half of it being of this substance.—*Annales de Chimie.*—*Phil. Trans.*—*Journ. of Nat. Phil. Chem. and the Arts.*

Adopter. A vessel with two necks placed between a retort and a receiver, and serving to increase the length of the neck of the former. See Laboratory.

Ætites, or **Eagle Stone**, is a name that has been given to a kind of hollow geodes of oxide of iron, often mixed with a larger or smaller quantity of silex and alumine, containing in their cavity some concretions, which rattle on shaking the stone. It is of a dull pale colour, composed of concentric layers of various magnitudes, of an oval or polygonal form, and often polished. Eagles were said to carry them to their nests, whence their name; and superstition formerly ascribed wonderful virtues to them.

Affinity (Chemical). See Attraction (Elective).

Agaricus. The mushroom, a genus of the order Fungi. Mushrooms appear to approach nearer to the nature of animal matter, than any other productions of the vegetable kingdom, as, beside hidrogen, oxigen, and carbon, they contain a considerable portion of nitrogen, and yield ammonia by distillation. Prof. Proust has likewise discovered in them the benzoic acid, and phosphat of lime.

A few of the species are eaten in this country, but many are recorded to have produced poisonous effects; though in some foreign countries, particularly by Russia, few if any are rejected. Perhaps it is of importance, that they should be fresh, thoroughly dressed, and not of a coriaceous texture. The Russians, however, are very fond of the *A. piperatus*, which we deem poisonous, preserved with salt throughout the winter: and our *ketchup* is made by sprinkling mushrooms with salt, and letting them stand till great part is resolved into a brown liquor, which is then boiled up with spices. The *A. piperatus* has been recommended in France to consumptive people. The *A. muscarius* has been prescribed in doses of a few grains in cases of epilepsy and palsy, subsequent to the drying up of eruptions.

In pharmacy two species of *Boletus* have formerly been used under the name of agaric. The *B. pini laricis*, or *male agaric* of the shops, was given as a purgative, either in substance, or in an extract made with vinegar, wine, or an alkaline solution: and the *B. igniarius*, spunk, or touchwood, called female agaric, was applied externally as a styptic, even after amputations. For this purpose the soft inner substance was taken, and beaten with a hammer to render it still softer. That of the oak was preferred. The Germans boil this in lye, dry it, and boil it again in a solution of nitrat of potash, to use as tinder.

Agaricus Mineralis, the *mountain milk*, or *mountain meal*, of the Germans, is one of the purest of the native carbonats of lime, found chiefly in the clefts of rocks, and at the bottom of some lakes, in a loose or semi-indurated form. It has been used internally in hæmorrhages, strangury, gravel, and dysenteries; and externally as an application to old ulcers, and weak and watery eyes.

Mr. Fabroni calls by the name of *mineral agaric*, or *fossil meal*, a stone of a loose consistence found in Tuscany in considerable abundance, of which bricks may be made, either with or without the addition of a twentieth part of argil, so light as to float in water; and which he supposes the ancients used for making their floating bricks. This, however, is very different from the preceding, not being even of the calcareous genus, since it appears on analysis to consist of silex 55 parts, magnesia 15, water 14, argil 12, lime 3, iron 1. Kirwan calls it *argillo-murite*.

Agate. The oriental agate is almost transparent, and of a vitreous appearance. The occidental is of various colours, and often veined with quartz or jasper. It is mostly found in small pieces covered with a crust, and often running in veins through rocks like flint and petrosilex, from which it does not seem to differ greatly. When agates contain arborisations they are called mocha stone. These are considerably valued when the internal figure nearly resembles some animal or plant.

Aggregate. When bodies of the same kind are united, the only consequence is, that one larger body is produced. In this case, the united mass is called an aggregate, and does not differ in its chemical properties from the bodies from which it was originally made. Elementary writers call the smallest parts into which an aggregate can be divided without destroying its chemical properties, integrant parts. Thus the integrant parts of common salt are the smallest parts which can be conceived to remain without change; and beyond these, any further subdivision cannot be made without developing the component parts, namely, the alkali and the acid; which are still further resolvable into their constituent principles.

Air was till lately used as the generic name for such invisible and exceedingly rare fluids as possess a very high degree of elasticity, and are not condensable into the liquid state by any degree of cold hitherto produced: but as this term is commonly employed to signify that compound of aëriform fluids which constitutes our atmosphere, it has been deemed advisable to restrict it to this signification, and to employ as the generic term the word Gas, (which see,) for the different kinds of air, except what relates to our atmospheric compound.

Air (Atmospherical, or Common). The immense mass of permanently elastic fluid, which surrounds the globe we inhabit, must consist of a general assemblage of every kind of air which can be formed by the various bodies that compose its surface. Most of these, however, are absorbed by water; a number of them are decomposed by combination with each other; and some of them are seldom disengaged in considerable quantities by the processes of nature. Hence it is that the lower atmosphere consists chiefly of oxigen and nitrogen, together with moisture and the occasional vapours or exhalations of bodies. The upper atmosphere seems to be composed of a large proportion of hidrogen, a fluid of so much less specific gravity than any other, that it must naturally ascend to the highest place, where being occasionally set on fire by electricity, it appears to be the cause of the aurora borealis and fire-balls. It may easily be understood, that this will only happen on the confines of the respective masses of common atmospherical air, and of the inflammable air; that the combustion will extend progressively, though rapidly, in flashings from the place where it commences; and that when by any means a stream of inflammable air, in its progress toward the upper atmosphere, is set on fire at one end, its ignition may be much more rapid than what happens higher up, where oxigen is wanting, and at the same time more definite in its figure and progression, so as to form the appearance of a fire-ball.

That the air of the atmosphere is so transparent as to be invisible, except by the blue colour it reflects when in very large masses, as is seen in the sky or region above us, or in viewing extensive landscapes; that it is without smell, except that of electricity, which it sometimes very manifestly exhibits; altogether without taste, and impalpable; not condensable by any degree of cold into the dense fluid state, though easily changing its dimensions with its temperature; that it gravitates and is highly elastic, are among the numerous observations and discoveries, which do honour to the sagacity of the philosophers of the seventeenth century. They likewise knew that this fluid is indispensably necessary to combustion: but no one, except the great, though neglected, John Mayow, appears to have formed any proper notion of its manner of acting in that process.

The air of the atmosphere, like other fluids, appears to be capable of holding bodies in solution. It takes up water in considerable quantities, with a diminution of its own specific gravity; from which circumstance, as well as from the consideration that water rises very plentifully in the vaporous state in vacuo, it seems probable, that the air suspends vapour, not so much by a real solution, as by keeping its particles asunder, and preventing their condensation. Water likewise dissolves or absorbs air.

Mere heating or cooling does not affect the chemical properties of atmospherical air; but actual combustion, or any process of the same nature, destroys its oxigen, and leaves its nitrogen separate. Whenever a process of this kind is carried on in a vessel containing atmospherical air, which is enclosed either by inverting the vessel over mercury, or by stopping its aperture in a proper manner, it is found that the process ceases after a certain time; and that the remaining air, which is about three-fourths of the whole bulk, is of such a nature as to be incapable of maintaining any combustion for a second time, or of supporting the life of animals. From these experiments it is clear, that one of the following deductions must be true: 1. The combustible body has emitted some principle, which, by combining with the air, has rendered it unfit for the purpose of further combustion: or, 2. It has absorbed part of the air which was fit for that purpose, and has left a residue of a different nature: or, 3. Both events have happened; namely, that the pure part of the air has been absorbed, and a principle has been emitted, which has changed the original properties of the remainder.

The facts must clear up these theories. The first induction cannot be true, because the residual air is not only of less bulk, but of less specific gravity, than before. The air cannot therefore have received so much as it has lost. The second is the doctrine of the philosophers, who deny the existence of phlogiston, or a principle of inflammability: and the third must be adopted by those who maintain that such a principle escapes from bodies during combustion. This residue was called phlogisticated air in consequence of such an opinion.

In the opinion that inflammable air is the phlogiston, it is not necessary to reject the second inference, that the air has been no otherwise changed than by the mere subtraction of one of its principles: for the pure or vital part of the air may unite with inflammable air supposed to exist in a fixed state in the combustible body; and if the product of this union still continues fixed, it is evident, that the residue of the air after combustion will be the same as it would have been, if the vital part had been absorbed by any other fixed body. Or, if the vital air be absorbed, while inflammable air or phlogiston is disengaged, and unites with the aëriform residue, this residue will not be heavier than before, unless the inflammable air it has gained exceeds in weight the vital air it has lost; and if the inflammable air falls short of that weight, the residue will be lighter.

These theories it was necessary to mention; but it has been sufficiently proved by various experiments, that combustible bodies take oxigen from the atmosphere, and leave nitrogen; and that when these two fluids are again mixed, in due proportions, they compose a mixture not differing from atmospherical air.

The respiration of animals produces the same effect on atmospherical air as combustion does, and their constant heat appears to be an effect of the same nature. When an animal is included in a limited quantity of atmospherical air, it dies as soon as the oxigen is consumed; and no other air will maintain animal life but that which maintains combustion; that is to say oxigen, or a mixture which contains it. Pure oxigen maintains the life of animals much longer than atmospherical air.

There are many provisions in nature by which the proportion of oxigen in the atmosphere, which is continually absorbed in respiration and combustion, is again restored to that fluid In fact there appears, as far as an estimate can be formed of the great and general operations of nature, to be at least as great an absorption of the nitrogen and emission of oxigen, as is sufficient to keep the general mass of the atmosphere at the same degree of purity. Thus, in volcanic eruptions there seems to be at least as much oxigen emitted or extricated by fire from various minerals, as is sufficient to maintain the combustion, and perhaps even to meliorate the atmosphere. And in the bodies of plants and animals, which appear in a great measure to derive their sustenance and augmentation from the atmosphere and its contents, it is found that a large proportion of nitrogen exists. Most plants emit oxigen in the sunshine, from which it is highly probable that they imbibe and decompose the air of the atmosphere, retaining its noxious part, and emitting the vital part. Lastly, if to this we add the decomposition of water, there will be numerous occasions in which this fluid will supply us with disengaged oxigen; while by a very rational supposition its hidrogen may be considered as having entered into the bodies of plants for the formation of oils, sugars, mucilages, &c., from which it may be again extricated.

To determine the respirability or purity of air, it is evident that recourse must be had to its comparative efficacy in maintaining combustion, or some other equivalent process. This subject will be considered under the article EUDIOMETER.

From the latest and most accurate experiments, the proportion of oxigen in atmospheric air is by measure about 21·5 per cent.; and it appears to be very nearly the same, whether it be in this country or on the coast of Guinea, on low plains or lofty mountains, or even at the height of 7250 yards above the level of the sea, as ascertained by Gay-Lussac in his aërial voyage in September 1805. The remainder of the air is nitrogen; with a small portion of aqueous vapour, amounting to about 1·4 per cent in the driest weather; and a still less portion of carbonic acid, not exceeding a thousandth part of the whole.

As oxigen and nitrogen differ in specific gravity in the proportion of 135 to 121, according to Kirwan, and of 139 to 120 according to Davy, it has been presumed, that the oxigen would be more abundant in the lower regions, and the nitrogen in the higher, if they constituted a mere mechanical mixture; which appears contrary to the fact. On the other hand it has been urged, that they cannot be in the state of chemical combination, because they both retain their distinct properties unaltered, and no change of temperature or density takes place on their union. But perhaps it may be said, that, as they have no repugnance to mix with each other, as oil and water have, the continual agitation, to which the atmosphere is exposed, may be sufficient to prevent two fluids, differing not more than oxigen and nitrogen in gravity from separating by subsidence, though simply mixed. On the contrary it may be argued, that to say chemical combination cannot take place, without producing new properties, which did not exist before in the component parts, is merely begging the question: for though this generally appears to be the case, and often in a very striking manner, yet combination does not always produce a change of properties; as appears in Mr. Biot's experiments with various substances, of which we may instance water, the refraction of which is precisely the mean of the oxigen and hidrogen, which are indisputably combined in it.

To get rid of the difficulty, Mr. Dalton of Manchester framed an ingenious hypothesis, that the particles of different gasses neither attract nor repel each other; so that one gas expands by the repulsion of its own particles, without any more interruption from the presence of another gas, than if it were in a vacuum. This would account for the state of atmospheric air, it is true; but it does not agree with certain facts. In the case of the carbonic acid gas in the Grotto del Cano, and over the surface of brewers' vats, why does not this gas expand itself freely upward, if the superincumbent gasses do not press upon it? Mr. Dalton himself too instances as an argument for his hypothesis, that oxigen and hidrogen gasses, when mixed by agitation, do not separate on standing: but why should either oxigen or hidrogen require agitation, to diffuse it through a vacuum, in which according to Mr. Dalton it is placed?—*C.*

The theory of Berthollet, which is also that of Mr. Murray, appears consistent with all the facts, and sufficient to account for the phænomenon. If two bodies be capable of chemical combination, their particles must have a mutual attraction for each other. This attraction, however, may be so opposed by concomitant circumstances, that it may be diminished in any degree. Thus we know, that the affinity of aggregation may occasion a body to combine slowly with a substance for which it has a powerful affinity, or even entirely prevent its combining with it: the presence of a third substance may equally prevent the combination: and so may the absence of a certain quantity of caloric. But in all these cases the attraction of the particles must subsist, though diminished or counteracted by opposing circumstances. Now we know that oxigen and nitrogen are capable of combination; their particles, therefore, must attract each other: but in the circumstances in which they are placed in our atmosphere, that attraction is prevented from exerting itself to such a degree as to form them into a chemical compound, though it operates with sufficient force to prevent their separating by their difference of specific gravity. Thus the state of the atmosphere is accounted for, and every difficulty obviated, without any new hypothesis.

Alabaster. Among the stones which are known by the name of marble, and have been distinguished by a considerable variety of denominations by statuaries, and others whose attention is more directed to their external characters and appearance than their component parts, alabasters are those which have a greater or less degree of imperfect transparency, a granular texture, are softer, take a duller polish than marble, and are usually of a white colour. Some stones, however, of a veined and coloured appearance, have been considered as alabasters, from their possessing the first mentioned criterion; and some transparent and yellow sparry stones have also received this appellation.

Chemists are at present agreed in applying this name only to such opake, consistent and semitransparent stones, as are composed of lime united with the sulphuric acid. But the term is much more frequent among masons and statuaries than chemists. Chemists in general confound the alabasters among the selenites, gypsums, or plaster of Paris, more especially when they allude only to the component parts, without having occasion to consider the external appearance, in which only these several compounds differ from each other.

As the semiopake appearance and granular texture arise merely from a disturbed or successive crystallization, which would else have formed transparent spars, it is accordingly found, that the calcareous stalactites, or drop-stones, formed by the transition of water through the roofs of caverns in a calcareous soil, do not differ in appearance from the alabaster, most of which is also formed in this manner. But the calcareous stalactites here spoken of consist of calcareous earth and carbonic acid; while the alabaster of the chemists is formed of the same earth and sulphuric acid, as has already been remarked.

Album Græcum. Innumerable are the instances of fanciful speculation, and absurd credulity, in the invention and application of subjects in the more ancient materia medica. The white and solid excrement of dogs, which subsist chiefly on bones, has been received as a remedy in the medical art, under the name of Album Græcum. It consists, for the most part, of the earth of bones, or lime in combination with phosphoric acid.

Albumen. This substance, which derives its name from the Latin for the white of an egg, in which it exists abundantly and in its purest natural state, is one of the chief constituent principles of all the animal solids. Beside the white of egg it abounds in the serum of blood, the vitreous and crystalline humours of the eye, and the fluid of dropsy. Fourcroy claims to himself the honour of having discovered it in the green feculæ of plants in general, particularly in those of the cruciform order, in very young ones, and in the fresh shoots of trees: though Rouelle appears to have detected it there long before. Vauquelin says it exists also in the mineral water of Plombieres.

Mr. Seguin has found it in remarkable quantity in such vegetables as ferment without yeast, and afford a vinous liquor; and from a series of experiments he infers, that albumen is the true principle of fermentation, and that its action is more powerful in proportion to its solubility, three different degrees of which he found it to possess.

The chief characteristic of albumen is its coagulability by the action of heat. If the white of an egg be exposed to a heat of about 134° F. white fibres begin to appear in it, and at 160° it coagulates into a solid mass. In a heat not exceeding 212° it dries, shrinks, and assumes the appearance of horn. It is soluble in cold water, before it has been coagulated, but not after; and when diluted with a very large portion it does not coagulate easily. Pure alkalies dissolve it, even after coagulation. Alcohol occasions an imperfect coagulation of it, leaving it still soluble in cold water. It is precipitated by muriat of mercury, nitro-muriat of tin, acetat of lead, nitrat of silver, muriat of gold, infusion of galls, and tannin. The acids and metallic oxides coagulate albumen. On the addition of concentrated sulphuric acid, it becomes black and exhales a nauseous smell. Strong muriatic acid gives a violet tinge to the coagulum, and at length becomes saturated with ammonia. Nitric acid, at 70° F., disengages from it abundance of azotic gas; and if the heat be increased prussic acid is formed, after which carbonic acid and carbonated hidrogen are evolved, and the residue consists of water containing a little oxalic acid, and covered with a lemon-coloured fat oil. If dry potash or soda be triturated with albumen, either liquid or solid, ammoniacal gas is evolved, and the calcination of the residuum yields an alkaline prussiat.

On exposure to the atmosphere in a moist state albumen passes at once to the state of putrefaction.

From its coagulability albumen is of great use in clarifying liquids. See CLARIFICATION.

It is likewise remarkable for the property of rendering leather supple, for which purpose a solution of whites of eggs in water is used by leather-dressers; and hence Dr. Lobb, of Yeovil in Somersetshire, was induced to employ this solution in cases of contraction and rigidity of the tendons, and derived from it the desired success.

Whites of eggs beaten in a basin with a lump of alum, till they coagulate, form the *alum curd* of Riverius, or *alum cataplasm* of the London Pharmacopœia, used to remove inflammations of the eyes.—*Fourcroy.*—*Ann. de Chim.*—*Mem. de l'Instit. Nation.*—*Journ. de Physique.*

ALCHEMY. The practice of chemistry, comprehending every operation which is not mechanical, must of course have been among the earliest consequences of those efforts of the human mind, which supply our wants, and distinguish civilized nations from the uncultivated. The various arts dependent upon this science were practised for ages, before the systematic reasoning and inferences of philosophers had traced its dependencies, and formed the science itself. Immediate profit is the object of pursuit in those who practise the arts; and while the several branches of chemical operation continued to be mere arts, their professors or practisers had in general no other views. It could not but happen, however, that men of abilities would be found among these professors, who would reason well or ill upon what they saw; and as all reasoning with regard to natural appearances consists chiefly in the classing of similar phænomena, and deducing other events from them by analogy, it would follow of course, that these men would discover rules, and establish general observations, by means of which their operations would be facilitated and extended. The spirit of trade would nevertheless intermix itself with their speculations, and lead them to consider their discoveries as lucrative secrets, not to be communicated but to others of the same profession, whose successful researches had enabled them to afford other secrets in return. Thus it was that philosophical chemistry had its birth: in its infancy it was alchemy, a science whose professors were tradesmen dazzled at the fruitful and extensive consequences to which their researches seemed to lead; looking down upon and despising the common operator, who possessed no clew to lead him beyond the ordinary course of his business; and extolling their own knowledge, which, from vanity as well as motives of profit, they either kept to themselves, or communicated in mysterious and enigmatical writings. The earliest philosophical writers on chemistry were alchemists, and distinguished themselves from common chemists by this appellation. As the true methods of philosophizing became better known, and liberality of sentiment increased, chemistry became a science in the hands of men of better taste and more enlightened judgment. The writings of the alchemists and their elevated professions continued notwithstanding to have their effects upon many persons, and are not entirely without their influence at the present instant. The efficacy of chemical preparations for medical use proved sufficient for a long time to enforce a certain degree of credit in favour of a panacea, or universal medicine, powerful to cure all diseases; and a number of facts ill understood, and taken as the ground of extensive and plausible inferences, have induced numbers to believe, that metals might be transmuted into each other. This last operation was chiefly aimed at the transmutation of metals of inferior price into gold. The pretence is still used by artful persons to impose on the ignorant, and in some instances, perhaps, by the ignorant, who impose on themselves.

ALCOHOL. This term is applied in strictness only to the pure spirit obtainable by distillation and subsequent rectification from all liquids in a state of vinous fermentation, and from none but such as are susceptible of it. But it is commonly used to signify this spirit more or less imperfectly freed from water in the state in which it is usually met with in the shops; and in which, as it was first obtained from the juice of the grape, it was long distinguished by the name of spirit of wine. At present it is extracted chiefly from grain or melasses in Europe, and from the juice of the sugar-cane in the West Indies; and in the diluted state in which it commonly occurs in trade constitutes the basis of the several spirituous liquors called brandy, rum, gin, whiskey, and cordials, however variously denominated or disguised.

Lavoisier concluded from his experiments, that alcohol consisted of the same principles as sugar, oxigen, hidrogen, and carbon; only containing a much larger proportion of carbon. By transmission through an ignited porcelain tube it yields olefiant and hydro-carburet gases, with a small proportion of carbonic acid gas; and a portion of fine light sooty charcoal remains in the tube. Mr. Sage put into a glass retort, large enough to contain at least twelve times the quantity, one part of alcohol and three parts of nitrous acid, adapted the retort to a series of globular receivers not luted, and applied a slow heat to the sand bath containing the retort. At 100° of Fahr. the mixture was decomposed; an effervescence with large bubbles and red fumes of nitrous gas arose; the ether passed into the receivers with an explosion, and perfumed the laboratory. The fire being kept up, and the distillation continued, till about a thirty-second part of the mixture remained, the whole was left to cool, when beautiful crystals of oxalic acid in tetraëdral prisms were found at the bottom of an acidulous water. From sixteen ounces of alcohol Mr. Sage thus obtained one ounce and four scruples of oxalic acid. During the combustion of alcohol a quantity of water exceeding the alcohol in weight is produced, and carbonic acid is generated.

We are neither able to compound alcohol immediately from its constituent principles, nor to obtain it directly in a pure state from the fluids in which it is contained: so that we are obliged to have recourse to the process of fermentation, by which its principles are first extricated from the substances in which they were combined, and then united into a new compound; to distillation, by which this new compound, the alcohol, is separated in a state of dilution with water, and contaminated with essential oil; and to rectification, by which it is ultimately freed from these.

It appears to be essential to the fermentation of alcohol, that the fermenting fluid should contain saccharine matter, which is indispensable to that species of fermentation called vinous. In France, where a great deal of wine is made, particularly at the commencement of the vintage, that is too weak to be a saleable commodity, it is a common practice to subject this wine to distillation, in order to draw off the spirit; and as the essential oil that rises in this process is of a more pleasant flavour than that of malt or melasses, the French brandies are preferred to any other; though even in the flavour of these there is a difference according to the wine from which they are produced. In the West Indies a spirit is obtained from the juice of the sugar-cane, which is highly impregnated with its essential oil, and well known by the name of *rum*. The distillers in this country use grain, or melasses, whence they distinguish the products by the name of *malt spirits*, and *melasses spirits*. It is said that a very good spirit may be extracted from the husks of gooseberries or currants, after wine has been made from them.

As the process of malting develops the saccharine principle of grain, it would appear to render it fitter for the purpose; though it is the common practice to use about three parts of raw grain with one of malt. For this two reasons may be assigned: by using raw grain the expense of malting is saved, as well as the duty on malt; and the process of malting requires some nicety of attention, since, if it be carried too far, part of the saccharine matter is lost, and if it be stopped too soon, this matter will not be wholly developed. Besides, if the malt be dried too quickly, or by an unequal heat, the spirit it yields will be less in quantity and more unpleasant in flavour. Another object of œconomical consideration is, what grain will afford the most spirit in proportion to its price, as well as the best in quality. Barley appears to produce less spirit than wheat; and if three parts of raw wheat be mixed with one of malted barley, the produce is said to be particularly fine. This is the practice of the distillers in Holland for producing a spirit of the finest quality; but in England they are expressly prohibited from using more than one part of wheat to two of other grain. Rye however affords still more spirit than wheat.

Whatever be the grain employed, it may be coarsely ground, and then mixed carefully with a little cold water, to prevent its running into lumps; water about 90° F. may then be added, till it is sufficiently diluted; and lastly a sufficient quantity of yeast. The whole is then to be allowed to ferment in a covered vessel, to which however the air can have access. Attention must be paid to the temperature; for if it exceed 77° F. the fermentation will be too rapid; if it be below 60° the fermentation will cease. The mean between these will generally be found most favourable. In this country it is the more common practice to mash the grain as for brewing malt liquors, and boil the wort. But in whichever way it be prepared, or if the *wash*, so the liquor intended for distillation is called, be made from melasses and water, due attention must be paid to the fermentation, that it be continued till the liquor grows fine, and pungent to the taste, which will generally be about the third day, but not so long as to permit the acetous fermentation to commence.

In this state the wash is to be committed to the still, of which, including the head, it should occupy at least three-fourths; and distilled with a gentle heat as long as any spirit comes over, which will be till about half the wash is consumed. The more slowly the distillation is conducted, the less will the product be contaminated with essential oil, and the less danger will there be of empyreuma. A great saving of time and fuel, however, may be obtained, by making the still very broad and shallow, and contriving a free exit for the steam. This has been carried to such a pitch in Scotland, that a still measuring 43 gallons, and containing 16 gallons of wash, has been charged and worked no less than four hundred and eighty times in the space of twenty-four hours. This would be incredible, were it not established by unquestionable evidence. See LABORATORY, article STILL.

The first product, technically termed *low wine*, is again to be subjected to distillation, the latter portions of what comes over, called *faints*, being set apart, to put into the wash still at some future operation. Thus a large portion of the watery part is left behind. This second product, termed *raw spirit*, being distilled again is called *rectified spirit*. It is calculated, that a hundred gallons of malt or corn wash will not produce above twenty of spirit, containing 60 parts of alcohol to 50 of water; the same of cider wash, 15 gallons; and of melasses wash, 22 gallons. The most spirituous wines of France, those of Languedoc, Guienne, and Rousillon, yield according to Chaptal from 20 to 25 gallons of excellent brandy from 100; but those of Burgundy and Champagne much less. Brisk wines, containing much carbonic acid, from the fermentation having been stopped at an early period, yield the least spirit.

The spirit thus obtained ought to be colourless, and free from any disagreeable flavour; and in this state it is fittest for pharmaceutical purposes, or the extraction of tinctures. But for ordinary sale something more is required. The brandy of France, which is most in esteem here, though perfectly colourless when first made, and often preserved so for use in that country by being kept in glass or stone bottles, is put into new oak casks for exportation, whence it soon acquires an amber colour, a peculiar flavour, and something like an unctuosity of consistence. As it is not only prized for these qualities, but they are commonly deemed essential to it, the English distiller imitates by design these accidental qualities. The most obvious and natural method of doing this would be by impregnating a pure spirit with the extractive, resinous, and colouring matter of oak shavings; but other modes have been contrived. The dulcified spirit of nitre, as it is called, is commonly used to give the flavour; and catechu, or burnt sugar, to impart the desired colour. A French writer has recommended three ounces and a half of finely powdered charcoal, and four ounces and a half of ground rice, to be digested for a fortnight in a quart of malt spirit.

The finest gin is said to be made in Holland from a spirit drawn from wheat mixed with a third or fourth part of malted barley, and twice rectified over juniper berries: but in general rye meal is used instead of wheat. They pay so much regard to the water employed, that many send vessels to fetch it on purpose from the Meuse: but all use the softest and clearest river water they can get. In England it is the common practice to add oil of turpentine, in the proportion of two ounces to ten gallons of raw spirit, with three handfuls of bay salt, and draw off till the faints begin to rise.

But corn or melasses spirit is flavoured likewise by a variety of aromatics, with or without sugar, to please different palates; all of which are included under the general technical term of *compounds*, or *cordials*.

Other articles have been employed, though not generally, for the fabrication of spirit, as carrots and potatoes; and we are lately informed by prof. Proust, that from the fruit of the carob tree he has obtained good brandy in the proportion of a pint from five pounds of the dried fruit.

To obtain pure alcohol different processes have been recommended; but the purest rectified spirit obtained as above described, being that which is least contaminated with foreign matter, should be employed. Rouelle recommends to draw off half the spirit in a water bath: to rectify this twice more, drawing off two thirds each time: to add water to this alcohol, which will turn it milky by separating the essential oil remaining in it: to distil the spirit from this water; and finally rectify it by one more distillation.

Baumé sets apart the first running, when about a fourth is come over, and continues the distillation till he has drawn off about as much more, or till the liquor runs off milky. The last running he puts into the still again, and mixes the first half of what comes over with the preceding first product. This process is again repeated, and all the first products being mixed together are distilled afresh. When about half the liquor is come over, this is to be set apart as pure alcohol.

Alcohol in this state, however, is not so pure as when, to use the language of the old chemists, it has been *dephlegmated*, or still further freed from water, by means of some alkaline salt. Boerhaave recommended for this purpose the muriate of soda, deprived of its water of crystallization by heat, and added hot to the spirit. But the subcarbonat of potash is preferable. About a third of the weight of the alcohol should be added to it in a glass vessel, well shaken, and then suffered to subside. The salt will be moistened by the water absorbed from the alcohol; which being decanted, more of the salt is to be added, and this is to be continued till the salt falls dry to the bottom of the vessel. The alcohol in this state will be reddened by a portion of the pure potash, which it will hold in solution, from which it must be freed by distillation in a water bath. Dry muriat of lime may be substituted advantageously for the alkali.

As alcohol is much lighter than water, its specific gravity is adopted as the test of its purity. Fourcroy considers it as rectified to the highest point when its specific gravity is 829, that of water being 1000: and perhaps this is nearly as far as it can be carried by the process of Rouelle or Baumé simply. Mr. Bories found the first measure that came over from twenty of spirit at 836 to be 820, at the temperature of 71° F. Sir Charles Blagden, by the addition of alkali, brought it to 813, at 60° F. Chaussier professes to have reduced it to 798; but he gives 998·35 as the specific gravity of water. Lowitz asserts, that he has obtained it at 791, by adding as much alkali as nearly to absorb the spirit; but the temperature is not indicated. In the shops it is about 835 or 840: according to the London College it should be 815.

It is by no means an easy undertaking to determine the strength or relative value of spirits, even with sufficient accuracy for commercial purposes. The following requisites must be obtained before this can be well done: the specific gravity of a certain number of mixtures of alcohol and water must be taken so near each other, as that the intermediate specific gravities may not perceptibly differ from those deduced from the supposition of a mere mixture of the fluids: the expansions or variations of specific gravity in these mixtures must be determined at different temperatures: some easy method must be contrived of determining the presense and quantity of saccharine or oleaginous matter which the spirit may hold in solution, and the effect of such solution on the specific gravity: and lastly, the specific gravity of the fluid must be ascertained by a proper floating instrument with a graduated stem, or set of weights; or, which may be more convenient, with both.

The strength of brandies in commerce is judged by the phial, or by burning. The phial proof consists in agitating the spirit in a bottle, and observing the form and magnitude of the bubbles that collect round the edge of the liquor, technically termed the *bead*, which are larger the stronger the spirit. These probably depend on the solution of resinous matter from the cask, which is taken up in greater quantities, the stronger the spirit. It is not difficult, however, to produce this appearance by various simple additions to weak spirit. The proof by burning is also fallacious; because the magnitude of the flame, and quantity of residue, in the same spirit, vary greatly with the form of the vessel it is burned in. If the vessel be kept cool, or suffered to become hot, if it be deeper or shallower, the results will not be the same in each case. It does not follow, however, but that manufacturers and others may in many instances receive considerable information from these signs, in circumstances exactly alike, and in the course of operations wherein it would be inconvenient to recur continually to experiments of specific gravity.

The importance of this object, as well for the purposes of revenue as of commerce, induced the British government to employ Dr. Blagden, now Sir Charles, to institute a very minute and accurate series of experiments. These may be considered as fundamental results; for which reason, I shall give a summary of them in this place, from the Philosophical Transactions for 1790.

The first object to which the experiments were directed was to ascertain the quantity and law resulting from the mutual penetration of water and spirit.

All bodies in general expand by heat; but the quantity of this expansion, as well as the law of its progression, is probably not the same in any two substances. In water and spirit they are remarkably different. The whole expansion of pure spirit from 30° to 100° of Fahrenheit's thermometer is not less than 1-25th of its whole bulk at 30°; whereas that of water, in the same interval, is only 1-145th of its bulk. The laws of their expansion are still more different than the quantities. If the expansion of quicksilver be, as usual, taken for the standard (our thermometers being constructed with that fluid), the expansion of spirit is, indeed, progressively increasing with respect to that standard, but not much so within the abovementioned interval; while water kept from freezing to 30°, which may easily be done, will absolutely contract as it is heated for ten or more degrees, that is, to 40° or 42° of the thermometer, and will then begin to expand as its heat is augmented, at first slowly, and afterward gradually more rapidly, so as to observe upon the whole a very increasing progression. Now, mixtures of these two substances will, as may be supposed, approach to the less or the greater of these progressions, according as they are compounded of more spirit or more water, while their total expansion will be greater, according as more spirit enters into their composition; but the exact quantity of the expansion, as well as law of the progression, in all of them, can be determined only by trials. These were, therefore, the two other principal objects to be ascertained by experiment.

The person engaged to make these experiments was Dr. Dollfuss, an ingenious Swiss gentleman then in London, who had distinguished himself by several publications on chemical subjects. As he could not conveniently get the quantity of spirit he wanted lighter than 825, at 60° F., he fixed upon this strength as the standard for alcohol.

These experiments of Dr. Dollfuss were repeated by Mr. Gilpin, clerk of the Royal Society; and as the deductions in this account will be taken chiefly from that last set of experiments, it is proper here to describe minutely the method observed by Mr. Gilpin in his operation. This naturally resolves itself into two parts: the way of making the mixtures, and the way of ascertaining their specific gravity.

1. The mixtures were made by weight, as the only accurate method of fixing the proportions. In fluids of such very unequal expansions by heat as water and alcohol, if measures had been employed, increasing or decreasing in regular proportions to each other, the proportions of the masses would have been sensibly irregular: now the latter was the object in view, namely, to determine the real quantity of spirit in any given mixture, abstracting the consideration of its temperature. Besides, if the proportions had been taken by measure, a different mixture should have been made at every different degree of heat. But the principal consideration was, that with a very nice balance, such as was employed on this occasion, quantities can be determined to much greater exactness by weight than by any practicable way of measurement. The proportions were therefore always taken by weight. A phial being provided of such a size as that it should be nearly full with the mixture, was made perfectly clean and dry, and being counterpoised, as much of the pure spirit as appeared necessary was poured into it. The weight of this spirit was then ascertained, and the weight of distilled water required to make a mixture of the intended proportions was calculated. This quantity of water was then added, with all the necessary care, the last portions being put in by means of a well-known instrument, which is composed of a small dish terminating in a tube drawn to a fine point: the top of the dish being covered with the thumb, the liquor in it is prevented from running out through the tube by the pressure of the atmosphere, but instantly begins to issue by drops, or a very small stream, upon raising the thumb. Water being thus introduced into the phial, till it exactly counterpoised the weight, which having been previously computed, was put into the opposite scale, the phial was shaken, and then well stopped with its glass stopple, over which leather was tied very tight, to prevent evaporation. No mixture was used till it had remained in the phial at least a month, for the full penetration to have taken place; and it was always well shaken before it was poured out to have its specific gravity tried.

2. There are two common methods of taking the specific gravity of fluids; one, by finding the weight which a solid body loses by being immersed in them; the other, by filling a convenient vessel with them, and ascertaining the increase of weight it acquires. In both cases a standard must have been previously taken, which is usually distilled water; namely, in the first method by finding the weight lost by the solid body in the water, and in the second method, the weight of the vessel filled with water. The latter was preferred for the following reasons:

When a ball of glass, which is the properest kind of solid body, is weighed in any spirituous or watery fluid, the adhesion of the fluid occasions some inaccuracy, and renders the balance comparatively sluggish. To what degree this effect proceeds is uncertain; but from some experiments made by Mr. Gilpin, with that view, it appears to be very sensible. Moreover, in this method a large surface must be exposed to the air during the operation of weighing, which, especially in the higher temperatures, would give occasion to such an evaporation as to alter essentially the strength of the mixture. It seemed also as if the temperature of the fluid under trial could be determined more exactly in the method of filling a vessel, than in the other; for the fluid cannot well be stirred while the ball to be weighed remains immersed in it; and as some time must necessarily be spent in the weighing, the change of heat which takes place during that period will be unequal through the mass, and may occasion a sensible error. It is true, on the other hand, that in the method of filling a vessel, the temperature could not be ascertained with the utmost precision, because the neck of the vessel employed, containing about ten grains, was filled up to the mark with spirit not exactly of the same temperature, as will be explained presently: but this error, it is supposed, would by no means equal the other, and the utmost quantity of it may be estimated very nearly. Finally, it was much easier to bring the fluid to any given temperature when it was in a vessel to be weighed, than when it was to have a solid body weighed in it; because in the former case the quantity was smaller, and the vessel containing it more manageable, being readily heated with the hand or warm water, and cooled with cold water: and the very circumstance, that so much of the fluid was not required, proved a material convenience. The particular disadvantage in the method of weighing in a vessel, is the difficulty of filling it with extreme accuracy; but when the vessel is judiciously and neatly marked, the error of filling will, with due care, be exceedingly minute. By several repetitions of the same experiments, Mr. Gilpin seemed to bring it within the 1-15000th part of the whole weight.

The above-mentioned considerations induced Dr. Blagden, as well as the gentlemen employed in the experiments, to give the preference to weighing the fluid itself; and that was accordingly the method practised both by Dr. Dollfuss and Mr. Gilpin in their operations.

The vessel chosen as most convenient for the purpose was a hollow glass ball, terminating in a neck of small bore. That which Dr. Dollfuss used held 5800 grains of distilled water; but as the balance was so extremely accurate, it was thought expedient, upon Mr. Gilpin's repetition of the experiments, to use one of only 2965 grains capacity, as admitting the heat of any fluid contained in it to be more nicely determined. The ball of this vessel, which may be called the weighing-bottle, measured about 2·8 inches in diameter, and was spherical, except a slight flattening on the part opposite to the neck, which served as a bottom for it to stand upon. Its neck was formed of a portion of a barometer tube, ·25 of an inch in bore, and about 1½ inch long; it was perfectly cylindrical, and on its outside, very near the middle of its length, a fine circle or ring was cut round it with a diamond, as the mark to which it was to be filled with the liquor. This mark was made by fixing the bottle in a lathe, and turning it round with great care, in contact with the diamond. The glass of this bottle was not very thick; it weighed 916 grains, and with its silver cap 936.

When the specific gravity of any liquor was to be taken by means of this bottle, the liquor was first brought nearly to the required temperature, and the bottle was filled with it up to the beginning of the neck only, that there might be room for shaking it. A very fine and sensible thermometer was then passed through the neck of the bottle into the contained liquor, which showed whether it was above or below the intended temperature. In the former case the bottle was brought into colder air, or even plunged for a moment into cold water; the thermometer in the mean time being frequently put into the contained liquor, till it was found to sink to the right point. In like manner, when the liquor was too cold, the bottle was brought into warmer air, immersed in warm water, or more commonly held between the hands, till upon repeated trials with the thermometer the just temperature was found. It will be understood, that during the course of this heating or cooling, the bottle was very frequently shaken between each immersion of the thermometer; and the top of the neck was kept covered, either with the finger, or a silver cap made on purpose, as constantly as possible. Hot water was used to raise the temperature only in heats of 80° and upwards, inferior heats being obtained by applying the hands to the bottle: when the hot water was employed, the ball of the bottle was plunged into it, and again quickly lifted out, with the necessary shaking interposed, as often as was necessary for communicating the required heat to the liquor; but care was taken to wipe the bottle dry after each immersion, before it was shaken, lest any adhering moisture might by accident get into it. The liquor having by these means been brought to the desired temperature; the next operation was to fill up the bottle exactly to the mark upon the neck, which was done with some of the same liquor, by means of a glass funnel with a very small bore. Mr. Gilpin endeavoured to get that portion of the liquor which was employed for this purpose, pretty nearly to the temperature of the liquor contained in the bottle; but as the whole quantity to be added never exceeded ten grains, a difference of ten degrees in the heat of that small quantity, which is more than it ever amounted to, would have occasioned an error of only 1-30th of a degree in the temperature of the mass. Enough of the liquor was put in to fill the neck rather above the mark, and the superfluous quantity was then absorbed to great nicety, by bringing into contact with it the fine point of a small roll of blotting paper. As the surface of the liquor in the neck would be always concave, the bottom or centre of this concavity was the part made to coincide with the mark round the glass; and in viewing it care was taken, that the near and opposite sides of the mark should appear exactly in the same line, by which means all parallax was avoided. A silver cap, which fitted tight, was then put upon the neck, to prevent evaporation; and the whole apparatus was in that state laid in the scale of the balance, to be weighed with all the exactness possible.

The spirit employed by Mr. Gilpin was furnished to him by Dr. Dollfuss, under whose inspection it had been rectified from rum supplied by government. Its specific gravity, at 60 degrees of heat, was ·82514. It was first weighed pure, in the abovementioned bottle, at every five degrees of heat, from 30 to 100 inclusively. Then mixtures were formed of it, and distilled water, in every proportion, from 1-20th of the water to equal parts of water and spirit; the quantity of water added being successively augmented, in the proportion of five grains to one hundred of the spirit; and these mixtures were also weighed in the bottle, like the pure spirit, at every five degrees of heat. The numbers hence resulting are delivered in the following table; where the first column shows the degrees of heat; the second gives the weight of the pure spirit contained in the bottle at those different degrees; the third gives the weight of a mixture in the proportions of 100 parts by weight of that spirit to 5 of water, and so on successively till the water is to the spirit as 100 to 5. They are the mean of three several experiments at least, as Mr. Gilpin always filled and weighed the bottle over again that number of times, if not oftener. The heat was taken at the even degree, as shown by the thermometer, without any allowance in the first instance, because the coincidence of the mercury with a division can be perceived more accurately than any fraction can be estimated; and the errors of the thermometers, if any, it was supposed would be less upon the grand divisions of 5 degrees than in any others. It must be observed, that Mr. Gilpin used the same mixture throughout all the different temperatures, heating it up from 30° to 100°; hence some small error in its strength may have been occasioned in the higher degrees, by more spirit evaporating than water; but this, it is believed, must have been trifling, and greater inconvenience would probably have resulted from interposing a fresh mixture.

The precise specific gravity of the pure spirit employed was ·82514; but to avoid an inconvenient fraction, it is taken, in constructing the table of specific gravities, as ·825 only, a proportional deduction being made from all the other numbers. Thus the following table gives the true specific gravity, at the different degrees of heat, of a pure rectified spirit, the specific gravity of which at 60° is ·825, together with the specific gravities of different mixtures of it with water, at those different temperatures.

Real Specific Gravities at the different Temperatures.

Heat	The pure spirit.	100 grains of spirit to 5 gr. of water.	100 grains of spirit to 10 gr. of water.	100 grains of spirit to 15 gr. of water.	100 grains of spirit to 20 gr. of water.	100 grains of spirit to 25 gr. of water.	100 grains of spirit to 30 gr. of water.	100 grains of spirit to 35 gr. of water	100 grains of spirit to 40 gr of water.	100 grains of spirit to 45 gr. of water.	100 grains of spirit to 50 gr. of water.
30°	·83896	·84995	·85957	·86825	·87585	·88282	·88921	·89511	·90054	·90558	·91023
35	83672	84769	85729	86587	87357	88059	88701	89294	89839	90345	90811
40	83445	84539	85507	86361	87134	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83834	84802	85664	86441	87150	87796	88398	88945	89458	89933
60	82500	83599	84568	85430	86208	86918	87569	88169	88720	89232	89707
65	82262	83362	84334	85193	85976	86686	87337	87938	88490	89006	89479
70	82023	83124	84092	84951	85736	86451	87105	87705	88254	88773	89252
75	81780	82878	83851	84710	85496	86212	86864	87466	88018	88538	89018
80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88605
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84308	85031	85688	86302	86879	87421	87915

Heat	100 grains of spirit to 55 gr. of water.	100 grains of spirit to 60 gr. of water.	100 grains of spirit to 65 gr. of water.	100 grains of spirit to 70 gr. of water.	100 grains of spirit to 75 gr. of water.	100 grains of spirit to 80 gr. of water.	100 grains of spirit to 85 gr. of water.	100 grains of spirit to 90 gr. of water.	100 grains of spirit to 95 gr. of water.	1 gra ofsp to 1 gr. wat
30°	·91449	·91847	·92217	·92563	·92889	·93191	·93474	·93741	·93991	·94
35	91241	91640	92009	92355	92680	92986	93274	93541	93790	94
40	91026	91428	91799	92151	92476	92783	93072	93341	93592	93
45	90812	91211	91584	91937	92264	92570	92859	93131	93382	93
50	90596	90997	91370	91723	92051	92358	92647	92919	93177	93
55	90367	90768	91144	91502	91837	92145	92436	92707	92963	93
60	90144	90549	90927	91287	91622	91933	92225	92499	92758	93
65	89920	90328	90707	91066	91400	91715	92010	92283	92546	92
70	89695	90104	90484	90847	91181	91493	91793	92069	92333	92
75	89464	89872	90252	90617	90952	91270	91569	91849	92111	92
80	89225	89639	90021	90385	90723	91046	91340	91622	91891	92
85	89043	89460	89843	90209	90558	90882	91186	91465	91729	91
90	88817	89230	89617	89938	90342	90668	90967	91248	91511	91
95	88588	89003	89390	89763	90119	90443	90747	91029	91290	91
100	88357	88769	89158	89536	89889	90215	90522	90805	91066	91

Heat	95 grains ofspirit to 100 gr. of water.	90 grains ofspirit to 100 gr. of water.	85 grains ofspirit to 100 gr. of water.	80 grains ofspirit to 100 gr. of water.	75 grains ofspirit to 100 gr. of water.	70 grains ofspirit to 100 gr. of water.	65 grains ofspirit to 100 gr. of water.	60 grains ofspirit to 100 gr. of water.	55 grains ofspirit to 100 gr. of water.	5 grai ofsp to 1 gr. wat
30°	·94447	·94675	·94920	·95173	·95429	·95681	·95944	96209	·96470	·967
35	94249	94484	94734	94988	95246	95502	95772	96048	96315	965
40	94058	94295	94547	94802	95060	95328	95602	95879	96159	964
45	93860	94096	94348	94605	94871	95143	95423	95705	95993	962
50	93658	93897	94149	94414	94683	94958	95243	95534	95831	961
55	93452	93696	93948	94213	94486	94767	95057	95357	95662	959
60	93247	93493	93749	94018	94296	94579	94876	95181	95493	958
65	93040	93285	93546	93822	94099	94388	94689	95000	95318	956
70	92828	93076	93337	93616	93898	94193	94500	94813	95139	954
75	92613	92865	93132	93413	93695	93989	94301	94623	94957	952
80	92393	92646	92917	93201	93488	93785	94102	94431	94768	951

Heat	45 grains ofspirit to 100 gr. of water.	40 grains ofspirit to 100 gr. of water.	35 grains ofspirit to 100 gr. of water.	30 grains ofspirit to 100 gr. of water.	25 grains ofspirit to 100 gr. of water.	20 grains ofspirit to 100 gr. of water.	15 grains ofspirit to 100 gr. of water.	10 grains ofspirit to 100 gr. of water.	5 grains ofspirit to 100 gr. of water.
30°	·96967	·97200	·97418	·97635	·97860	·98108	·98412	·98804	·99334
35	96840	97086	97319	97556	97801	98076	98397	98804	99344
40	96706	96967	97220	97472	97737	98033	98373	98795	99345
45	96563	96840	97110	97384	97666	97980	98338	98774	99338
50	96420	96708	96995	97284	97589	97920	98293	98745	99316
55	96272	96575	96877	97181	97500	97847	98239	98702	99284
60	96122	96437	96752	97074	97410	97771	98176	98654	99244
65	95962	96288	96620	96959	97309	97688	98106	98594	99194
70	95802	96148	96484	96836	97203	97596	98028	98527	99134
75	95638	95987	96344	96708	97086	97495	97943	98454	99066
80	95467	95826	96192	96568	96963	97385	97845	98367	98991

From this table, when the specific gravity of any spirituous liquor is ascertained, it will be easy to find the quantity of rectified spirit of the abovementioned standard, contained in any given quantity of it, either by weight or measure.

Dr. Blagden concludes this part of the report with observing, that as the experiments were made with pure spirit and water, if any extraneous substances are contained in the liquor to be tried, the specific gravity in the tables will not give exactly the proportions of water and spirit in it. The substances likely to be found in spirituous liquors, where no fraud is suspected, are essential oils; sometimes empyreumatic, mucilaginous or extractive matter, and perhaps some saccharine matter. The effect of these, in the course of trade, seems to be hardly such as would be worth the cognizance of the excise, nor could it easily be reduced to certain rules. Essential and empyreumatic oils are nearly of the same specific gravity as spirit, in general rather lighter, and therefore, notwithstanding the mutual penetration, will probably make little change in the specific gravity of any spirituous liquor in which they are dissolved. The other substances are all heavier than spirit; the specific gravity of common gum being 1·482, and of sugar 1·606, according to the tables of M. Brisson. The effect of them therefore will be to make spirituous liquors appear less strong than they really are. An idea was once entertained of endeavouring to determine this matter with some precision; and accordingly Dr. Dollfuss evaporated 1000 grains of brandy, and the same quantity of rum, to dryness; the former left a residuum of 40 grains, the latter only of 8½ grains. The 40 grains of residuum from the brandy, dissolved again in a mixture of 100 of spirit, with 50 of water, increased its specific gravity ·00041: hence the effect of this extraneous matter upon the specific gravity of the brandy containing it, would be to increase the fifth decimal by 6 nearly, equal to what would indicate in the above-mentioned mixture, about one seventh of a grain of water more than the truth, to 100 of spirit; a quantity much too minute for the consideration of government.

The most remarkable characteristic property of alcohol, is its solubility or combination in all proportions with water; a property possessed by no other combustible substance. When it is burned in a chimney which communicates with the worm-pipe of a distilling apparatus, the product which is condensed is found to consist of water, which exceeds the spirit in weight about one eighth part. If alcohol be burned in closed vessels with vital air, the product is found to be water and carbonic acid. Whence it is inferred that alcohol consists of hidrogen, united either to carbonic acid or its acidifiable base; and that the oxigen uniting on the one part with the hidrogen, forms water; and on the other with the base of the carbonic acid, forms that acid.

A considerable number of the uses of this fluid as a menstruum, will pass under our observation in the various articles of this work. The mutual action between alcohol and acids produces a light, volatile, and inflammable oil, called ether. See ETHER. Pure alkalis unite with spirit of wine, and form alkaline tinctures. Few of the neutral salts unite with this fluid, except such as contain ammonia. The carbonated fixed alkalis are not soluble in it. From the strong attraction which exists between alcohol and water, it unites with this last in saline solutions, and in most cases precipitates the salt. This is a pleasing experiment, which never fails to surprise those who are unacquainted with chemical effects. If, for example, a saturated solution of nitre in water be taken, and an equal quantity of strong spirit of wine be poured upon it, the mixture will constitute a weaker spirit, which is incapable of holding the nitre in solution; it therefore falls to the bottom instantly, in the form of minute crystals.

The degrees of solubility of many neutral salts in alcohol are exactly ascertained by experiments made by Macquer, of which an account is published in the Memoirs of the Turin Academy. The alcohol he employed was carefully freed from superabundant water by repeated rectifications, without addition of any intermediate substance. The salts employed in his experiments were previously deprived of their water of crystallization by a careful drying. He poured into a matrass, upon each of the salts thus prepared, half an ounce of his alcohol, and set the matrass in a sand-bath. When the spirit began to boil, he filtrated it while it was hot, and left it to cool, that he might observe the crystallizations which took place. He then evaporated the spirit, and weighed the saline residuums. He repeated these experiments a second time, with this difference, that instead of evaporating the spirit in which the salt had been digested, he set fire to it in order to examine the phænomena which its flame might exhibit. The principal results of his experiments are subjoined.

Quantity of grains.	*Salts soluble in 200 grains of spirit.*	*Peculiar phænomena of the flame.*
4	Nitrate of potash	Flame larger, higher, more ardent, yellow and luminous
5	Muriate of potash	Large, ardent, yellow, and luminous
9	Sulphate of soda	Considerably red

Quantity of grains.	*Salts soluble in 200 grains of spirit.*	*Peculiar phænomena of the flame.*
15	Nitrate of soda	Yellow, luminous, detonating
0	Muriate of soda	Larger, more ardent, and reddish
0	Sulphate of ammonia	None
108	Nitrate of ammonia	Whiter, more luminous
24	Muriate of ammonia	None
288	Nitrate of lime	Larger, more luminous, red and decrepitating
228	Muriate of lime	Like that of the calcareous nitre
84	Nitrate of silver	None
204	Muriate of mercury	Large, yellow, luminous and decrepitating
4	Nitrate of iron	Red and decrepitating
86	Muriate of iron	More white, luminous and sparkling
44	Nitrate of copper	More white, luminous and green, much smoke. The saline residuum became black and burnt
48	Muriate of copper	Fine green, white, and red fulgurations

Macquer accompanies the relation of his experiments with many judicious reflections, not easily capable of abridgment.

If sulphur in sublimation meet with the vapour of alcohol, a very small portion combines with it, which communicates a hidrosulphurous smell to the fluid. The increased surface of the two substances appears to favour the combination. It had been supposed, that this was the only way in which they could be united: but Mr. Favre has lately asserted, that, having digested two drams of flowers of sulphur in an ounce of alcohol, over a gentle fire not sufficient to make it boil, for twelve hours, he obtained a solution that gave twenty-three grains of precipitate. A similar mixture left to stand for a month in a place exposed to the solar rays afforded sixteen grains of precipitate; and another, from which the light was excluded, gave thirteen grains. If alcohol be boiled with one fourth of its weight of sulphur for an hour, and filtered hot, a small quantity of minute crystals will be deposited on cooling; and the clear fluid will assume an opaline hue on being diluted with an equal quantity of water, in which state it will pass the filter, nor will any sediment be deposited for several hours. The alcohol used in the last-mentioned experiment did not exceed ·840.

Phosphorus is sparingly soluble in alcohol, but in greater quantity by heat than in cold. The addition of water to this solution affords an opake milky fluid, which gradually becomes clear by the subsidence of the phosphorus.

Earths seem to have scarce any action upon alcohol. Quick-lime, however, produces some alteration in this fluid, by changing its flavour and rendering it of a yellow colour. A small portion is probably taken up.

Soaps are dissolved with great facility in alcohol, with which they combine more readily than with water. None of the metals, or their oxides, are acted upon by this fluid. Resins, essential oils, camphor, bitumen, and various other substances, are dissolved with great facility in alcohol, from which they may be precipitated by the addition of water. From its property of dissolving resins it becomes the menstruum of one class of varnishes. See VARNISH.

Camphor is not only extremely soluble in alcohol, but assists the solution of resins in it. Fixed oils, when rendered drying by metallic oxides, are soluble in it, as well as when combined with alkalis.

Wax, spermaceti, biliary calculi, urea, and all the animal substances of a resinous nature are soluble in alcohol: but it curdles milk, coagulates albumen, and hardens the muscular fibre and coagulum of the blood.

The uses of alcohol are various. As a solvent of resinous substances and essential oils it is employed both in pharmacy and by the perfumer. When diluted with an equal quantity of water, constituting what is called proof spirit, it is used for extracting tinctures from vegetable and other substances, the alcohol dissolving the resinous parts and the water the gummy. From giving a steady heat without smoke when burnt in a lamp, it was formerly much employed to keep water boiling on the tea-table. In thermometers for measuring great degrees of cold it is preferable to mercury, as we cannot bring it to freeze. It is in common use for preserving many anatomical preparations, and certain subjects of natural history; but to some it is injurious, the molluscæ for instance, the calcareous covering of which it in time corrodes. It is of considerable use too in chemical analysis; as appears under the different articles to which it is applicable.

From the great expansive power of alcohol, it has been made a question, whether it might not be applied with advantage in the working of steam engines. From a series of experiments made by Betancourt, it appears, that the steam of alcohol has in all cases of equal temperature, more than double the force of that of water; and that the steam of alcohol at 174° F. is equal to that of water at 212°: thus there is a considerable diminution of the consumption of fuel, and where this is so expensive as to be an object of great importance, by contriving the machinery so as to prevent the alcohol from being lost, it may possibly at some future time be used with advantage, if some other fluid of great expansive power, and inferior price, be not found more economical.

It was observed at the beginning of this article, that alcohol might be decomposed by transmission through a red-hot tube: it is also decomposable by the strong acids, and thus affords that remarkable product, Ether, and Oleum Vini; which see.—*Lavoisier.—Henry.—Sage.—Fourcroy.—Phil. Trans.—Nich. Journ.—Parliament. Reports.*

Ale. See Beer.

Alembic, *or* **Still.** This part of chemical apparatus, used for distilling or separating volatile products by first raising them by heat, and then condensing them into the liquid state by cold, is of extensive use in a variety of operations. It is described under the article Laboratory; which see.

Alembroth Salt. Corrosive muriat of mercury is rendered much more soluble in water by the addition of muriat of ammonia. From this solution crystals are separated by cooling, which were called sal alembroth by the earlier chemists, and appear to consist of ammonia, muriatic acid, and mercury; but in what state the muriatic acid may be, whether the common or oxigenated, does not seem to have been ascertained.

Algaroth (Powder of). Among the numerous preparations which the alchemical researches into the nature of antimony have afforded, the powder of algaroth is one. When butter of antimony is thrown into water, it is not totally dissolved; but part of the metallic oxide falls down in the form of a white powder, which is the powder of algaroth. It is violently purgative, and emetic in small doses of three or four grains. See Antimony.

Alkahest. The pretended universal solvent, or menstruum, of the ancient chemists. Kunckel has very well shown the absurdity of searching for a universal solvent, by asking, "If it dissolve all substances, in what vessels can it be contained?"

Alkalescent. Any substance in which alkaline properties are beginning to be developed, or to predominate, is termed alkalescent. The only alkali usually observed to be produced by spontaneous decomposition is the volatile; and from their tendency to produce this, some species of vegetables, particularly the cruciform, are styled alkalescent, as are some animal substances. See Fermentation (Putrid).

Alkali. Modern chemistry has discovered many acids, and has succeeded in decomposing them into simpler substances, and recomposing them. But the alkalis still remain in number only three, Ammonia, Potash, and Soda, which see; and nothing has yet been effected to show an unequivocal decomposition of the two fixed alkalis. Guyton-Morveau and Desormes indeed have inferred from certain experiments, that potash is composed of lime and hidrogen; soda, of magnesia and hidrogen; and ammonia, of azot and hidrogen: whence they are inclined to consider hidrogen as the alkalizing principle, and entitled to the name of *alkaligen.* The general characters in which the three alkalis agree are the following:

1. They have a peculiar taste, which is disagreeably caustic, even when diluted with water. 2. They change blue vegetable colours to a green. 3. They have a very strong attraction for water, with which they unite in all proportions, and even attract it in sufficient quantities from the atmosphere to become fluid. 4. They combine with acids in the humid way, by a stronger affinity than is possessed in general by any other substances. 5. They melt in a moderate heat, and in a stronger heat they are volatilized. 6. In the dry way, they dissolve all earths and metallic oxides.

The volatile alkali or ammonia possesses the above general properties, except so far as its disposition to rise in the aëriform state at a heat less than that of boiling water prevents its being exhibited in the dry way. Its affinities are also less strong.

All the alkalis when uncombined are caustic, and in this state are sometimes coupled with the epithet *pure* or *caustic,* to distinguish them from their carbonats, to which the term *mild* is applied.

The usual tests of alkalis are the tincture of turnsole, or litmus, and the sirup of violets. For the salts they form with acids, see the different Acids respectively.

Alkali (Phlogisticated, *or* **Prussian).** When a fixed alkali is ignited with bullock's blood, or other animal substances, and lixiviated, it is found to be in a great measure saturated with the prussic acid: from the theories formerly adopted respecting this combination, it was distinguished by the name of phlogisticated alkali. See Acid (Prussic).

Alkali (Volatile). See Ammonia.

Alkanet. The alkanet plant is a kind of bugloss, which is a native of the warmer parts of Europe, and cultivated in some of our gardens. The greatest quantities are raised in Germany and France, particularly about Montpelier, whence we are chiefly supplied with the roots. These are of a superior quality to such as are raised in England. This root imparts an elegant deep red colour to pure alcohol, to oils, to wax, and to all unctuous substances. The aqueous tincture is of a dull brownish colour; as is likewise the spirituous tincture when inspissated to the consistence of an extract. The principal use of alkanet root is, that of colouring oils, unguents, and lip-salves. Wax tinged with it, and applied on warm marble, stains it of a flesh colour, which sinks deep into the stone; as the spirituous tincture gives it a deep red stain.

As the colour of this root is confined to the bark, and the small roots have more bark in proportion to their bulk than the great ones, these also afford most colour.

Allay, or Alloy. Where any precious metal is mixed with another of less value; the assayers call the latter the alloy, and do not in general consider it in any other point of view than as debasing or diminishing the value of the precious metal. Philosophical chemists have availed themselves of this term to distinguish all metallic compounds in general. Thus brass is called an alloy of copper and zinc; bell metal an alloy of copper and tin.

Almonds. Almonds consist chiefly of an oil of the nature of fat oils, together with farinaceous matter. The oil is so plentiful, and so loosely combined or mixed with the other principles, that it is obtained by simple pressure, and part of it may be squeezed out with the fingers. Five pounds and a half have yielded one pound six ounces of oil by cold expression, and three quarters of a pound more on heating them. There are two kinds of almonds, the sweet and bitter. The bitter almonds yield an oil as tasteless as that of the other, all the bitter matter remaining in the cake after the expression. Great part of the bitter matter dissolves by digestion, both in watery and spirituous liquors; and part arises with both in distillation. Rember obtained from them 1-3d of watery extract, and 3-32ds of spirituous. Bitter almonds are poisonous to birds, and to some animals. A water distilled from them, when made of a certain degree of strength, has been found from experiment to be poisonous to brutes; and there are instances of cordial spirits impregnated with them being poisonous to men. It seems, indeed, that the vegetable principle of bitterness in almonds and the kernels of other fruits is destructive to animal life, when separated by distillation from the oil and farinaceous matter. The distilled water from laurel leaves appears to be of this nature, and its poisonous effects are well known.

Sweet almonds are made into an emulsion by trituration with water, which on standing separates a thick cream floating on the top. The emulsion may be curdled by heat, or the addition of alcohol or acids. The whey contains gum, extractive matter, and sugar, according to prof. Proust: and the curd, when washed and dried, yields oil by expression, and afterward by distillation the same products as cheese. The whey is a good diluent.

Aloes. This is a bitter juice, extracted from the leaves of a plant of the same name. Three sorts of aloes are distinguished in the shops, by the names of aloe soccotrina, aloe hepatica, and aloe caballina. The first denomination, which is applied to the purest kind, is taken from the island of Zocotora; the second, or next in quality, is called hepatica, from its liver colour; and the third, caballina, from the use of this species being confined to horses. These kinds of aloes are said to differ only in purity, though, from the difference of their flavours, it is probable that they may be obtained in some instances from different species of the same plant. It is certain, however, that the different kinds are all prepared at Morviedro in Spain, from the same leaves of the common aloe. Deep incisions are made in the leaves, from which the juice is suffered to flow, and this, after decantation from its sediment, and inspissation in the sun, is exposed to sale in leathern bags by the name of soccotrine aloes. An additional quantity of juice is obtained by pressure from the leaves, and this, when decanted from its sediment and dried, is the hepatic aloes. And lastly, a portion of juice is obtained by strong pressure of the leaves, and is mixed with the dregs of the two preceding kinds to form the caballine aloes. The first kind is said to contain much less resin. The principal characters of good aloes are these: it must be glossy, not very black, but brown; when rubbed or cut, of a yellow colour; compact, but easy to break; easily soluble; of an unpleasant peculiar smell, which cannot be described, and an extremely bitter taste.

Aloes appears to be an intimate combination of gummy and resinous matter, so well blended together, that watery or spirituous solvents, separately applied, dissolve the greater part of both. It is not determined whether there be any difference in the medical properties of these solutions. Both are purgative, as is likewise the aloes in substance; and, if used too freely, are apt to prove heating, and produce hemorrhoidal complaints.

Althea, or Marsh Mallow. Two ounces of the dry root yielded, with water, ten drams fifty grains of mucilaginous extract; and afterwards, with spirit, forty-one grains of resin. The same quantity, treated with spirit, gave six drams of a resinous extract, a considerable portion of the mucilage dissolving in that menstruum along with the resin; the remainder, boiled in water, gave out five drams and forty-eight grains of pure mucilage. The insoluble matter amounts to somewhat more than one fourth of the weight.

Aludel. The process of sublimation differs from distillation in the nature of its product which instead of becoming condensed in a fluid assumes the solid state, and the form of the receivers may of course be very different. The receivers for sublimates are of the nature of chimneys, in which the elastic products are condensed, and adhere to their internal surface. It is evident, that the head of an alembic will serve very well to receive and condense such sublimates as are not very volatile. The earlier chemists, whose notions of simplicity were not always the most perfect, thought proper to use a number of similar heads, one above the other, communicating in succession by means of a perforation in the superior part of each, which received the neck of the capital immediately above it. These heads differing in no respect from the common heads of alembics, excepting in their having no nose or beak, and in the other circumstances here mentioned, were called aludels. They are seldom now to be seen in chemical laboratories, because the operations of this art may be performed with greater simplicity of instruments, provided attention be paid to the heat and other circumstances. See LABORATORY.

ALUM. This is a crystallizable salt composed of sulphuric acid united with alumine, and about 20 per cent. of sulphat of potash, or of ammonia or of both together. It has an austere, sweetish, and strongly astringent taste, which seems to proceed chiefly from a portion of the sulphuric acid, which is necessary to its solubility in water and crystalline form, though it is more than requisite to produce neutralization. If the excess of acid in alum be taken away, the taste, the solubility, and the original properties of the salt, are greatly changed, or lost.

Crystallized alum requires, in a mean heat, about fourteen times its weight of water to dissolve it; but boiling water dissolves one third more than its own weight of this salt, most of which consequently separates by cooling. If crystallized alum be exposed to a gradual heat, it first becomes fluid by a kind of aqueous fusion, in which its own water of crystallization is the principal agent; the remaining mass, after most of the water has been expelled, grows opake, swells, foams, and at length remains quiet, spongy, and friable. Ignition drives off some of its superabundant acid. The quantity of earthy basis in alum may be determined by precipitation with fixed or volatile alkali. In this way, however, there is a source of inaccuracy arising from the insolubility of the alum, which takes place as soon as its superabundant acid has combined with the alkali. At this period, a portion of the neutral combination of clay and sulphuric acid falls down without further decomposition. Long continued digestion in an alkaline lixivium is necessary to separate the whole of the acid. The volatile alkali is preferable in clearing the base of alum, because it would unite to fixed alkalis. The most commodious method of obtaining pure argillaceous earth consists in precipitating it in this manner from alum.

In this way Bergman found one hundred parts of crystallized alum to contain forty-four of water, eighteen of alumine, and consequently thirty-eight of sulphuric acid and alkali.

Alum is produced, but in a very small quantity, in the native state; and this is mixed with heterogeneous matters. It effloresces in various forms upon ores during calcination, but it seldom occurs crystallized. The greater part of this salt is factitious, being extracted from various minerals called alum ores, such as, 1. Sulphurated clay. This constitutes the purest of all aluminous ores, namely, that of la Tolfa, near Civita Vecchia, in Italy. It is white, compact, and as hard as indurated clay; whence it is called petra aluminaris. It is tasteless and mealy: one hundred parts of this ore contain above forty of sulphur and fifty of clay, a small quantity of potash, and a little iron. Bergman says it contains forty-three of sulphur in one hundred, thirty-five of clay, and twenty-two of siliceous earth. This ore is first torrefied to acidify the sulphur, which then acts on the clay, and forms the alum.

2. The pyritaceous clay, which is found at Schwemsal, in Saxony, at the depth of ten or twelve feet. It is a black and hard, but brittle substance, consisting of clay, pyrites, and bitumen. It is exposed to the air for two years; by which means the pyrites are decomposed, and the alum is formed. The alum ores of Hesse and Liege are of this kind: but they are first torrefied, which is said to be a disadvantageous method.

3. The shistus aluminaris contains a variable proportion of petroleum and pyrites intimately mixed with it. When the last are in a very large quantity, this ore is rejected as containing too much iron. Professor Bergman very properly suggested, that by adding a proportion of clay this ore may turn out advantageously for producing alum. But if the petrol be considerable, it must be torrefied. The mines of Becket in Normandy, and those of Whitby in Yorkshire, are of this species.

4. Volcanic aluminous ores. Such is that of Solfaterra near Naples. It is in the form of a white saline earth, after it has effloresced in the air; or else it is in a stony form.

5. Bituminous alum ore is called shale, and is in the form of a shistus, impregnated with so much oily matter, or bitumen, as to be inflammable. It is found in Sweden, and also in the coal mines at Whitehaven, and elsewhere.

6. Alum might also be extracted from many species of pyrites; but so contaminated with iron, as scarce to pay the expenses of the operation.

The preparation of alum consists in rendering the ores aluminous in the first place, and next in dissolving and purifying the salt. Most of the alum ores contain clay and sulphur, which last requires to be converted into acid before it can form the aluminous combination. For this purpose exposure to the air and occasional watering is effectual, and is in many places used: but it is less expeditious than the conversion of the sulphur into acid by actual combustion. The chief difficulty of this process is, that the sulphur must be gradually and sufficiently burned without expelling it by too great a heat, which would likewise be attended with a fusion of the earthy parts, that would render them capable of resisting the subsequent action of the water. After the ore has been, partly by calcination, and partly by spontaneous efflorescence, reduced to such a state as that it can be made into a paste by the hand, it is fit for boiling, which is usually performed in large leaden caldrons. In many manufactories a cold elixation is performed, until the saline solution is saturated; after which it is boiled until it is sufficiently strong for crystallization. This should not be too much loaded, because otherwise it would begin to deposit crystals by cooling before its earthy impurities had subsided. Some take the floating of a newly laid egg as a token of the boiling being finished; a rough method indeed, as well because the part above the liquor may be very different, and likewise because the specific gravity of eggs soon changes. The specific gravity of a fluid which just prevents a newly laid egg from sinking is about 1·081. When the ore itself does not contain potash, as that of la Tolfa does, it is necessary to add a sufficient portion of this alkali, or of ammonia; to furnish which many use putrid urine. Some of the English manufacturers use a lixivium of the ashes of kelp; but this is a bad practice, as only the potash in these is of any service.

The lixivium, sufficiently concentrated by evaporation, is conveyed through channels into coolers, where, in about an hour, it is freed, by deposition, from the grosser heterogeneous particles; it is then put into either stone or wooden receptacles. In eight or ten days the lixivium, commonly called magistral water, flows into another vessel, leaving behind a number of crystals, generally small and impure, which incrust the bottom and sides of the vessel. These are collected, and washed from the impurities, which adhere externally, with cold water; the impurities remaining in the reservoir after washing are kept by themselves.

The washed crystals are then put into the boiler used for purifying them, and are dissolved in a quantity of water so small as barely to suspend the salt when boiling hot; and sometimes bullock's blood is added to clarify the solution. The alum liquor is then poured into large strong wooden casks, the staves and hoops of which are all numbered, that they may be more readily put together. In these the alum gradually shoots into large crystals about the sides; the liquor in the middle is then let off by a cock in the bottom, and the vessel turned upside down for the more effectual draining of the remaining fluid. Lastly, the crystals are dried in a stove, and packed up in casks for sale.

Chaptal has fabricated alum on a large scale from its component parts. For this purpose he constructed a chamber 91 feet long, 48 wide, and 31 high in the middle. The walls are of common masonry, lined with a pretty thick coating of plaster. The floor is paved with bricks, bedded in a mixture of raw and burnt clay: and this pavement is covered with another, the joints of which overlap those of the first, and instead of mortar the bricks are jointed with a cement of equal parts of pitch, turpentine, and wax, which, after having been boiled till it ceases to swell, is used hot. The roof is of wood, but the beams are very close together, and grooved lengthwise, the intermediate space being filled up by planks fitted into the grooves, so that the whole is put together without a nail. Lastly, the whole of the inside is covered with three or four successive coatings of the cement above mentioned, the first being laid on as hot as possible; and the outside of the wooden roof was varnished in the same manner. The purest and whitest clay being made into a paste with water, and formed into balls half a foot in diameter, these are calcined in a furnace, broken to pieces, and a stratum of the fragments laid on the floor. A due proportion of sulphur is then ignited in the chamber, in the same manner as for the fabrication of sulphuric acid; and the fragments of burnt clay, imbibing this as it forms, begin after a few days to crack and open, and exhibit an efflorescence of sulphat of alumine. When the earth has completely effloresced, it is taken out of the chamber, exposed for some time in an open shed that it may be the more intimately penetrated by the acid, and is then lixiviated and crystallized in the usual manner. The cement answers the purpose of lead on this occasion very effectually, and according to M. Chaptal costs no more than lead would at three farthings a pound.

Curaudau has lately recommended a process for making alum without evaporation. One hundred parts of clay and five of muriat of soda are kneaded into a paste with water, and formed into loaves. With these a reverberatory furnace is filled, and a brisk fire is kept up for two hours. Being powdered, and put into a sound cask, one fourth of their weight of sulphuric acid is poured over them by degrees, stirring the mixture well at each addition. As soon as the muriatic gas is dissipated, a quantity of water equal to the acid is added, and the mixture stirred as before. When the heat is abated, a little more water is poured in, and this is repeated till eight or ten times as much water as there was acid is added. When the whole has settled, the clear liquor is drawn off into leaden vessels, and a quantity of water equal to this liquor is poured on the sediment. The two liquors being mixed, a solution of potash is added to them, the alkali in which is equal to one fourth of the weight of the sulphuric acid. Sulphat of potash may be used, but twice as much of this as of the alkali is necessary. After a certain time the liquor by cooling affords crystals of alum equal to three times the weight of the acid used. It is refined by dissolving it in the smallest possible quantity of boiling water. The residue may be washed with more water, to be employed in lixiviating a fresh portion of the ingredients.

As the mother water still contains alum, with sulphat of iron very much oxided, it is well adapted to the fabrication of Prussian blue. This mode of making alum is particularly advantageous to the manufacturers of Prussian blue, as they may calcine their clay at the same time with their animal matters, without additional expense: they will have no need in this case to add potash; and the presence of iron, instead of being injurious, will be very useful. If they wished to make alum for sale, they might use the solution of sulphat of potash arising from the washing of their Prussian blue, instead of water, to dissolve the combination of alumine and sulphuric acid.

The residuums of distillers of aqua fortis are applicable to the same purposes, as they contain the alumine and potash requisite, and only require to be reduced to powder, sprinkled with sulphuric acid, and lixiviated with water, in the manner directed above. The mother waters of these alums are also useful in the fabrication of Prussian blue. As the residuum of aqua fortis contains an over-proportion of potash, it will be found of advantage to add an eighth of its weight of clay calcined as above.

Alum is used in large quantities in many manufactories. When added to tallow, it renders it harder. Printers' cushions, and the blocks used in the calico manufactory, are rubbed with burnt alum to remove any greasiness, which might prevent the ink or colour from sticking. Wood sufficiently soaked in a solution of alum does not easily take fire; and the same is true of paper impregnated with it, which is fitter to keep gunpowder, as it also excludes moisture. Paper impregnated with alum is useful in whitening silver, and silvering brass without heat. Alum mixed in milk helps the separation of its butter. If added in a very small quantity to turbid water, in a few minutes it renders it perfectly limpid, without any bad taste or quality; while the sulphuric acid imparts to it a very sensible acidity, and does not precipitate so soon, or so well, the opake earthy mixtures that render it turbid, as I have often tried. It is used in making pyrophorus, in tanning, and many other manufactories, particularly in the art of dyeing, in which it is of the greatest and most important use, by cleansing and opening the pores on the surface of the substance to be dyed, rendering it fit for receiving the colouring particles (by which the alum is generally decomposed), and at the same time making the colour fixed. Alum constitutes the basis of crayons, which generally consist of the earth of alum, finely powdered, and tinged for the purpose. In medicine it is employed as an astringent, and when calcined as an escharotic.

Alum is prepared in England, and many other parts of the world, and was formerly distinguished by various names. The rock alum is supposed to derive its name from an ancient city in Syria, called Roccho, at present Edessa, where one of the earliest manufactories was carried on. The Roman alum has been considered as the best sort. It has a rosy tinge, which arises from about 1-20th of its weight of a rose-coloured earth, the nature of which was not ascertained by Bergman, though he found that the goodness of the alum does not depend upon it. This alum is not preferred to other good alum by our manufacturers. Plume alum is a name given to two very different substances. The one appears to be true alum produced by the desiccation of aluminous waters, which transude through grottoes and caverns, and leave this salt behind in feathery crystals. This is seldom met with. The other substance to which this name has been given is the fibrous asbestos, which contains no alum; but from half to three fourths of its weight of silex, from one eighth to one third of carbonat of magnesia, and the rest lime, with a minute proportion of clay, and sometimes iron.

M. Vauquelin has lately instituted a set of experiments to ascertain the differences between various kinds of alums, and according to him they are very trifling, notwithstanding the Roman is double the price of the French. It is true the Roman is most free from iron, but none contained more than ·003; the Roman contained no ammonia, the English rather the most; and in the rose coloured earth of the Roman a little nickel was found. The proportions of the component parts of alum he gives are; alumine 10·50, sulphuric acid 30·52, potash 10·40, water 48·58. We must observe, however, that it appears to have been his object, to prove to the French manufacturers, that the alum of their own country is equal in quality to the English, which, next to the Roman, they decidedly prefer. To get rid of the last portions of iron he recommends, either to disturb the lixivium in the first crystallization, or precipitate it by the addition of a small quantity of prussiat of potash: Clement and Desormes calcine and crystallize it, but this deprives it of part of the superabundant acid. Thenard and Roard affirm, that a thousandth part of iron influences the effect of alum in dyeing.

Alumine. See Earths.

Aluta montana. This is one of the names of the coriaceous asbestos, or mountain cork. It is easily distinguished by its elasticity and lightness, for it floats a long time on water. Its colour is either white, yellow, brown, green, or black; and its texture resembles those substances from which it has received its names: 100 parts of it contain from 56 to 62 of silex; from 22 to 26 of carbonat of magnesia; from 10 to 12 of carbonat of lime; from 2 to 2·8 of alumine; and about 3 of iron.

Amalgam. This name is applied to the combinations or mixtures of mercury with other metallic substances. As this metal is so exceedingly fusible as to be always in the fluid state in climates of a moderate temperature, it unites with many of the metals, without any greater heat than that which it usually possesses. For this purpose, therefore, nothing more is necessary, than to triturate thin leaves, or plates, or filings of the metallic substance with mercury. In other instances, where the disposition to combine is less powerful, it is found necessary either to fuse or ignite the metal intended to be amalgamated. When a small quantity of mercury is combined with any metal, it renders it brittle, or rather friable; a greater quantity of mercury produces a kind of imperfect fluidity resembling that of butter. This is commonly called the consistence of an amalgam. A still greater quantity of mercury renders the mass more fluid, but not uniformly so; for a portion of the amalgam either floats at the top, or sinks to the bottom, instead of intimately combining with the whole of the mercury. This fact is of the same kind as that wherein salts are soluble in water in limited quantities, beyond which they cease to be taken up. Mercury very readily combines with gold, silver, lead, tin, bismuth, and zinc. In making an amalgam of gold or silver, the clippings of the leaves from the gold-beaters may be used, or thin plates of the metals may be ignited, and plunged in mercury previously heated, so as to smoke. When the quantity of mercury is so large as to be fluid when cold, the superfluous mercury may be strained off by pressure through a leathern bag. The remaining amalgam of gold contains about one third of its weight of mercury, but is perfectly white. The amalgam of silver sinks in mercury, and consequently is heavier than either mercury or silver. Equal parts of lead and mercury, and of bismuth and mercury, form solid amalgams; but if these be mixed together, they become fluid; and after this fluid has stood a few days in a temperature not exceeding 40° F., cubic crystals of nearly pure bismuth will be formed in it.

Mercury unites with difficulty into an amalgam with copper and arsenic; and scarcely at all with platina, or with iron. This latter metal, however, does not absolutely refuse to combine with mercury, for it adheres to, and coats the ends of iron pestles used for the trituration of amalgams; and Dr. Lewis has observed, that a plate of tough iron is rendered brittle by keeping it immersed in mercury for some days; a fact which has been experienced in another way by M. de Luc, who found that springs immersed under mercury, in the construction of a barometer, were rendered brittle and useless by its action. Iron ignited to a white heat, and thrown into a large mass of mercury, becomes completely covered with a ferruginous bright amalgam. Mr. Arthur Aikin has formed an amalgam of iron by uniting an amalgam of zinc with iron filings, and adding muriat of iron, the acid of which combines with the zinc, which may thus be separated. Antimony unites with mercury, though with great difficulty. Nickel, cobalt, rhodium, and manganese, are said to unite with mercury; and its action on tungsten, chrome, molybdena, and some of the other metals, is not known.

Amalgams are applied to a considerable number of useful purposes. The amalgam of gold is used in the process called water gilding, in which the mercury first serves as the medium of adhesion between the gold and copper, and is afterward driven off by heat. See Gilding. Looking-glasses are silvered by an amalgam of tin. See Silvering. The amalgam of zinc, triturated with tallow, is found to assist the excitation or production of electricity, by the friction of a cushion against glass, in a wonderful degree; insomuch that the quantity of electricity is 20 or 30 times as great as without it.

When mercury is contaminated with any imperfect metal, it is found, that by agitation, in contact with oxigen gas, or the air of the atmosphere, the imperfect metal becomes converted into a black powdery calx, which separates from the mercury.

Amandola. This is a green marble, having the appearance of a honey-comb; and containing white spots: 100 parts of it contain 76 of carbonat of lime; 20 of shistus; 2 of iron, partly calcined. The cellular appearance proceeds from the shistus.

Amber is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semitransparent or opake, and of a glossy surface: it is found of all colours, but chiefly yellow or orange, and often contains leaves or insects; its specific gravity is from 1·065 to 1·100; its fracture is even, smooth, and glossy; it is capable of a fine polish, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable smell, particularly when it melts, that is at 550° of Fahrenheit; but it then loses its transparency; projected on burning coals, it burns with a whitish flame, and a whitish yellow smoke, but gives very little soot, and leaves brownish ashes; it is insoluble in water and alcohol, though the latter, when highly rectified, extracts a reddish colour from it; but it is soluble in the sulphuric acid, which then acquires a reddish purple colour, and is precipitable from it by water; no other acid dissolves it, nor is it soluble in essential or expressed oils, without some decomposition and long digestion; but pure alkali dissolves it. By distillation it affords a small quantity of water, with a little acetous acid, an oil, and a peculiar acid. See Acid (Succinic). The oil rises at first colourless; but, as the heat increases, becomes brown, thick, and empyreumatic. The oil may be rectified by successive distillations: or it may be obtained very light and limpid at once, if it be put into a glass alembic with water, as the elder Rouelle directs, and distilled at a heat not greater than 212° F. It requires to be kept in stone bottles, however, to retain this state; for in glass vessels it becomes brown by the action of light.

Amber is met with plentifully in regular mines in some parts of Prussia. The upper surface is composed of sand, under which is a stratum of loam, and under this a bed of wood partly entire, but chiefly mouldered or changed into a bituminous substance. Under the wood is a stratum of sulphuric or rather aluminous mineral, in which the amber is found. Strong sulphureous exhalations are often perceived in the pits.

Amber having been formerly considered as a valuable substance, and the specimens, which are large, or contain entire or perfect insects within them, being still of considerable price, the methods of softening it so as to introduce these extraneous bodies, or of uniting smaller pieces together, have been kept as profitable secrets, if it be true that they ever were discovered. It is said, that two pieces of this substance may be united by wetting them with the solution of potash (called oil of tartar), and applying them together with heat; and Wallerius mentions, that pieces of yellow amber may be softened, formed into one, and even dissolved, by means of oil of turnip-seed, in a gentle heat; and that, according to some authors, it may be rendered transparent by boiling in rapeseed oil, linseed oil, salt water, &c. Neumann, however, denies that either salt water or linseed oil produces this effect; though he states, as the common practices of workmen, the following methods: the one consists in surrounding the amber with sand in an iron pot, and cementing it with a gradual fire for forty hours, some small pieces placed near the sides of the vessel being occasionally taken out for judging of the effect of the operation: the second method, which he says is that most generally practised, is by digesting and boiling the amber about twenty hours with rapeseed oil, by which it is rendered both clear and hard.

Both the oil and powder of amber were formerly used in medicine, but are now disregarded. The oil, however, is used for making *eau de luce*; one dram being added to two ounces of alcohol, in which six grains of white soap have been dissolved, and this solution being well shaken with eight ounces of water of pure ammonia, so as to form a milky liquid. Dr. Hopson directs as much as eight scruples of soap to this quantity of the other ingredients; and the proportions are varied by different chemists. In France, the acid liquor that comes over has been made into a sirup, with the addition of opium, and much vaunted, under the name of *sirup of amber*.

Amber is also used in varnishes. See Varnish.

Ambergris is found in the sea, near the coasts of various tropical countries; and has also been taken out of the intestines of the physeter macrocephalus, the spermaceti whale. As it has not been found in any whales but such as are dead or sick, its production is generally supposed to be owing to disease, though some have a little too peremptorily affirmed it to be the cause of the morbid affection. As no large piece has ever been found without a greater or less quantity of the beaks of the sepia octopodia, the common food of the spermaceti whale, interspersed throughout its substance, there can be little doubt of its originating in the intestines of the whale; for if it were occasionally swallowed by it only, and then caused disease, it must much more frequently be found without these, when it is met with floating in the sea, or thrown upon the shore.

Ambergris is found of various sizes; generally in small fragments, but sometimes so large as to weigh near two hundred pounds. When taken from the whale it is not so hard as it becomes afterward, on exposure to the air. Its specific gravity ranges from 780 to 926. If good, it adheres like wax to the edge of a knife with which it is scraped, retains the impression of the teeth or nails, and emits a fat odoriferous liquid on being penetrated with a hot needle. It is generally brittle; but, on rubbing it with the nail, it becomes smooth like hard soap. Its colour is either white, black, ash-coloured, yellow, or blackish; or it is variegated; namely, gray with black specks, or gray with yellow specks. Its smell is peculiar, and not easy to be counterfeited. At 144° it melts; and, at 212°, is volatilized in the form of a white vapour. But, on a red-hot coal, it burns, and is entirely dissipated. Water has no action on it: acids act feebly on it: alkalis combine with it, and form a soap: ether and the volatile oils dissolve it: so do the fixed oils, and also ammonia, when assisted by heat: alcohol dissolves a portion of it, and is of great use in analysing it, by separating its constituent parts. According to Bouillon la Grange, who has given the latest analysis of it, 3820 parts of ambergris consist of adipocere 2016 parts, a resinous substance 1167, benzoic acid 425, and coal 212.

It has occasionally been employed in medicine, but its use is now confined to the perfumer. Dr. Swediaur took thirty grains of it without perceiving any sensible effect. A sailor, who took half an ounce of it, found it a good purgative.

Mr. Magellan mentions an undoubtedly vegetable ambergris gathered from a tree which grows in Guyana, and is called Cuma. Specimens of this were presented to him by M. Aublet, author of the Histoire de la Guyane, published in 1774, who himself collected it on the spot; and Mr. Magellan presented part of it to the late Dr. Fothergill, and also to Dr. Combe. It was of a whitish brown colour, with a yellowish shade; melted and burned like wax on the fire, but was rather of a more powdery consistence than any other ambergris he had seen.

Amer. This name has been given to a principle supposed to occasion the bitter taste of certain vegetables, and to be distinguished by peculiar properties. It may be obtained from several plants by infusion for some time in cold water. Its characters, as originally described by Welther, and since examined by Dr. Thomson, are thus given: If water, impregnated with this principle, be evaporated gently to dryness, it leaves a brownish yellow substance, which retains a certain degree of transparency, continues for some time ductile, but at length becomes brittle. Its taste is intensely bitter. When heated, it softens, swells, grows black, burns away without much flame, and leaves a small quantity of ashes. It is very soluble both in water and alcohol. It does not affect blue vegetable colours. It is not precipitated by the waters of lime, barytes, or strontian; and is not changed by alkalis. Neither the tincture, infusion, nor pure acid of galls has any effect on it. Nitrat of silver, and acetit of lead, are the only metallic salts that precipitate it; and as the acetit of lead produces with it a copious precipitate, this is the best test for discovering the bitter principle, when no other substance that will decompose the acetit is present.

In Mr. Hatchett's experiments on the formation of tan by the action of nitric acid on different substances, the bitter principle appears to have been formed, along with tan, from indigo and some others.—*Henry*.

Amethyst. The amethyst is a gem of a violet colour and great brilliancy, said to be as hard as the ruby or sapphire, from which it only differs in colour. This is called the oriental amethyst, and is very rare. When it inclines to the purple or rosy colour, it is more esteemed than when it is nearer to the blue. These amethysts have the same figure, hardness, specific gravity, and other qualities, as the best sapphires or rubies, and come from the same places, particularly from Persia, Arabia, Armenia, and the West Indies. The occidental amethysts are merely coloured crystals or quartz.

Amianthus, Mountain Flax. This fossil is commonly of a grayish or greenish white, somewhat greasy to the feel, and of a fibrous texture. It breaks into long splintery fragments, and its fibres are sufficiently flexible to be made into cloth. It is often confounded with asbestos, from which it differs, chiefly in being more fusible, in being less acted upon by acids, and in its fibres being commonly more flexible. See Asbestos.

Ammonia. This alkali, commonly distinguished by the epithet *volatile*, on account of its tendency to assume the form of gas, in which only it can be obtained unmixed, may be procured by the destructive distillation of all animal substances that have not undergone spontaneous decomposition, as well as from some plants, chiefly the fungi, and those of the cruciform kind. Putrefaction likewise disengages it from these substances. It appears to be a compound of azot and hidrogen. See Gas (Ammoniacal).

For use, it is generally kept in a liquid form, in which it is usually obtained in large manufactories from refuse bones, and the pith of horns, the residuum of which is afterward made into bone black, or, by calcining to whiteness, into burnt bone, or burnt hartshorn. Urine likewise, and other refuse animal matters, are used for the same purpose. The ammonia at first is greatly contaminated by the animal oil that rises with it; and after it is freed from great part of this, by re-distilling it once or twice, it is commonly sold by the name of *spirit of hartshorn*. The apparatus employed consists of a large iron pot, to which a head is affixed, with its worm refrigeratory and receiver. It is said, that, if no lute be employed, five times as much ammonia may be procured, as when the parts of the apparatus are closely luted together; owing, probably, to the absorption of nitrogen from the atmosphere.

The volatile alkali thus obtained, however, is rendered in some degree mild by the presence of carbonic acid, from which it may be freed, as well as from the animal oil, by adding a little lime, and rectifying it with a gentle fire.

If to this alkali be added, in due quantities, first diluted sulphuric acid, and afterward muriate of soda, the soda takes the sulphuric acid from the ammonia with which it had united, and the ammonia combines with the muriatic acid. Thus sulphat of soda and muriat of ammonia are formed, and may be separated by evaporation and crystallization. The muriat commonly called *sal ammoniac*, is sublimed into cakes for sale. The greater part, if not the whole of this salt, which was formerly imported from Egypt, is now thus made here for home consumption.

Messrs. Minish have, for many years, used the preceding process, with the improvement of substituting the sulphat of lime or plaster of Paris instead of sulphuric acid. In this case the products are chalk, sulphat of soda, and sal ammoniac, or muriat of ammonia.

It has likewise been manufactured by Dr. H. Campbell, by adding sulphat of magnesia to muriat of soda, and adding carbonat of ammonia to the muriat of magnesia thus formed; so that the products obtained were muriat of ammonia, sulphat of soda, and carbonat of magnesia.

From this muriat the purest ammonia may be obtained. Mix two parts of powdered and sifted lime with one of muriat of ammonia, and put them into a retort, the neck of which is to be luted to a tubulated receiver, with slips of moistened bladder, bound round with pack-thread. From the other opening of the receiver a right-angled tube, with Welter's addition, is to proceed, and terminate in a bottle with two necks. This bottle should contain a quantity of water, equal in weight to one fourth of the muriat of ammonia, and the aperture of the tube should be beneath the surface of the water. A second right-angled tube should connect this with a similar bottle, containing a like quantity of water. By applying heat to the retort, a decomposition will take place, and the ammoniacal gas will be absorbed by the water in the bottles, which should be surrounded with snow or pounded ice.

It may be made also, by adding the muriat dissolved in six parts of water, to the quicklime previously slacked in an equal weight of water, and then distilling off one part of the liquid; but the former process is preferable.

Ammonia may be combined with sulphur by mixing together two parts of muriat of ammonia, two of lime, and one of sulphur, and distilling in the pneumatic apparatus, with a small quantity of water in the receiver. A yellow liquor is obtained, containing sulphuret of ammonia, formerly known by the name of Boyle's fuming liquor. With fat oils it forms soaps. It has a striking property of forming fulminating precipitates, and of reducing the oxides of several metals, either wholly or partially, to the metallic state. When in excess, it redissolves most of the oxides it had before thrown down. It dissolves a small portion of alumine.

As a test it is of very extensive use. In medicine it is seldom employed pure, on account of its causticity, except externally combined with twice or thrice its quantity of oil, which makes the *linimentum ammoniæ*, or *volatile liniment*, prescribed as a stimulant and discutient. Greatly diluted with water, however, it is recommended internally against the effects of the bites of serpents; as it is in doses of a few drops, in as much water as will allow it to be swallowed with ease, in some cases of debility of the stomach, where a stimulant of speedy effect is required.

As the quality of pure ammonia in a liquid form depends on its strength, this is best known by its specific gravity, which, when the water is saturated, should be about 0·905, at 60° F. The following table, drawn up by Mr. Davy, exhibits the proportion of water and ammonia contained in 100 parts of liquid ammonia of different specific gravities.

Specific Gravity.	Ammonia.	Water.
0·9054	25·37	74·63
0·9166	22·07	77·98
0·9255	19·54	80·46
0·9326	17·52	82·48
0·9385	15·88	84·12
0·9435	14·53	85·47
0·9476	13·46	86·54
0·9513	12·40	87·60
0·9545	11·56	88·44
0·9573	10·82	89·18
0·9597	10·17	89·83
0·9619	9·60	90·40
0·9631	9·50	90·50
0·9639	9·09	90·91
0·9713	7·17	92·83

If any carbonic acid be present with it, this may be detected by its precipitating a solution of muriat of lime.

The *spirit of hartshorn* is sometimes adulterated by mixing with it the water of pure ammonia, to increase the pungency of its smell, and enable it to bear an addition of water. This may be detected by adding alcohol; for if no considerable coagulation ensue, the adulteration is proved. It may also be discovered by the usual effervescence not happening with acids. Its specific gravity should be about 1·5.

Ammoniac (Gum). This is a gum resin, from an ounce of which six drams may be dissolved in ardent spirit, or six drams two scruples and a half by water, according to Neumann.

Ammonites. These petrifactions, which have likewise been distinguished by the name of cornu ammonis, and are called *snakestones* by the vulgar, consist chiefly of lime-stone. They are found of all sizes, from the breadth of half an inch to more than two feet in diameter; some of them rounded, others greatly compressed, and lodged in different strata of stones and clays. They appear to owe their origin to shells of the nautilus kind.

Amomum. See Pimento.

Ampelites. A solid, dry, hard, opake, black fossil coal, not fusible, but easily inflammable, and burning with a bright vivid white flame, with much smoke, and a bituminous or pitchy smell. In the north of England it is called cannel coal, perhaps by corruption, instead of candle coal, as it is used to supply the place of candles in poor families. An alum ore found in Burgundy, and consisting of clay, pyrites, and bitumen, is also distinguished by this name.

Amygdaloides, or **Mandel-stein.** A stone of the siliceous genus, which consists of a martial jasper, in which elliptical kernels of calcareous spar and serpentine stone are included.

Anacardium, Cashew Nut, or Marking Nut. At one extremity of the fruit of the cashew tree is a flattish kidney-shaped nut, between the rind of which and the thin outer shell is a small quantity of a red, thickish, inflammable, and very caustic liquor. This liquor forms a useful marking ink, as any thing written on linen or cotton with it is of a brown colour, which gradually grows blacker, and is very durable.

Analysis. Chemical analysis consists of a great variety of operations performed for the purpose of separating the component parts of bodies. In these operations, the most extensive knowledge of such properties of bodies as are already discovered must be applied, in order to produce simplicity of effect, and certainty in the results. Chemical analysis can hardly be executed with success by one who is not in possession of a considerable number of simple substances in a state of great purity, many of which, from their effects, are called reagents. The word analysis is applied by chemists to denote that series of operations, by which the component parts of bodies are determined, whether they be merely separated, or exhibited apart from each other; or whether these distinctive properties be exhibited by causing them to enter into new combinations, without the perceptible intervention of a separate state. The forming of new combinations is called synthesis; and, in the chemical examination of bodies, analysis or separation can scarcely ever be effected, without synthesis taking place at the same time.

As most of the improvements in the science of chemistry consist in bringing the art of analysis nearer to perfection, it is not easy to give any other rule to the learner, than the general one of consulting and remarking the processes of the best chemists, such as Scheele, Bergman, Berthollet, Kirwan, and others. The bodies which present themselves more frequently for examination than others, are minerals and mineral waters. In the examination of the former, it was the habit of the earlier chemists to avail themselves of the action of fire, with very few humid processes, which are such as might be performed in the usual temperature of the atmosphere. Modern chemists have improved the process by fire, by a very extensive use of the blow-pipe (see Blowpipe); and have succeeded in determining the component parts of minerals to great accuracy in the humid way. For the method of analysing mineral waters, see Waters (Mineral); and for the analysis of metallic ores, see Ores.

Several authors have written on the examination of earths and stones: the following is the method of Mr Kirwan:

When earths, or pulverulent mineral substances, are well dried, and separated from every visible heterogeneous substance, a portion of them should be weighed, and distilled in a glass retort until the bottom begins to grow red hot. In some cases it may be proper to receive the air that arises in a pneumatic apparatus; and in all it will be proper to examine what distils over or sublimes, whether it be acid or alkaline, with paper tinged blue by litmus, and part of its surface reddened by distilled vinegar. If the blue be reddened, an acid exists in the distilled liquid; if the red be effaced, and the blue restored, a volatile alkali is the cause of it; if the liquor precipitate lime-water, but does not precipitate a solution of nitrat of lime, then it contains carbonic acid; if it precipitate also nitrat of lime, it contains the sulphuric acid; if it contain the muriatic acid, it will not precipitate nitrat of lime, but it will nitrat of silver. The loss of weight of the residuum in the retort, and the weight of water in the receiver, will show the proportion of the volatile ingredients.

Another portion of the earth to be examined should be digested in about six or eight times its weight of pure water, and the properties of that water examined, to find whether the earth contain neutral salts. See Waters (Mineral).

The first step in the examination of consistent earths or stones is somewhat different from that of such as are pulverulent. Their specific gravity should first be examined; also their hardness, whether they will strike fire with steel, or can be scratched by the nail, or only by crystal, or stones of still greater hardness; also their texture, perviousness to light, and whether they be manifestly homogeneous or compound species, &c.

2d. In some cases, we should try whether they imbibe water, or whether water can extract any thing from them by ebullition or digestion.

3d. Whether they be soluble in, or effervesce with, acids, before or after pulverization; or whether decomposable by boiling in a strong solution of potash, &c., as gypsums and ponderous spars are.

4th. Whether they detonate with nitre.

5th. Whether they yield the fluor acid by distillation with sulphuric acid, or ammonia by distilling them with potash.

6th. Whether they be fusible per se with a blowpipe, and how they are affected by soda, borax, and microcosmic salt; and whether they decrepitate when gradually heated.

7th. Stones that melt per se with the blowpipe are certainly compound, and contain at least three species of earth, of which the calcareous is probably one; and if they give fire with steel, the siliceous is probably another.

The best general solvent for stones or earths appears to be aqua regia, composed of two parts nitric and one of muriatic acid: if the stone or earth effervesce strongly with acids, no other preparation is requisite, than a separation of such parts as are visibly heterogeneous, and pulverization; the solution is then easily performed in a digesting heat, if requisite. The undissolved residuum, if purely siliceous, will melt into a transparent glass with about ½ its weight of soda; if not, it is still compounded, and its soluble parts will yield to a reiterated digestion.

If the stone do not effervesce, or easily dissolve in acids after pulverization and digestion, but leaves an insoluble residuum evidently compound, or but slightly altered, it will require to be pulverized, and mixed with twice or thrice its weight of soda, and to be exposed to a low red heat for one or two hours. Mica was found to require a mixture of 4 times its weight of soda; after which it is to be separated from the alkali by lixiviation and filtration, washing it with distilled water until the water is absolutely tasteless, and precipitates no metallic solution.

The powdered stone, thus edulcorated, is to be dried by heating it to redness, and then weighed, and 100 grains taken for subsequent experiments: it were better if still more were used, but the analysis would be more expensive.

The powder is next to be digested in 8 or ten times its weight of aqua regia, in a boiling heat, in a retort to which a receiver is luted, and the digestion reiterated as long as any thing appears to be dissolved by fresh portions of the acid. Mica was found to require 50 times its weight of aqua regia before it was entirely decomposed, as the acid is so volatile as very soon to distil over. Sulphuric acid has the advantage of bearing a greater heat, dissolving sulphat of barytes, and of acting more powerfully on clay than aqua regia; but a large retort must be used, for often towards the end it puffs and throws up the earth or stone, and carries it into the receiver; besides, it does not sufficiently act on calces of iron, if these be much oxided. Nitric acid affects them still less: hence Mr. Kirwan often uses the sulphuric first; then what has been dissolved he precipitates by an alkaline carbonat, and redissolves the precipitate in aqua regia. A perfect solution being thus effected, the residuum is to be well washed, and the washings added to the solution: the residuum well dried and weighed, gives the weight of siliceous earth in the compound.

The solution is next to be examined; which we will suppose to contain the four soluble earths, lime, magnesia, barytes, and alumine; and also an oxide of iron. It always contains an excess of acid, of which it is in great measure deprived by boiling for a considerable time, as both acids are very volatile; and indeed of the muriatic none remains but what is combined with the oxide of iron, as the nitric chases it from the earths. By getting rid of this excess of acid, less alkali will be required for the succeeding precipitation, and less carbonic acid set loose, which would retain much of the precipitate by redissolving it: the solution should then be evaporated to about half a pint.

The solution being thus prepared, it is usual to precipitate the calx of iron from it by the prussiat of potash; but to this method Mr. Kirwan has two objections: 1st. that the barytes, if any, would also be precipitated and confounded in the Prussian blue; and, 2d. that this precipitation, beside being exceeding slow, seldom fails of leaving some iron still in the solution, as the excess of the prussiat of potash, which must necessarily be added to be certain that all the iron is precipitated, never fails to redissolve a portion of the Prussian blue, which thus remains in the liquor, and cannot be got rid of. Hence the method he uses is as follows: First, he prepares the prussiat of potash after the manner of Mr. Bergman, by digesting and boiling a pure alkaline solution over Prussian blue, until the alkali no longer effervesces with acids, or precipitates a solution of nitrat of lime, or any other earth, except barytes: he even makes it a little stronger; for if it be barely saturated with the prussic acid, it soon spoils, and precipitates other earths; the prussic acid evaporating. He next examines how much of this alkali is necessary to precipitate one grain of iron from its solution in dilute sulphuric or muriatic acid, and marks this on the label of the bottle that contains the alkali. Next follows the application.

The solution of the earths being weighed, take 100 grains of it, and on these gradually pour the prussiat of potash (a portion of which is also previously weighed), until all the iron, or barytes and iron, is precipitated; the weight of the alkali used gives that of the iron contained in 100 grains of the solution, and the quantity contained in 100 grains of the solution gives that contained in the whole solution, by the rule of proportion, from which the barytes, if any be found in subsequent experiments, is to be deducted.

The quantity of iron being thus found, the remainder of the solution is to be precipitated by the subcarbonat of soda, and then boiled for half an hour, to expel as much as possible of the carbonic acid; by this means the whole of its contents are precipitated, and nothing remains in solution but nitrat of soda and a little common salt: when the precipitate has settled, after one or two days rest, the liquor is to be poured off, and the last portions taken up with a glass syringe. Distilled water is then to be added to the precipitate, and boiled over it, and afterward poured off and taken up, until it comes off tasteless.

The precipitate, being sufficiently dried, is to be redissolved in nitric acid twice, and evaporated to dryness; then calcined for one hour in a white heat; and, lastly, treated with about six or eight times its weight of distilled vinegar, in a heat of about 60 degrees, for one or two hours: by this means the barytic, calcareous, and magnesian earths will be extracted and separated from the clay and oxide of iron, which will remain undissolved.

Of this acetous solution 100 grains should be taken and examined with the prussiat of potash: if any part be precipitated it is barytes, and by heating this to redness its weight may be known; or still better, by a previous experiment determining the quantity requisite to precipitate one grain of acetit of barytes, and, by the rule of proportion, the quantity of it in the whole solution may be found.

The remainder of the acetous solution is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water: the lime (if any) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve one grain, so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed; its weight gives that of the pure lime, from which that of the barytes (if any) is to be deducted: the lime-water may also be precipitated by an alkaline carbonat.

Lastly, the clay, and oxide of iron, which remained undissolved by the acetous acid, are to be heated slightly, to prevent their cohering, and reiteratedly boiled in nitric acid to dryness, and finally dissolved in that acid, which will then take up only the alumine, which may be precipitated, dried, and weighed; though indeed this troublesome operation may be unnecessary, as the weight of the martial part being known by the experiment with the prussiat of potash, that of the alumine is known of course when only the two remain. This is even better, as the oxide always increases in weight by these operations.

Beside this general method, some others may be used in particular cases.

Thus, to discover a small proportion of alumine or magnesia in a solution of a large quantity of lime, pure ammonia may be applied, which will precipitate the alumine or magnesia (if any be), but not the lime. Distilled vinegar applied to the precipitate will discover whether it be alumine or magnesia.

2dly. A minute portion of lime or barytes, in a solution of alumine or magnesia, may be discovered by the sulphuric acid, which precipitates the lime and barytes: the solution should be dilute, else the alumine also would be precipitated. If there be not an excess of acid, the oxalic acid is still a nicer test of lime: 100 grains of gypsum contain about 32 of lime: 100 grains of sulphat of barytes contain 67 of barytes; 100 grains of oxalat of lime contain 45 of lime. The insolubility of sulphat of barytes in 500 times its weight of boiling water sufficiently distinguishes it. From these data the quantities are easily investigated.

3dly. A minute proportion of alumine in a large quantity of magnesia may be discovered, either by precipitating the whole, and treating it with distilled vinegar; or by heating the solution nearly to ebullition, and adding more carbonat of magnesia, until the solution is perfectly neutral, which it never is when alumine is contained in it, as this requires an excess of acid to keep it in solution. By these means the alumine is precipitated in the state of embryon alum, which contains about half its weight of alumine (or for greater exactness it may be decomposed by boiling it in volatile alkali). After the precipitation the solution should be largely diluted, as the sulphat of magnesia, which remained in solution while hot, would precipitate when cold, and mix with the embryon alum.

4thly. A minute portion of magnesia in a large quantity of alumine is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

Lastly, Lime and barytes are separated either by precipitating the barytes by the prussiat of potash, or the lime by a caustic fixed alkali; or by precipitating both with the sulphuric acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with 500 times its weight of boiling water; what remains undissolved is sulphat of barytes.

But many refractory stones require in the first instance to be resolved by means of alkalis. For this purpose the common subcarbonat was usually employed, till Klaproth showed the alkali itself to be preferable. The stone, being reduced to an impalpable powder, and mixed with three times its weight of potash and a portion of water, is commonly set over the fire in a silver or platina crucible, and after the water is evaporated, kept for some hours at a red heat, after which it is lixiviated and tested with various reagents. Vauquelin indeed exposes the powdered stone and potash dry to a heat sufficient to convert it to a frit. The inconveniences of employing so great a heat, however, are obvious, and Mr. Lowitz informs us, that they may be avoided without the least disadvantage. Over the flame of a spirit lamp, that will hold an ounce and half, and is placed in a cylindrical tin furnace four inches high and three in diameter, with air-holes, and a cover perforated to hold the crucible, he boils the stone prepared as directed above, stirring it frequently. His crucible, which, as well as the spatula, is of very fine silver, holds two ounces and half, or three ounces. As soon as the matter is boiled dry, he pours in as much hot water as he used at first; and this he repeats two or three times more, if the refractoriness of the fossil require it. Large tough bubbles arising during the boiling are in general a sign that the process will be attended with success. Even the sapphire, though the most refractory of all Mr. Lowitz tried, was not more so in this than in the dry way.

Mr. Davy observes, that the boracic acid is very useful in analysing stones that contain a fixed alkali; as its attraction for the different earths at the heat of ignition is considerable, and the compounds it forms with them are easily decomposed by the mineral acids dissolved in water. His process is as follows: Let 100 grains of the stone to be examined be reduced to a fine powder, mixed with 200 grains of boracic acid, and fused for about half an hour at a strong red heat in a crucible of platina or silver. Digest the fused mass in an ounce and half of nitric acid diluted with seven or eight times the quantity of water, till the whole is decomposed; and then evaporate the solution till it is reduced to an ounce and half, or two ounces. If the stone contained silex, it will separate in this process, and must be collected on a filter, and edulcorated with distilled water, to separate the saline matter. The fluid, mixed with all the water that has been passed through the filter, being evaporated till reduced to about half a pint, is to be saturated with carbonat of ammonia, and boiled with an excess of this salt, till all that will precipitate has fallen down. The earths and metallic oxides being separated by filtration, mix nitric acid with the clear fluid till it has a strongly sour taste, and then evaporate till the boracic acid remains free. Filter the fluid, evaporate it to dryness, and expose it to a heat of 450° F., when the nitrat of ammonia will be decomposed, and the nitrat of potash or soda will remain in the vessel. The earths and metallic oxides, that remained on the filter, may be distinguished by the common processes. The alumine may be separated by solution of potash, the lime by sulphuric acid, the oxide of iron by succinat of ammonia, the manganese by hidrosulphuret of potash, and the magnesia by pure soda.

Under the head of mineral analysis nothing is of so much general importance as the examination of soils, with a view to the improvement of such as are less productive, by supplying the ingredients they want in due proportions to increase their fertility. To lord Dundonald and Mr. Kirwan we are much indebted for their labours in this field of inquiry; but Mr. Davy, assisted by the labours of these gentlemen, the facts and observations of Mr. Young, and his own skill in chemistry, having given at large, in a manner best adapted for the use of the practical farmer, an account of the methods to be pursued for this purpose, we shall here copy them.

The substances found in soils are certain mixtures or combinations of some of the primitive earths, animal and vegetable matter in a decomposing state, certain saline compounds, and the oxide of iron. These bodies always retain water, and exist in very different proportions in different lands, and the end of analytical experiments is the detection of their quantities and mode of union.

The earths commonly found in soils are principally silex, or the earth of flints; alumine, or the pure matter of clay; lime, or calcareous earth; and magnesia: for the characters of which see EARTHS. Silex composes a considerable part of hard gravelly soils, hard sandy soils, and hard stony lands. Alumine abounds most in clayey soils, and clayey loams; but even in the smallest particles of these soils it is generally united with silex and oxide of iron. Lime always exists in soils in a state of combination, and chiefly with carbonic acid, when it is called carbonat of lime. This carbonat in its hardest state is marble; in its softest, chalk. Lime united with sulphuric acid is sulphat of lime, or gypsum; with phosphoric acid, phosphat of lime, or the earth of bones. Carbonat of lime, mixed with other substances, composes chalky soils and marles, and is found in soft sandy soils. Magnesia is rarely found in soils: when it is, it is combined with carbonic acid, or with silex and alumine. Animal decomposing matter exists in different states, contains much carbonaceous substance, volatile alkali, inflammable aëriform products, and carbonic acid. It is found chiefly in lands lately manured. Vegetable decomposing matter usually contains still more carbonaceous substance, and differs from the preceding principally in not producing volatile alkali. It forms a great proportion of all peats, abounds in rich mould, and is found in larger or smaller quantities in all lands. The saline compounds are few, and in small quantity: they are chiefly muriat of soda, or common salt, sulphat of magnesia, muriat and sulphat of potash, nitrat of lime, and the mild alkalis. Oxide of iron, which is the same with the rust produced by exposing iron to air and water, is found in all soils, but most abundantly in red and yellow clays, and red and yellow siliceous sands.

The instruments requisite for the analysis of soils are few. A pair of scales capable of holding a quarter of a pound of common soil, and turning with a single grain when loaded: a set of weights, from a quarter of a pound troy to a grain: a wire sieve, coarse enough to let a peppercorn pass through: an Argand lamp and stand: a few glass bottles, Hessian crucibles, and china or queen's ware evaporating basins: a Wedgwood pestle and mortar: some filters made of half a sheet of blotting paper, folded so as to contain a pint of liquid, and greased at the edges: a bone knife: and an apparatus for collecting and measuring aëriform fluids.

The reagents necessary are muriatic acid, sulphuric acid, pure volatile alkali dissolved in water, solution of prussiat of potash, soap lye, and solutions of carbonat of ammonia, muriat of ammonia, neutral carbonat of potash, and nitrat of ammonia.

1. When the general nature of the soil of a field is to be ascertained, specimens of it should be taken from different places, two or three inches below the surface, and examined as to the similarity of their properties. It sometimes happens, that on plains the whole of the upper stratum of the land is of the same kind, and in this case one analysis will be sufficient. But in valleys, and near the beds of rivers, there are very great differences, and it now and then occurs, that one part of a field is calcareous, and another part siliceous; and in this and analogous cases, the portion different from each other should be analysed separately. Soils when collected, if they cannot be examined immediately, should be preserved in phials quite filled with them, and closed with ground glass stopples The most convenient quantity for a perfect analysis is from two hundred grains to four hundred. It should be collected in dry weather, and exposed to the air till it feels dry. Its specific gravity may be ascertained, by introducing into a phial, which will contain a known quantity of water, equal bulks of water and of the soil; which may easily be done, by pouring in water till the phial is half full, and then adding the soil till the fluid rises to the mouth. The difference between the weight of the water, and that of the soil, will give the result. Then if the bottle will contain four hundred grains of water, and gains two hundred grains when half filled with water and half with soil, the specific gravity of the soil will be 2; that is, it will be twice as heavy as water: and if it gained one hundred and sixty-five grains, its specific gravity would be 1825, water being 1000. It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains, these substances being always most abundant in the lighter soils. The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus siliceous soils are generally rough to the touch, and scratch glass when rubbed upon it: aluminous soils adhere strongly to the tongue, and emit a strong earthy smell when breathed upon: and calcareous soils are soft, and much less adhesive than aluminous soils.

2. Soils, when as dry as they can be made by exposure to the air, still retain a considerable quantity of water, which adheres with great obstinacy to them, and cannot be driven off without considerable heat: and the first process of analysis is to free them from as much of this water as possible, without affecting their composition in other respects. This may be done by heating the soil for ten or twelve minutes in a china basin over an Argand lamp, at a temperature equal to 300° F.; and if a thermometer be not used, the proper degree of heat may easily be ascertained by keeping a piece of wood in the basin in contact with its bottom; for as long as the colour of the wood remains unaltered, the heat is not too high; but as soon as it begins to be charred, the process must be stopped. In several experiments, in which Mr Davy collected the water that came over at this degree of heat, he found it pure, without any sensible quantity of other volatile matter being produced. The loss of weight in this process must be carefully noted; and if it amount to 50 grains in 400 of the soil, this may be considered as in the greatest degree absorbent and retentive of water, and will generally be found to contain a large proportion of aluminous earth: if the loss be not more than 10 or 20 grains, the land may be considered as slightly absorbent and retentive, and the siliceous earth as most abundant.

3. None of the loose stones, gravel, or large vegetable fibres, should be separated from the soil, till the water is thus expelled; for these bodies are often highly absorbent and retentive, and consequently influence the fertility of the land. But after the soil has been heated as above, these should be separated by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres or wood, and of the gravel and stones, should be separately noted down, and the nature of the latter ascertained: if they be calcareous, they will effervesce with acids; if siliceous, they will scratch glass; if aluminous, they will be soft, easily scratched

with a knife, and incapable of effervescing with acids.

4. Most soils, beside stones and gravel, contain larger or smaller proportions of sand of different degrees of fineness; and the next operation necessary is to separate this sand from the parts more minutely divided, such as clay, loam, marle, and vegetable and animal matter. This may be done sufficiently by mixing the soil well with water; as the coarse sand will generally fall to the bottom in the space of a minute, and the finer in two or three; so that by pouring the water off after one, two, or three minutes, the sand will be for the most part separated from the other substances; which, with the water containing them, must be poured into a filter. After the water has passed through, what remains on the filter must be dried and weighed; as must also the sand; and their respective quantities must be noted down. The water must be preserved, as it will contain the saline matter, and the soluble animal or vegetable matter, if any existed in the soil.

5. A minute analysis of the sand thus separated is seldom or never necessary, and its nature may be detected in the same way as that of the stones and gravel. It is always siliceous sand, or calcareous sand, or both together. If it consist wholly of carbonat of lime, it will dissolve rapidly in muriatic acid with effervescence: but if it consist partly of this and partly of siliceous matter, a residuum will be left after the acid has ceased to act on it, the acid being added till the mixture has a sour taste, and has ceased to effervesce. This residuum is the siliceous part; which being washed, dried, and heated strongly in a crucible, the difference of its weight from that of the whole, will indicate the quantity of the calcareous sand.

6. The finely divided matter of the soil is usually very compound in its nature: it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportions of these with tolerable accuracy, is the most difficult part of the subject. The first process to be performed in this part of the analysis is the exposure of the fine matter of the soil to the action of muriatic acid. This acid, diluted with double its bulk of water, should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter. The mixture should be often stirred, and suffered to remain for an hour, or an hour and half, before it is examined. If any carbonat of lime, or of magnesia, exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron, but very seldom any alumine. The fluid should be passed through a filter; the solid matter collected, washed with distilled or rain water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution; which, if not sour to the taste, must be made so by the addition of fresh acid; and a little solution of prussiat of potash must be mixed with the liquor. If a blue precipitate occur, it denotes the presence of oxide of iron, and the solution of the prussiat must be dropped in, till no further effect is produced. To ascertain its quantity, it must be collected on a filter in the same manner as the other solid precipitates, and heated red: the result will be oxide of iron. Into the fluid freed from oxide of iron a solution of carbonat of potash must be poured till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alkaline salt. The precipitate that falls down is carbonat of lime; which must be collected on a filter, dried at a heat below that of redness, and afterward weighed. The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if there be any, will be precipitated combined with carbonic acid, and its quantity must be ascertained in the same manner as that of the carbonat of lime. If any minute proportion of alumine should, from peculiar circumstances, be dissolved by the acid, it will be found in the precipitate with the carbonat of lime, and it may be separated from it by boiling for a few minutes with soap lye sufficient to cover the solid matter: for this lye dissolves alumine, without acting upon carbonat of lime. Should the finely divided soil be sufficiently calcareous to effervesce very strongly with acids, a simple method of ascertaining the quantity of carbonat of lime, sufficiently accurate in all common cases, may be adopted. As carbonat of lime in all its states contains a determinate quantity of acid, which is about 45 parts in a hundred by weight, the quantity of this acid given out during the effervescence occasioned by its solution in a stronger acid will indicate the quantity of carbonat of lime present. Thus, if you weigh separately one part of the matter of the soil, and two parts of the acid diluted with an equal quantity of water, and mix the acid slowly in small portions with the soil, till it ceases to occasion any effervescence, by weighing the mixture and the acid that remains, you will find the quantity of carbonic acid lost; and for every four grains and half so lost you will estimate ten grains of carbonat of lime. You may also collect the carbonic acid in the *pneumatic apparatus for the analysis of soils*, described in the article LABORATORY; and allow for every ounce measure of the carbonic acid two grains of carbonat of lime.

7. The quantity of insoluble animal and vegetable matter may next be ascertained with sufficient precision by heating it to a strong red heat in a crucible over a common fire, till no blackness remains in the mass,

stirring it frequently meanwhile with a metallic wire. The loss of weight will ascertain the quantity of animal and vegetable matter there was, but not the proportions of each. If the smell emitted, during this process, resemble that of burnt feathers, it is a certain indication of the presence of some animal matter; and a copious blue flame almost always denotes a considerable proportion of vegetable matter. Nitrat of ammonia, in the proportion of twenty grains to a hundred of the residuum of the soil, will greatly accelerate this process, if the operator be in haste; and not affect the result, as it will be decomposed and evaporate.

8. What remains after this decomposition of the vegetable and animal matter, consists generally of minute particles of earthy matter, which are usually a mixture of alumine and silex with oxide of iron. To separate these, boil them two or three hours in sulphuric acid diluted with four times its weight of water, allowing a hundred and twenty grains of acid for every hundred grains of the residuum. If any thing remain undissolved by this acid, it may be considered as silex, and be separated, washed, dried, and weighed, in the usual manner. Carbonat of ammonia being added to the solution in quantity more than sufficient to saturate the acid, the alumine will be precipitated; and the oxide of iron, if any, may be separated from the remaining liquid by boiling it. It scarcely ever happens, that any magnesia or lime escapes solution in the muriatic acid; but, if it should, it will be found in the sulphuric acid; from which it may be separated as directed above for the muriatic. This method of analysis is sufficiently precise for all common purposes: but if very great accuracy be an object, the residuum after the incineration must be treated with potash, and in the manner in which stones are analysed, as given in the first part of this article.

9. If the soil contained any salts, or soluble vegetable or animal matter, they will be found in the water used for separating the sand. This water must be evaporated to dryness at a heat below boiling. If the solid matter left be of a brown colour, and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be strong and fetid, it contains animal mucilaginous or gelatinous matter. If it be white and transparent, it may be considered as principally saline. Nitrat of potash or of lime is indicated in this saline matter by its sparkling when thrown on burning coals: sulphat of magnesia may be detected by its bitter taste: and sulphat of potash produces no alteration in a solution of carbonat of ammonia, but precipitates a solution of muriat of barytes.

10. If sulphat or phosphat of lime be suspected in the soil, a particular process is requisite to detect it. A given weight of the entire soil, as four hundred grains for instance, must be mixed with one third as much powdered charcoal, and kept at a red heat in a crucible for half an hour. The mixture must then be boiled a quarter of an hour in half a pint of water, and the solution, being filtered, exposed some days to the open air. If any soluble quantity of sulphat of lime, or gypsum, existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion.

Phosphat of lime, if any be present, may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil in quantity more than sufficient to saturate the soluble earths. The solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphat of lime untouched.

11. When the examination of a soil is completed, the products should be classed, and their quantities added together; and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must however be observed, that when phosphat or sulphat of lime is discovered by the independent process, No. 10, just mentioned, a correction must be made for the general process, by subtracting a sum equal to their weight from the quantity of carbonat of lime obtained by precipitation from the muriatic acid. In arranging the products, the form should be in the order of the experiments by which they are obtained. Thus 400 grains of a good siliceous sandy soil may be supposed to contain

		grains.
Of water of absorption - -		18
Of loose stones and gravel, principally siliceous - - - - - -		42
Of undecompounded vegetable fibres		10
Of fine siliceous sand - - -		200
Of minutely divided matter, separated by filtration, and consisting of		
Carbonat of lime - -	25	
Carbonat of magnesia -	4	
Matter destructible by heat, principally vegetable - -	10	
Silex - - - - - -	40	
Alumine - - - - -	32	
Oxide of iron - - - -	4	
Soluble matter, principally sulphat of potash and vegetable extract - - - - -	5	
Gypsum - - - - -	3	
Phosphat of lime - -	2	
	—	125
Amount of all the products		395
Loss - - - - -		5
		400

In this instance the loss is supposed small; but in general, in actual experiments, it will be found much greater, in consequence of the difficulty of collecting the whole quantities of the different precipitates; and when it is within thirty for four hundred grains, there is no reason to suspect any want of due precision in the processes.

12. When the experimenter is become acquainted with the use of the different instruments, the properties of the reagents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid, No 6, may be omitted: in examining peat soils, he will principally have to attend to the operation by fire and air, No. 7: and in the analysis of chalks and loams, he will often be able to omit the experiment with sulphuric acid, No. 8.

In the first trials that are made by persons unacquainted with chemistry, they must not expect much precision of result. Many difficulties will be met with: but in overcoming them the most useful kind of practical knowledge will be obtained; and nothing is so instructive in experimental science, as the detection of mistakes. The correct analyst ought to be well grounded in general chemical information; but perhaps there is no better mode of gaining it, than that of attempting original investigations. In pursuing his experiments, he will be continually obliged to learn from books the history of the substances he is employing or acting upon; and his theoretical ideas will be more valuable in being connected with practical operation, and acquired for the purpose of discovery.

The *analysis of vegetables* requires various manipulations, and peculiar attention, as their principles are extremely liable to be altered by the processes to which they are subjected. It was long before this analysis was brought to any degree of perfection. Formerly they were treated by fire alone; but the inadequacy of this instrument is obvious, as it not only changes their principles, but gives nearly similar products from vegetable substances of very different qualities. As an auxiliary, however, it is still of great use. The vegetable was first exposed to the gentle heat of a water-bath, to expel its aqueous parts: it was treated with boiling water, to extract its volatile oil, which distilled over with the water: and lastly it was exposed to destructive distillation in a retort, in which a coal remained, while in the receiver adapted to it were found a more or less saline phlegm, an empyreumatic oil, and the volatile salt, if they afforded any. The coal was after this lixiviated, to extract its fixed alkali, and frequently different metals may be detected in it. This process has been improved since the introduction of pneumatic chemistry, by collecting the aëriform products. Nitrat of potash is sometimes burnt with vegetable substances, to destroy their hidrogen and carbon more completely, to extract from them their fixed saline and earthy substances, and to detect the existence of some metallic oxides, particularly those of manganese and iron.

The action of the acids on vegetables is very striking. That the powerful acids may act only as simple solvents of the vegetable substances, it is necessary that they should be very dilute. There is scarcely any vegetable substance, that is not susceptible of being dissolved by all the acids when diluted with water, either with or without the aid of heat. If this solution be effected without sensible decomposition, there is no change of colour in the vegetable substance, and no alteration in the acid, from which it may frequently be separated by means of an earth or alkali. If such a solution be kept, however, the vegetable substance will be found gradually to alter, till its properties are the same as if it had been treated by the acid in a stronger state. The sulphuric acid appears to alter vegetable substances to which it is applied, by attracting a portion of their oxigen and hidrogen, so as to form water, with which it becomes considerably weakened, without any alteration of its own properties; while thus it sets free a portion of their carbon, so that they appear more or less charred. A portion of the vegetable substance too is converted into the state of an acid, which is commonly the acetous.

The muriatic acid appears to act upon them in a similar manner; and when, after remaining long in contact with them, muriat of ammonia is extracted from the mixture, we may conclude, not that this alkali previously existed in it, but that it has been formed in the process by a combination of its principles.

Very strong nitric acid burns vegetable substances with such activity, that it inflames several. According to the nature of the substance, therefore, on which it is intended to act, it must be diluted with half its weight of water, or even twice or thrice its weight; and its action, if necessary, may be promoted, or made to commence, by a greater or less increase of temperature. If the action be but slight, nitrous oxide mixed with a small quantity of carbonic acid will be evolved, with a slow and gentle effervescence: if it be more powerful, these airs will be evolved more speedily, and in larger quantity: if it be still further augmented, a portion of the acid will be completely decomposed; for, as we employ from three to six times the quantity of the vegetable substance thus treated, there is always more present than is necessary to obtain the products we seek. The stronger the acid is, the more carbonic acid and nitrous oxide are generally obtained; consequently the more oxigen is separated from the nitric acid, and the more carbon is taken from the vegetable substance and burned by the oxigen. The general and most abundant product of this reciprocal decomposition is a series of different vegetable acids, sometimes three or four, at others, perhaps, a single one, all consisting of oxigen, hidrogen, and carbon, in various proportions.

Beside converting them into acids, there are some vegetable substances, a portion of which the nitric acid converts into a kind of fat oil; others from which it produces a fat of resin. In the first, it forms powders insoluble in water, but soluble in the alkalis, though not fusible like fats: in the last it disengages and compresses prussic acid, and almost always evolves ammonia at the same time.

Some of the immediate materials of vegetables are separated to our hands by Nature in a state of greater or less purity, as the gums, resins, and balsams, that exude from plants. The expressed juices contain various matters, that may be separated by the appropriate reagents. Maceration, infusion, and decoction in water, take up certain parts soluble in this menstruum; and alcohol will extract others that water will not dissolve. The mode of separating and distinguishing these materials will easily be collected from their characters, as given under the head VEGETABLE KINGDOM, and under the different articles themselves.

The nature of the vegetable substance we wish to examine, and the particular object of our inquiry, will determine to which of the methods above indicated we must have recourse, either singly or combined: but we cannot expect a complete analysis without employing various means.

The *analysis of animal substances*, like that of vegetables, was formerly conducted by fire alone, and has since been greatly improved by the employment of reagents. When an animal substance is heated in a retort, water is first repelled from it, more or less in quantity, according to the state of the substance, and impregnated with its aroma. This water soon begins to come over brown and turbid, containing different ammoniacal salts; and is presently accompanied with carbonat of ammonia, which at first dissolves in it, and then crystallizes in the neck of the retort and against the sides of the receiver. This is succeeded by an oil, which grows thicker and deeper coloured as the operation proceeds. When this oil rises, little or no water comes over: but the carbonat of ammonia continues to sublime, and gases are evolved. When nothing more is extricated, the fire is put out, the vessels are left to cool, and a coaly matter is found in the retort. All these products require a separate examination.

If the colour, and turbid water that comes over after the evaporation of the mere aqueous part, be rectified by a subsequent distillation, it generally comes over more clear, if not transparent; and carbonat of ammonia is frequently separated from it. If treated with the metallic solutions, it precipitates them; if with lime, ammonia is disengaged; and by adding phosphoric acid after the lime, and dissolving in water, a portion of acetous acid, combined with animal matter, will be obtained, which Berthollet mistook for a peculiar acid, and called the zoonic. In fact, this liquor always contains an ammoniacal soap, and carbonat of ammonia; beside which, the ammonia is sometimes in combination with the muriatic, prussic, sebacic, and acetous acids.

The oil differs from that obtained from vegetables in a similar way, by its abundance, consistency, and ammoniacal nature; it has a very fetid smell, and turns blue vegetable colours green. By repeated distillations it may be rendered limpid, odorous, and very volatile. In this rectification the carbon that coloured it is separated from it.

The gasses, which are very fetid, very combustible, and frequently burn with an oily flame, are a mixture of carbonated hidrogen, frequently too sulphurated and even phosphorated at the same time, and carbonic acid gas.

The coal, which frequently adheres so firmly to the retort that its weight cannot be ascertained but by weighing them together, is generally less in proportion than is left after the destructive distillation of a vegetable substance; and it is so difficult of incineration, that the strong fire necessary for this purpose frequently changes the nature of its residuum, and volatilizes a part of its salts. It is advisable, therefore, to detonate this coal with nitrat or oximuriat of potash, in vessels proper for collecting the gaseous products, and the pulverulent residuum. The incombustibility of this coal may be attributed to the little carbon it contains, its dense state, and its union with the phosphats of lime and soda, and oxides of iron and maganese.

Most of the animal fluids are miscible with water; but a heat of 160° F. or upward, separates albumen from it by coagulating it, while gelatine is more easily dissolved in water in proportion as the heat employed is greater. Water likewise loosens the texture of the soft parts, but, by long maceration, completely alters their nature. See ADIPOCERE.

Alcohol dissolves the resinous parts of animal substances, and powerfully coagulates the albuminous.

The weaker acids, and the more powerful acids, if much diluted, coagulate and thicken the albuminous fluids, quickly dissolve the gelatinous and membranous parts, and by the assistance of heat dissolve the fibrin. This solution, if it contain a large proportion of fibrin, is of a gelatinous consistence. They dissolve and partly decompose the harder solids, converting their phosphat of lime into an acidulous salt. If they remain long in contact with the soft membranous or fibrous substance, they will be found partly saturated with ammonia.

But the action of the nitric acid is most eminent. If five ounces, troy, of muscular flesh be put into a matrass, with an equal weight of nitric acid at 32°, and of water, and boiled gently, it will give out a hundred cubic inches of gas, ninety of which will be azot, and ten carbonic acid. The residuum will consist of matter retaining its original fibrous structure, a yellowish liquor, and a yellow greasy substance floating on it. If the grease be separated, and the liquor filtered off, the solid residuum will impart a yellow colour to boiling water, and the property of reddening vegetable blues. After repeated washings, it does not render the water acid, though it continues to tinge it. Washing renders its colour deeper than at first; and when diffused in a little water, it still reddens litmus paper. Dissolved in an alkali, it assumes a deep blood colour, and acids precipitate it in yellow flakes. This flaky matter feels fat and pitchy, has a rancid smell, and a very bitter taste. Placed on burning coals, it melts, swells emits a greasy fetid vapour, and leaves but little coal. It saturates alkalis so as nearly to conceal their properties; and forms, with potash, or ammonia, a soap that lathers in water, is not decomposed by carbonic acid, and precipitates the solutions of lead and mercury in yellowish white flakes. It decomposes alkaline carbonats with effervescence; and by the assistance of water and a gentle heat it decomposes acetit of potash.

This yellow matter being exposed to the action of alcohol, a small quantity of fat, which it contained, is dissolved, and an acid is left behind. This acid is of a deeper colour than when combined with the fat, reddens litmus paper more quickly, does not melt as before, or exhale the same rancid smell, but emits a fetid ammoniacal vapour. By distillation, it affords the usual products of animal substances, so that it appears to be a compound of nitrogen, hidrogen, carbon, and oxigen.

The colour of the nitric acid, with which the muscular flesh was decomposed, resembles that of a solution of chromat of potash. On being saturated with carbonat of potash, the liquor at first assumes an orange colour, after which it becomes turbid, and lastly deposits a small quantity of an orange red powder. This mixture on distillation affords a clear colourless liquid, of a rancid smell, containing a little ammonia, probably formed by the nitric acid, and leaves in the retort a blackish brown residuum.

If the nitric solution itself be distilled, a similar limpid liquor comes over; and the liquor remaining in the retort becomes yellower by concentration, and at length flattish crystals form in it, when the mother water attains the consistency of a solution of gum. Nitric acid occasions a copious emission of red fumes from the concentrated solution.

The mother water has an acid and bitter taste: on the addition of a little potash it becomes of a blood red colour: alcohol throws down from it a flaky precipitate, which afterward forms itself into fine semi-transparent grains of a pleasant acid flavour. Half a gramme of this salt, being calcined, left ·21 of a gramme of a very light yellowish residuum, which dissolved with effervescence in nitric acid, and on evaporation produced crystals of sulphat of lime and nitrat of potash. It was ascertained to be a mixture of sulphat of lime and acidulous oxalat of potash.

After this precipitation, by means of alcohol, the mother water affords a second precipitate on the addition of lime-water, which consists of oxalat of lime. After this, gentle evaporation converts it into a brown viscid fluid like a sirup, which has a bitter taste, resembling that of the outer husks of walnuts. A considerable portion of alcohol coagulates this, and a copious white precipitate is thrown down, which is pure malat of lime, the yellow acrid substance being dissolved in the alcohol. The alcohol likewise holds in solution a small portion of nitrat of lime. If this alcoholic solution be concentrated, carbonat of potash separates from it a small portion of granulated crystals, very inflammable, and very detonant, like those obtained from indigo.

Thus, on treating the muscular part of animals with nitric acid, we obtain a considerable portion of nitrogen, and some carbonic acid gas; fatty matter; a bitter substance; a yellow insipid matter, of little solubility, though acid; another acid yellow matter, bitter, and more soluble; an inflammable detonating substance; and oxalic and malic acids.

This yellow acid matter, which has been recently detected by Fourcroy and Vauquelin, appears, according to them, to have considerable analogy with the coloured matter of bilious concretions, and that found in the urine of icteric patients; and they observe, that acetat of soda, alkaline carbonats, and yolks of eggs, all of which have been found serviceable in jaundice, are its best solvents. They add, that it likewise resembles the acids that may be obtained from fat grown rancid and yellow by keeping, or lard mixed with nitric acid to form oxigenated pomatum.

See ANIMAL KINGDOM, and the different kinds of animal substances under their respective names.

Angelica. The roots have a pungent agreeable bitterish taste, and a strong aromatic smell, somewhat of the musky kind. Their activity resides in an essential oil and a resinous matter. The oil is obtained by distillation with water. The oil and the resin are totally extracted by digestion in alcohol; and water, by the like treatment, extracts them, though in part only.

These roots, like those of most of the umbelliferous plants, are very apt to be preyed upon by worms, to become carious, and fall into powder. So long as they are merely worm-eaten, and not powdery, they are as fit for making the essential oil, or the tinctures in ardent spirit or water, as in their most perfect state; the insects preying first upon the mucilaginous and insipid parts, and not upon the resinous and oily parts. When such roots are made use of, care must be taken to beat out the worms and dust as much as possible. To preserve the roots of angelica, they must be thoroughly dried and kept in close vessels or packages in a dry place.

Anil, or Nil. This plant, from the leaves of which indigo is prepared, grows in America. It has several slender knotty stalks, which spread into small branches, clothed each with from eight to ten pair of leaves, and an odd one at the end. The leaf is small, fleshy, and soft, of a greenish brown colour on the upper side, pale and as it were silvery-coloured beneath. The plant rises to the height of about two feet, and produces reddish flowers, in shape resembling those of broom, but smaller, followed by oblong pods containing the seeds.

The culture of this plant is as follows: The ground being thoroughly cleared of weeds, which is a principal object, a number of slaves, ranged in a line, march across, making little trenches of the width of their hoes, and two or three inches deep, about a foot distant from each other every way. Then, returning, they drop some seeds in each trench, and afterward cover them with the earth taken out. In moist weather the plant comes up in two or three days; and in about two months it is fit for cutting. If suffered to stand till it runs into flower, the leaves become too dry and too hard, and the indigo obtained from them proves less in quantity, and less beautiful. The due point of maturity is known by the leaves beginning to grow less supple or more brittle. In a rainy season the cutting may be repeated every six weeks. Cutting in dry weather kills the plant, which, if this be avoided, continues to afford fresh crops for two years. For the preparation of Indigo, see that article.

Animal Kingdom. The various bodies around us, which form the objects of chemical research, have all undergone a number of combinations and decompositions before we take them in hand for examination. These are all consequences of the same attractions or specific properties that we avail ourselves of, and are modified likewise by virtue of the situations and temperatures of the bodies presented to each other. In the great mass of unorganized matter, the combinations appear to be much more simple than such as take place in the vessels of organised beings, namely plants and animals: in the former of which there is at least a peculiar structure of tubes conveying various fluids; and in the latter there is not only an elaborate system of vessels, but likewise, for the most part, an augmentation of temperature. From such causes as these it is, that some of the substances afforded by animal bodies are never found either in vegetables or minerals; and so likewise in vegetables are found certain products never unequivocally met with among minerals. Hence, among the systematical arrangements used by chemists, the most general is that which divides bodies into three kingdoms, the animal, the vegetable, and the mineral.

Animal as well as vegetable bodies may be considered as peculiar apparatus for carrying on a determinate series of chemical operations. Vegetables seem capable of operating with fluids only, and at the temperature of the atmosphere, as we have just noticed. But most animals have a provision for mechanically dividing solids by mastication, which answers the same purpose as grinding, pounding, or levigation does in our experiments; that is to say, it enlarges the quantity of surface to be acted upon by solvents. The process carried on in the stomach appears to be of the same kind as that which we distinguish by the name of digestion; and the bowels, whatever other uses they may serve, evidently form an apparatus for filtering or conveying off the fluids; while the more solid parts of the aliments, which are probably of such a nature as not to be rendered fluid, but by an alteration which would perhaps destroy the texture of the machine itself, are rejected as useless. When this filtered fluid passes into the circulatory vessels, through which it is driven with considerable velocity by the mechanical action of the heart, it is subjected, not only to all those changes which the chemical action of its parts is capable of producing, but is likewise exposed to the air of the atmosphere in the lungs, into which that elastic fluid is admitted by the act of respiration. Here it undergoes a change of the same nature as happens to other combustible bodies when they combine with its vital part, or oxigen. This vital part becomes condensed, and combines with the blood; at the same time that it gives out a large quantity of heat, in consequence of its own capacity for heat being diminished. A small portion of azot likewise is absorbed, and carbonic acid is given out. Some curious experiments of Spallanzani show, that the lungs are not the sole organs by which these changes are effected. Worms, insects, shells of land and sea animals, eggshells, fishes, dead animals, and parts of animals, even after they have become putrid, are capable of absorbing oxigen from the air, and giving out carbonic acid. They deprive atmospheric air of its oxigen as completely as phosphorus. Shells, however, lose this property when their organization is destroyed by age. Amphibia, deprived of their lungs, lived much longer in the open air, than others in air destitute of oxigen. It is remarkable, that a larva, weighing a few grains, would consume almost as much oxigen in a given time as one of the amphibia a thousand times its bulk. Fishes, alive and dead, animals, and parts of animals confined under water in jars, absorbed the oxigen of the atmospheric air over the water. Muscles, tendons, bones, brain, fat, and blood, all absorbed oxigen in different proportions, but the blood did not absorb most; and bile appeared not to absorb any.

It would lead us too far from our purpose, if we were to attempt an explanation of the little we know respecting the manner in which the secretions or combinations that produce the various animal and vegetable substances are effected, or the uses of those substances in the œconomy of plants and animals. Most of them are very different from any of the products of the mineral kingdom. We shall therefore only add, that these organized beings are so contrived, that their existence continues, and all their functions are performed, as long as the vessels are supplied with food or materials to occupy the place of such as are carried off by evaporation from the surface, or otherwise, and as long as no great change is made, either by violence or disease, in those vessels or the fluids they contain. But as soon as the entire process is interrupted in any very considerable degree, the chemical arrangements become altered; the temperature in land animals is changed, the minute vessels are acted upon and destroyed, life ceases, and the admirable structure, being no longer sufficiently perfect, loses its figure, and returns, by new combinations and decompositions, to the general mass of unorganized matter, with a rapidity which is usually greater, the more elaborate its construction.

The parts of vegetable or animal substances may be obtained, for chemical examination, either by simple pressure, which empties the vessels of their contents; by digestion in water, or in other fluids, which dissolve certain parts, and often change their nature; by destructive distillation, in which the application of a strong heat alters the combination of the parts, and causes the new products to pass over into the receiver in the order of their volatility; by spontaneous decomposition or fermentation, wherein the component parts take a new arrangement, and form compounds which did not for the most part exist in the organized substance; or, lastly, the judicious chemist will avail himself of all these several methods singly, or in combination. He will, according to circumstances, separate the parts of an animal or vegetable substance by pressure, assisted by heat; or by digestion or boiling in various fluids added in the retort which contains the substance under examination. He will attend particularly to the products which pass over, whether they be permanently elastic, or subject to condensation in the temperatures we are able to produce. In some cases, he will suffer the spontaneous decomposition to precede the application of chemical methods; and in others he will attentively mark the changes which the products of his operations undergo in the course of time, whether in closed vessels, or exposed to the open air. Thus it is that, in surveying the ample field of nature, the philosophical chemist possesses numerous means of making discoveries, if applied with judgment and sagacity; though the progress of discovery, so far from bringing us nearer the end of our pursuit, appears continually to open new scenes, and, by enlarging our powers of investigation, never fails to point out additional objects of inquiry. See ANALYSIS of animal substances.

Animal and vegetable substances approach each other by insensible gradations; so that there is no simple product of the one which may not be found in greater or less quantity in the other. The most general distinctive character of animal substances is that of affording volatile alkali by destructive distillation. Some plants however afford it likewise. Neither contain it ready formed; but it appears to be produced by the combination of hidrogen and azot, during the changes produced either by fire, or by the putrefactive process. See AMMONIA; and GAS (AMMONIACAL).

Our knowledge of the products of the animal kingdom by the help of chemical analysis, is not yet sufficiently matured to enable us to arrange them according to the nature of their component parts, which appear to consist chiefly of hidrogen, oxigen, carbon, and azot; and with these, sulphur, phosphorus, lime, magnesia, and soda, are frequently combined in variable proportions. Animal substances may therefore be conveniently divided into, 1. Such as are usually obtained without destroying life. These are milk, eggs, urine, excrement, the matter of perspiration, ambergris, &c. wax, honey, lac, silk, hair, horn, feathers, &c. Or, 2. Such parts of animals as are obtained by destroying them, or depriving them of life. These are blood; various solids confounded under the name of flesh; fat, adipocere, gluten, gelatine, bile, the gastric juice, and several acids; together with calcareous earth, and other substances common to the mineral and vegetable kingdoms. For the properties of which, see the respective articles.

When animal substances are left exposed to the air, or immersed in water or other fluids, they suffer a spontaneous change, which is more or less rapid according to circumstances. The spontaneous change of organized bodies is distinguished by the name of fermentation. In vegetable bodies there are distinct stages or periods of this process, which have been divided into the vinous, acetous, and putrefactive fermentations. Animal substances are susceptible only of the latter, during which, as in all other spontaneous changes, the combinations of chemical principles become in general more and more simple. There is no doubt but much instruction might be obtained from accurate observations of the putrefactive processes in all their several varieties and situations; but the loathsomeness and danger attending on such inquiries has hitherto greatly retarded our progress in this department of chemical science. See FERMENTATION (PUTREFACTIVE).

ANIME, improperly called gum anime, is a resinous substance imported from New Spain and the Brasils. There are two kinds, distinguished by the names of oriental and occidental. The former is dry, and of an uncertain colour, some specimens being greenish, some reddish, and some of the brown colour of myrrh. The latter is in yellowish, white, transparent, somewhat unctuous tears, and partly in larger masses, brittle, of a light pleasant taste, easily melting in the fire, and burning with an agreeable smell. Like resins, it is totally soluble in alcohol, and also in oil. Water takes up about 1-16th of the weight of this resin by decoction. The spirit, drawn off by distillation, has a considerable degree of the taste and flavour of the anime; the distilled water discovers on its surface some small portion of essential oil.

This resin is used by perfumers, and also in certain plasters, wherein it has been supposed to be of service in nervous affections of the head and other parts; but there are no reasons to think that, for medical purposes, it differs from common resins.

ANISEED contains, beside its essential odorous oils, a gross one of the expressible kind. The essential oil, and the smell and taste of the seeds which depend upon it, are confined to the outer thin skin: the inner kernel, which is commonly divided longitudinally into two portions, has little or no smell, and exceeding little taste: in this resides the gross oil, naturally inodorous and insipid, but which, nevertheless, in its separation from the seed by the press, brings with it a part of the essential oil, so as to become strongly impregnated with the peculiar flavour of the aniseed; its colour is greenish.

The essential oil, though mild in taste, has an extremely strong smell, which it communicates to whatever it touches in such a degree as scarcely to be overpowered. It coagulates in a temperature much warmer than is necessary to freeze water. The term of its congelation, which seems to be about 50 degrees of Fahrenheit's thermometer, but is not very easy to be determined with great accuracy, because it is a bad conductor of heat, was proposed by Boyle, in the infancy of the thermometer, to be used as a fixed point in the graduation of that instrument. This oil, like other essential oils, is soluble in alcohol, from which it in part separates by cooling. Neumann observes, that it dissolves sulphur in greater quantity than any other oil expressed or distilled. Another singular fact is noticed by the same author, viz. that whereas the distillation of essential oil from other vegetables is in general facilitated by the addition of salt to the water which is added to the vegetable substance, such an addition is particularly hurtful in this process, the aniseed yielding only half as much oil as it does when distilled with pure water.

ANNEAL. We know too little of the arrangement of particles to determine what it is that constitutes or produces brittleness in any substance. In a considerable number of instances of bodies which are capable of undergoing ignition, it is found that sudden cooling renders them hard and brittle. This is a real inconvenience in glass, and also in steel, when this metallic substance is required to be soft and flexible. The inconveniencies are avoided by cooling them very gradually, and this process is called annealing. Glass vessels, or other articles, are carried into an oven or apartment over the great furnace, called the leer, where they are permitted to cool, in a greater or less time, according to their thickness and bulk. The annealing of steel, or other metallic bodies, consists simply in heating them, and suffering them to cool again either upon the hearth of the furnace, or in any other situation where the heat is moderate, or at least the temperature is not very cold.

ANNOTTO. The pellicles of the seeds of the *bixa orellana*, a liliaceous shrub, from 15 to 20 feet high in good ground, afford the red masses brought into Europe under the name of Annotto, Orlean, and Roucou. The red seeds, cleared from the pods, are first pounded, and then steeped in water for a few weeks, or even months, when the coloured liquor is pressed through sieves. The seeds thus strained out are then left to ferment, when they are again pounded, steeped in water, and strained; and this is repeated till no more of the colouring matter is left. The liquor is then set by till the colour is deposited, which it usually is in about a fortnight; it is poured off, to be used again for the same purpose. The sediment is boiled to the consistence of a paste, continually stirring it, and is then dried in the shade in cakes, 7 or 8 inches thick.

Mr. Leblond, who gives this account in the An. de Chemie, justly reprobates this practice of the planters in French Guyana, and recommends that the seeds be simply washed, to divest them of the colouring matter, which is entirely on their surface: to pass the water through fine sieves, in order to free it from the pellicles: to precipitate the colour by lemon-juice or vinegar: and then to dry it in the ordinary way, or by setting it to drain in bags like indigo. According to the testimony of Vauquelin, and of some dyers at Paris, the annotto thus prepared goes at least four times as far as that of the shops, is more soluble, and affords a purer colour.

The annotto commonly met with among us is moderately hard, of a brown colour on the outside, and a dull red within. It is difficultly acted upon by water, and tinges the liquor only of a pale brownish yellow colour. In rectified spirit of wine it very readily dissolves, and communicates a high orange or yellowish red. Hence it is used as an ingredient in varnishes, for giving more or less of an orange cast to the simple yellows. Alkaline salt renders it perfectly soluble in boiling water, without altering its colour.

Labat informs us, that the Indians prepare an annotto greatly superior to that which is brought to us. of a bright shining red colour, almost equal to carmine; that, for this purpose, instead of steeping and fermenting the seeds in water, they rub them with the hands, previously dipped in oil, till the pellicles come off and are reduced into a clean paste, which is scraped off from the hands with a knife, and laid on a clean leaf in the shade to dry. De Laet, in his notes on Margrave's Natural History of Brazil, mentions also two kinds of annotto; one of a permanent crimson colour (coccineus), used as a fucus; and another, which gives a colour inclining more to that of saffron. This last, which is our annotto, he supposes to be a mixture of the first sort with certain resinous matters, and with the juice of the roots of the tree.—The goodness of annotto is commonly tried by rubbing it on the nail, soaping the place, and washing it with water, when it ought to leave a stain.

Beside its use in dyeing, (see that article,) it is employed for colouring cheese

Anthemis, Chamomile. Two species of this plant are used in medicine, and one in dyeing. The flowers of the *anthemis nobilis*, common chamomile, are much used as a warm bitter. They give out 3-8ths of their weight to spirit, and ½ their weight to water. The root of the *anthemis pyrethrum*, pellitory of Spain, is a very warm stimulant aromatic, but it is used only as a masticatory, in tooth-ach, rheumatic pains of the face, or paralytic affections of the mouth and tongue. According to Neumann, it yields 1-48th of spirituous extract, and 7-32ds of watery; but Cartheuse says, 1-24th of spirituous, and 3-8ths of watery.

The *anthemis tinctoria*, oxeye chamomile, according to Schæffer, gives a fine yellow to silk, if a little solution of tin, mixed with tartar sufficient to turn it yellow, be dropped into a decoction of it. The dye is to be kept warm, but not boiling; and soft water, that does not precipitate solution of tin, should be employed.

Anthracite of Hauy.
Anthracolite, of Some. } A species of stone coal, found only, according to Dolomieu, in the primitive mountains. It consists of about 64 oxide of carbon, 32·5 silex, and 3·5 iron.

Antimony. The word antimony is always used in commerce to denote a metallic ore, consisting of sulphur combined with the semimetal which is properly called antimony. Sometimes this sulphuret is termed crude antimony, to distinguish it from the pure metal, or regulus, as it was formerly called. According to prof. Proust, the sulphuret contains 26 per cent. of sulphur. He heated 100 parts of antimony with an equal weight of sulphur in a glass retort, till the whole was well fused and the excess of sulphur expelled, and the sulphuret remaining was 135. The result was the same after repeated trials: 100 parts of antimony, with 300 of red sulphuret of mercury, afforded 135 to 136 of sulphur. These artificial sulphurets lost nothing by being kept in fusion an hour: and heated with an equal weight of sulphur they could not be made to take up more. Some of the native sulphurets of the shops, however, appear to have a small portion more of sulphur united with them, as they will take up an addition of 7 or 8 per cent. of antimony.

Antimony is of a dusky white colour, very brittle, and of a plated or scaly texture. Its specific gravity, according to Brisson, is 6·7021, but Bergman makes it 6·86. Soon after ignition it melts, and by a continuance of the heat it becomes oxided, and rises in white fumes, which may afterward be volatilized a second time, or fused into a hyacinthine glass, according to the management of the heat: the first were formerly called argentine flowers of regulus of antimony. In closed vessels, the antimony rises totally without decomposition. This metallic substance is not subject to rust by exposure to air, though its surface becomes tarnished by that means. Its oxides are a little soluble in water; and in this respect they resemble the oxide of arsenic, probably by an approach toward the acid state.

If antimony be brought to a white heat, and then shaken, it takes fire with a kind of explosion. If a little be fused on a bit of charcoal before the blowpipe, and thrown out, it will divide into globules, and burn with a brilliant white light as it falls to the ground.

The white oxide has somewhat of acidity to the taste, and is used for giving to gas or enamel an orange or saffron colour. M. Thenard calculates, that this oxide contains 0·20 of oxigen; and he adds, if it be carefully and gently heated in a crucible, it first passes to a yellow oxide, very vitrifiable, and containing 0·19 of oxigen; then to an orange, containing 0·18; next to a chesnut brown, holding 0·16; and, lastly, to black oxide, having only 0·02; before it resumes the metallic state. Antimony, however, appears capable, as will be seen below, of taking up 30 per cent. of oxigen.

If the nitric sulphuret of antimony be roasted slowly in a broad shallow vessel, it loses the greater part of its sulphur, and is converted into a gray oxide; formerly the *gray calx*, now *gray sulphurated oxide of antimony*. This, which consists of about 78 parts of antimony, 16 of oxigen, and 6 of sulphur, being melted quickly in a strong heat, is converted into *glass of antimony*, or *vitreous sulphurated oxide*.

The sulphuret of antimony forms a triple compound with potash, either by fusion, or in the humid way. Lemery directs pure alkali, in a liquid state, to be diluted with thrice as much water, put in a clean iron pan, and set over the fire. When it has begun to boil, well levigated sulphuret of antimony, equal in weight to a sixteenth of the alkali, is to be stirred in. After it has boiled seven or eight minutes, it is to be filtered as soon as removed from the fire, and, as it cools, the hidrosulphuret, or *kermes mineral*, will fall down. This being separated from the cold solution, a further precipitation will ensue on the addition of dilute sulphuric acid, the *golden sulphur of antimony*. According to Thenard, the first consists of 72·760 of brown oxide of antimony, 20·298 of sulphurated hidrogen, and 4·156 of sulphur; 2·786 being lost in water, &c.: the last of 68·300 of orange oxide, 17·877 of sulphurated hidrogen, and 11 or 12 of sulphur.

If crude antimony, finely powdered, be mixed with thrice its weight of nitrat of potash, and projected gradually into a red-hot crucible, it detonates, and a white oxide combined with sulphat of potash is the result. This, the *solvent of Rotrou*, or *unwashed calx of antimony* of the old chemists, is somewhat deliquescent; and if the sulphat of potash be separated from it by repeated affusion of water, we have the *calcined antimony* of the London Pharmacopœia, or the *ceruse of antimony*, *diaphoretic antimony* of others, a substance apparently inert, at least in doses of a dram or two. Some oxide of antimony is dissolved in the water, which may be precipitated by acids, and is then the *materia perlata* of Kerkrinius. The compound salt obtained by evaporation and crystallization after the precipitation of the oxide was very improperly called the *antimoniated nitre* of Stahl.

If, however, the nitrat of potash be only thrice the weight of the antimony, we have the *mild antimonial emetic* of Boerhaave, which occasions slight nausea and gentle vomiting, with a considerable discharge of saliva and thick urine. When equal parts are used, the produce is of a dark brownish red colour. This, the *crocus antimonii* *, *crocus metallorum*, or *hepar antimonii*, is an extremely violent emetic, given from one grain to five or six. When the nitrat is only half the weight of the antimony, we have the *crocus antimonii mitior*, which is still strongly emetic in a similar dose: if the nitrat be but one sixth, the product is in general more mildly emetic, and likewise purgative, in doses of eight or ten grains: and when the nitrat is only one eighth, it is said to act chiefly as an alterative or diaphoretic in doses of fifteen or twenty grains. The last has been termed *crocus antimonii medicinalis*.

When four parts of nitrat to one of antimony are taken, the oxide contains 32 per cent. of oxigen, and acquires, in some measure, the character of an acid, as it forms a crystallizable compound with potash, though it appears to be of itself the least soluble of the antimonial oxides.

As a considerable portion of the matter, sometimes as much as half of it, is left by detonating antimony with nitrat of potash in the open air, Bergman recommends the mixture to be put into a cold crucible, the crucible to be covered over; and the fire to be increased till the matter is fused. Thus there is very little left, and this is the mode generally practised by operative chemists.

If sulphuret of antimony be mixed with thrice its weight of corrosive muriat of mercury, noxious fumes begin immediately to rise very copiously, which must be carefully avoided. The mixture being put into a wide-necked retort, and the fire cautiously increased, a muriat of antimony will rise, and congeal in the neck of the retort. This, on exposure for some time to the air, will become fluid: or, it may be melted from the neck of the retort, by cautiously applying a live coal, and be rendered permanently fluid by distillation in another re-

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* The London college add a twelfth part of muriat of soda to one part each of the nitrat and sulphuret.

tort. In the former way it is somewhat less corrosive. This was formerly called *butter of antimony*, or *antimonial caustic*. It acts exceeding quickly, the eschar coming off in general the same day, but is now seldom if ever used except by farriers. The London college direct two parts of muriat of soda, and one of *crocus antimonii* to be mixed and added gradually to one part of sulphuric acid in a retort, which is then to be placed on a sand heat. The distilled matter is to remain some days exposed to the air, and the fluid part to be then poured off from the dregs. If this muriat be diluted with a considerable quantity of water, a white oxide is precipitated; formerly called *mercurius vitæ*, on account of the muriat of mercury employed in the original mode of making it, though no mercury really entered into its composition; or powder of *algaroth*, from the name of its inventor, a Veronese physician. This oxide is a violent emetic, and has consequently fallen into disuse; but some chemists prefer it as the basis of tartarised antimony. If nitrous acid were dropped into the muriat of antimony till no further effervescence was excited, or if it were poured on the precipitate from the muriat, and all the acid were expelled by distillation, and exposure for some time to a red heat, the remaining oxide was termed *mineral bezoar*. After the distillation of the muriat of antimony from the mercurial muriat, a black powder consisting of mercury and sulphur remained in the retort. This being urged to a red heat, was sublimed into a mass of a needly structure, and a little darker hue than the common red sulphuret of mercury, from which it differs only in containing a somewhat larger proportion of sulphur, though it was distinguished by the name of *cinnabar of antimony*.

In all the various ways, however, in which antimony has been tortured by the ingenuity of chemists, we are acquainted with no preparation of it more valuable than the *tartarised antimony*, formerly *emetic tartar*, or *stibiated tartar*, for which we are indebted to Mynsicht. To prepare this, the London college directs a pound and half of powdered crocus of antimony, and two pounds of acidulous tartrit of potash, to be boiled in two gallons of water, in a glass vessel, about a quarter of an hour. The liquor is then to be filtered, and set by to crystallize. The Edinburgh college orders an oxide to be formed by precipitating the muriat of antimony with hot water, in which potash enough to precipitate all the antimony has been dissolved. The precipitate being well washed and dried, nine drams are to be boiled with two ounces and half of acidulous tartrit of potash, finely powdered, in five pounds of water, till the powders are dissolved. The solution, being strained, is to be evaporated to a pellicle, and set by to crystallize. Some of the continental chemists prefer the vitreous sulphurated oxide for the basis of this preparation, as more soluble in the tartarous acid: but with them it has far from generally superseded the use of the hidrosulphurated brown and orange oxides. The tartarised antimony crystallizes in regular tetraëdra, triangular pyramids, or elongated octaëdra: but it effloresces on exposure, loses its transparency, and becomes white and pulverulent. It is soluble in eighty parts of water at 60° Fahr. To ascertain its purity, Mr. Henry directs a few drops of sulphuret of ammonia to be added to its solution, which will immediately throw down a gold-coloured sulphuret of antimony: or acetat of lead, which should give with it a precipitate perfectly soluble in dilute nitrous acid.

About the middle of the last century Dr. Robert James, a physician in London, invented a preparation of antimony, which he kept a secret, and for which he afterward took out a patent. He called it his *fever powder*, and was so successful in his practice with it, that it obtained very great reputation, which it still in some measure retains. Probably, however, his success was in great measure owing to his free use of the bark, which he always gave as largely as the stomach would bear, as soon as he had completely evacuated the primæ viæ by the use of his antimonial preparation, with which at first he used to combine a little mercurial. His specification, lodged in chancery, is as follows: "Take antimony, calcine it with a continued protracted heat, in a flat, unglazed, earthen vessel, adding to it from time to time a sufficient quantity of any animal oil and salt, well dephlegmated: then boil it in melted nitre for a considerable time, and separate the powder from the nitre by dissolving it in water." The preparation sold as *James's powder*, however, appears from a careful analysis by Dr. Pearson, given in the Phil. Trans., to be an oxide of antimony combined with calcareous phosphat. Accordingly both the London and Edinburgh colleges have directed an *antimonial powder* to be prepared by mixing the sulphuret of antimony coarsely powdered with an equal weight of hartshorn shavings (or those of bone or ivory, Ed.), putting the mixture into a broad iron pot, heated to a white (red, Ed.) heat, and constantly stirring till the mass has acquired a grayish colour. When this is cold, it is to be powdered, and put into a coated crucible, with another, having a small hole in the bottom, inverted over it. The crucibles being luted together, the fire is to be kindled under them, and gradually increased to a white heat, at which it is to be kept for two hours. When cold it is to be powdered. This powder, however, is certainly more active than that of Dr. James. We have known three grains with one of calomel operate with considerable violence both upward and downward. Mr. Chenevix recommends to dissolve in the least possible quantity of muriatic acid equal parts of phosphat of lime and the oxide precipitated by water from the muriat of antimony. These, either dissolved together, or dissolved separately and then mixed, are to be poured gradually into water alkalizated with a sufficient quantity of pure ammonia. The precipitate, well washed and dried, is his substitute for James's powder. This has the advantage of not being liable to variation in its quality from those unavoidable differences in the operation, to which all preparations by means of fire are exposed; and it is milder than the *antimonial powder*, as it seldom produces nausea or vomiting in doses of less than eight or ten grains.

As it is frequently convenient to have antimony in a liquid form, different tinctures of it have been devised; but the British colleges have discarded all except the *antimonial wine* prepared by digesting the vitreous sulphurated oxide, finely powdered, in white wine, which is an excellent medicine; and they have added of late years a solution of tartarised antimony in the same menstruum, under the name of *wine of tartarised antimony*.

While on this subject we must not omit to mention the *perpetual pill and cup*, once in some repute. These were made of the pure metal, cast into the shape of a cup and of a pill: the former imparted an emetic quality to wine suffered to stand in it a little time, without any apparent diminution of its substance for ages; and the latter, though it often proved violently emetic, might be transmitted from generation to generation, without its virtues being at all impaired, however frequently it was employed as a purgative.

The reader may have remarked, that the complete oxides of antimony are inert, and the sulphuret of antimony appears to be equally so; though, from the instance last given, the pure metal seems to possess powers of very great activity, at least with no other preparation than it undergoes in the stomach and intestines, or by the action of wine. It may appear singular too, that sulphuret of antimony calcined with an equal weight of nitrat of potash is an active medicine; while either an increase or diminution of the proportion of nitrat diminishes the activity of the product, till it becomes altogether inert. May we not account for this by ascribing the action of antimonials to the pure metal contained in them alone? so that the calcination with nitrat of potash renders it active in proportion as it robs the metal of the sulphur that rendered it bland; and, when it is employed more largely, destroys its activity in a different way, by oxiding a greater portion of it? This too might account for its variable action, which is most conspicuous when the solid preparations are administered; since, however accurately the medicine may be prepared, the state of the fluids in the primæ viæ must be always liable to variation.

Beside the extensive use of antimony in medicine, it enters into the composition of some alloys, as those used for printers' types, small shot, and mirrors of telescopes; it is employed in colouring glass and enamels, and painting on china; and for its use in scorifying copper and other metals mixed with gold was styled by the alchemists *balneum regis*, or *balneum solis*.

For its ores, and the reduction of the metal, see Ores.

Ants. See Acid (Formic).

Aplanatic. The researches of chemists and manufacturers to remove those defects in glass (see that article), which have prevented the accomplishment of a complete correction of the aberration of the rays of light in the telescopes termed achromatic, induced Dr. Robert Blair to try the effects of fluid mediums; and his success in this respect was such, as to induce him to give the term *aplanatic*, or 'free from error,' to the glasses he thus constructed.

In the course of his inquiry he found, that the solutions of metals proved in all cases more dispersive than crown glass. Some of the salts, as the muriat of ammonia for instance, greatly increased the dispersive power of water. The muriatic acid disperses very considerably, and this in proportion to its strength. And accordingly the most dispersive fluids are found to be those in which metals are combined with this acid. The muriat of antimony in its most concentrated state, when it has attracted just sufficient humidity to render it fluid, disperses the rays of light to such a degree, that three wedges of crown glass are necessary to remove the colour produced by one wedge of this substance of an equal refracting angle opposed to them. The muriat of mercury added to a solution of muriat of ammonia in water ranked next in dispersive power among the fluids examined by the doctor. It may be made so strong as to require a wedge of crown glass of double the refracting angle to counteract its effect.

Essential oils came next to the metallic solutions; and the most dispersive were those obtained from bituminous minerals. When the refraction is without colour, the proportion of the refracting angle of a prism of the latter to the refracting angle of a prism of crown glass acting in opposition is about two to three. The essential oil of sassafras is little inferior to these. Genuine oil of lemons requires the angles to be as three to four; oil of turpentine as seven to six. Oil of rosemary is still less dispersive.

Some of the expressed oils, rectified spirit, and nitrous and vitriolic ether did not differ sensibly from crown glass.

In applying these principles to practice, Dr. Blair took two double convex lenses of crown glass, the radii of convexity in each of which were as two to one; turned their less convex sides toward each other; kept them at a proper distance by means of a glass ring; and filled the cavity with the strongest muriat of antimony. Thus, the wedges of glass being to those of the muriat as three to one, the colour was removed; but on directing the instrument to a planet, and using a deep eyeglass, the fluid was found to be subject, like flint glass, to great irregularities of density, discoverable by streams of light radiating from the disk of the planet. This may be remedied by reducing the muriat to a sufficient degree of fluidity by means of alcohol, or vitriolic ether, into which a small quantity of muriatic acid had been previously dropped: but solutions of this or other saline substances so diluted do not differ materially in dispersive power from the essential oils.

It is sometimes advantageous, however, to employ those fluids that have least density, as for instance where it is required to produce a single refraction, in which there shall be no difference of refrangibility of heterogeneous light: for Dr. Blair has shown, that there are cases of single refraction, in which the violet rays are the least refrangible; others in which all the rays are equally refrangible; and others in which the red are refracted from the perpendicular, the violet toward it, and the mean refrangible rays neither way. By the doctor's experiments too it appears, that, in mediums which disperse the light but little, green is the mean refrangible ray; in most of the more dispersive, including flint glass, metallic solutions, and essential oils, the green is one of the less refrangible rays; and in another class, including the nitrous and muriatic acids, the green is among the more refrangible. It was found necessary, therefore, to apply mediums of different orders to correct each other; and as the metallic solutions and acids are of this description, by combining them together the complicated structure of refracting the rays first through one medium then through the other is avoided. Thus an addition of muriatic acid to the muriat of antimony removes the green and purple fringes arising from the irregular refraction of those two intermediate rays by the muriat alone; but if too much of the acid be added, they reappear in an inverted order. Thus, too, from a solution of the muriats of ammonia and mercury mixed in a certain proportion the rays emerge equally refracted: but if the muriatic acid predominate from an excess of the muriat of ammonia, the green rays will emerge less refracted than the united red and violet; and if the metal predominate from an excess of the mercurial muriat, the opposite effect will be produced.—*Edinburgh Transactions, vol. ii.* —*Nicholson's Journal, 4to, vol. i.*

Apparatus. See Laboratory.

Apples. See Acid (Malic).

Apyrous. Bodies which sustain the action of a strong heat for a considerable time, without change of figure or other properties, have been called apyrous; but the word is seldom used in the art of chemistry. It is synonymous with *refractory*.

Aqua Fortis. This name is given to a weak and impure nitric acid, commonly used in the arts. It is distinguished by the terms *double* and *single*, the single being only half the strength of the other. The artists who use these acids call the more concentrated acid, which is much stronger even than the double aqua fortis, *spirit of nitre*. This distinction appears to be of some utility, and is therefore not improperly retained by chemical writers. See Acid (Nitric).

The manufacturers of soap in France and elsewhere call their lixivium or soap-lees by the name of strong water; and this name, *eau forte*, which is likewise employed by artists of a different description for our aqua fortis, being consequently used to denote the caustic alkali in recipes for dyeing and other processes, has given rise to several mistakes.

Aqua Marine, or Augites. The Beryl of some. A precious stone of a transparent green blue, fusible by the blow-pipe; it is nearly the same both in form and specific gravity with the Peruvian emerald, and the chrysolite. Its specific gravity is from 2·65 to 2·72, and its hardness nearly the same as that of quartz. According to Vauquelin's analysis it contains silex ·69, alumine ·13, glucine ·16, lime ·005, oxide of iron ·01. In value it ranks low among the gems.

Aqua Regia, or Regis. This acid, being compounded of a mixture of the nitric and muriatic acids, is now termed by chemists nitro-muriatic acid. When one or two parts of pale concentrated nitric acid are mixed with four of muriatic acid, an effervescence soon takes place, and oxigenated muriatic acid flies off in the elastic form, at the same time that the mixture becomes of a deep red colour: it has obtained its name from its property of dissolving gold, the royal metal of the alchemists, which is not perceptibly acted upon by either of the acids that compose it. See Acid (Nitric).

Aqua secunda. This name is sometimes given to an exceedingly diluted aqua fortis, used in the arts for cleaning the surface of metals and some other bodies.

Aqua Vitæ. Ardent spirit of the first distillation has been distinguished in commerce by this name. The distillers of malt and melasses spirits call it low wines.

Aquila alba. One of the names given to the combination of muriatic acid and mercury in that state which is more commonly known by the denomination of *mercurius dulcis, calomel,* or *mild muriat of mercury*.

Arabic (Gum). This is reckoned the

purest of gums, and does not greatly differ from gum Senegal, vulgarly called gum seneca, which is supposed to be the strongest, and is on this account, as well as its greater plenty and cheapness, mostly used by calico-printers and other manufacturers. The gums of the plum- and the cherry-tree have nearly the same qualities as gum arabic. All these substances facilitate the mixture of oils with water, and they are said to suffer a decomposition, or considerable change, by freezing, but of what nature has not been clearly explained.

Arable Lands. It is a problem in chemistry, and by no means one of the least importance to society, to determine what are the requisites which distinguish fruitful lands from such as are less productive. Since vegetable substances evidently imbibe from the earth and surrounding atmosphere the principles of oils, mucilages, and other peculiar products only found in organized substances; it can scarcely be doubted, but that manure, or the remains of other decayed organized substances, renders lands fruitful, by supplying these materials ready formed. It may happen, however, that the putrefactive process in a considerable quantity of manure may be so effective as to overcome the vital powers, or destroy the organization of the plant; and on this account an excess of manure must be hurtful. In those cases wherein vegetation is performed without the presence of any thing which may be called manure, it seems proper, as far as the few and imperfect lights of chemistry can serve to direct us, to ascribe the growing or augmentation of vegetables to the decomposition of water, or the air of the atmosphere, rather than to any considerable addition of earthy particles; more especially, as it appears from good experiments that the earth in which vegetables grow suffers very little loss of its weight in consequence of their increase. From the indispensable necessity of water in vegetation, it appears, that this fluid either supplies the greatest part of the mass of vegetables, or is at least the vehicle or medium by which aërial fluids are condensed and conveyed into the vegetable substance; which leads to a conclusion, that, generally speaking, those earths which are the best adapted to imbibe and retain water, and at the same time admit the access of air, are most fruitful. Sand or small particles of siliceous earth are evidently the least adapted to this purpose. Clays of considerable purity will be too stiff, impenetrable, and adhesive. Chalky or calcareous soils are not only hard and permanent, so as to be with considerable difficulty penetrated by the roots of vegetables, but are little adapted either to imbibe more water than they naturally possess, or to part with that they already have. Little need be said of barytes and magnesia, as they do not enter in any notable proportions as ingredients in soils: but lime made from a limestone containing a certain portion of magnesia, when used to improve the fertility of land, as pure lime would do, has been found to prove injurious.

If we might therefore overlook the presence of saline and combustible matter, which are indeed necessary to fertility, and the latter of which is the cause of the dark colour of mould, our attention would be naturally directed to a mixture of the siliceous, calcareous, and argillaceous earths, that is to say, of sand, chalk or lime, and clay. The first being totally insoluble in water, can scarcely be expected to answer any other purpose than that of mechanically separating the parts of the mass, or at least of rendering them more easily separable by frost and other atmospherical changes. The calcareous and argillaceous earths form the composition distinguished by the name of marle, and this will vary in its properties according to the nature of its composition; the friability and solubility of the lime in water serving greatly to correct the bad effects of the mere clay, while this on the other hand produces a change of equal advantage in the chalk or lime. It may easily be apprehended, that the presence of sulphuric acid or other acidifiable substances, together with the access of air, cannot but produce changes by combination with these two earths, which will be still more considerable, and cannot indeed be followed by any conjectural reasoning, though the little we know of the subject sufficiently evinces the great utility of experiments in this department of chemical inquiry. See Soils.

Arbor Dianæ. All bodies whatever, in their transition from the fluid to the solid state, are disposed to arrange themselves in peculiar symmetrical figures. See Crystallization. When one body is precipitated from its solvent by the addition of another, the transition to solidity is usually so quick, that the parts have not time to arrange themselves, excepting in such minute masses as constitute the pulverulent form. When silver is dissolved in nitric acid, and mercury is added, the elective attraction between the mercury and the acid acts with such a degree of slowness, that the silver in certain cases is separated in the form of a tree or shrub, which the earlier chemists in their usual fanciful way called the tree of Diana. In this, as in all precipitations, there are a variety of concomitant circumstances, which influence the peculiar form, and for this reason one process usually succeeds better than another. Lemery directs, that an ounce of fine silver be dissolved in a sufficient quantity of pure and moderately strong nitric acid. This solution must then be mixed in a matrass with about twenty ounces of distilled water; and lastly, two ounces of mercury are to be added to the mixture; after which the whole must be suffered to remain at rest. During a space of about forty days, a kind of tree of silver will be formed on the surface of the mercury, with branches greatly resembling a vegetable substance in its ramifications. Macquer affirms, that this process succeeds very well, but the following of Homberg is much shorter.

Make an amalgam, without heat, of four drams of leaf silver, with two drams of mercury. Dissolve this amalgam in four ounces, or a sufficient quantity of pure nitric acid of a moderate strength; dilute this solution in about a pound and a half of distilled water, agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of an amalgam of gold or silver, as soft as butter, is to be added; after which the vessel must be left at rest: soon afterward, small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs.

In the above experiment of Lemery, the nitric acid deposits its silver, at the same time that it takes up mercury; and, in consequence of the liquor being so much diluted, the process goes on slowly, and the precipitated silver has time to arrange itself according to the laws of its crystallization, whether this depend on the polarity of its particles, or on any other property not yet explained. In the process of Homberg, there are two circumstances which appear calculated to forward the process: in the first place, the nitric acid already contains mercury in solution, which may probably render it more disposed to part with the silver; and in the next place, the mercury is combined with silver or gold in the form of an amalgam. These may, perhaps, facilitate the precipitation of the silver, by presenting a base for it to combine with, which may be more perfectly at repose, because less agitable than the fluid mercury in the former experiment. After all, however, though the general theory of the experiment is not difficult, yet it does not seem easy to point out the effectual cause of the differences between the two results.

Arcanum Corallinum. This name has been given to red nitrat of mercury, on which alcohol has been two or three times burnt, with an intention of rendering it milder. See Mercury.

Arcanum Duplicatum. A name formerly given to the combination of potash and sulphuric acid, more commonly called vitriolated tartar, and now sulphat of potash.

Archil, Archilla, Rocella, Orseille. A whitish moss growing upon rocks in the Canary and Cape Verd islands, which yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered: those who prepare it for the use of the dyer grind it betwixt stones, so as thoroughly to bruise, but not to reduce it into powder, and then moisten it occasionally with a strong spirit of urine, or urine itself mixed with quicklime: in a few days it acquires a purplish red, and at length a blue colour; in the first state it is called archil, in the latter, lacmus or litmus.

The dyers rarely employ this drug by itself, on account of its dearness, and the perishableness of its beauty. The chief use they make of it is for giving a bloom to other colours, as pinks, &c. This is effected by passing the dyed cloth or silk through hot water lightly impregnated with the archil. The bloom thus communicated soon decays upon exposure to the air. Mr. Hellot informs us, that by the addition of a little solution of tin, this drug gives a durable dye; that its colour is at the same time changed toward a scarlet; and that it is the more permanent, in proportion as it recedes the more from its natural colour.

Prepared archil very readily gives out its colour to water, to volatile spirits, and to alcohol; it is the substance principally made use of for colouring the spirits of thermometers. As exposure to the air destroys its colour upon cloth, the exclusion of the air produces a like effect in those hermetically sealed tubes, the spirits of large thermometers becoming in the compass of a few years colourless. The abbé Nollet observes (in the French Memoirs for the year 1742), that the colourless spirit, upon breaking the tube, soon resumes its colour, and this for a number of times successively; that a watery tincture of archil, included in the tubes of thermometers, lost its colour in three days; and that in an open deep vessel it became colourless at the bottom, while the upper part retained its colour.

A solution of archil, in water, applied on cold marble, stains it of a beautiful violet or purplish blue colour, far more durable than the colour which it communicates to other bodies. Mr. du Fay says, he has seen pieces of marble stained with it, which in two years had suffered no sensible change. It sinks deep into the marble, sometimes above an inch, and at the same time spreads upon the surface, unless the edges be bounded by wax or some similar substance. It seems to make the márble somewhat more brittle.

Linnæus informs us, in the Swedish Transactions for the year 1742, that the true archil moss is to be found on the western coasts of England; and suspects, that there are several other more common mosses, from which valuable colours might be extracted. A quantity of sea moss having rotted in heaps upon the shore, he observed the liquor in the heaps to look like blood; the sea-water, and the sun, and the putrefaction having brought out the colour. Mr. Kalm, in an Appendix to Linnæus's Paper in the year 1745, mentions two sorts of mosses actually employed in some parts of

Sweden for dyeing woollen red: one is the lichenoides coralliforme apicibus coccineis of Ray's Synopsis; the other, the lichenoides tartareum, farinaceum, scutellarum umbone fusco of Dillenius. This last is a white substance, like meal clotted together, found on the sides and tops of hills. It is shaved off from the rocks after rain; purified from the stony matters intermixed among it, by washing with water; then dried in the sun, ground in mills, and again washed and dried: it is then put into a vessel with urine, and set by for a month. A little of this tincture added to boiling water makes the dyeing liquor.—In the same Transactions, for the year 1754, there is an account of another moss, which, prepared with urine, gives a beautiful and durable red or violet dye to wool and silk. This is the lichen foliaceus, umbilicatus subtus lacunesus Linn. Flor. Suec. It grows upon rocks, and is readily distinguished from others of that class, by its looking as if burnt or parched, consisting of leaves as thin as paper, convex all over on the upper side, with corresponding cavities underneath; adhering firmly to the stones by a little root under the leaves, and coming asunder, when dry, as soon as touched. It is gathered after rain, as it then holds best together, and parts easiest from the stone.

In France, a crustaceous moss, growing upon rocks in Auvergne, is prepared with lime and urine, and employed by the dyers as a succedaneum to the Canary archil, to which it is said to be very little inferior: it is called Orseille d'Auvergne, or Perelle, but appears from the experiments of Dr. Westring not to be prepared from the lichen parellus. Mr. Hellot relates, that he has met with several other mosses, which, on being prepared in the same manner, acquire the same colour. The most expeditious way, he says, of trying whether any moss will yield an archil or not, is, to moisten a little of it with a mixture of equal parts of ammonia and strong lime water, and add a small proportion of muriat of ammonia. The glass is then to be tied over with a piece of bladder, and set by for three or four days. If the moss is of the proper kind, the little liquor which runs from it upon inclining the vessel will appear of a deep crimson colour; and this afterward evaporating, the plant itself acquires the same colour.

Lewis tried a good number of the common mosses, both of the crustaceous and foliaceous kind, and not a few of the fungi; as also the herbs chamomile and milfoil, which yield a blue essential oil; and thyme, the oil of which becomes blue by digestion with volatile alkali; but did not meet with any that yielded a colour like archil. Most of them gave a yellow or reddish brown tincture; and if there were a scarcity of other drugs for these kind of dyes, some of the mosses might be made to afford not inelegant ones. A few gave a deep red colour to the liquor; but when diluted it showed a yellowish cast, and when applied on cloth it gave only a yellowish red.

Dr. Westring has likewise made various experiments on the lichens in Sweden, related in different volumes of the Memoirs of the Swedish Academy, and says, there are several superior to archil, and that equal parts of nitre and common salt are of great use in improving and fixing their colours. The lichen pustulatus he considers as little inferior to cochineal: and from the lichen pulmonarius he obtained beautiful orange and carmelite dyes.

There is a considerable consumption of an article of this kind manufactured in Scotland, and sold by the name of cudbear. It fetches about 19*d.* or 20*d.* a pound in London. We have seen beautiful specimens of silk thus dyed, the colours of which were said to be very permanent, of various shades from pink and crimson to a bright Mazarin blue.

Litmus is likewise used in chemistry as a test, either staining paper with it, or by infusing it in water, when it is very commonly, but with great impropriety, called *tincture of turnsole.* The persons by whom this article was prepared formerly gave it the name of turnsole, pretending that it was extracted from the turnsole, heliotropium tricoccum, in order to keep its true source a secret. The tincture should not be too strong, otherwise it will have a violet tinge, which however may be removed by dilution. The light of the sun turns it red even in close vessels. It may be made with spirit instead of water. This tincture, or paper stained with it, is presently turned red by acids: and if it be first reddened by a small quantity of vinegar, or some weak acid, its blue colour will be restored by an alkali.

Archil is never used alone as a dye, except for lilacs, because it is not sufficiently permanent: but it is very extensively employed for deepening and improving the beauty of other dyes, and giving a fine bloom, which is not to be obtained by other means. When silk is dyed with archil only, a quantity proportionate to the colour required is boiled in a proper vessel: and the clear liquor is poured quite hot into a trough, in which the silk, carefully cleansed from soap, is to be turned with great care till it has acquired the proper shade. The silk is then to be beetled once in the river. The solution of tin, which gives it a red approaching to scarlet, is the only thing capable of increasing the durability of this dye.

Ardent Spirit. See Alcohol.

Areometer. See Hydrometer.

Argal. Crude tartar, in the state in which it is taken from the inside of wine vessels, is known in the shops by this name.

Argentate of Ammonia, fulminating silver.

Argillaceous Earth, or Alumine. See **Earths.**

Armenus Lapis. Armenian Stone. This is a soft blue stone, which does not admit of a polish, and consists of calcareous earth, or gypsum, penetrated with the blue oxide of copper. Hence it sometimes effervesces with acids, and sometimes not. It is too soft to give fire with steel, and loses its colour when heated. In its hardest state it approaches the lapis lazuli, but is not speckled with gold, though it is sometimes with green spots. It is used in mosaic work, and likewise in painting.

Aroma. The supposed principle of smell in vegetables, formerly called *Spiritus Rector.*

Aromatics. Plants which possess a fragrant smell united with pungency, and at the same time are warm to the taste, are called aromatics. Their peculiar flavour appears to reside in their essential oil, and rises in distillation either with water or spirit.

Arrack. A spirituous liquor imported from the East Indies. It is chiefly manufactured at Batavia, and at Goa upon the Malabar coast. There are various accounts of the processes and materials used in making it; and the disagreement of these accounts seems to arise from the general appellation of *arrack* being given, in the East Indies, to every kind of spirituous liquor; and also from the disposition which the Dutch so eminently possess of endeavouring to keep their manufacturing processes to themselves. It is certain, that the flavours of the several kinds of arrack differ as much from each other, as those of brandy, rum, corn spirits, or any other of the spirituous liquors of Europe. The materials from which ardent spirit is distilled in the East Indies are rice, melasses, and toddy, or the juice of the cocoa-nut tree. The Chinese distil a spirit from rice, which they distinguish by the name of sam shu, and of which considerable quantities are exported to Batavia, for the purpose, as it is said, of being converted into arrack by a second distillation: though perhaps it may be consumed among the numerous Chinese who inhabit that city. The common Batavia arrack appears to be distilled from a mixture of the wort or infusion of rice and the toddy, after both have passed through the vinous process. And to these, according to circumstances, it seems they add other ingredients, particularly spices.

Of European spirits the common malt spirit before rectification resembles arrack the most. Arrack is reckoned less intoxicating than rum or brandy; but this difference arises from its being very seldom of equal strength. Of five specimens procured from different channels, I found the specific gravity between 965 and 967, water being 1000; whence it follows, that proof spirit lowered with about ¼ of its bulk of water would have been of the same strength as this arrack.

Arsenic in the metallic state is of a blueish white colour, subject to tarnish and grow first yellowish, then black by exposure to air. It is brittle, and when broken exhibits a laminated texture. Its specific gravity, according to Muschenbroeck and Bergman, is 8·310, but Brisson gives it at no more than 5·763. This Kirwan attributes to the blebs with which it commonly abounds. In close vessels it sublimes entire; but burns with a small flame if respirable air be present.

The arsenic met with in commerce has the form of a white oxide. It is brought chiefly from the cobalt works in Saxony, where zaffre is made. Cobalt ores contain much arsenic, which is driven off by long torrefaction. The ore is thrown into a furnace resembling a baker's oven, with a flue, or horizontal chimney, nearly two hundred yards long, into which the fumes pass, and are condensed into a grayish or blackish powder. This is refined by a second sublimation in close vessels, with a little potash, to detain the impurities. As the heat is considerable, it melts the sublimed flowers into those crystalline masses which are met with in commerce.

The oxide of arsenic is so far in the saline state, as to be soluble in about eighty times its weight of water, at the temperature of 60°, or in fifteen times its weight of boiling water. See **Acid (Arsenious).**

The metal may be obtained from this, either by quickly fusing it together with twice its weight of soft soap and an equal quantity of alkali, and pouring it out, when fused, into a hot iron cone; or by mixing it in powder with oil, and exposing it in a matrass to a sand heat. This process is too offensive to be performed, except in the open air, or where a current of air carries off the fumes. The decomposed oil first rises; and the arsenic is afterwards sublimed, in the form of a flaky metallic substance. It may likewise be obtained by mixing two parts of the arsenious acid with one of black flux; putting the mixture into a crucible, with another inverted over it, and luted to it with clay and sand; and applying a red heat to the lower crucible. The metal will be reduced, and line the inside of the upper crucible.

It is among the most combustible of the metals, burns with a blue flame, and garlic smell, and sublimes in the state of arsenious acid.

Concentrated sulphuric acid does not attack arsenic when cold; but if it be boiled upon this semi-metal, sulphurous acid gas is emitted, a small quantity of sulphur sublimes, and the arsenic is reduced to an oxide.

Nitrous acid readily attacks arsenic, and converts it into arsenious acid, or, if much be employed, into arsenic acid.

Boiling muriatic acid dissolves arsenic, but affects it very little when cold. This solution affords precipitates upon the addition of alkalies. The addition of a little nitric acid expedites the solution; and this solution, first heated and condensed in a close vessel, is wholly sublimed into a thick liquid, formerly termed *butter of arsenic*. Thrown in powder into oxigenated muriatic acid gas, it burns with a bright white flame, and is converted into arsenous acid; which readily passes to the state of arsenic acid, on the addition of liquid oxigenated muriatic acid, this being deoxigenated by it.

None of the earths or alkalies act upon it, unless it be boiled a long while in fine powder, in a large proportion of alkaline solution.

Nitrats detonate with arsenic, convert it into arsenic acid, and this, combining with the base of the nitrat, forms an arseniat, that remains at the bottom of the vessel.

Muriats have no action upon it; but if three parts of superoxigenated muriat of potash be mixed with one part of arsenic in fine powder, which must be done with great precaution, and a very light hand, a very small quantity of this mixture, placed on an anvil, and struck with a hammer, will explode with flame and a considerable report: if touched with fire, it will burn with considerable rapidity: and if thrown into concentrated sulphuric acid, at the instant of contact a flame rises into the air like a flash of lightning, which is so bright as to dazzle the eye.

Arsenic readily combines with sulphur by fusion and sublimation, and forms a yellow compound called *orpiment*, or a red called *realgar*. The nature of these, and their difference, are not accurately known: but Fourcroy considers the first as a combination of sulphur with the oxide, and the second as a combination of sulphur with the metal itself, as he found the red sulphuret converted into the yellow by the action of acids.

Arsenic is soluble in fat oils in a boiling heat: the solution is black, and has the consistence of an ointment when cold. Most metals unite with arsenic; which most probably exists in the metallic state in such alloys as possess the metallic brilliancy.

Arsenic is used in a variety of arts. It enters into metallic combinations wherein a white colour is required. Glass manufacturers use it; but its effect in the composition of glass does not seem to be clearly explained. Orpiment and realgar are used as pigments. See ACIDS (ARSENIC, and ARSENIOUS.)

ARUM. The common *Arum*, or Wake-robin, is a plant of extreme acrimony: the fresh root, slightly chewed, seems to burn and corrode the tongue; and oftentimes its pungent impression continues for two or three days. The seat of this acrimony has hitherto eluded our inquiries: the distilled water and spirit have nothing of it, and the watery and spirituous extracts exceedingly little; and yet the root is, by these operations, deprived of it.

Greatest part of the acrimony is destroyed by simple exsiccation: the dry root appears white and farinaceous, and affects the tongue but little. In this state it is given medicinally for attenuating viscid juices: formerly it was used as starch for linen, before the discovery of that from wheat; and it is said to have occasioned a rawness and soreness of the hands very difficultly relievable by ointments. If this have been the case, however, it was probably owing to some neglect in the preparation, as we never heard any complaint of this kind in a part of England where it has been long in use, and continues so to this day. A few years ago, the Society of Arts gave a premium to a person for making it known. In some parts of France, it is still employed in bleaching; being supposed by its corrosive quality to dissolve unctuosities, and make the linen white.

From an ounce of the dry root Neumann obtained scarcely a scruple of spirituous extract: the same quantity yielded of watery extract near three drams. The first had some slight pungency; the latter none.

ASAFŒTIDA is obtained from a large umbelliferous plant growing in Persia. The root resembles a large parsnep externally, of a black colour: on cutting it transversely, the asafœtida exudes in form of a white thick juice, like cream; which, from exposure to the air, becomes yellower and yellower, and at last of a dark brown colour. It is very apt to run into putrefaction; and hence those who collect it carefully defend it from the sun. The fresh juice has an excessively strong smell, which grows weaker and weaker upon keeping: a single dram of the fresh fluid juice smells more than a hundred pounds of the dry asafœtida brought to us. The Persians are commonly obliged to hire ships on purpose for its carriage, as scarcely any one will receive it along with other commodities, its stench infecting every thing that comes near it.

The common asafœtida of the shops is of a yellowish or brownish colour, unctuous and tough, of an acrid or biting taste, and a strong disagreeable smell, resembling that of garlic. From four ounces Neumann obtained, by rectified spirit, two ounces six drams and a half of resinous extract; and afterward, by water, three drams and half a scruple of gummy extract; about six drams and a scruple of earthy matter remaining undissolved. On applying water at first, he gained, from four ounces, one ounce three scruples and a half of gummy extract. The same quantity yielded, with strong French wine, two ounces and a half and fifteen grains; from which about one fifth may be deducted, for the solid matter contained in the wine. Schroder says, that asafœtida may be dissolved over the fire, in water, vinegar, or wine; but only a part of it can be dissolved in any of these liquors. The smell of the asafœtida resides wholly in an essential oil, which arises in distillation both with water and spirit: four ounces, distilled with water, yielded about a dram of oil.

Asafœtida is administered in nervous and hysteric affections, as a deobstruent, and sometimes as an anthelmintic. A tincture of it is kept in the shops, and it enters into the composition of the compound galbanum pill of the London college, the gum pill of former dispensatories.

Asbestos, or Asbestus. The most obvious characters of the asbestos are, a greater or less degree of flexibility, and their resisting the fire. The *Amianthus* is often confounded with it. Cronstedt distinguishes two kinds:—The asbestos which is composed of soft and thin membranes, and is the amianthus of Wallerius. The membranes of this are either parallel, in which case he calls it Mountain Leather; or twisted, which he distinguishes by the name of Mountain Cork. Both these kinds are white when pure; or of a yellowish brown when contaminated with iron. The impure sort melts pretty easily into a black slag.—The second kind of asbestos distinguished by Cronstedt has its fibres fine and flexible, and either parallel, of a light green or white colour; or of a greenish colour, somewhat more brittle, and contaminated with iron. This last is fusible into a semitransparent glass. There is also a light green martial asbestos, with broken fibres, which belongs to this kind.

The ancients manufactured cloth out of the fibres of asbestos, for the purpose, it is said, of wrapping up the bodies of the dead, when exposed on the funeral pile. Several moderns have likewise succeeded in making this cloth; the chief artifice of which seems to consist in the admixture of flax and a liberal use of oil; both which substances are afterward consumed by exposing the cloth for a certain time to a red heat. Although the cloth of asbestos, when soiled, is restored to its primitive whiteness by heating in the fire; it is found, nevertheless, by several authentic experiments, that its weight diminishes by such treatment. The fibres of asbestos, exposed to the violent heat of the blow-pipe, exhibit slight indications of fusion; though the parts, instead of running together, moulder away, and part fall down, while the rest seem to disappear before the current of air. Ignition impairs the flexibility of asbestos in a slight degree.

According to Bergman, the fibrous asbestos contains from 53 to 74 parts of siliceous earth, from 12 to 28 of carbonat of magnesia, from 7 to 14 of carbonat of lime, from 2 to 6 of alumine, and from 1 to 10 of iron; the whole mass being supposed to be divided into 100 parts. The martial asbestos contains 62 of siliceous earth, 1·37 of magnesia, 12 of calcareous earth, 1·7 of alumine, and 10·6 of iron. This affords a white slag by fusion.

The mountain cork or leather contains in the hundred from 56 to 62 parts of siliceous earth, from 22 to 26 of carbonate of magnesia, from 10 to 12 of carbonat of lime, from 2 to near 3 of alumine, and about 3 of iron.

Ashes. The fixed residue of combustible substances, which remains after they have been burned, is called ashes. In chemistry it is most commonly used to denote the residue of vegetable combustion. Vegetable ashes contain alkali; which may be washed out with water, and the insoluble part is found to consist of a calcareous earth, for the most part some alumine, and a much less portion of magnesia. All these products vary in the different species of vegetables. Most plants afford likewise iron and manganese; and Mr. Sage, by experiments which have been verified by other chemists, has proved, that gold is a very common ingredient, though in so small a quantity as by no means to pay the charge of extracting it. See Potash, Soda, and the respective articles that afford ashes of use in the arts.

Asparagus. A new vegetable principle has lately been said to have been discovered in this well-known plant by M. Robiquel, of Paris. At the suggestion of M. Parmentier, he had begun to subject the juice of asparagus to chemical analysis, and some of it, concentrated by evaporation, produced, on standing some time, a considerable number of crystals. These were of two sorts; one of them was probably manna; the other was cool and slightly nauseous to the taste, so as to occasion a secretion of saliva; hard, brittle, and regularly crystallized in right rhomboidal prisms, with facets on the borders of the base and at its two acute angles, the obtuse angles being about 130°. They were moderately soluble in water, but not in alcohol; and the solution gave no signs of either acid or alkali; and was not at all affected by infusion of galls, acetat of lead, oxalat of ammonia, muriat of barytes, or hidrosulphuret of potash. Caustic potash triturated with it disengaged no ammonia, but appeared to render it more soluble in water. Burnt in a crucible, at first it swelled up, and emitted penetrating vapours affecting the eyes and nose like smoke of wood. It afforded a large portion of charcoal, which had no taste, and left nothing after its incineration but an almost imperceptible trace of earth, which, no doubt, was casually present. Toward the end, the odour emitted was somewhat similar to that of animal matter, and likewise inclining to that of ammonia. Nitric acid decomposes it, and nitrous gas being evolved, while the fluid assumes a yellow colour and bitter taste like that of animal substances. When the action of the nitric acid is completed, lime disengages abundance of ammonia from the liquid. This alkali must be formed in the operation just described, since the substance afforded no perceptible signs of it before.

Hence, as it contains neither earth nor alkali, it is not a neutral salt; and it is not an acid. M. Vauquelin therefore infers, that it is an immediate principle of the asparagus, composed of hidrogen, oxigen, and carbon, in particular proportions, with probably a small quantity of nitrogen.—*Annals de Chimie*, Jan. 1806.

Asphaltum. This substance, likewise called Bitumen Judaicum, or Jews Pitch, is a smooth, hard, brittle, black or brown substance, which breaks with a polish, melts easily when heated, and when pure burns without leaving any ashes. It is found in a soft or liquid state on the surface of the Dead Sea *, but by age grows dry and hard. The same kind of bitumen is likewise found in the earth in other parts of the world; in China; America, particularly in the island of Trinidad; and some parts of Europe, as the Carpathian hills, France, Neufchatel, &c. Its specific gravity, according to Boyle, is 1·400, to Kirwan, from 1·07 to 1·65. A specimen from Albania, of the specific gravity of 1·205, examined by Mr. Klaproth, was found to be soluble only in oils and in ether. Five parts of rectified oil of petroleum dissolved one of the asphaltum, without heat, in 24 hours. Analysed in the dry way, 100 grains afforded 32 of bituminous oil, 6 of water faintly ammoniacal, 30 of charcoal, 7¼ of silex, 7½ of alumine, ¾ of lime, 1¼ oxide of iron, ½ oxide of manganese, and 36 cubic inches of hidrogen gas.

According to Neumann, the asphaltum of the shops is a very different compound from the native bitumen; and varies, of course, in its properties, according to the nature of the ingredients made use of in forming it. On this account, and probably from other reasons, the use of asphaltum, as an article of the materia medica, is almost totally laid aside.

Aspic. A plant which grows in plenty in Languedoc, in Provence, and especially on the mountain of St. Baumé in France. It is a kind of lavender, pretty much like that which grows in our gardens, both with regard to its flowers, which are blue, and to the figure and green colour of its leaves. The botanists call it male lavender, lavendula mas in Latin. They also give it other names, as spica nardi, pseudo-nardus, &c. The oil of aspic that painters, farriers, and other artificers use, which is likewise of some use in medicine, being employed in several Galenical compositions, is extracted from the flowers and small leaves of this plant. It is very inflammable, and when once on fire it is almost impossible to extinguish it.

The true oil of aspic is white, and of an aromatic scent. It is the only dissolvent of sandarac; by which means it may be easily distinguished from that which is counterfeited, and which is nothing but oil of turpentine mixed with a little oil of petroleum.

In the above article, which is taken from Postlethwaite, the author, who refers to Savary as his authority, affirms, that as sandarac, or gum sandarac, is very soluble in spirit of wine, he concludes that Mr. Savary is mistaken, and must have meant karabé, or yellow amber. I find, in fact, that gum sandarac, though it differs from resins in several essential respects, particularly in not being soluble in olive oil, agrees with them, nevertheless, in this particular, that alcohol dissolves it.

Assay, *or* **Essay.** This operation consists in determining the quantity of valuable or precious metal contained in any mineral or metallic mixture, by analysing a small part thereof. The practical difference between the analysis and the assay of an ore, consists in this: The analysis, if properly made, determines the nature and quantities of all the parts of the compound; whereas, the object of the assay consists in ascertaining how much of the particular metal in question may be contained in a certain determinate quantity of the material under examination. Thus, in the assay of gold or silver, the baser metals are considered as of no value or consequence; and the problem to be resolved is simply, how much of each is contained in the ingot or piece of metal intended to be assayed. The examination of metallic ores may be seen under their respective titles; the present article will therefore consist of an account of the assaying of gold and silver.

To obtain gold or silver in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows: The precious metal is put, together with a due propor-

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* In the Mem. of the Academy of Sciences of Paris for 1778, there is an analysis of the water of this sea by Messrs. Macquer, Lavoisier, and Sage, by which it appears to contain 22 per cent. of muriat of magnesia, 16¼ of muriat of lime, and 6½ of muriat of soda. Its specific gravity is 1·25. It is limpid, and without smell.

to a shallow crucible, made
es, called a cupel; and the
etals is effected by exposing
iderable heat in a muffle, or
ven, fixed in the midst of a
lead continually vitrifies, or
rted into a glassy calx, which
ne imperfect metals. This
a its contents, sokes into the
es the precious metal in a
During the cupellation, the
down on all sides of the
produce an appearance called
y which the operator judges
process be going on well.
etal is nearly pure, certain
urs flash suddenly across the
globule, which soon after-
very brilliant and clean:
e brightening, and shows that
a is ended.

has passed the cupel, it may
either of the other perfect
a or silver. The former is
cted; the latter is separated
ations called quartation and
tation consists in adding three
r to the supposed gold, and
ogether; by which means the
at most one fourth of the mass
tention of this is to separate
of gold from each other, so
y not cover and defend the
he action of the nitric acid,
e used in the process of part-
consists in exposing the mass,
ammered or rolled out thin,
of seven or eight times its
oiling nitric acid of a due
e first portion of nitric acid
off, about half the quantity,
at greater strength, is to be
e remaining gold: and if it
that this has not dissolved all
may even be repeated a se-
For the first operation an acid
gravity of 1·220 may be used,
an equal quantity of water:
d, an acid about 1·26 may be
ed. If the acid be not too
it dissolves the silver, and
old in a porous mass, of the
; but, if too strong, the gold
ry form, which may be wash-
. The weight of the original
cupellation, and in all the sub-
s, serves to ascertain the de-
ess of the ingot, or ore, of
part.

ng or expressing the fineness
whole mass spoken of is sup-
h twenty-four carats of twelve
ither real, or merely propor-
he assayers weights; and the
called fine. Thus, if gold be
carats fine, it is to be under-
a mass weighing 24 carats,

the quantity of pure gold amounts to 23 carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality or fineness by the touch. This is a method of comparing the colour, and other properties, of a minute portion of the metal, with those of small bars the composition of which is known. These bars are called touch-needles; and they are rubbed upon the black basaltes, which, for this reason, is called the touchstone. Black flint or pottery will serve the same purpose. Sets of gold needles may consist of — Pure gold; pure gold 23½ carats, with half a carat of silver; 23 carats of gold, with one carat of silver; 22½ carats gold, with 1½ carat silver; and so on, till the silver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition consisting either of equal parts silver and copper, or such proportions as the occasions of business require. The examination by the touch may be advantageously employed previous to quartation, to indicate the quantity of silver necessary to be added.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touchstone by the metal under examination, with that produced by his needle; but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aqua fortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red-hot by the fire, or by the blowpipe, if thin black pottery be used; in which case the phænomena of calcination will differ, according to the nature and quantity of the alloy.

The French Government has from time to time caused various experimental inquiries to be made respecting the art of assaying gold, which have thrown much light on this subject, and greatly tend to produce uniformity in the results of the operation. The latest report on this subject may be seen in the Annales de Chimie, vol. vi. p. 64; which may be consulted for a full account of the experiments and history of former proceedings. The general result is as follows, nearly in the words of the authors;

Six principal circumstances appear to effect the operation of parting: namely, the quantity of acid used in parting, or in the first boiling; the concentration of this acid; the time employed in its application; the quantity of acid made use of in the reprise, or second operation; its concentration; and the time during which it is applied. From the experiments it has been shown, that each of these unfavourable circumstances might easily occasion a loss of from the half of a thirty-second part of a carat or two thirty-second parts. The writers explain their technical language by observing that, the whole mass consisting of twenty-four carats, this thirty-second part denotes 1-768th part of the mass. It may easily be conceived, therefore, that if the whole six circumstances were to exist, and be productive of errors falling the same way, the loss would be very considerable.

It is therefore indispensably necessary, that one uniform process should be followed in the assays of gold; and it is a matter of astonishment, that such an accurate process should not have been prescribed by Government for assayers in an operation of such great commercial importance, instead of every one being left to follow his own judgment. The process recommended in the report before us is as follows.

Twelve grains of the gold intended to be assayed must be mixed with thirty grains of fine silver, and cupelled with 108 grains* of lead. The cupellation must be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button must be reduced by lamination into a plate of 1½ inch, or rather more, in length, and four or five lines in breadth. This must be rolled up upon a quill, and placed in a matrass capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aqua fortis, of the strength of 20 degrees of Baumé's areometer, must then be poured upon it; and the matrass being placed upon hot ashes, or sand, the acid must be kept gently boiling for a quarter of an hour: the acid must then be cautiously decanted, and an additional quantity of 1½ ounce must be poured on the metal, and slightly boiled for twelve minutes. This being likewise carefully decanted, the small spiral piece of metal must be washed with filtered river-water, or distilled water, by filling the matrass with this fluid. The vessel is then to be reversed, by applying the extremity of its neck against the bottom of a crucible of fine earth, the internal surface of which is very smooth. The annealing must then be made, after having separated the portion of water which had fallen into the crucible; and, lastly, the annealed gold must be weighed. For the certainty of this operation, two assays must be made in the same manner, together with a third assay upon gold of twenty-four carats, or upon gold the fineness of which is perfectly and generally known.

No conclusion must be drawn from this assay, unless the latter gold should prove to be of the fineness of twenty-four carats exactly, or of its known degree of fineness; for, if there be either loss or surplus, it may be inferred, that the other two assays, having undergone the same operation, must be subject to the same error. The operation being made according to this process, by several assayers, in circumstances of importance, such as those which relate to large fabrications, the fineness of the gold must not be depended on, nor considered as accurately known, unless all the assayers have obtained a uniform result, without communication with each other. The authors observe, however, that this identity must be considered as existing to the accuracy of half of the thirty-second part of a carat. For, notwithstanding every possible precaution or uniformity, it very seldom happens that an absolute agreement is obtained between the different assays of one and the same ingot, because the ingot itself may differ in its fineness in different parts of its mass.

The assaying of silver does not differ from that of gold, excepting that the parting operation is not necessary. A certain small portion of the silver is absorbed by the cupel, and the more when a larger quantity of lead is used, unless the quantity of lead be excessive; in which case most of it will be scorified before it begins to act upon the silver. Mess. Hellot, Tillet, and Macquer, from their experiments made by order of the French Government, have ascertained, that four parts of lead are requisite for silver of eleven pennyweights twelve grains fine, or containing this weight of pure silver, and twelve grains of alloy, in twelve pennyweights; six parts of lead for silver of eleven pennyweights; eight parts lead for silver of ten pennyweights; ten parts lead for silver of nine pennyweights; and so on in the same progression.

Astringent Principle. The effect, called astringency, considered as distinguish-

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* 1½ gross. Though these doses of silver and lead appeared to be proper for all operations of assaying gold, the commissaries observe, nevertheless, that gold of a lower title than eighteen carats may be alloyed with two parts, and even less, of silver; in order that the small mass of metal, when it comes to be laminated, may not be too thin, so as to break in pieces during the parting.

ole by the taste, is incapable of being de-
ned. It is perceived in the husks of nuts,
walnuts, in green tea, and eminently in
e nut gall. This is probably owing to
e circumstance, that acids have likewise
e property of corrugating the fibres of
e mouth and tongue, which is considered
characteristic of astringency as it relates
taste; and hence the gallic acid, which
commonly found united with the true
tringent principle, was long mistaken for
Seguin first distinguished them, and,
om the use of this principle in tanning
ins, has given it the name of *tannin*. Their
aracteristic differences are, the gallic acid
rms a black precipitate with iron; the
tringent principle forms an insoluble
mpound with albumen. See TANNIN.

ATHANOR. A kind of furnace, which has
ng since fallen into disuse. The very long
d durable operations of the ancient che-
ists rendered it a desirable requisite, that
eir fires should be constantly supplied
ith fuel in proportion to the consumption.
he athanor furnace was peculiarly adapt-
l to this purpose. Beside the usual parts,
was provided with a hollow tower, into
hich charcoal was put. The upper part
f the tower, when filled, was closely shut
y a well-fitted cover; and the lower part
ommunicated with the fire-place of the
urnace. In consequence of this disposition,
he charcoal subsided into the fire-place
gradually as the consumption made room
or it; but that which was contained in
he tower was defended from combustion
y the exclusion of a proper supply of
ur.

ATMOSPHERE. See AIR (ATMOSPHERI-
CAL).

ATTRACTION. The instances of attraction which are exhibited by the phænomena around us are exceedingly numerous, and continually present themselves to our observation. The effect of gravity, which causes the weight of bodies, is so universal, that we can scarcely form an idea how the universe could subsist without it. Other attractions, such as those of magnetism and electricity, are likewise observable; and every experiment in chemistry tends to show, that bodies are composed of various principles or substances, which adhere to each other with various degrees of force, and may be separated by known methods. It is a question among philosophers, whether all the attractions which obtain between bodies be referable to one general cause modified by circumstances, or whether various original and distinct causes act upon the particles of bodies at one and the same time. The philosophers at the beginning of the present century were disposed to consider the several attractions as essentially different, because the laws of their action differ from each other; but the moderns appear disposed to generalize this subject, and to consider all the attractions which exist between bodies, or at least those which are permanent, as depending upon one and the same cause, whatever it may be, which regulates at once the motions of the immense bodies that circulate through the celestial spaces, and those minute particles that are transferred from one combination to another in the operations of chemistry. The earlier philosophers observed, for example, that the attraction of gravitation acts upon bodies with a force which is inversely as the squares of the distances; and from mathematical deduction they have inferred, that the law of attraction between the particles themselves follows the same ratio: but, when their observations were applied to bodies very near each other, or in contact, an adhesion took place, which is found to be much greater than could be deduced from that law applied to the centres of gravity. Hence they concluded, that the cohesive attraction is governed by a much higher ratio, and probably the cubes of the distances. The moderns, on the contrary, among whom are Bergmann, Gayton-Morveau, and others, have remarked, that these deductions are too general, because for the most part drawn from the consideration of spherical bodies, which admit of no contact but such as is indefinitely small, and exert the same powers on each other, whichever side may be obverted. They remark likewise, that the consequence depending on the sum of the attractions in bodies not spherical, and at minute distances from each other, will not follow the inverted ratio of the square of the distance taken from any point assumed as the centre of gravity, admitting the particles to be governed by that law; but that it will greatly differ, according to the sides of the solid which are presented to each other, and their respective distances; insomuch that the attractions of certain particles indefinitely near each other will be indefinitely increased, though the ratio of the powers acting upon the remoter particles may continue nearly the same.

This doctrine, which however requires to be much more strictly examined by the application of mathematical principles, obviously points to a variety of interesting consequences. The polarity of particles, or their disposition to present themselves in their approach to each other in certain aspects, though it has been treated as a chimerical notion by a few superficial writers, is one of the first of these results; and may be not unaptly shown by the experiment of floating bodies upon water, which depress the surface of that fluid, and form a cavity into which they subside, and produce an appearance of attraction by rushing together; in which case their mode of application to each other is considerably governed by their figure, which causes them to turn round, and apply themselves to each other in such a manner as that the sum of the forces that act upon the two bodies may be nearly in equilibrio.

As a proof that gravitation and chemical attraction are two distinct properties, instead of the latter being a modification of the former, it has been noticed that this last is not governed by the masses or specific gravities of the particles. Thus, for example, since alcohol dissolves resin, and water does not; it would follow as an inference upon this system, that the particles of the alcohol are denser than those of the water; whereas the opposite conclusion might have been drawn, if the experiment had been made with gum instead of resin; this substance being dissolved by water, and not by alcohol. Nevertheless, it is a good answer to this objection, that admitting the masses to govern the attractions, yet the modifications of figure may be such as even to have a greater influence in the total effect than the mass itself. Thus it may be conceived that two cubes of lead may adhere more strongly by their flat surfaces than two spheres of gold, which cannot touch each other but in a point; and the superiority of attraction in the one case over the other may prevail in all the small distances to which chemical effects extend themselves; not to mention, that magnitude of particles will as greatly modify the consequences as figure itself.

These are speculations, which, with regard to the present state of chemistry, stand in much the same situation as the theory of gravity, which is minutely described in Plutarch, did with regard to astronomy before the time of Newton. As the celestial phænomena were formerly arranged from observation merely, but are now computed from the physical cause, gravitation; so, at present, chemistry is the science of matter of fact duly arranged, without the assistance of any extensive theory immediately deduced from the figures, volumes, densities, or mutual actions of the particles of bodies. What it may hereafter be, must depend on the ability and research of future chemists; but at present we must dismiss this remoter part of theory, to attend more immediately to the facts.

That the parts of bodies do attract each other, is evident from that adhesion which produces solidity, and requires a certain force to overcome it. For the sake of perspicuity, the various effects of attraction have been considered as different kinds of affinity, or powers. That power which physical writers call the attraction of cohesion, is generally called the attraction of aggregation by chemists. Aggregation is considered as the adhesion of parts of the same kind. Thus a number of pieces of brimstone united by fusion form an aggregate, the parts of which may be separated again by mechanical means. These parts have been called integrant parts; that is to say, the minutest parts into which a body can be divided, either really or by the imagination, so as not to change its nature, are called integrant parts. Thus, if sulphur and an alkali be combined together, and form liver of sulphur, we may conceive the mass to be divided and subdivided to an extreme degree, until at length the mass consists of merely a particle of brimstone and a particle of alkali. This then is an integrant part; and if it be divided further, the effect which chemists call decomposition will take place; and the particles, consisting no longer of liver of sulphur, but of sulphur alone and alkali alone, will be what chemists call component parts or principles.

The union of bodies in a gross way is called mixture. Thus, sand and an alkali may be mixed together. But, when the very minute parts of a body unite with those of another so intimately as to form a body which has properties different from those of either of them, the union is called combination, or composition. Thus, if sand and an alkali be exposed to a strong heat, the minute parts of the mixture combine, and form glass.

The earlier chemists were very desirous of ascertaining the first principles, or elements of bodies; and they distinguished by this name such substances as their art was incapable of rendering more simple. They seem however to have overlooked the obvious circumstance, that the limits of art are not the limits of nature. At present we hear little concerning elements. Those substances which we have not hitherto been able to analyse, or which, if decomposed, have hitherto eluded the observation of chemists, are indeed considered as simple substances relative to the present state of our knowledge, but in no other respect; for a variety of experiments give us reason to hope, that future inquiries may elucidate their nature and composition. Some writers, calling these simple substances by the name of Primary Principles, have distinguished compounds of these by the name of Secondary Principles, which they suppose to enter again into combinations without decomposition or change. It must be confessed, nevertheless, that no means have yet been devised to show whether any such subordination of principles exists. We may indeed discover, that a compound body consists of three or more principles; but whether two of these be previously united, so as to form a simple substance with relation to the third, or what in other respects may be their arrangement, we do not know. That it does exist, however, seems clear by making combinations in varied orders. Thus a weak solution of alkali will not dissolve oil; but a combination of oil and alkali will not separate by the addition of water. The alkali therefore adheres to that with which it was ee also the article VEGE-

ies, disposed to combine
ht into contact with each
s which touch will com-
compound; and if the
hich this new compound
form be higher than the
e experiment, the process
r, because this new com-
rposed between the two
t their further access to
if, on the contrary, the
the compound be lower
ure, liquefaction will en-
particles being at liberty
lves according to the law
s, the process will go on,
ass will gradually be con-
v compound in the fluid
e of this may be exhibited
on salt and perfectly dry
her. The crystals of the
liquefy unless very much
ls of the water, that is to
not liquefy unless heated
wo degrees of Fahrenheit;
urse supposed the tempe-
eriment to be lower than
water is in the solid state.
nown fact, that brine, or
tion of sea salt in water,
unless it be cooled thirty-
er than the freezing point
follows then, that, if the
he experiment be higher
combinations of salt and
fluid brine, and the com-
eed until the temperature
gradually sunk as low as
of brine; after which it
were not that surround-
nually tend to raise the
d accordingly it is found
at, if the ice and the salt
oled below the tempera-
rine, the combination and
not take place. See CA-

n which solid bodies thus
not being very numerous,
which ensues immediately
cement of this kind of ex-
nduced several chemists to
n one or both of the bo-
ch other, to be a necessary
order that they may pro-
ion upon each other. *Cor-*
i sint fluida.
odies applied to each other
emperature of the experi-
ill successively unite with
solid, which will by that
led in the fluid, and disap-
uid is called a solvent or
the solid body is said to

es unite together in all pro-

portions. In this way the acids unite with water. But there are likewise many substances, which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain proportion. Thus, water will dissolve only about one fourth of its weight of common salt; and if more salt be added, it will remain solid. A fluid which holds in solution as much of any substance as it can dissolve is said to be saturated with it. But saturation with one substance is so far from preventing a fluid from dissolving another body, that it very frequently happens, that the solvent power of the compound exceeds that of the original fluid itself. Chemists likewise use the word saturation in another sense; in which it denotes such a union of two bodies as produces a compound the most remote in its properties from the properties of the component parts themselves. In other combinations, where one of the principles predominates, the other is said to be supersaturated, and the other principle is said to be undersaturated.

Heat in general increases the solvent power of fluids, probably by preventing part of the dissolved substance from congealing, or assuming the solid form.

It often happens, that bodies which have no tendency to unite are made to combine together by means of a third, which is then called the medium. Thus, water and fat oils are made to unite by the medium of an alkali, in the combination called soap. Some writers, who seem desirous of multiplying terms, call this tendency to unite the *affinity of intermedium*. This case has likewise been called *disposing affinity*; but Berthollet more properly styles it *reciprocal affinity*. He likewise distinguishes affinity into *elementary*, when it is between the elementary parts of bodies; and *resulting*, when it is to a compound only, and would not take place with the elements of that compound.

It very frequently happens, on the contrary, that the tendency of two bodies to unite, or remain in combination together, is weakened or destroyed by the addition of a third. Thus, alcohol unites with water in such a manner as to separate most salts from it. A striking instance of this is seen in a saturated or strong solution of nitre in water. If to this there be added an equal measure of alcohol, the greater part of the nitre instantly falls down. Thus magnesia is separated from a solution of Epsom salt by the addition of an alkali which combines with the sulphuric acid, and separates the earth. The principle which falls down is said to be precipitated, and in many instances is called a precipitate. Some modern chemists use the term precipitation in a more extended, and rather forced sense; for they apply it to all substances thus separated. In this enunciation therefore they would say, that potash precipitates soda from a solution of common salt, though no visible separation or precipitation takes place; for the soda, when disengaged from its acid, is still suspended in the water by reason of its solubility.

From a great number of facts of this nature it is clearly ascertained, not as a probable hypothesis, but as simple matter of fact, that some bodies have a stronger tendency to unite than others; and that the union of any substance with another will exclude, or separate, a third substance, which might have been previously united with one of them; excepting only in those cases wherein the new compound has a tendency to unite with that third substance, and form a triple compound. This preference of uniting, which a given substance is found to exhibit with regard to other bodies, is by an easy metaphor called elective attraction, and is subject to a variety of cases, according to the number and the powers of the principles which are respectively presented to each other. The cases which have been most frequently observed by chemists are those called simple elective attractions, and double elective attractions.

When a simple substance is presented or applied to another substance compounded of two principles, and unites with one of these two principles so as to separate or exclude the other, this effect is said to be produced by simple elective attraction.

It may be doubted whether any of our operations have been carried to this degree of simplicity. All the chemical principles we are acquainted with are simple only with respect to our power of decomposing them; and the daily discoveries of our contemporaries tend to decompose those substances, which chemists a few years ago considered as simple. Without insisting however upon this difficulty, we may observe, that water is concerned in all the operations which are called humid; and beyond a doubt modifies all the effects of such bodies as are suspended in it; and the variations of temperature, whether arising from an actual igneous fluid, or from a mere modification of the parts of bodies, also tend greatly to disturb the effects of elective attraction. These causes render it difficult to point out an example of simple elective attraction, which may in strictness be reckoned as such.

Double elective attraction takes place when two bodies, each consisting of two principles, are presented to each other, and mutually exchange a principle of each; by which means two new bodies, or compounds, are produced, of a different nature from the original compounds.

Under the same limitations as were pointed out in speaking of simple elective attraction, we may offer instances of double elective attraction. Let mercury be dissolved to saturation in the nitric acid, the water will then contain nitrat of mercury. Again, let potash be dissolved to saturation in the sulphuric acid, and the result will be a solution of sulphat of potash. If mercury were added to the latter solution, it would indeed tend to unite with the acid, but would produce no decomposition; because the elective attraction of the acid to the alkali is the strongest. So likewise, if the nitric acid alone be added to it, its tendency to unite with the alkali, strong as it is, will not effect any change, because the alkali is already in combination with a stronger acid. But if the nitrat of mercury be added to the solution of sulphat of potash, a change of principles will take place, the sulphuric acid will quit the alkali, and unite with the mercury, while the nitric acid combines with the alkali; and these two new salts, namely nitrat of potash, and sulphat of mercury, may be obtained separately by crystallization.

The most remarkable circumstance in this process is, that the joint effects of the attractions of the sulphuric acid to mercury, and the nitric acid to alkali, prove to be stronger than the sum of the attractions between the sulphuric acid and the alkali, and between the nitrous acid and the mercury; for, if the sum of these two last had not been weaker, the original combinations would not have been broken.

Mr. Kirwan, who first in the year 1782 considered this subject with that attention it deserves, calls the affinities which tend to preserve the original combinations, the quiescent affinities. He distinguishes the affinities or attractions which tend to produce a change of principles, by the name of the divellent affinities.

Some eminent chemists are disposed to consider as effects of double affinities those changes of principles only which would not have taken place without the assistance of a fourth principle. Thus, the mutual decomposition of sulphat of soda and nitrat of potash, in which the alkalis are changed, and sulphat of potash and nitrat of soda are produced, is not considered by them as an instance of double decomposition; because the nitre would have been decomposed by simple elective attraction, upon the addition of the acid only.

There are various circumstances which modify the effects of elective attraction, and have from time to time misled chemists in their deductions. The chief of these is the temperature, which, acting differently upon the several parts of compounded bodies, seldom fails to alter, and frequently reverses the effects of the affinities. Thus, if alcohol be added to a solution of nitrat of potash, it unites with the water, and precipitates the salt at a common temperature. But if the temperature be raised, the alcohol rises on account of its volatility, and the salt is again dissolved. Thus again, if sulphuric acid be added, in a common temperature, to a combination of phosphoric acid and lime, it will decompose the salt, and dis-

sphoric acid; but if this
hese principles be exposed
heat, the sulphuric acid
action to the lime so much
it will rise, and give place
phoric, which will combine
Again, mercury kept in a
ry nearly equal to volati-
orb oxigen, and become
e red oxide formerly called
; but if the heat be aug-
e, the oxigen will assume
and fly off, leaving the
iginal state. Numberless
ke nature continually pre-
the observation of che-
sufficient to establish the
he elective attractions are
at one and the same tem-

hers are of opinion, that
oduced by change of tem-
n the elective attraction of
itself. But there are no
nts either in confirmation
his hypothesis.

e operation of heat, which
change in the elective at-
ll find, that most of the
ttending this subject arise
t state of chemical science.
of two principles a third
ct of this must necessarily
rding to its quantity, and
to the state of saturation
iples of the compounded
d principle which is added
y dissolve and suspend the
may be newly formed, and
h might have been preci-
etallic solutions, decom-
tion of an alkali, afford no
ous cases when the alkali
se this excess dissolves the
would else have fallen
e other hand, one of the
the compound body be in
n of a third substance may
excess, and leave a neu-
xhibiting very different
e former. Thus, if cream
a salt of difficult solubi-
potash united to an excess
ar, be dissolved in water,
ed, the excess unites with
f the chalk, and forms a
lt; and the neutral com-
nains after the privation
id, is a very soluble salt,
taste and properties from
ar. The metals and the
rd various phænomena,
degree of oxidation. A
tion is in general necessary
metals in acids; and the
act very differently, ac-
are more or less acidified.
acid gives place to acids which are weaker than the nitric acid: the sulphurous acid gives place to acids greatly inferior in attractive power or affinity to the sulphuric acid. The deception arising from effects of this nature is in a great measure produced by the want of discrimination on the part of chemical philosophers; it being evident, that the properties of any compound substance depend as much upon the proportion of its ingredients, as upon their respective nature.

The presence and quantity of water is probably of more consequence than is yet supposed. Thus bismuth is dissolved in nitrous acid, but falls when the water is much in quantity. The same is said of silver. Ribaucout has shown the last (Annales de Chimie, xv. 122.) in alum, and it is likely that the fact is more common than is suspected. Whether the attraction and strength as to quantity in saturation be not variable by the presence or absence of water, must be referred to experiment.

The power of double elective attractions too is disturbed by this circumstance. If muriat of lime be added to a solution of carbonat of soda, they are both decomposed, and the results are muriat of soda and carbonat of lime. But if lime and muriat of soda be mixed with just water sufficient to make them into a paste, and this be exposed to the action of carbonic acid gas, a saline efflorescence consisting of carbonat of soda will be formed on the surface, and the bottom of the vessel will be occupied by muriat of lime in a state of deliquescence.

Mr. Berthollet has lately made a great number of experiments, from which he further deduces the following anomaly: that in elective attractions the power exerted is not in the ratio of the affinity simply, but in a ratio compounded of the force of affinity and the quantity of the agent; so that quantity may compensate for weaker affinity. Thus an acid which has a weaker affinity than another for a given base, if it be employed in a certain quantity, is capable of taking part of that base from the acid which has a stronger affinity for it; so that the base will be divided between them in the compound ratio of their affinity and quantity. This division of one substance between two others, for which it has different affinities, always takes place, according to him, when three such are present under circumstances in which they can mutually act on each other. And hence it is, that the force of affinity acts most powerfully when two substances first come into contact, and continues to decrease in power as either approaches the point of saturation. For the same reason it is so difficult to separate the last portions of any substance adhering to another. Hence, if the doctrine laid down by Mr. Berthollet be true, to its utmost extent, it must be impossible ever to free a compound completely from any one of its constituent parts by the agency of elective attraction; so that all our best established analyses are more or less inaccurate.

The solubility or insolubility of principles, at the temperature of any experiment, has likewise tended to mislead chemists of inferior accuracy, who have deduced consequences from the first effects of their experiments. It is evident, that many separations may ensue without precipitation; because this circumstance does not take place unless the separated principle be insoluble, or nearly so. The soda cannot be precipitated from a solution of sulphat of soda, by the addition of potash, because of its great solubility; but, on the contrary, the new compound itself, or sulphat of potash, which is much less soluble, may fall down, if there be not enough water present to suspend it. No certain knowledge can therefore be derived from the appearance or the want of precipitation, unless the products be carefully examined. In some instances all the products remain suspended, and in others they all fall down, as may be instanced in the decomposition of sulphat of iron by lime. Here the acid unites with the lime, and forms sulphat of lime, which is scarcely at all soluble; and the still less soluble oxide of iron, which was disengaged, falls down along with it.

Many instances present themselves, in which decomposition does not take place, but a sort of equilibrium affinity is perceived. Thus, soda, added to the supertartrit of potash, forms a triple salt by combining with its excess of acid. So likewise ammonia combines with a portion of the acid of muriat of mercury, and forms the triple compound formerly distinguished by the barbarous name of sal alembroth.

When we reflect maturely upon all the circumstances enumerated, or slightly touched upon, in the foregoing pages, we may form some idea of the extensive field of research, which yet remains to be explored by chemists. If it were possible to procure simple substances, and combine two together, and to this combination of two to add one more of the other simple substances, the result of the experiment would in many cases determine, by the exclusion of one of the three, that its affinity to either of the remaining two was less than that between those two respectively. In this way it would be ascertained, in the progress of experimental inquiry, that the simple attractions of a series of substances were gradually increasing or diminishing in strength. Thus, ammonia separates alumine from the sulphuric acid; magnesia, in like manner, separates the ammonia; lime predominates, in the strength of affinity, over magnesia, as appears by its separating this last earth; the soda separates the lime, and itself gives place to the potash; and, lastly, potash yields its acid to barytes. The simple elective attractions of these several substances to sulphuric acid are therefore in the inverted order of their effects; barytes is the strongest; and this is succeeded regularly by potash, soda, lime, magnesia, ammonia, and alumine. It is evident that results of this nature, being tabulated, as was first done by the celebrated Geoffroy, and afterward by Bergman, must afford a valuable mass of chemical knowledge It must be remarked, however, that these results merely indicate, that the powers are greater or less than each other; but how much greater or less is not determined, either absolutely or relatively. Tables of this nature cannot therefore inform us of the effects which may take place in the way of double affinity, for want of the numerical relations between the attracting powers. Thus, when we are in possession of the order of the simple elective attractions between the sulphuric acid and a series of substances, and also between the nitrous acid and the same substances; and when, in addition to this, the respective powers of each of the acids upon every one of the substances singly taken, are known, so far as to determine which will displace the other—yet we cannot thence foretel the result of applying two combinations to each other, each containing an acid united with one of the number of simple substances. Or, more concisely, a table of simple elective attractions can be of no use to determine the effects of double elective attraction, unless the absolute power of the attractions be expressed by number instead of their order merely.

It appears therefore, that the present state of chemistry affords us no indication, by which we may come at the results of double elective attraction without actual experiment; and, in this way, we may ascertain, whenever a double decomposition takes place, that the sum of the attractions which tend to produce the new combinations is greater than the sum of those attractions which tend to preserve the compounds in their original form. But as these attractions, in the simplest cases, are four in number, and the effect may arise from an excess or defect of any one of the four, or may be distributed in an infinity of proportions among them, it must easily be seen how numerous the difficulties are which attend these researches, and what ample space is left for exercising the sagacity of philosophers in chemical analysis.

There have not been wanting a number of eminent philosophers, who have exerted themselves in attempting to discover data, by which the phænomena of chemistry might be subjected to computation; and though the difficulty of the subject has hitherto prevented any thing of a conclusive nature from being done, their researches have nevertheless thrown great light on the subject. Mr. Guyton-Morveau first attempted to ascertain the proportional powers of attraction between mercury and other metals, by

e quantity of weight or re-
y to separate a metallic sur-
dimensions from its contact
f this fluid. This method,
ot be extensively applied in
ts. Mr. Wenzel, by a series
in which metallic cylinders
ensions, coated on all sides
urnish or covering, excepting
re exposed to the action of
ought himself authorised to
he affinities of bodies with a
t are inversely in proportion
ssary for their solution; or,
ne thing, directly in propor-
antities dissolved in equal
f time. It is very probable,
sion would prove true, if we
r experiments with simple
as this is not the case, his
ot be applied to various
e admit it to be true with
periments with the nitrous
t follow, that his conse-
pplied to the muriatic acid,
gn circumstance intervenes,
e attractions. The nitrous
ecomposed, readily oxides
dily dissolves them when
uriatic acid appears to be
d, decomposable in our ex-
herefore acts slowly, and in
not at all, upon metallic
from the true test of supe-
nely, the decomposing of
dy formed, the attraction
cid, slow as its effects are,
onger than that of the ni-
h it separates many metallic
kewise be observed, even
the nitrous acid, that the
simple, are likewise modi-
ction of the metal for oxi-
count, though tin or anti-
idly attacked by the nitric
place, nevertheless, in the
ion, to lead, which is much
olved. And accordingly it
Ir. Wenzel's numbers, ex-
owers of attraction, do not
eal experiments of double

ave considered the means of
d explaining the chemical
ctions; in which two lead-
quired to be done; namely,
udicious and well-directed
the deduction of proper
hem. Most of the errors
indeed of the cultivators
of any science, arise from the subject being viewed in too confined a light; so that some essential object is overlooked. Nothing can be clearer than that the more simple the description or enunciation of these objects, the less the mind will be burdened, and the less probable it will be that any thing of importance will be overlooked. Hence the advantage of a concise, simple, and accurate style, which may direct the mind steadily to the subject in contemplation, without misleading by ambiguous terms, or the language of the vulgar, which is applicable to so many and such various ideas. The advantages of this are strongly felt in the mathematical sciences, where by diagrams exhibited to the eye, by terms constantly appropriated to the expression of the same ideas, or by symbols, the quantity, value, and application of which vary with their relative positions, the mind is occupied by no other objects than such as tend to forward the desired investigation. This has in some degree been effected in chemical science by Geoffroy, in his first table of simple elective attractions; by Bergman, in his Symbolical Expression of the Effects of Compound Attractions; and by others, in their tables of the component parts of bodies. A description of the tables contained in the ensuing pages, will sufficiently explain their nature and application.

Tables I to VI contain in substance the two tables of Attractiones Electivæ Simplices, placed at the end of Bergman's treatise upon elective attractions, as given by Dr. Pearson, with such corrections and additions as subsequent discoveries have rendered necessary, and arranged in such a manner, as has tended to facilitate the insertion of them in the regular pages of the book, instead of adopting the much less convenient method of printing upon a large sheet, to be occasionally folded out. It will be seen therefore that I have avoided repetitions, and altered the arrangement of the columns; but have in no material respect changed the substance of the tables themselves.

These tables require no other explanation, than that the substances enumerated are considered to be simple, as far as relates to the facts exhibited in these sketches. The order of position denotes that the higher any substance stands in any column, the stronger is its elective attraction to the substance at the head of that column. The under part of each table exhibits the attractions in the dry way, and must be considered as entirely distinct from the upper part.

TABLE I.

Simple Elective Attractions.

ACIDS.

IN THE HUMID WAY.

SULPHURIC ACID.	SULPHUROUS ACID.	NITRIC ACID.	BORACIC ACID.	SUCCINIC ACID.	ACETOUS ACID.
Barytes	Barytes	Potash	Lime	Barytes	Barytes
Strontian	Lime	Soda	Barytes	Lime	Potash
Potash	Potash	Barytes	Strontian	Potash	Soda
Soda	Soda	Strontian	Magnesia	Soda	Strontian ?
Lime	Strontian	Lime	Potash	Ammonia	Lime
Magnesia	Magnesia	Magnesia	Soda	Magnesia	Ammonia
Ammonia	Ammonia	Glucine	Ammonia	Alumine	Magnesia
Glucine	Glucine	Yttria	Glucine	Metallic oxides	Metallic oxides
Yttria	Alumine	Alumine	Alumine	Water	Glucine
Alumine	Zircon	Zircon	Zircon	Alcohol	Alumine
Zircon	Metallic oxides	Metallic oxides	Metallic oxides	N. B. The citric and benzoic follow the same order, except that lime should come before barytes, and for the citric Zircon should be added after alumine.	Zircon
Metallic oxides	N. B. The carbonic acid follows the same order in the humid way.	Water	Water		Water
Water		Alcohol	Alcohol		Alcohol
Alcohol		N. B. The muriatic, oxymuriatic, and nitro-muriatic follow the same order.	N. B. The oxalic, tartarous, sebacic, phosphoric, & arsenic follow the same order: so do the fluoric and tungstic, substituting silex for metallic oxides.		**CAMPHORIC ACID.**
				PRUSSIC ACID.	Lime
				Potash	Potash
				Soda	Soda
				Ammonia	Barytes
				Lime	Ammonia
				Barytes	Alumine
				Strontian	Magnesia
				Magnesia	**MOLYBDIC ACID.**
				Alumine	Sulphur ?
				Metallic oxides	Potash
				Water	Soda
				Alcohol	The earths
					Metallic oxides
					CHROMIC ACID.
					Fixed alkalis
					Oxide of lead
					Oxide of copper

IN THE DRY WAY.

SULPHURIC ACID.	SULPHUROUS ACID.	NITRIC ACID.	BORACIC ACID.
Potash		Barytes	Lime
Soda		Strontian	Barytes
Barytes		Potash	Strontian
Strontian		Soda	Magnesia
Lime		Lime	Potash
Magnesia		Magnesia	Soda
Zircon		Metallic oxides	Metallic oxides
Metallic oxides		Ammonia	Ammonia
Ammonia		Alumine	Alumine
Alumine		N. B. The muriatic, oxymuriatic, nitro-muriatic, and acetous, follow the same order in the dry way.	N. B. The fluoric, benzoic, sebacic, phosphoric, and Arsenic, follow the same order in the dry way.

TABLE II.

Simple Elective Attractions.

ALKALIS AND EARTHS.

phosphoric oxalic tartarous arsenic succinic citric benzoic acetous mucous boracic sulphurous nitrous carbonic prussic Water Fat oils Sulphur Metallic oxides Soda and ammonia follow the same order both in the humid and dry way, except that with ammonia the sulphuric acid comes first in both.	mucous molybdic nitric muriatic sebacic suberic citric tartarous arsenic benzoic acetous boracic sulphurous nitrous carbonic prussic Water Fat oils Sulphur Sulphuretted hidrogen Phosphorus	nitric muriatic succinic acetous arsenic boracic carbonic Water Fat oils Sulphur Sulphuretted hidrogen	phosphoric mucous nitric muriatic sebacic suberic fluoric arsenic citric malic benzoic acetous boracic sulphurous nitrous molybdic carbonic lithic prussic Water Fat oils Sulphur Phosphorus	sebacic arsenic mucous succinic nitric muriatic tartarous citric malic ? benzoic acetous boracic sulphurous nitrous carbonic prussic Sulphur	arsenic fluoric tartarous succinic mucous citric phosphoric benzoic acetous boracic sulphurous nitrous carbonic prussic	Strontian

(The DRY WAY on next page.)

TABLE II.

(CONTINUED.)

Continuation of Table II.

IN THE DRY WAY.

Potash.	Barytes.	Strontian.	Lime.	Magnesia.	Alumine.	Silex.
Acids, phosphoric boracic arsenic sulphuric nitric muriatic sebacic fluoric succinic benzoic acetous Barytes Lime Magnesia Alumine Silex Sulphur	Acids, phosphoric boracic arsenic sulphuric nitric muriatic fluoric sebacic succinic benzoic acetous Fixed alkalis Sulphur Oxide of lead		As barytes	As barytes	As barytes	Potash Soda Phosphoric acid Oxide of lead

TABLE III.

Simple Elective Attractions.

WATER AND COMBUSTIBLE SUBSTANCES.

IN THE HUMID WAY.

WATER.	SULPHUR.	SALINE SULPHURETS.	ALCOHOL.	ETHER.
Potash	Oxigen	Oxigen	Water	Alcohol
Soda	Molybdic oxide and acid	Oxide of gold	Ether	Volatile oils
Ammonia	Oxide of lead	silver	Volatile oils	Water
Deliquescent salts	tin	mercury	Ammonia	Sulphur
Alcohol	silver	arsenic	Fixed alkali	
Carbonat of ammonia	mercury	antimony	Alkaline sulphurets	
Ether	arsenic	bismuth	Sulphur	
Sulphuric acid	antimony	copper	Muriats	
Non-deliquescent salts	iron	tin	Phosphoric acid	
	Potash	lead		
	Soda	nickel		
	Barytes	cobalt		
	Strontian	manganese		
	Lime	iron		
	Magnesia	Other metallic oxides		
	Phosphorus	Carbon		
	Fat oils	Water		
	Ammonia	Alcohol		
	Ether	Ether		
	Hidrogen ?			

FAT OILS.	VOLATILE OILS.
Barytes ?	Ether
Strontian ?	Alcohol
Lime	Fat oils
Metallic oxides	Fixed alkalis
Ether	Sulphur
Volatile oils	Phosphorus
Fixed alkalis	
Ammonia	
Sulphur	
Phosphorus	

IN THE DRY WAY.

Oxigen	Manganese
Potash	Iron
Soda	Copper
Iron	Tin
Copper	Lead
Tin	Silver
Lead	Gold
Silver	Antimony
Cobalt	Cobalt
Nickel	Nickel
Bismuth	Bismuth
Antimony	Mercury
Mercury	Arsenic
Arsenic	Carbon ?
Uranium ?	
Molybdena	
Tillurium	

TABLE IV.

Simple Elective Attractions.

OXYGEN AND METALS.

IN THE HUMID WAY.

OXYGEN.	OXIDE OF GOLD.	OXIDE OF SILVER.	OXIDE OF PLATINA.	OXIDE OF MERCURY.	OXIDE OF LEAD.
Bases of the muriatic and other undecomposed acids	Acids, gallic	Acids, gallic	Acids, gallic	Acids, sebacic	Acids, gallic
Carbon	muriatic	muriatic	muriatic	gallic	sulphuric
Phosphorus	nitric	sebacic	nitric	muriatic	sebacic
Hidrogen ?	sulphuric	oxalic	sulphuric	oxalic	mucic
Sulphur	arsenic	sulphuric	arsenic	succinic	oxalic
Zinc	fluoric	mucous	fluoric	phosphoric	arsenic
Copper	tartarous	phosphoric	tartarous	sulphuric	tartarous
Lead	phosphoric	sulphurous	phosphoric	mucous	phosphoric
Iron	acetous	nitric	sebacic	tartarous	muriatic
Silver	sebacic	arsenic	oxalic	citric	sulphurous
Platina	prussic	fluoric	citric	malic	suberic
Mercury	Fixed alkalis	tartarous	acetous	sulphurous	nitric
Gold	Ammonia	citric	succinic	nitric	fluoric
Nitrous oxide	Sulphuretted hidrogen	succinic	prussic	fluoric	citric
Muriatic acid		acetous	carbonic	acetous	malic
Nitrous acid		prussic	Ammonia	benzoic	succinic
Sulphurous acid		carbonic		boracic	acetous
White oxide of manganese		Ammonia		prussic	benzoic
Volatile oils				carbonic	boracic
Alcohol				Ammonia	prussic
					carbonic
					Fixed alkalis
					Fat oils
					Ammonia

IN THE DRY WAY.

	GOLD.	SILVER.	PLATINA.	MERCURY.	LEAD.
Carbon	Mercury	Lead	Arsenic	Gold	Gold
Zinc	Copper	Copper	Gold	Silver	Silver
Iron	Silver	Mercury	Copper	Platina	Copper
Hidrogen	Lead	Bismuth	Tin	Lead	Mercury
Manganese	Bismuth	Tin	Bismuth	Tin	Bismuth
Cobalt	Tin	Gold	Zinc	Zinc	Tin
Nickel	Antimony	Antimony	Antimony	Bismuth	Antimony
Lead	Iron	Iron	Nickel	Copper	Platina
Tin	Platina	Manganese	Cobalt	Antimony	Arsenic
Phosphorus	Zinc	Zinc	Manganese	Arsenic	Zinc
Copper	Nickel	Arsenic	Iron	Iron	Nickel
Bismuth	Arsenic	Nickel	Lead	Alkaline sulphurets	Iron
Antimony	Cobalt	Platina	Silver	Sulphur	Alkaline sulphurets
Mercury at 600°	Manganese	Alkaline sulphurets	Mercury		Sulphur
Arsenic	Alkaline sulphurets		Alkaline sulphurets		
Sugar					
Sulphur					
Gold					
Silver					
Platina					
Mercury at upward of 1000°					
White oxide of manganese					

TABLE V.

Simple Elective Attractions.

METALS (CONTINUED).

IN THE HUMID WAY.

OXIDE OF IRON.	OXIDE OF TIN.	OXIDE OF BISMUTH.	OXIDE OF NICKEL.	OXIDE OF ARSENIC.
Acids, gallic	Acids, gallic	Acids, oxalic	Acids, oxalic	Acids, gallic
oxalic	sebacic	arsenic	muriatic	muriatic
tartarous	tartarous	tartarous	sulphuric	oxalic
camphoric	muriatic	phosphoric	tartarous	sulphuric
sulphuric	sulphuric	sulphuric	nitric	nitric
mucous	oxalic	sebacic	sebacic	sebacic
muriatic	arsenic	muriatic	phosphoric	tartarous
nitric	phosphoric	nitric	fluoric	phosphoric
sebacic	nitric	fluoric	mucous	fluoric
phosphoric	succinic	mucous	succinic	mucous
arsenic	fluoric	succinic	citric	succinic
fluoric	mucous	citric	acetous	citric
succinic	citric	acetous	arsenic	arsenic
citric	acetous	prussic	boracic	acetous
acetous	boracic	carbonic	prussic	prussic
boracic	prussic	Ammonia	carbonic	Fixed alkalis
prussic	Potash		Ammonia	Ammonia
carbonic	Soda			Fat oils
	Ammonia			Water

IN THE DRY WAY.

IRON.	TIN.	BISMUTH.	NICKEL.	ARSENIC.
Nickel	Zinc	Lead	Iron	Nickel
Cobalt	Mercury	Silver	Cobalt	Cobalt
Manganese	Copper	Gold	Arsenic	Copper
Arsenic	Antimony	Mercury	Copper	Iron
Copper	Gold	Antimony	Gold	Silver
Gold	Silver	Tin	Tin	Tin
Silver	Lead	Copper	Antimony	Lead
Tin	Iron	Platina	Platina	Gold
Antimony	Manganese	Nickel	Bismuth	Platina
Platina	Nickel	Iron	Lead	Zinc
Bismuth	Arsenic	Zinc	Silver	Antimony
Lead	Platina	Alkaline sulphurets	Zinc	Alkaline sulphurets
Alkaline sulphurets	Bismuth	Sulphur	Alkaline sulphurets	Sulphur
Sulphur	Cobalt		Sulphur	
	Alkaline sulphurets			
	Sulphur			

TABLE VI.

Simple Elective Attractions.

METALS (CONCLUDED).

IN THE HUMID WAY.

OXIDE OF COBALT.	OXIDE OF ZINC.	OXIDE OF ANTIMONY.	OXIDE OF MANGANESE.	OXIDE OF TELLURIUM.	OXIDE OF TITANIUM.
Acids, oxalic	Acids, gallic	Acids, gallic	Acids, oxalic	Acids, nitric	Acids, sulphuric
muriatic	oxalic	sebacic	tartarous	nitro-muriatic	nitric
sulphuric	sulphuric	muriatic	citric	sulphuric	muriatic
tartarous	muriatic	benzoic	fluoric	Sulphur	prussic
nitric	mucous	oxalic	phosphoric	Alkalis	
sebacic	nitric	sulphuric	nitric	Mercury	
phosphoric	sebacic	nitric	sulphuric		
fluoric	tartarous	tartarous	muriatic		
mucous	phosphoric	mucous	sebacic		
succinic	citric	phosphoric	arsenic		
citric	succinic	citric	acetous		
acetous	fluoric	succinic	prussic		
arsenic	arsenic	fluoric	carbonic		
boracic	acetous	arsenic			
prussic	boracic	acetous			
carbonic	prussic	boracic			
Ammonia	carbonic	prussic			
	Fixed alkalis	carbonic			
	Ammonia	Sulphur			
		Fixed alkalis			
		Ammonia			

OXIDE OF URANIUM.
Acids, sulphuric
nitro-muriatic
muriatic
nitric
phosphoric
acetous
gallic
prussic
carbonic
Sulphur

IN THE DRY WAY.

COBALT.	ZINC.	ANTIMONY.	MANGANESE.	TELLURIUM.
Iron	Copper	Iron	Copper	Mercury
Nickel	Antimony	Copper	Iron	Sulphur
Arsenic	Tin	Tin	Gold	
Copper	Mercury	Lead	Silver	
Gold	Silver	Nickel	Tin	
Platina	Gold	Silver	Alkaline sulphurets	
Tin	Cobalt	Bismuth		
Antimony	Arsenic	Zinc		
Zinc	Platina	Gold		
Alkaline sulphurets	Bismuth	Platina		
Sulphur	Lead	Mercury		
	Nickel	Arsenic		
	Iron	Cobalt		
		Alkaline sulphurets		
		Sulphur		

sion of compound affinities, it is clear, from what has already been said
hat the sketches must either be made from actual experiment in every
deduction from the numerical expressions of the forces of attraction. I
some of the difficulties which oppose the deduction of these numbers; but
l set of numbers, inferred from such facts as we possess, may be useful in
to point out the probability of decompositions previous to trial, I have
Ir. Guyton-Morveau's table of the numerical expression of affinity between
soluble earths and the five principal acids.

TABLE VII.

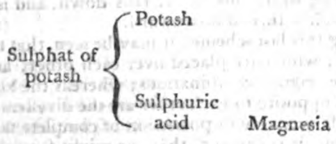
al Expression of Affinities by GUYTON MORVEAU.

VITRIOLIC ACID.	NITROUS ACID.	MARINE ACID.	ACETOUS ACID.	AERIAL ACID, OR FIXED AIR.
66	62	36	28	14
62	58	32	26	9
58	50	31	25	8
54	44	23	19	12
46	38	21	20	4
50	40	22	17	6
40	36	18	15	2

is according to the last corrections of its author, and will be found to
rhaps most cases of double elective attraction, but not in all: when it is
wever, that it embraces near 500 different cases, we cannot wonder at its
ct.

d of exemplifying or exhibiting simple or compound affinities by symbols,
Bergman, consists in placing those substances which are applied to each
e same horizontal line of direction; the component parts of the substances
t the two extremities of a vertical bracket; and the new products, if any, are
ove the other, at the middle part of a horizontal bracket, connecting their
inciples. This will be rendered clearer by an example.

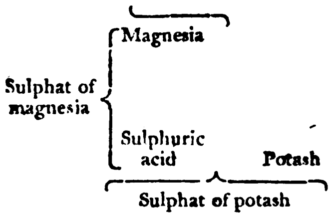
nagnesia to be presented to a solution of sulphat of potash, it will be found
position takes place. These facts are expressed as follows:



e scheme, the sulphat of potash is placed opposite the point of a vertical
ts two component parts, potash and sulphuric acid, are placed within the ex-
he same bracket. Horizontally opposite the sulphuric acid is placed mag-
ote, that it is presented to that acid. And as these two substances are not

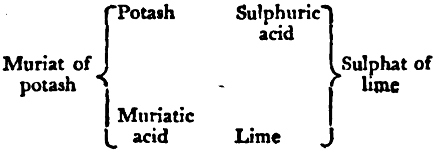
connected by a bracket, it is to be understood from the scheme, that they do not unite, and consequently that the sulphat of potash remains undecomposed.

II. On the contrary, if to a solution of sulphat of magnesia, potash be added, a decomposition will ensue, which is expressed as follows:



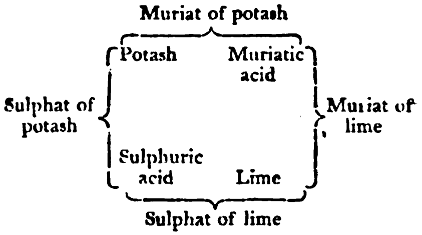
The arrangements in this scheme depend on the same principles as those of the foregoing: but the bracket underneath the sulphuric acid and potash denotes, that these two substances unite, and form sulphat of potash, which is accordingly placed beneath the middle of the bracket. The point of the bracket being turned up, is made to denote that the compound remains suspended, or in solution. The magnesia is of course disengaged: and half a bracket, with the point downward, is placed over it, to denote, that it falls to the bottom, or is precipitated.

III. The above instances exhibit simple elective attractions: but this method is more particularly applicable to the compound attractions; for example, Suppose a solution of the muriat of potash be added to sulphat of lime, no decomposition will take place. This is expressed as under:



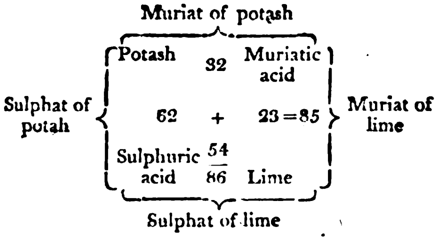
The want of horizontal brackets in this scheme denotes, that the principles presented to each other do not unite, and consequently that no decomposition ensues.

IV. On the contrary, if sulphat of potash be presented to the muriat of lime, a mutual decomposition will ensue: thus,



In this scheme we see, that the principles presented to each other do unite, as is shown by the horizontal brackets, and form the new compounds, muriat of potash and sulphat of lime; the former of which remains in solution, as is shown by its bracket being turned upward; while the latter, being nearly insoluble, falls down, and is accordingly denoted by a bracket the point of which is turned downward.

V. By attentively observing this last scheme, it may be seen, that the attractions exerted between the simple substances, which are placed over each other, are the quiescent affinities, and tend to preserve the original combinations; whereas the attractions between the simple substances which stand opposite to each other are the divellent affinities, and tend to produce new combinations. If we were in possession of complete tables of the numerical expression of simple attraction, it is evident, that we might foretel every result, which might be produced by the application of compound substances to each other; and we shall see the utility of Guyton-Morveau's table, by applying the numbers to the preceding scheme.



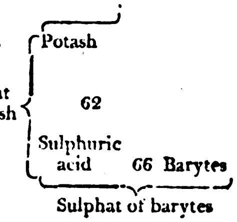
ction between the potash and sulphuric acid is expressed by the number 62;
raction between the muriatic acid and lime is expressed by the number 23.
he quiescent affinities, and their sum 85 expresses the tendency to preserve the
ms of sulphat of potash and muriat of lime. On the other hand, the attrac-
en the potash and muriatic acid is expressed by 32, and the attraction
phuric acid and lime by 54. The sum of 32 and 54 amounts to 86, and ex-
divellent affinities, which tend to produce new combinations. And as this
ceeds the sum of the quiescent affinities, it follows, that the double decomposi-
ce place.

ese examples we have designedly taken them the reverse of each other; but
nce, singly exhibited, does in fact point out both the affirmative and the ne-
positions. Thus, from the facts first exhibited, that magnesia does not de-
e combination of potash and sulphuric acid, it likewise follows, that potash
ose the combination of sulphuric acid and magnesia. And accordingly,
wo schemes of double affinity, it it clearly ascertained, from the mutual de-
of sulphat of potash and muriat of lime, that the muriat of potash and sul-
e will not decompose each other.

horizontal bracket, which in the humid way was used to denote solution, is
ote sublimation in experiments in the dry way.

wing schemes from Bergman will requre no explanation, after the instances
nibited.

emes of Elective Attractions in the Humid Way.



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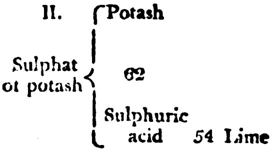

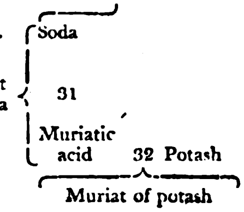

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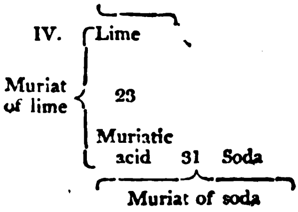
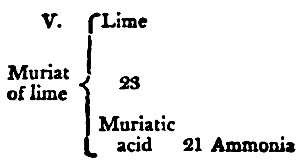
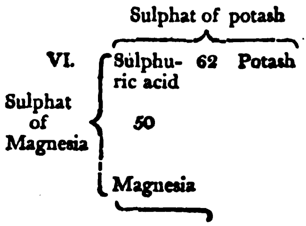
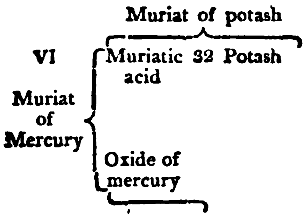
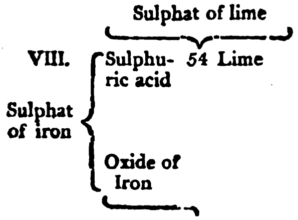


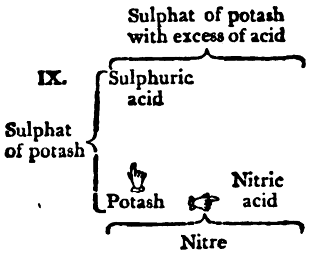
Schemes of Elective Attractions in the Humid Way.

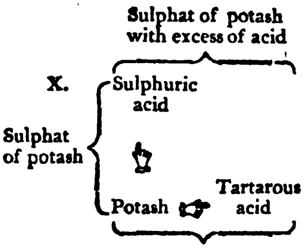


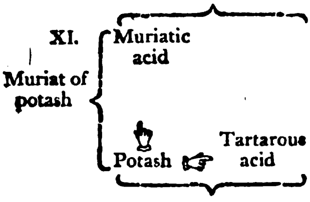


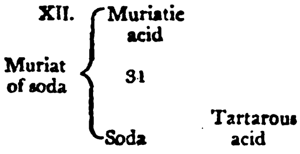


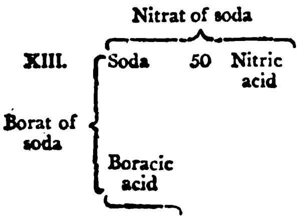


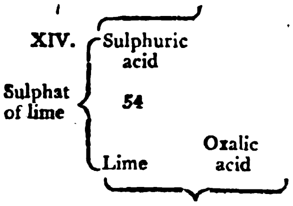












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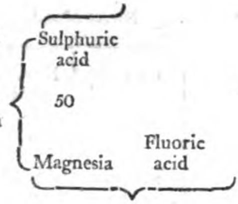

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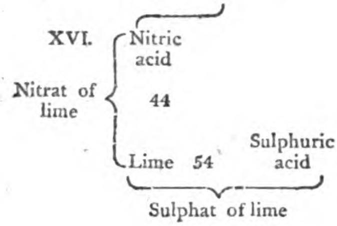

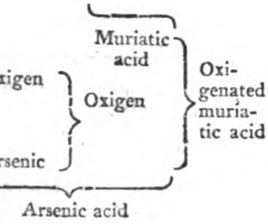

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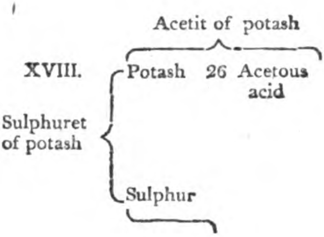

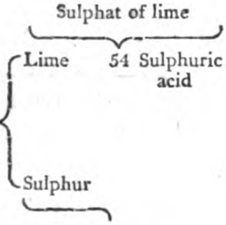

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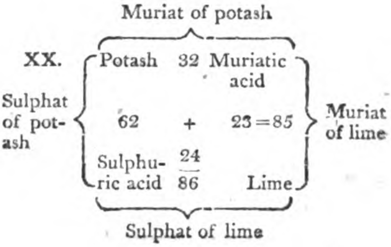

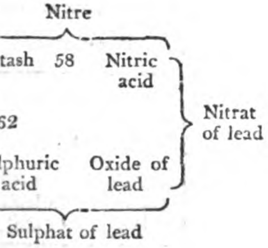

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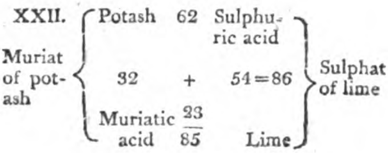
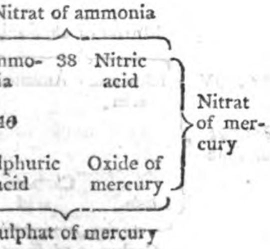
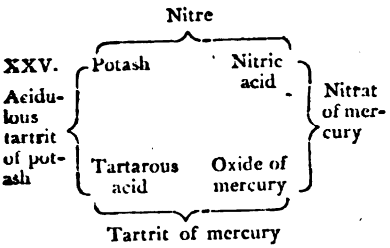
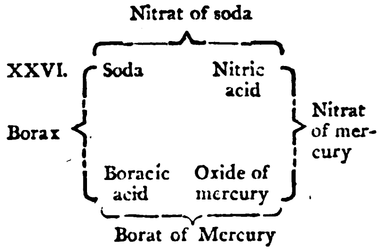


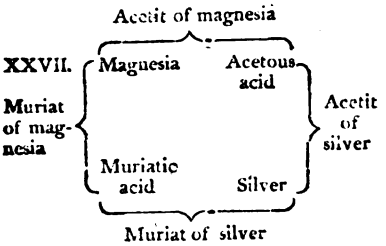


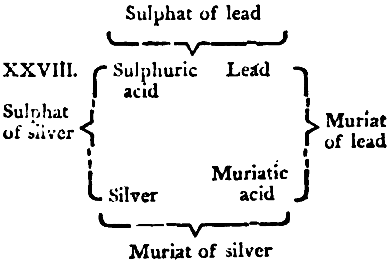
XXIV.

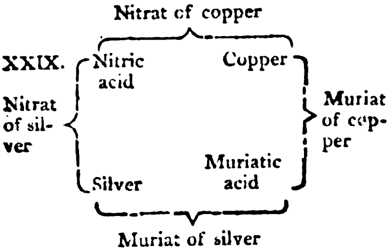
Schemes of Elective Attractions in the Humid Way.

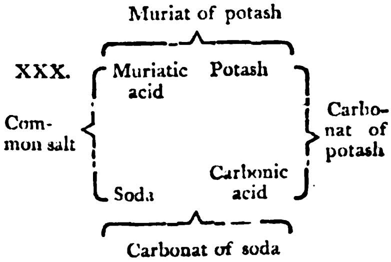


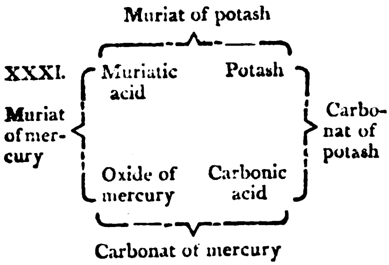


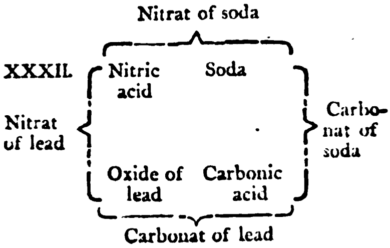


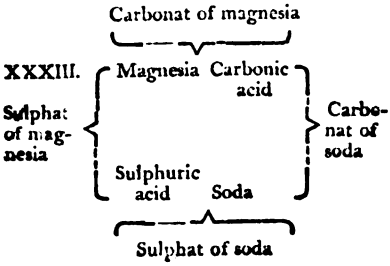


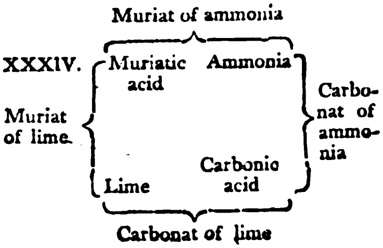












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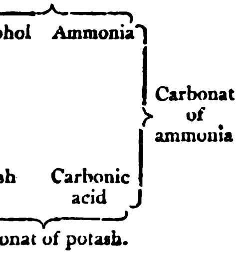

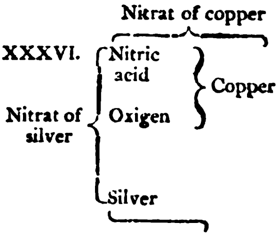

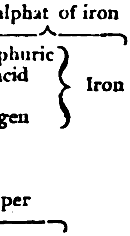

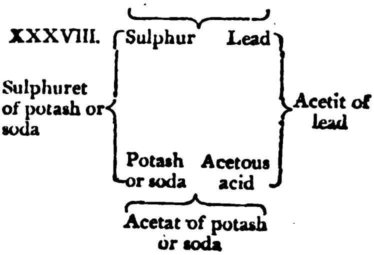

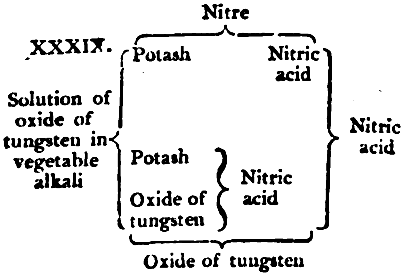

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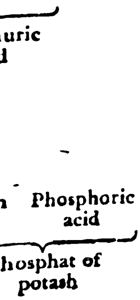

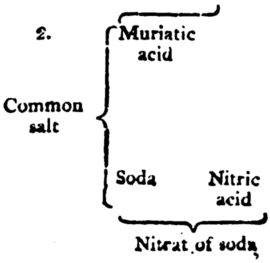

Schemes of Elective Attractions in the Dry Way.

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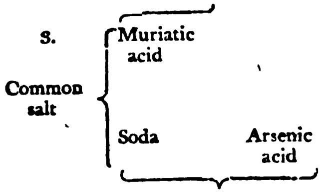

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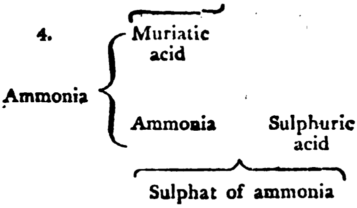

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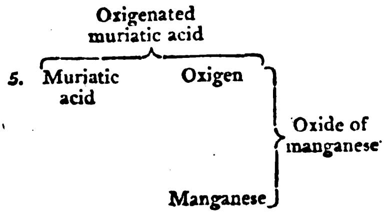

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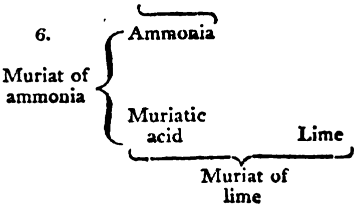

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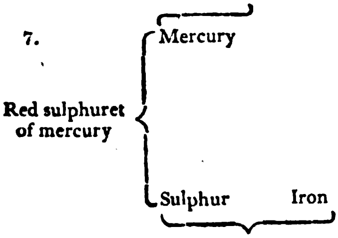

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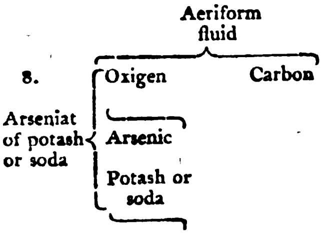

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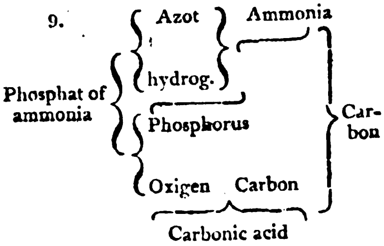

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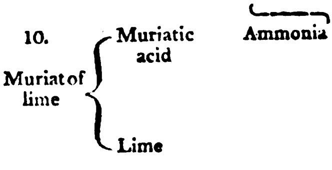

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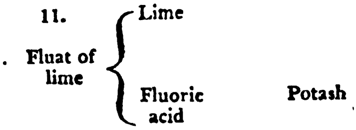

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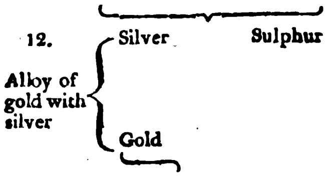
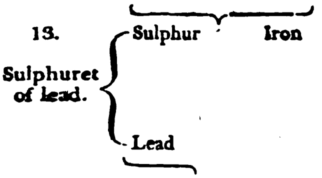


Schemes of Elective Attractions in the Dry Way.

13.



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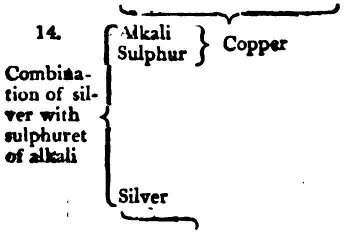

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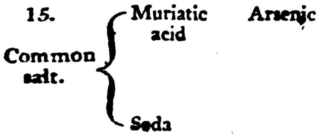

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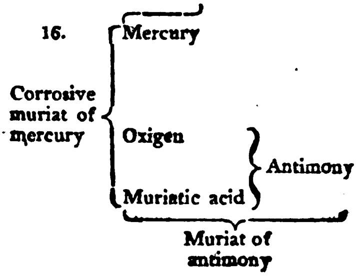

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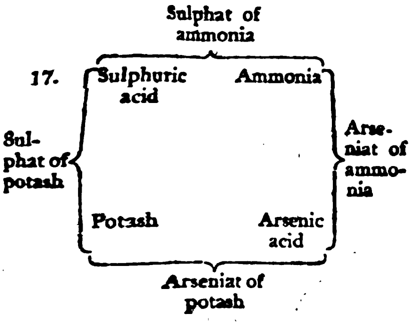

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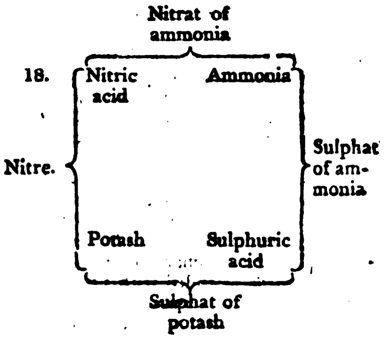

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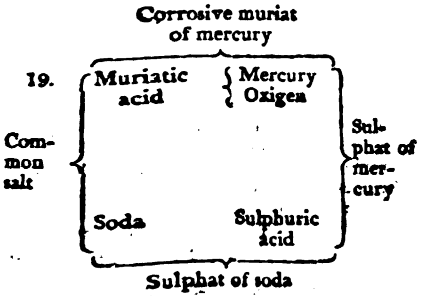

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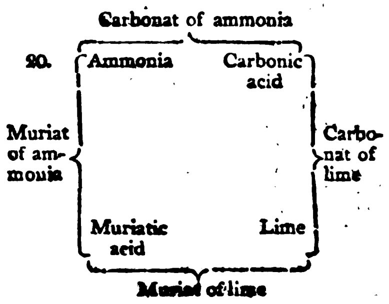
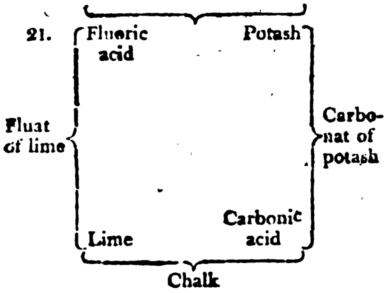


Schemes of Elective Attractions in the Dry Way.

21.



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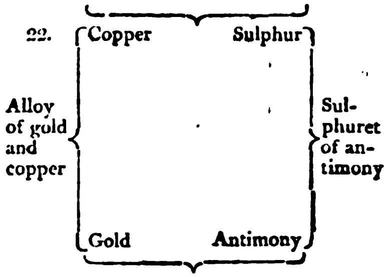

I have inserted the whole of Bergman's schemes, excepting those numbered 17 a, 38 a, 39 a, in the humid way, and 5 a, 8 a, 9 a, 15 a, 16 a, 19 a, in the dry way, which are merely schemes according to the phlogistic doctrine, the duplicates of which, according to the modern theory, are here retained; 25, which includes the acid of sorrel, at present known to be a compound; and 55 and 56, which relate to experiments with the nitrous acid, which may be considered as doubtful, because a large part of the product assumes the permanently elastic state, and has not been examined. My chief inducement for inserting all the others is, that the whole together form so considerable a body of chemical knowledge, expressed with so much perspicuity by virtue of this happy arrangement, that their value and effect cannot but greatly tend to promote the researches of experienced chemists, as well as the advancement of the learner. I speak on this occasion as if the sketches were now first published; and this, with respect to the greater number of chemical readers, is really the case: for Bergman published them in characters; a method which is indeed attended with peculiar advantages both in the enunciation and practice of chemistry; but which, never having been in general use, is very far from being familiar even to the learned. The tables have not, that I know of, been before printed in words at length. I have also inserted the numbers of Mr. Morveau, which answer as far as they can be applied; and the contemplation of those schemes which contain only partial numbers, will show what experiments require to be made to extend them farther. Thus, in scheme 7, it is seen that the adhesion of muriatic acid to the oxide of mercury, in the humid way, will require a less numerical expression than 32; and in scheme 8, that the attraction of sulphuric acid to oxide of iron is less than 54; and the numerical expressions of these indeterminate quantities must be taken so as to agree with all the experiments known, as we have no other method of ascertaining them. The intelligent chemist will find no difficulty in extending them to more particular cases, by attending to the rules of arrangement already described and exemplified.

Augites. See Aqua Marina.

Aurum Fulminans. See Gold.

Aurum Musivum, *or* Mosaicum. A combination of tin and sulphur, which is thus made: Melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with seven ounces of sulphur, and three of muriat of ammonia. Put the powder into a matrass, bedded rather deep in sand, and keep it for several hours in a gentle heat; which is afterward to be raised, and continued for several hours longer. If the heat have been moderate, and not continued too long, the golden-coloured scaly porous mass, called Aurum Musivum, will be found at the bottom of the vessel; but if it have been too strong, the aurum musivum fuses to a black mass of a striated texture. This process is thus explained: As the heat increases, the tin, by stronger affinity, seizes and combines with the muriatic acid of the muriat of ammonia; while the alkali of that salt, combining with a portion of the sulphur, flies off in the form of a sulphuret. The combination of tin and muriatic acid sublimes, and is found adhering to the sides of the matrass. The mercury, which served to divide the tin, combines with part of the sulphur, and forms cinnabar, which also sublimes; and the remaining sulphur, with the remaining tin, forms the aurum musivum which occupies the lower part of the vessel. It must be admitted, however, that this explanation does not indicate the reasons why such an indirect and complicated process should be required to form a simple combination of tin and sulphur.

It does not appear that the proportions of the materials require to be strictly attended to. The process of the marquis de Bullion, as described by Chaptal in his Elements of Chemistry, consists in amalgamating eight ounces of tin with eight

nercury, and mixing this with
f sulphur, and four of muriat
. This mixture is to be exposed
urs on a sand heat sufficient to
ottom of the matrass obscurely
ut Chaptal himself found, that
s containing the mixture were
a naked fire, and violently
mixture took fire, and a sub-
formed in the neck of the ma-
ting of the most beautiful aurum
large hexagonal plates. The
Bullion obtained a good aurum
dissolving eight ounces of tin
tic acid, precipitating it by car-
da, and mixing the precipitate
unces of sulphur. He used this
ead of the foregoing, but found
musivum unfit to increase the
e electric machine, as the former
ivum did, which he found to
parts out of seven of mercury,
h, accordingly, he attributes the
ctrical excitation.

musivum has no taste, though
nens exhibit a sulphureous smell.
uble in water, acids, or alkaline
But in the dry way it forms a
huret, soluble in water. It de-
th nitre. Bergman mentions a
m musivum from Siberia, con-
sulphur, and a small proportion

musivum is used as a pigment
a golden colour to small statue
figures. It is likewise said to be
mixed with melted glass to imitate lapis lazuli.

Avidity. This term is in common use among chemists, who apply it to denote that kind of tendency to combination, which exerts its effects in a short time. It does not therefore denote the power of attraction, or that by which combinations are most strongly maintained; but that modification of the attractive powers, which conduces most to their speedy exertion. Thus, metallic bodies not being soluble in acids but at a certain determinate degree of calcination, and the nitric acid being more easily decomposed than the muriatic, it is found, that the nitric acid dissolves most metallic substances with considerable rapidity, though the muriatic does not; but, on the other hand, the attraction of the muriatic acid to many of the metallic oxides is such, that it takes them from the nitric. The nitric acid, therefore, is said to dissolve the metals with more avidity than the muriatic acid, notwithstanding the attraction of the latter appears to be stronger.

Azot. See Gas (Nitrogen).

Azure. This term, which was formerly applied to the fine blue extracted from lapis lazuli, and at present known by the name of Ultramarine, is now more generally applied to denote the blue glass made by the combination of calx of cobalt with glass. When this is in masses, or a coarse powder, it is called Smalt. See Cobalt and Ultramarine.

B.

E. The beginning and end of
act chemical process consists in
With imperfect instruments this
will be tedious and inaccurate;
good balance, the results will be
; and much time, which is so
experimental researches, will be

nce is a lever, the axis of motion
formed with an edge like that
and the two dishes at its extre-
ung upon edges of the same
se edges are first made sharp,
ounded with a fine hone, or a
uff leather. The excellence of
ment depends, in a great mea-
regular form of this rounded
the lever is considered as a mere
o outer edges are called Points
on, and the inner the Fulcrum.
of suspension are supposed to be
stances from the fulcrum, and
ed with equal weights when

fulcrum be placed in the centre
f the beam, and the three edges
same right line, the balance
will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales be on or off, empty or loaded.

2. If the centre of gravity of the beam, when level, be immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest will descend; and it will do this with more swiftness, the higher the centre of gravity, and the less the points of suspension are loaded.

3. But if the centre of gravity of the beam be immediately below the fulcrum, the beam will not rest in any position but when level; and, if disturbed from this position, and then left at liberty, it will vibrate, and at last come to rest on the level. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the centre of gravity, and the less the weight upon the points of suspension.

4. If the fulcrum be below the line joining the points of suspension, and these be loaded, the beam will overset, unless prevented by the weight of the beam tending to produce a horizontal position, as in § 3,

In this last case, small weights will equilibrate, as in § 3; a certain exact weight will rest in any position of the beam, as in § 1; and all greater weights will cause the beam to overset, as in § 2. Many scales are often made this way, and will overset with any considerable load.

5. If the fulcrum be above the line joining the points of suspension, the beam will come to the horizontal position, unless prevented by its own weight, as in § 2. If the centre of gravity of the beam be nearly in the fulcrum, all the vibrations of the loaded beam will be made in times nearly equal, unless the weights be very small, when they will be slower. The vibrations of balances are quicker, and the horizontal tendency stronger, the higher the fulcrum.

6. If the arms of a balance be unequal, the weights in equipoise will be unequal in the same proportion. It is a severe check upon a workman to keep the arms equal, while he is making the other adjustments in a strong and inflexible beam.

7. The equality of the arms of a balance is of use, in scientific pursuits, chiefly in making of weights by bisection. A balance with unequal arms will weigh as accurately as another of the same workmanship with equal arms, provided the standard weight itself be first counterpoised, then taken out of the scale, and the thing to be weighed be put into the scale, and adjusted against the counterpoise; or when proportional quantities only are considered, as in chemical and in other philosophical experiments, the bodies and products under examination may be weighed against the weights, taking care always to put the weights into the same scale. For then, though the bodies may not be really equal to the weights, yet their proportions among each other may be the same as if they had been accurately so.

8. But though the equality of the arms may be well dispensed with, yet it is indispensably necessary, that their relative lengths, whatever they may be, should continue invariable. For this purpose, it is necessary, either that the three edges be all truly parallel, or that the points of suspension and support should be always in the same part of the edge. This last requisite is the most easily obtained.

The balances made in London are usually constructed in such a manner, that the bearing parts form notches in the other parts of the edges; so that the scales being set to vibrate, all the parts naturally fall into the same bearing. The balances made in the country have the fulcrum edge straight, and confined to one constant bearing by two side plates. But the points of suspension are referred to notches in the edges, like the London balances. The balances here mentioned, which come from the country, are enclosed in a small iron japanned box; and are to be met with at the Birmingham and Sheffield warehouses, though less frequently than some years ago; because a pocket contrivance for weighing guineas and half-guineas has got possession of the market. They are, in general, well made and adjusted, turn with the twentieth of a grain when empty, and will sensibly show the tenth of a grain, with an ounce in each scale. Their price is from five shillings to half a guinea; but those which are under seven shillings have not their edges hardened, and consequently are not durable. This may be ascertained by the purchaser, by passing the point of a penknife across the small piece which goes through one of the end boxes; if it makes any mark or impression, the part is soft.

9. If a beam be adjusted so as to have no tendency to any one position, as in § 1, and the scales be equally loaded; then, if a small weight be added in one of the scales, that balance will turn, and the points of suspension will move with an accelerated motion, similar to that of falling bodies, but as much slower, in proportion, very nearly, as the added weight is less than the whole weight borne by the fulcrum.

10. The stronger the tendency to a horizontal position in any balance, or the quicker its vibrations, § § 3, 5, the greater additional weight will be required to cause it to turn, or incline to any given angle. No balance therefore can turn so quick as the motion deduced in § 9. Such a balance as is there described, if it were to turn with the ten thousandth part of the weight, would move at quickest ten thousand times slower than falling bodies; that is, the dish containing the weight, instead of falling through sixteen feet in a second of time, would fall through only two hundred parts of an inch; and it would require four seconds to move through one third part of an inch: consequently, all accurate weighing must be slow. If the indexes of two balances be of equal lengths, that index which is connected with the shorter balance will move proportionally quicker than the other. Long beams are the most in request, because they are thought to have less friction; this is doubtful: but the quicker angular motion, greater strength, and less weight of a short balance, are certainly advantages.

11. Very delicate balances are not only useful in nice experiments, but are likewise much more expeditious than others in common weighing. If a pair of scales with a certain load be barely sensible to one tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small. But if no greater accuracy were required, and scales were used which would turn with the hundredth of a grain, a tenth

ore or less, would make so great
in the turn, that it would be
ately.
alance be found to turn with a
ion, and is not moved by any
ht, a greater sensibility may be
at balance, by producing a tre-
ion in its parts. Thus, if the
unt saw, a file, or other similar
be drawn along any part of the
ort of a balance, it will produce
hich will diminish the friction
ng parts so much, that the turn
nt with one third or one fourth
ion that would else have been
this way, a beam which would
by the addition of one tenth of
l turn with one thirtieth or
grain.
ance the horizontal tendency of
ds only on its own weight, as in
n with the same addition, what-
e the load; except so far as a
l will produce a greater fric-

balance the horizontal tendency
pends only on the elevation of
, as in § 5, will be less sensible
the load; and the addition re-
oduce an equal turn will be in
o the load itself.
der to regulate the horizontal
some beams, the fulcrum is
w the points of suspension, as
a sliding weight is put upon
index, by means of which the
ravity may be raised or depress-
a useful contrivance.
hts are made by a subdivision
rd weight. If the weight be
halved, it will produce the
, which is the smallest number
between its extremes, without
weight in the scale with the
examination. Granulated lead
onvenient substance to be used
ation of halving, which, how-
tedious. The readiest way to
all weights, consists in weigh-
n quantity of small wire, and
utting it into such parts, by
are desired; or the wire may
close round two pins, and then
with a knife. By this means it
ed into a great number of equal
mall rings. The wire ought to
s that one of these rings may
ce a sensible effect on the beam.
ty (as, for example, a grain) of
be weighed, and the number
ed, the grain may be subdivided
rtion, by dividing that number,
the weights equal to as many
as the quotient of the division
hen, if 750 of the rings amount-
; and it were required to di-
ain decimally, downwards, $\frac{9}{10}$
ual to 675 rings, $\frac{8}{10}$ would be

equal to 600 rings, $\frac{7}{10}$ to 525 rings, &c. Small weights may be made of thin leaf brass. Jewellers foil is a good material for weights below $\frac{1}{10}$ of a grain, as low as to $\frac{1}{100}$ of a grain; and all lower quantities may be either estimated by the position of the index, or shown by actually counting the rings of wire, the value of which has been determined.

17. In philosophical experiments, it will be found very convenient to admit no more than one dimension of weight. The grain is of that magnitude as to deserve the preference. With regard to the number of weights the chemist ought to be provided with, writers have differed according to their habits and views. Mathematicians have computed the least possible number, with which all weights within certain limits might be ascertained; but their determination is of little use. Because, with so small a number, it must often happen, that the scales will be heavily loaded with weights on each side, put in with a view only to determine the difference between them. It is not the least possible number of weights which it is necessary an operator should buy to effect his purpose, that we ought to inquire after, but the most convenient number for ascertaining his inquiries with accuracy and expedition. The error of adjustment is the least possible, when only one weight is in the scale; that is, a single weight of five grains is twice as likely to be true, as two weights, one of three, and the other of two grains, put into the dish to supply the place of the single five; because each of these last has its own probability of error in adjustment. But, since it is as inconsistent with convenience to provide a single weight, as it would be to have a single character for every number; and as we have nine characters, which we use in rotation, to express higher values according to their position, it will be found very serviceable to make the set of weights correspond without numerical system. This directs us to the set of weights as follows: 1000 grains, 900 g. 800 g. 700 g. 600 g. 500 g. 400 g. 300 g. 200 g. 100 g. 90 g. 80 g. 70 g. 60 g. 50 g. 40. g. 30 g. 20 g. 10 g. 9 g. 8 g. 7 g. 6 g. 5. g. 4 g. 3 g. 2 g. 1 g. $\frac{9}{10}$ g. $\frac{8}{10}$ g. $\frac{7}{10}$ g. $\frac{6}{10}$ g. $\frac{5}{10}$ g. $\frac{4}{10}$ g. $\frac{3}{10}$ g. $\frac{2}{10}$ g. $\frac{1}{10}$ g. $\frac{9}{100}$ g. $\frac{8}{100}$ g. $\frac{7}{100}$ g. $\frac{6}{100}$ g. $\frac{5}{100}$ g. $\frac{4}{100}$ g. $\frac{3}{100}$ g. $\frac{2}{100}$ g. $\frac{1}{100}$ g. With these the philosopher will always have the same number of weights in his scales as there are figures in the number expressing the weights in grains.

Thus 742·5 grains will be weighed by the weights 700, 40, 2, and $\frac{5}{10}$.

I shall conclude this chapter with an account of some balances I have seen or heard of, and annex a table of the correspondence of weights of different countries.

Muschenbroek, in his Cours de Physique (French translation, Paris, 1769), tom. ii. p. 247, says, he used an ocular balance of great accuracy, which turned (trebuchoit) with $\frac{1}{20}$ of a grain. The substances he weighed were between 200 and 300 grains. His balance therefore weighed to the [illegible] part of the whole; and would ascertain such weights truly to four places of figures.

In the Philosophical Transactions, vol. lxvi. p. 509, mention is made of two accurate balances of Mr. Bolton; and it is said that one would weigh a pound, and turn with $\frac{1}{10}$ of a grain. This, if the pound be avoirdupois, is $\frac{1}{70000}$ of the weight; and shows, that the balance could be well depended on to four places of figures, and probably to five. The other weighed half an ounce, and turned with $\frac{1}{100}$ of a grain. This is $\frac{1}{20000}$ of the weight.

In the same volume, p. 511, a balance of Mr. Read's is mentioned, which readily turned with less than one pennyweight, when loaded with 55 pounds, before the Royal Society; but very distinctly turned with four grains, when tried more patiently. This is about $\frac{1}{96000}$ part of the weight; and therefore this balance may be depended on to five places of figures.

Also, page 576, a balance of Mr. Whitehurst's weighs one pennyweight, and is sensibly affected with $\frac{1}{300}$ of a grain. This is [illegible] part of the weight.

I have a pair of scales of the common construction, § 8, made expressly for me by a skilful workman in London. With 1200 grains in each scale, it turns with $\frac{1}{10}$ of a grain. This is $\frac{1}{12000}$ of the whole; and therefore about this weight may be known to five places of figures. The proportional delicacy is less in greater weights. The beam will weigh near a pound troy; and when the scales are empty, it is affected by $\frac{1}{1000}$ of a grain. On the whole, it may be usefully applied to determine all weights between 100 grains and 4000 grains to four places of figures.

A balance belonging to Mr. Alchorne of the Mint in London, is mentioned, vol. lxxvii. p. 205, of the Philosophical Transactions. It is true to 3 grains with 15lb. an end. If these were avoirdupois pounds, the weight is known to $\frac{1}{35000}$ part, or to four places of figures, or barely five.

A balance (made by Ramsden, and turning on points instead of edges) in the possession of Dr. George Fordyce, is mentioned in the seventy-fifth volume of the Philosophical Transactions. With a load of four or five ounces, a difference of one division in the index was made by $\frac{1}{1000}$ of a grain. This is [illegible] part of the weight, and consequently this beam will ascertain such weights to five places of figures, beside an estimate figure.

I have seen a strong balance in the possession of my friend Mr. Magellan, of the kind mentioned in § 15, which would bear several pounds, and showed $\frac{1}{10}$ of a grain, with one pound an end. This is $\frac{1}{70000}$ of the weight, and answers to five figures. But I think it would have done more by a more patient trial than I had time to make.

The Royal Society's balance, which was lately made by Ramsden, turns on steel edges, upon planes of polished crystal. I was assured, that it ascertained a weight to the seven-millionth part. I was not present at this trial, which must have required great care and patience, as the point of suspension could not have moved over much more than the $\frac{1}{10}$ of an inch in the first half minute. but, from some trials which I saw, I think it probable, that it may be used in general practice to determine weights to five places and better.

From this account of balances, the student may form a proper estimate of the value of those tables of specific gravities, which are carried to five, six, and even seven places of figures, and likewise of the theoretical deductions in chemistry, that depend on a supposed accuracy in weighing, which practice does not authorise. In general, where weights are given to five places of figures, the last figure is an estimate, or guess figure; and where they are carried farther, it may be taken for granted, that the author deceives either intentionally, or from want of skill in reducing his weights to fractional expressions, or otherwise.

Among the numerous public exertions, which our learned neighbours, the French, have made in favour of the sciences, the determination of the relative proportions of the weights used in various parts of Europe is by no means one of the least. The most exact standard weights were procured by means of the ambassadors of France, resident in various places; and these were compared by Mons. Tillet with the standard mark in the pile preserved in the Cour de Monnoies de Paris. His experiments were made with an exact balance made to weigh one marc, and sensible to one quarter of a grain. Now, as the mark contains 18432 quarter grains, it follows, that this balance was a good one, and would exhibit proportions to four places, and a guess figure. The results are contained in the following table, extracted from Mons. Tillet's excellent Paper in the Memoirs of the Royal Academy of Sciences for the year 1767. I have added the two last columns, which show the number of French and English grains contained in the compound quantities against which they stand. The English grains are computed to one tenth of a grain, although the accuracy of weighing came no nearer than about two tenths.

The weights of the kilogramme, gramme, decigramme, and centigramme, which are now frequently occurring in the French chemical writers, are added at the bottom of this table, according to the latest determination of their respective values.

Table of the Weights of different Countries.

nd Denomination of Weight.	Marc.	oz.	gros.	grains.	F. grains.	E. grains.
e marc of 16 loths - -	—	7	5	16	4408	3616·3
dsmiths weight of 8 ounces -	1	—	½	4	4648	3813·2
nd of 16 ounces, for merchan- - - - - . -	2	1	¼	6	9834	8067·7
nmon pound varies very consi- bly in other towns of the canton.						
othecaries weight of 8 ounces -	—	7	5½	26	4454	3654·
- - - -	—	7	5	6¼	4398¾	3608·6
he marc, or original troyes - - - -	1	—	—	21	4629	3797·6
ne marc of 16 loths - -	—	7	5	11	4403	3612·2
ple. The cheki, or 100 drachms	1	2	3	28	6004	4925·6
. Goldsmiths weight; com- posed equal to the marc of	—	7	5½	10⅓	4438⅓	3641·2
. Merchants weight of 16 loths	1	—	1	22½	4702½	3857·9
eight; commonly supposed he marc of Cologn -	—	7	5	3½	4395½	3606·
he pound (anciently used by ns) - -	1	3	½	20	6392	5 44·
e peso sottile - - -	1	2	2¼	30	5970	4897·7
e peso grosso - .	1	2	3	5	5981	4906·7
weight; commonly supposed he Cologn marc -	—	7	5	7¼	4399¼	3609·4
Another weight - -	—	7	7	23	4559	3740·2
Brussels marc used; but the oved - -	1	—	—	24	4632	3800·1
e marc, or half pound - -	—	7	3½	34	4318	3542·4
he pound troy - -	1	4	1½	1	7021	5760·
he pound avoirdupois - -	1	6	6½	6	8538	7004·5
e pound - - -	1	3	—	23	6359¼	5217·
he marc royal of Castile - -	—	7	4	8¼	4328	3550·7
e pound - - -	1	2	2½	21	5961	4890·4
(The Cologn marc) - -	—	7	5	10	4402	3611·5
e marc - - -	—	7	5	33¼	4425	3630·2
e libra grossa - -	3	—	7½	—	14364½	11784·
The Cologn marc) - -	—	7	5	11	4403½	3612·3
e pound of 12 ounces - -	1	2	3½	27½	6039	4954·3
e weight for gold: of 128 crowns	1	6	—	24	8088	6635·3
e weight for ducats: of 64 - - -	—	7	2	22	4208	3452·3
he marc of 8 ounces - -	1	—	—	24	4632	3800·1
The pound of 16 ounces -	2	2	4½	6	10698	8776·5
e pound of 12 ounces - -	1	3	½	14	6386	5239·
The pound of 2 marcs -	1	5	7	8	8000	6563·1
(The Cologn marc) - -	—	7	5	11¼	4403¾	3612·6
e marc of 8 ounces - -	—	—	—	22¼	4630¼	3799·
in they have also a pound of 12 e above ounces. But, in their ecaries pound of 12 ounces, unce is one sixth lighter.						
he pound - - -	1	5	2	12	7644	6271·
e libra grossa of 12 ounces -	1	7	4½	25½	8989½	7374·5
e peso sottile of 12 ounces -	1	1	6½	24	5676	4656·5
pounds dependant on Venice, pound differs considerably in						
e marc of commerce - -	1	1	1	16	5272	4325·
he marc of money - .	1	1	1	26	5282	4333·3
The grain - -	—	—	—	—	0.82039	1·
e grain - - -	—	—	—	—	1.	1·21895
e kilogramme - -	4	—	5	35	18827·15	15445·5
e gramme - - -	—	—	—	—	18·827	15·445
e decigramme - -	—	—	—	—	1·8827	1·5445
e centigramme - -	—	—	—	—	·18827	·15445

L 4

Balas, or Balais Ruby. A precious stone of a pale red colour, inclining to violet. It comes chiefly from the Brazils; although some likewise come from the East Indies. The value of the Balas ruby is about thirty shillings per carat, according to Dutens.

Balloon. Receivers of a spherical form are called Balloons, by the French, and likewise by several translators from that language.

Balloon (Air, or Aerostatical). The first experiment for floating bodies in the atmosphere, by including within them a fluid specifically less heavy than common air, was made by Messrs. Stephen and John Mongolfier, at Avignon, in the month of November 1782. They raised a bag of silk, by inflating it with common air heated or altered by combustion; it being evident that such a bag must rise on the same principle as smoke ascends from a chimney. This experiment led several French philosophers to the consideration, that hidrogen gas, of which the great levity had been ascertained by Mr. Cavendish in 1766, might, with more permanent advantage, be applied to this purpose; and, accordingly, M. Faujas St. Fond constructed a machine on this principle by public subscription at Paris, which was suffered to rise into the atmosphere from the Champ de Mars, in the month of August 1783. Pilatre de Rozier first ascended into the air with a balloon on Mongolfier's principle; and Messrs. Charles and Robert made the first experiment of ascending with a balloon filled with hidrogen gas.

Cavallo's Treatise on the History and Practice of Aerostation may be consulted for an account of the methods of constructing and filling these machines. The most usual means of obtaining the hidrogen gas, has been to dissolve iron shavings or turnings in diluted sulphuric acid; but it appears probable, that the calcination of ignited iron by steam would prove the cheapest, if the demand for machines of this kind were ever to become considerable.

Balls (Martial). A medical composition, consisting of iron filings and cream of tartar, used to impregnate water, or other liquids, with iron dissolved by the tartarous acid. To make these balls, one part of filings of iron and two parts of powdered cream of tartar are mixed well together, and put into an earthen or iron vessel with some water. This mixture is to be stirred from time to time, until it becomes almost dry, and then it is to receive more water, and to be stirred as before. This treatment is to be continued until it acquires, when nearly dry, somewhat of the consistence and tenacity of softened resin. Then it is to be rolled up into the form of a ball, which is generally kept tied up in a rag; and when intended to be used, it is to be infused in water until it gives some colour to that liquid.

In this composition, part of the tartarous acid, which is redundant in the cream of tartar, combines with part of the iron; and the remaining or greater part of the cream of tartar and iron continues solid in this way of proceeding. The infusion of the martial ball in water does not therefore differ, as Macquer observes, from the tartarized tincture of iron. Its virtues are much the same as those of other martial medicines. These balls are unknown to us in England.

Balls (Mercurial). These consist of an amalgam of tin and mercury, in which the former metal so far predominates, as to give the mass a solid form. Macquer mentions the use of them by travellers to purify water, in which they are boiled for this purpose. I do not see, however, in what respect they would produce any material advantage. The mercurial impregnation, which the water would slightly receive from this treatment, does not seem likely to counteract, in any considerable degree, the bad qualities of another nature, which may predominate in water.

Balsam. The several vegetable principles in commerce have been distinguished by various names, which bear no relation to their properties, considered with regard to scientific arrangement. Balsams have been usually considered to be oily aromatic substances, imperfectly fluid, obtained from incisions made in certain trees. Several French chemists, among whom are Fourcroy and Chaptal, have adopted the distinction of Bucquet, who has confined this denomination to such resinous matters alone as possess a fragrant smell, and more especially contain acid, odorant, and concrete salts, that may be extracted by decoction or sublimation. The principal balsams, according to this division, are Benzoin, balsam of Tolu or Peru, and storax; which see, as well as the proper names of those fluid substances, which still generally retain the name of balsams in this country.

Balsam of Sulphur. A solution of sulphur in oil.

All oils, whether expressed or essential, can dissolve sulphur. To make this solution, the oil must be poured on the sulphur, and sufficient heat applied to melt the substance. While the oil dissolves the sulphur, it acquires a reddish or brown colour, an acrid, disagreeable taste, and a strong fetid smell, somewhat hepatic, resembling that of the combination of oil with sulphuric acid.

It is not well ascertained what happens in this combination. The fixed oils deposit sulphur in the crystallized state; but when the balsam of sulphur is distilled, the sulphur itself is totally decomposed, or at least it is no where found in a disengaged state.

y distillation with a very slow
d sulphurous acid, sulphuric
ous degrees of strength, some
fluid and partly thick, and a
c, but no sulphur. From this
it appears, that the acid prin-
oil acidifies a certain part of
; and it is more than probable,
rogen of the oil comes over in
form, in combination with an-
f the sulphur.
ome danger of explosion, when
s of oil and sulphur are too
d considerably heated.
s Tar. Petroleum, long ex-
ir, becomes converted into this
It is viscid, brown, black, or
not soluble in alcohol; easily
urns with much smoke. It con-
on of succinic acid. See Pe-

or **Barillor.** The term given
to the impure mineral alkali
om Spain and the Levant. It is
rning to ashes different plants
n the seashore, chiefly of the
, and is brought to us in hard
s, of a speckled brown colour.
ill more impure alkali made in
by burning various seaweeds,
called *British barilla.* See

. Carbonat of barytes.
See Earths.
. A dark gray or black stone,
a ferruginous appearance ex-
d crystallized in large prisms,
gonal, but frequently consisting
or less number of sides. It has
of controversy among various
, whether the basaltes has been
he humid or in the dry way.
ss is perfectly consistent with
w of volcanic phænomena. The
ppears, however, to be in fa-
chemists, who suppose basal-
ts liquefaction to water; for
fusible by fire, it then forms
of a very different appearance
hich is supposed to have been
volcanoes; as, when thus fus-
black glass.
ither found in irregular masses
ometimes lamellated like slate,
dimensions, and at other times
d blocks. But the most re-
the columnar basaltes, which
nse masses, composed of co-
, forty, or more feet in height,
ous thickness. Nay, those at
two hundred and fifty feet
constitute some of the most
cenes in nature for the im-
regularity of their parts. The
im in Ireland, for the space of
n length, exhibits a very mag-
ty of columnar cliffs: and the
way consists of a point of that

coast formed of similar columns, and projecting into the sea upon a descent for several hundred feet. These columns are, for the most part, hexagonal, and fit very accurately together, being in some instances united by a stony cement, but most frequently not adherent to each other, though water cannot penetrate between them; which proves, that they cannot have been thus fissured by the shrinking of the mass on cooling. And the basaltic appearances on the Hebrides islands on the coast of Scotland, as described by sir Joseph Banks, who visited them in 1772, are upon a scale still more striking for its vastness and variety.

An extensive field of inquiry is here offered to the geological philosopher, in his attempts to ascertain the alterations to which the globe has been subjected. The inquiries of the chemist equally cooperate in these researches, and tend likewise to show to what useful purposes this and other substances may be applied. Bergman found, that the component parts of various specimens of basaltes were, at a medium, 52 parts silex, 15 alumine, 8 carbonat of lime, and 25 iron. The differences seem, however, to be considerable; for Faujas de St. Fond gives these proportions:—46 silex, 30 alumine, 10 lime, 6 magnesia, and 8 iron. The amorphous basaltes known by the name of rowley rag, the ferrilite of Kirwan, of the specific gravity of 2·748, afforded Dr. Withering 47·5 of silex, 32·5 of alumine, and 20 of iron, at a very low degree of oxidation, probably. Dr. Kennedy, in his analysis of the basaltes of Staffa, gives the following as its component parts:—silex 48, alumine 16, oxide of iron 16, lime 9, soda 4, muriatic acid 1, water and volatile parts, 5. Klaproth gives, for the analysis of the prismatic basaltes of Hasenberg: silex 44·5, alumine 16·75, oxide of iron 20, lime 9·5, magnesia 2·25, oxide of manganese 0·12, soda 2·60, water 2. On a subsequent analysis, with a view to detect the existence of muriatic acid, he found slight indications of it, but it was in an extremely minute proportion.

Basaltes, when calcined and pulverized, is said to be a good substitute for puzzolana in the composition of mortar, giving it the property of hardening under water. Wine bottles have likewise been manufactured with it, but there appears to be some nicety requisite in the management to ensure success. Mr. Castelveil, who heated his furnace with wood, added soda to the basaltes, to render it more fusible: while Mr. Giral, who used pitcoal, found it necessary to mix with his basaltes a very refractory sand. The best mode probably would be, to choose basaltes of a close fine grain and uniform texture, and to employ it alone, taking care to regulate the heat properly; for, if this be carried too high, it will drop from the iron almost like water.

Basis, or Base. The chemical philosophers have, for a long time, been in the habit of considering the acids as bodies possessing an activity peculiar to themselves; and have, in general, overlooked the circumstance, that an equal activity, or power of attraction, must exist in those substances with which they combine, and are by this means deprived of their distinctive properties. The substances with which acids enter into combination, and are said to be neutralized, are for the most part less volatile than the acids themselves; and accordingly communicate a degree of fixity to those acids. From both these reasons, writers have been led to distinguish the substance, which is united with any acid, by the name of the basis of the compound, or neutral salt. As a considerable advantage, with regard to chemical language, is obtained from the use of this term, which is not altogether improper, it is still much used by chemical authors. Thus, we say, salts with earthy bases, salts with alkaline bases, or salts with metallic bases, accordingly as the case may be; by which it is to be understood, that these substances are united with an acid.

Base is likewise used sometimes for that which forms an acid by its union with oxigen; but which is now more generally called the *radical* of the acid: and hence we meet with the distinction of salifiable and acidifiable bases There would be more of precision, no doubt, in confining base to the former significations; but when it is employed as synonymous to radical, there can be little danger of its occasioning mistake or obscurity.

Bath. The heat communicated from bodies in combustion must necessarily vary according to circumstances; and this variation not only influences the results of operations, but in many instances endangers the vessels, especially if they be made of glass. Among the several methods of obviating this inconvenience, one of the most usual consists in interposing a quantity of sand, or other matter, between the fire and the vessel intended to be heated. The sand bath and the water bath are most commonly used; the latter of which was called Balneum Mariæ by the elder chemists. A bath of steam may, in some instances, be found preferable to the water bath. Some chemists have proposed baths of melted lead, of tin, and of other fusible substances. These may perhaps be found advantageous in a few peculiar operations, in which the intelligent operator must indeed be left to his own sagacity.

The water bath is nothing more than a pot or vessel containing water, which is kept boiling, and in which the digesting or distillatory vessels are kept immersed. As the heat of boiling water is nearly stationary, this temperature is found very advantageous in the distillation of essential oils, and all other substances in which an empyreumatic taint is to be feared. It may easily be imagined, that the form of the bath, as well as of the vessels, may be varied according to the purposes respectively aimed at.

The sand bath consists of sand placed either in an iron pot, or upon an iron hearth with fire underneath. In this the heat is gradually communicated, although less uniformly than by the water bath; and it may likewise be carried to ignition. As the heat is greatest towards the bottom of the sand, the operator possesses a power of moderating it by raising the vessels when necessary. The extensive sand bath which is formed by spreading sand upon an iron hearth is very useful for digestion, solution, evaporation, and other chemical processes, which may be carried on at the same time in a considerable number of vessels.

Bdellium. A gum resin, supposed to be of African origin. The best bdellium is of a yellowish brown, or dark brown colour, according to its age; unctuous to the touch, brittle, but soon softening, and growing tough betwixt the fingers; in some degree transparent, not unlike myrrh; of a bitterish taste, and a moderately strong smell. It does not easily take flame, and, when set on fire, soon goes out. In burning, it sputters a little, owing to its aqueous humidity; but cannot be said to explode, much less to explode like gunpowder, as Hermann Valentini reports.

An ounce of picked bdellium, treated with water, afforded Neumann six drams two scruples of gummy extract; and afterward, with alcohol, two scruples of resin, two scruples remaining undissolved. Another scruple, treated first with alcohol, yielded two drams of resinous extract; and afterward, with water, five drams two scruples of gum, only one scruple remaining undissolved. The distilled spirit has no taste or smell of the bdellium, and the distilled water very little.

Bee-glue. A soft unctuous glutinous matter, used by the bees for cementing the combs to the hives, and closing up the cells. See Propolis.

Beer is the wine of grain. Malt is usually made of barley. The grain is steeped for two or three days in water until it swells, becomes somewhat tender, and tinges the water of a bright reddish brown colour. The water being then drained away, the barley is spread about two feet thick upon a floor, where it heats spontaneously, and begins to grow, by first shooting out the radicle. In this state, the germination is stopped by spreading it thinner, and turning it over for two days; after which it is again made into a heap, and suffered to become sensibly hot, which usually happens in little more than a day. Lastly, it is conveyed to the kiln, where, by a gradual and low heat, it is rendered dry and crisp. This is malt; and its qualities differ according as it is more or less soaked, drained, germinated, dried, and

is, as in other manufactories,
t operators often make a
heir processes, from views of
:hers pretend to peculiar se-
lly possess none.

, and probably all large grain,
be suffered to grow into the
l as root, before it is fit to be
alt. For this purpose, it is
two or three inches deep in
and covered with loose earth;
twelve days it springs up. In
is taken up and washed, or
ear it from its dirt; and then
iln for use.

of heat to which the malt is
his process gradually changes
om very pale to actual black-
nply dries it, or converts it to
r. Combrune, who made many
on the subject, gives us the
le of the colour produced in
rent degrees of heat according
t's thermometer.

hite.
eam colour.
ght yellow.
nber colour.
gh amber.
le brown.
own.
igh brown.
rown inclining to black.
igh brown speckled with black.
ackish brown with black specks.
olour of burnt coffee.
ack.

r of the malt not only affects
of the liquor brewed from it;
equence of the chemical opera-
heat applied on the principles
eloped in the grain during the
malting, materially alters the
he beer, especially with regard
erties of becoming fit for drink-
ving fine. With regard to their
ne, Mr. Combrune has given us
g table.

se, when properly brewed, be-
ome spontaneously fine, even as
r as 138°: when brewed for
nber by repeated fermentations,
hey become pellucid.

precipitation these grow bright
a short time.

h precipitation these require
ght or ten months to become
right.

h precipitation these may be
xed, but will never become
right.

Degrees.
167 } These with difficulty can be brewed
171 } without setting the goods, and
176 } will by no means become bright, not even with the strongest acid menstruum.

The following table shows the time that beer must be kept before it is fit for drinking, according to the degree of heat in which the malt has been dried.

Degrees.	
119	Two weeks.
124	One month.
129	Three months.
134	Four months.
138	Five months.
143	Six months.
148	Ten months.
152	Fifteen months.
157	Twenty months.
162	Two years.

Beer is made from malt previously ground, or cut to pieces, by a mill. This is placed in a tun, or tub with a false bottom; hot water is poured upon it, and the whole stirred about with a proper instrument. The temperature of the water in this operation, called Mashing, must not be equal to boiling; for, in that case, the malt would be converted into a paste, from which the impregnated water could not be separated. This is called Setting. After the infusion has remained for some time upon the malt, it is drawn off, and is then distinguished by the name of Sweet Wort. By one or more subsequent infusions of water, a quantity of weaker wort is made, which is either added to the foregoing, or kept apart, according to the intention of the operator. The wort is then boiled with hops, which gives it an aromatic bitter taste, and is supposed to render it less liable to be spoiled in keeping; after which it is cooled in shallow vessels, and suffered to ferment, with the addition of a proper quantity of yeast. The fermented liquor is beer; and differs greatly in its quality, according to the nature of the grain, the malting, the mashing, the quantity and kind of the hops and the yeast, the purity or admixtures of the water made use of, the temperature and vicissitudes of the weather, &c.

Beside the various qualities of malt liquors of a similar kind, there are certain leading features by which they are distinguished, and classed under different names, and to produce which, different modes of management must be pursued. The principal distinctions are into beer, properly so called; ale; table or small beer; and porter, which is commonly termed beer in London. Beer is a strong, fine, and thin liquor; the greater part of the mucilage having been separated by boiling the wort longer than for ale, and carrying the fermentation farther, so as to convert the saccharine matter into alcohol. Ale is of a more sirupy consistence, and sweeter taste; more of the mucilage being retained in it, and the fermentation not having been carried so far as to decompose all the sugar. Small beer, as its name implies, is a weaker liquor; and is made, either by adding a large portion of water to the malt, or by mashing with a fresh quantity of water what is left after the beer or ale wort is drawn off. Porter was probably made originally from very high dried malt; but it is said, that its peculiar flavour cannot be imparted by malt and hops alone. As long ago as the reign of Queen Anne, brewers were not to mix sugar, honey, Guinea pepper, essentia bina, occulus Indicus, or any other unwholesome ingredient, in beer, under a certain penalty; from which, we may infer, that such at least was the practice of some; and writers, who profess to discuss the secrets of the trade, mention most of these and some other articles as essentially necessary. The essentia bina is sugar boiled down to a dark colour, and empyreumatic flavour. Broom tops, wormwood, and other bitter plants, were formerly used to render beer fit for keeping, before hops were introduced into this country; but are now prohibited to be used in beer made for sale.

Beer appears to have been of ancient use, as Tacitus mentions it among the Germans, and has been usually supposed to have been peculiar to the northern nations; but the ancient Egyptians, whose country was not adapted to the culture of the grape, had also contrived this substitute for wine; and Mr. Park has found the art of making malt, and brewing from it very good beer, among the negroes in the interior parts of Africa.

Beet. The root of the beet affords a considerable quantity of sugar, and has lately been cultivated for the purpose of extracting it to some extent in Germany. See Sugar. It is likewise said, that if beet roots be dried in the same manner as malt, after the greater part of their juice is pressed out, very good beer may be made from them.

Belly. When a metallic ore is found, not in veins, but in distinct masses, these are called Bellies or Stock Works, by the miners. In the iron-founderies, likewise, the large air vessels which receive the air from iron bellows, worked by steam engines, and transmit it in an equal stream to the furnace by the reaction of water, are called, by the workmen, Regulating Bellies.

Bellmetal. The basis of the composition called Bellmetal, is copper, which is alloyed chiefly with tin. Silver is said to be sometimes added. A small proportion of tin, added to copper, deprives it of its malleability so far as to render it quite brittle; and the specific gravity of the compound is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. In certain proportions, it even exceeds that of the heavier metal. The colour of bellmetal is much whiter than might be expected from the proportion of tin which enters into its composition; and when this last metal constitutes one third of the mass, the compound is so perfectly white, as to reflect the images of all coloured bodies without alteration, when duly polished. See Speculum.

Ben (Oil of). This is obtained from the ben nut, by simple pressure. It is remarkable for its not growing rancid in keeping, or at least not until it has stood for a number of years; and on this account it is used in extracting the aromatic principle of such odoriferous flowers as yield little or no essential oil in distillation. These preparations are made in Spain, Portugal, and more especially Italy, by the following method, according to Neumann:—Some fine carded cotton is dipped in oil, and laid in the bottom of a proper vessel: on this is spread a pretty thick layer of fresh flowers, above these some more of the dipped cotton; and thus alternately till the vessel is full. The whole is then digested, for a day and a night, in the heat of a water bath; after which the flowers are taken out, the cotton stratified in the same manner with fresh flowers, and the process repeated until the oil squeezed out from the cotton is found to be sufficiently impregnated with the odour of the subject. The digesting vessel is either of tin, with a cover to screw upon it; or of porcelain, composed of two parts which are closely luted together. Most of them have an air-hole in the top, which is stopped with a dossil of the oiled cotton, which retains such of the odorous effluvia as would otherwise make their escape. Some, instead of the oil of ben, take the ben itself, cut it in pieces, stratify it repeatedly with the flowers, and then press out its oil; but the oil thus obtained is greatly inferior in fragrance to the other.

Benzoin, *or* Benjamin. The tree which produces Benzoin is a native of the East Indies, particularly of the island Siam and Sumatra[*]. The juice exsudes from incisions, in the form of a thick white balsam. If collected as soon as it has grown somewhat solid, it proves internally white like almonds, and hence it is called Benzoë Amygdaloides: if suffered to lie long exposed to the sun and air, it changes more

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[*] Consult the Philosophical Transactions, vol. lxxvii. page 307, for a botanical description and drawing of the tree, by Dryander.

a brownish, and at last to a
brown colour. The dealers
odity never sell us the fine
by itself, but mix it with the
fouler kinds, that one may
other. Hence, in the very
of the shops we meet with
ous colours—white, yellowish
v, brownish yellow, brown,
n, and gray, all united in one
dark-coloured benzoin, how-
e free from earth and woody
nd from admixtures of any
loes not appear to be inferior
the white.

s moderately hard and brittle,
agreeable smell when rubbed
When chewed, it impresses a
ss on the palate. It is totally
ohol; from which, like other
be precipitated by the addi-

opake fluid thus obtained has
ac Virginale; and is still sold,
grant additions, by perfumers,
. Boiling water separates a
y of the peculiar acid of ben-
cid (Benzoic).

e has lately analysed this sub-
y with a view to ascertain the
ferent menstrua on it. Ether,
ohol, he found dissolved it with
y. Water precipitated it from
likewise. Nitric acid produces
fervescence when poured on
nzoin, and converts it into an
red mass. Six ounces of the
ty of 1·36 being poured on a
ins, and heated in a sand bath
, a light yellow solution was
the solution cooled benzoic
osited, and, after some days
e whole of this acid appeared
ted. Water poured into this
ently made, precipitated the
arently unaltered. From its
itromuriatic acid, neither wa-
kalis precipitate it. If sulphuric
red on powdered benzoin, an
takes place; part of the ben-
ved, forming a deep red liquor,
ubstance remains on the sur-
the solution sulphurous acid
. Alkalis form no precipitate
on till after some hours stand-
dark coloured precipitate is
ter produces a lilac precipi-
ecent solution. Neither mu-
etous acid has any effect on
etic acid dissolves it, even in
he solution be assisted by heat,
ery turbid on cooling, owing
tion of the benzoic acid. Ace-
solves benzoin without heat.
ivium of potash or soda im-
rms a dark brown solution
, which becomes turbid after
posure to the air. No alteration is produced in these solutions by diluting them largely with water; but the acids form precipitates in them which are redissolved on the application of heat, if nitric or acetic acid be added in excess. Ammonia dissolves a small quantity of benzoin, which is precipitated by the acids.

The products Mr. Brande obtained by distillation were from a hundred grains; benzoic acid 9 grains, acidulated water 5·5, butyraceous and empyreumatic oil 60, brittle coal 22, and a mixture of carburetted hidrogen and carbonic acid gas computed at 3·5. On treating the empyreumatic oil with water, however, 5 grains more of acid were extracted, making 14 in the whole.

The oil obtained by the distillation of benzoin possesses a strong empyreuma, but when rectified by a second distillation its smell is exceedingly fragrant and pleasant. Its taste is acrimonious and very disagreeable. Distilled with water it imparts to it some of its taste. It is perfectly soluble in alcohol, and this solution is rendered turbid by water. It sinks in water; and forms soaps with the alkalis.—*Nicholson's Journal.*

Beryl. A precious stone of a blue green colour, by many authors confounded, and perhaps justly, with the aqua marine. Cronstedt, however, calls the lighter-coloured stone Aqua Marine, and the darker the Beryl. See Aqua Marine. The Saxon Beryl was the stone in which professor Tromsdorf supposed he had discovered a new earth, which, from the insipidity of its compounds with the acids, he named *ugustine*. According to this analysis, it contained 78 of this earth, 4·5 alumine, and 15 silex: but Vauquelin afterward found that this earth was the phosphat of lime, and M. Chenevix likewise has demonstrated the fact. What is called Saxon beryl, therefore, is properly an apatite.

Bezoar. This name, which is derived from a Persian word implying an antidote to poison, was given to a concretion found in the stomach of an animal of the goat kind, which was once very highly valued for this imaginary quality, and has thence been extended to all concretions found in animals. The medical bezoar has been distinguished into oriental, or such as is brought from the east, and occidental, or that which is brought from South America and the Spanish West Indies. The oriental bezoar has a smooth glossy surface, and a dark green or olive hue. The occidental is uneven on the surface, of a dirty green colour, heavier, and more brittle. The hog bezoar, found in the gall bladder of the wild boar in the East Indies, has likewise been highly valued, selling for ten times its weight in gold: and the biliary calculi of the porcupine and monkey, called likewise Malacca stones, have been valued much higher.

The bezoar was formerly much prized in medicine, but has gradually grown into disuse, and is now totally rejected by our college. A composition of it with absorbent powders has been much in repute, as a popular remedy for disorders in children, by the name of Gascoigne's powder, and Gascoigne's ball; but the real Bezoar was rarely if ever used for these, its price offering such a temptation to counterfeit it. Some have employed for this purpose a resinous composition, capable of melting in the fire, and soluble in alcohol: but Neumann supposed, that those nearest resembling it were made of gypsum, chalk, or some other earth, to which the proper colour was imparted by some vegetable juice. We understand, however, that tobaccopipe clay tinged with ox-gall is commonly employed, at least for the Gascoigne's powder, this giving a yellow tint to paper rubbed with chalk, and a green to paper rubbed over with quicklime, which are considered as proofs of genuine bezoar, and which a vegetable juice would not effect.

Bezoar (Bovine). A yellowish concretion found in the gall-bladder of the ox, and used as a yellow pigment in miniature painting.

Bezoar (Jovial). A compound of oxide of antimony and oxide of tin, made by melting three parts of antimony with two of tin; levigating the mixture; adding five parts of corrosive muriat of mercury; distilling in a retort; and, lastly, distilling the muriat of antimony and tin three times with thrice its weight of nitric acid. The powder is then to be calcined, thrown into alcohol while in a state of ignition, and dried. It differs very little from the antihectic of Poterius, like which it has fallen into disuse.

Bezoar (Mineral). This preparation is an oxide of antimony, produced by distilling the nitric acid several times to dryness from the muriat of antimony. See Antimony.

Bile. See Gall.

Birdlime. This substance has been classed among the immediate productions of vegetables. Fourcroy has considered it as a gluten; but it had never been fully examined, till it was analysed by Bouillon Lagrange.

The best birdlime is made of the middle bark of the holly, boiled seven or eight hours in water, till it is soft and tender; then laid in heaps in pits in the ground and covered with stones, the water being previously drained from it; and in this state left for two or three weeks to ferment till it is reduced to a kind of mucilage. This being taken from the pit is pounded in a mortar to a paste; washed in river water; and kneaded, till it is freed from extraneous matters. In this state it is left four or five days in earthen vessels, to ferment and purify itself, when it is fit for use.

It may likewise be obtained from the misleto, the viburnum lantana, young shoots of elder, and other vegetable substances.

It is sometimes adulterated with turpentine, oil, vinegar, and other matters.

Good birdlime is of a greenish colour, and sour flavour; gluey, stringy, and tenacious; and in smell resembling linseed oil. By exposure to the air it becomes dry and brittle, so that it may be powdered; but its viscidity is restored by wetting it. It reddens tincture of litmus. Exposed to a gentle heat it liquefies slightly, swells in bubbles, becomes grumous, emits a smell resembling that of animal oils, grows brown, but recovers its properties on cooling, if not heated too much. With a greater heat it burns, giving out a brisk flame and much smoke. The residuum contains sulphat and muriat of potash, carbonat of lime and alumine, with a small portion of iron. If birdlime be boiled in water, it acquires a little increase of fluidity, which it loses on cooling; the water merely taking from it a little mucilage, with a small portion of extractive matter, and becoming slightly acid. A concentrated lixivium of potash dissolves it at once into a white magma, which is rendered brown by evaporation, and gives out ammonia. This grows hard by exposure to the air, resembles soap in taste and smell, and is almost wholly soluble both in water and alcohol. The weak acids soften birdlime, and partly dissolve it. Concentrated sulphuric acid chars it; and if powdered lime be then added, so as to form a thick magma, acetic acid and ammonia are obtained. Part of this acid is naturally present in the birdlime. Nitric acid acts little upon it cold, but by heat converts it into a hard brittle mass, which an additional quantity of nitric acid dissolves, part being converted into malic and oxalic acids. By continuing the evaporation a yellow substance like wax is obtained, which forms a brown soap with potash, partly soluble in alcohol. Muriatic acid does not act upon birdlime cold: with heat it turns black. Oxigenated muriatic acid converts it into a white pulverable substance, insoluble in water, not liquefiable by heat, and not convertible into a resin by nitric acid. Acetous acid softens birdlime, and dissolves a certain portion. Some metallic oxides are easily reduced when heated with it. Litharge may be incorporated into a plaster with it. Boiling alcohol dissolves it, but on cooling becomes turbid, and deposits a kind of wax. The filtered liquor is bitter, nauseous, and acid, and leaves a resin on evaporation. Sulphuric ether is the proper solvent of birdlime. On adding a little water the mixture thickens, and the ether swims on the top; but if water enough to dissolve the ether be poured in, a body of oil, considerably analogous to that of linseed, is formed on the surface. If the solution of ether be evaporated, a greasy yellow substance is obtained, of the softness of wax. It appears, therefore, that birdlime differs considerably from gluten.—*Annales de Chimie.*

Bismuth is a semimetal of a yellowish or reddish white colour, little subject to change in the air. It is somewhat harder than lead, and is scarcely, if at all, malleable; being easily broken, and even reduced to powder, by the hammer. The internal face, or place of fracture, exhibits large shining plates, disposed in a variety of positions; thin pieces are considerably sonorous. At a temperature not exceeding the 460th degree of Fahrenheit, it melts; and its surface becomes covered with a greenish gray or brown calx. A stronger heat ignites it, and causes it to burn with a small blue flame; at the same time that a yellowish oxide, known by the name of Flowers of Bismuth, is driven up. This oxide appears to rise in consequence of the combustion; for it is very fixed, and runs into a greenish glass when exposed to heat alone. Bismuth urged by a strong heat in a closed vessel, sublimes entire. This semimetal crystallizes very distinctly when gradually cooled.

The sulphuric acid has a slight action upon bismuth when it is concentrated and boiling. Sulphurous acid gas is exhaled, and part of the bismuth is converted into a white oxide. A small portion combines with the sulphuric acid, and affords a deliquescent salt in the form of small needles.

The nitric acid dissolves bismuth with the greatest rapidity and violence; at the same time that much heat is extricated, and a large quantity of nitric oxide escapes. The solution, when saturated, affords crystals as it cools; the salt detonates weakly, and leaves a yellow oxide behind, which effloresces in the air. Upon dissolving this salt in water, it renders that fluid of a milky white, and lets fall an oxide of the same colour.

The nitric solution of bismuth exhibits the same property when diluted with water, most of the metal falling down in the form of a white calx, called Magistery of Bismuth. M. Buckholtz asserts, that the nitric solution, if prepared by means of heat, is not decomposable by water: and that the solution prepared without will deposit its oxide in a crystalline form merely by warming it gradually. This precipitation of the nitric solution, by the addition of water, is the criterion by which bismuth is distinguished from all other metals. The magistery or oxide is a very white and subtile powder: when prepared by the addition of a large quantity of water, it is used as a paint for the complexion, and is thought gradually to impair the skin. The liberal use of any paint for the skin seems indeed likely to do this; but there is reason to suspect, from the resemblance between the general properties of lead and bismuth, that the oxide of this semimetal may be attended with effects similar to those which the oxides of lead are known to produce. If a small portion of muriatic acid be mixed with the nitric, and the precipitated oxide be washed with but a small quantity of cold water, it will appear in minute scales of a pearly lustre, constituting the *pearl powder* of perfumers. These paints are liable to be turned black by sulphuretted hidrogen gas.

The muriatic acid does not readily act upon bismuth. It is necessary that the acid should be concentrated, and kept a long time in digestion upon it; or that it should be distilled from the semimetal. The residue, when washed with water, affords a saline combination, which does not easily crystallize, but may be sublimed in the form of a soft fusible salt, called Butter of Bismuth. The muriatic solution of bismuth likewise affords a precipitate of oxide by the addition of water. Muriatic acid seizes the oxide of bismuth, when added to its solution in nitric acid, and forms a compound of sparing solubility, which falls to the bottom. Alkalis likewise precipitate its oxide; but not of so beautiful a white colour as that afforded by the affusion of pure water.

The gallic acid precipitates bismuth of a greenish yellow, as prussiat of potash does of a yellowish colour.

The effects of earths and alkalis upon bismuth, in the dry way, have been little attended to. Silex unites with its oxide into a clear greenish yellow glass. Nitre oxides it, with scarcely any perceptible detonation. Muriat of ammonia is not decomposed by bismuth in the metallic state, although its oxide readily combines with the acid of this salt, and disengages the volatile alkali. Sulphur unites with bismuth by fusion, and forms a blueish gray brilliant mass, of a needle-formed texture.

This semimetal unites with most metallic substances, and renders them in general more fusible. When calcined with the imperfect metals, its glass dissolves them, and produces the same effect as lead in cupellation; in which process it is even said to be preferable to lead.

Bismuth is used in the composition of pewter, in the fabrication of printers' types, and in various other metallic mixtures. With an equal weight of lead it forms a brilliant white alloy, much harder than lead, and more malleable than bismuth, though not ductile; and if the proportion of lead be increased, it is rendered still more malleable. Eight parts of bismuth, five of lead, and three of tin, constitute the fusible metal, sometimes called Newton's from its discoverer, which melts at the heat of boiling water, and may be fused over a candle in a piece of stiff paper without burning the paper. One part of bismuth, with five of lead, and three of tin, forms plumbers' solder. It forms the basis of a sympathetic ink. The oxide of bismuth precipitated from nitric acid has been recommended in spasmodic disorders of the stomach, and given in doses of four grains four times a day. A writer in the Jena Journal says he has known the dose carried gradually to one scruple without injury.

Bismuth is sometimes found native; and may be analysed in the humid way by solution in nitric acid, and precipitation by the addition of water, which throws down one hundred and thirteen grains of oxide for every hundred of metallic bismuth. It is likewise found in the calciform state; and mineralized by sulphur, of a gray colour, resembling galena, but heavier. These ores may also be analysed by nitric acid, like the foregoing.

Bismuth is easily separable, in the dry way, from its ores, on account of its great fusibility. It is usual, in the processes at large, to throw the bismuth ore into a fire of wood; beneath which a hole is made in the ground to receive the metal, and defend it from oxidation. The same process may be imitated in the small way, in the examination of the ores of this metal; nothing more being necessary, than to expose it to a moderate heat in a crucible, with a quantity of reducing flux; taking care, at the same time, to perform the operation as speedily as possible, that the bismuth may be neither oxided nor volatilized.

Bistre. A brown pigment, consisting of the finer parts of wood soot, separated from the grosser by washing. The soot of the beech is said to make the best.

Bit-noben. See Bitumen (Salt of).

Bitter Principle. See Amer.

Bittern. The mother water which remains after the crystallization of common salt in sea water, or the water of salt springs. It abounds with sulphat of magnesia, to which its bitterness is owing. See Water (Sea).

Bitumen. This term includes a considerable range of inflammable mineral substances, of an oily or resinous nature; burning with flame in the open air, without being converted into an acid like sulphur, or into an oxide like the metals. They are of different consistency, from a thin fluid to a solid; but the solids are for the most part liquefiable at a moderate heat. The fluid are, 1. Naphtha; a fine, white, thin, fragrant, colourless oil, which issues out of white, yellow, or black clays in Persia and Media. This is highly inflammable, and is decomposed by distillation. It dissolves resins, and the essential oils of thyme and lavender; but is not itself soluble either in alcohol or ether. It is the lightest of all the dense fluids, its specific gravity being 0·708. 2. Petroleum, which is a yellow, reddish, brown, greenish, or blackish soil, found dropping from rocks, or issuing from the earth, in the duchy of Modena, and in various other parts of Europe and Asia. This likewise is insoluble in alcohol, and seems to consist of naphtha, thickened by exposure to the atmosphere. It contains a portion of the succinic acid. 3. Barbadoes tar, which is a viscid, brown, or black inflammable substance, insoluble in alcohol, and containing the succinic acid. This appears to be the mineral oil in its third state of alteration. The solid are, 1. Asphaltum, mineral pitch, of which there are three varieties: the cohesive; the semicompact, maltha; the compact, or asphaltum. These are smooth, more or less hard or brittle, inflammable substances, which melt easily, and burn without leaving any or but little ashes, if they be pure. They are slightly and partially acted on by alcohol and ether. 2 Mineral tallow, which is a white substance of the consistence of tallow, and as greasy, although more brittle. It was found in the sea on the coasts of Finland, in the year 1786; and is also met with in some rocky parts of Persia. It is near one fifth lighter than tallow; burns with a blue flame, and a smell of grease, leaving a black viscid matter behind, which is more difficultly consumed. 3. Elastic bitumen, or mineral caoutchouc, of which there are two varieties. Beside these, there are other bituminous substances, as jet and amber, which approach the harder bitumens in their nature; and all the varieties of pitcoal, and the bituminous schistus, or shale, which contain more or less of bitumen in their composition. See the different kinds of bitumen and bituminous substances in their respective places in the order of the alphabet.

A different species of bitumen from any yet enumerated appears to be found accompanying the Bovey coal. It was first noticed by Dr. Milles, who says, that among the clay, but adhering to the coal, are found lumps of a bright yellow loam, extremely light, and so saturated with petroleum, that they burn like sealing-wax, emitting a very agreeable aromatic scent. Mr. Hatchett has since examined this more minutely, and analysed it. According to his description, it is of a pale brownish ochraceous yellow. Its fracture is imperfectly conchoidal. It appears earthy externally; but, when broken, exhibits a slight degree of vitreous lustre. The fragments are irregularly angular, and completely opaque at the edges. It is extremely brittle. It does not apparently become softened, when held for some time in the hand, but emits a faint resinous odour. Its specific gravity, at 65° F. is 1·135. Placed on a heated iron, it immediately melts, smokes much, burns with a bright flame, and yields a very fragrant odour like some of the sweet scented resins, but which at last becomes slightly tainted with that of asphaltum. The melted mass, when cold, is black, very brittle, and breaks with a glossy fracture.

A hundred grains, distilled till the bulb of the retort became red-hot, afforded of water slightly acid 3; thick brown oily bitumen, very similar to that obtained from Bovey coal, but possessing slightly the odour of vege-

ight spongy coal, 23; mixed
of hidrogen, carburetted
carbonic acid, by computa-

elded about 3½ grains of ashes,
lumine, iron, and silex, with a

en was not affected by long
boiling water. Lixivium of
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every property of that of re-
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this bitumen gave of resin
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Steinkohle, &c.
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which he therefore gives the
sphaltum.
ELASTIC). See CAOUTCHOUC.
SALT OF). A saline substance
imported from India by this
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lled in the country *bit-noben,*
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or black salt. According to
n of Bengal, to whom we are
is account, it is the *sal nap*··
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speech, cutaneous affections, worms, old rheumatisms, and indeed in all chronic disorders, both of man and beast. The native farriers always administer water after it, to extricate the sulphuretted hidrogen gas, on which its virtues appear to depend.—*Philosophical Magazine.*—*Nicholson's Philosophical Journal.*

BLACKNESS. Lewis, in his Philosophical Commerce of Arts, has given a history of the means of producing black colours. Since blackness, in general, is the consequence of a defect of light, any circumstance, that prevents the reflection of most of the luminous rays which fall upon bodies, will cause such bodies to exhibit what is commonly called a Black Colour. Opticians have shown, that this effect may arise either from the exquisite polish of bodies, which causes all the light to be reflected in one direction; or from the smallness of the primary particles, which transmit the light to the internal part of the body, instead of reflecting it. In this way we find, that all metallic substances, and likewise several other bodies, may be rendered black by mere mechanical trituration; and it is on account of the smallness of the particles, that black pigments are capable of completely covering and destroying the effect of other colours. The substances described by Lewis, are—1. The black chalk of the shops, which seems to consist of an argillaceous earth, impregnated with bituminous matter, reduced to the state of coal. 2. Pitcoal, which affords a brown black, and is not easily ground to a sufficient fineness. 3. The black ferruginous sands, which are of little use as pigments. 4. Plumbago, or black lead, used for pencils. 5. Black vegetable juices; of which he enumerates the anacardium, or marking nut, from the East Indies, the juice of which stains linen or cotton of a reddish brown colour, that soon changes to a black, not to be discharged by alkalis; and various species of the toxicodendron, or poison tree, from North America, which produces a deep black permanent stain. 6. The cuttle-fish ink, or black fluid contained in a peculiar vessel of that animal; but whether this ink was of considerable value for its permanency, he had no opportunity of ascertaining.

Among the blacks produced by fire, the Doctor found, that the coals of wood, and of animal substances, possess various properties, according to their nature, or original texture, when used as crayons or as pigments. The soot blacks are in general much softer, and more easily unite with oils. Several of the metals, such as manganese, cobalt, and iron, are of a black colour in certain states of calcination. On the subject of blackness, see INK, VARNISH, and DYEING.

BLACK JACK. The miners distinguish blende, or mock lead, by this name. It is an ore of zinc, containing that metal in combination with iron and sulphur, and occasionally other ingredients.

BLACK LEAD. See PLUMBAGO.

BLACK WADD. One of the most remarkable ores of manganese. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterward suffered to cool for about an hour, and then two ounces of linseed oil be gradually poured on it, mixing the whole loosely, like barm with flour, little clots will be formed: and, in something more than half an hour, the whole will grow hot, and at last burst into a flame. The temperature of the room, where this experiment was repeated, was about 30 degrees of Fahrenheit; and the heat this ore was exposed to, while drying, might be about 130 degrees.

According to Wedgewood's analysis, 100 parts of black wadd contain 43 of manganese, as much of iron, 4·5 of lead, and near 5 of micaceous earth.

BLEACHING is the art of rendering the various kinds of thread, cloths, &c., white, by depriving them of the colour they usually possess in their original state. In this article I shall first describe the usual, or old processes, and then proceed to the improvements, which modern chemistry has made in the art.

The method of bleaching silk.—The silk, being still raw, is put into a bag of thin linen, and thrown into a vessel of boiling river water, in which has been dissolved good Genoa or Toulon soap.

After the silk has boiled two or three hours in that water, the bag being frequently turned, it is taken out to be beaten, and is then washed in cold water. When it has been thus thoroughly washed and beaten, they wring it slightly, and put it for the second time into the boiling vessel, filled with cold water, mixed with soap and a little indigo; which gives it that blueish cast commonly observed in white silk.

When the silk is taken out of this second water, they wring it hard with a wooden peg, to press out all the water and soap; after which they shake it to untwist it, and separate the threads. Then they suspend it in a kind of stove, constructed for that purpose, where they burn sulphur; the vapour of which gives the last degree of whiteness to the silk.

The method of bleaching woollen stuffs.—There are three ways of doing this. The first is with water and soap; the second with the vapour of sulphur; and the third with chalk, indigo, and the vapour of sulphur.

Bleaching with soap and water.—After the stuffs are taken out of the fuller's mill, they are put into soap and water, a little warm, in which they are again worked by the strength of the arms over a wooden bench: this finishes; giving them the whitening which the fuller's mill had only begun. When they have been sufficiently worked with the hands, they are washed in clear water and put to dry.

This method of bleaching woollen stuffs is called the Natural Method.

Bleaching with sulphur.—They begin with washing and cleaning the stuffs thoroughly in river water; then they put them to dry upon poles or perches. When they are half dry, they stretch them out in a very close stove, in which they burn sulphur; the vapour of which diffusing itself, adheres by degrees to the whole stuff, and gives it a fine whitening; this is commonly called Bleaching by the Flower, or Bleaching of Paris, because they use this method in that city more than any where else.

Bleaching with chalk, indigo, and sulphur.—When the stuffs have been well washed in clear water, they throw them into a bucket of cold water, containing chalk and a little indigo, wherein the stuffs are well stirred and agitated: then they take them out, and wash them again in clear water; after which they hang them on poles: when they are half dry, they put them into a stove to receive the vapour of sulphur, which finishes their perfect whitening.

This bleaching, which is not the best, though very agreeable to the eye, is called Bleaching of Beauvais; because the inhabitants of that city were the first who practised this method of bleaching woollen stuffs.

It must be observed that, when woollen stuffs have once imbibed the vapour of sulphur, it is a difficult matter to make them take a good colour in dyeing, unless it be a black or blue.

The manner of bleaching fine linen cloths, with the method of preparing them, as practised in Picardy, and particularly near St. Quintin.—After the linens are taken from the loom, they are put to soak in clear water for a whole day: when they have been well washed and cleaned, they are taken out, and thrown into a bucking-tub filled with cold lye, made of wood ashes and water, which has been used in former processes.

When they are taken out of that lye, they are washed again in clear water, and spread in a meadow, where they are occasionally watered with clear water out of small canals, made for that purpose in the grounds. They water them with scoops, or hollow and narrow wooden peels, with a long handle.

After lying a certain time on the ground, they pass them through a fresh lye, poured on hot: this lye is of different strength, according to the quality of the linens.

Being taken out of this second lye, they are washed in clear water, and laid again in the meadow; all which several operations are repeated until the linen has acquired the desired degree of whiteness.

They are afterward put into a weak lye, to restore the softness which the preceding strong lyes had deprived them of; and

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ed. In fair weather they may be bleached in a month's time; but, in foul weather, six weeks, or more, are hardly sufficient to complete the operation.

It must also be observed, that all the linens, of whatever kind they are, which are bleached in Holland, Flanders, and Picardy, are dipped in cows' milk after the cream is taken off; it being certain, that it is this liquor which gives them that delicate whiteness so much admired in the linens which come from those different countries.

It is customary with the merchants who send their linens to the bleaching-grounds of Flanders and Picardy, to mark them at each end with one or more letters of their names (which marks are made with thread of Epinay, worked with the needle); and to fasten at the places where these marks are put, some small twists, made also of the same thread of Epinay; which twists have a certain number of knots, at some distance from each other; each knot having its particular value, according as every merchant thinks proper. The marks are put, in order to know to whom each piece belongs; and the twists, to remember the prices.

The method of bleaching common linens, as it is practised in Anjou.—Immediately after the pieces are taken from the loom, they are carried to the whitster, or bleacher, who puts them directly into wooden troughs, full of cold clear water; where, with wooden mallets, which are moved by a water-mill, they are so well agitated and beaten, that they are insensibly cleared from all their impurities.

Being taken out of the mill, they are spread on a meadow, where the dew which they receive during a week begins to bleach them.

Then they are put into a kind of wooden tubs, when they throw over them a common lye, quite hot.

The linens having thus gone through the lye, they take them out of the tub, to clean them again in the mill; then they spread them a second time in the meadow, where they leave them a week, after which they give them a second lye: all these several operations are repeated until the linens have acquired a perfect degree of whiteness. Then they fold them up, after a manner proper to each sort, and to the places for which they are designed.

I do not find, that any very considerable improvement in the whitening of silk and woollens has been lately made, excepting that it is asserted, that silk may be cleared of its impurities to better advantage by the mild alkali of soda than by soap-lees or soap; the former of which is apt to injure its texture, and the latter is expensive. It is even said, that mere water will accomplish the same, especially if its vapour be confined, when heated in a vessel upon the principle of Papin's Digester. In all probability, however, a process of this nature must require peculiar management; because the water thus confined would doubtless be as active in dissolving the silk itself, as caustic alkali might be. The remedy or precaution will consist in suffering the steam to escape through an aperture, covered by a valve, loaded with no greater weight than experiment shall show to be sufficient for the intended purpose.

The oxigenated muriatic acid, first discovered by Scheele, has since been applied to the art of bleaching linens and cottons. Several chemists of the first eminence have attended to the properties of this substance. Mr. Berthollet was the first who made this use of the acid; and he was followed in France by Chaptal, Descroizilles, Fourcroy, and Pajot des Charmes; in Germany by Gren, Westrumb, and others; and in this country by Kirwan, Henry, Higgins, Rupp, and other chemists or manufacturers, who have written on the subject, or carried it into practice.

Under the head Oxigenated Muriatic Acid we have already described the preparation of this article; and the chief difference respecting it to be noticed here is the apparatus, which must be on an extensive scale, and adapted to the purpose of immersing and agitating the goods to be bleached. The proportions of the ingredients are varied too, and must in some measure depend on the goodness of the articles. Mr. Rupp of Manchester recommends manganese 3 parts, more or less according to its quality, common salt 8, oil of vitriol 6, water 12. Mr. Tennant of Glasgow equal weights of manganese, salt, and sulphuric acid, with a quantity of water equal to the acid in measure. In Ireland, the common proportions are said to be manganese 6 parts, common salt 6, sulphuric acid 5, water 5. In France and Germany we understand they vary little from the following: manganese 20 parts, common salt 64, sulphuric acid 44, water 54. It must be observed, however, that, as the efficacy of the acid depends upon the oxigen imparted to it by the manganese, a deficiency of this article must render it less efficacious. The process of distillation may be performed in a large leaden alembic, *g g*, Plate I. fig. 1. supported by an iron trevet *f*, in an iron boiler *e*. This is heated by a furnace *b*, of which *a* is the ashhole, *c* the place for introducing the fuel: *d* is the handle of a stopper of burnt clay, for regulating the draught. To the top of the alembic is fitted a leaden cover *i*, which is luted on, and has three perforations; one for the curved glass or leaden funnel *h*, through which the sulphuric acid is to be poured in; one in the centre for the agitator *k*, made of iron coated with lead; and the third for the leaden tube *l*, three inches in diameter internally, through which the gas is conveyed into the tubulated leaden receiver *m*. To prevent the agitator from reaching to the bottom of the alembic, it is furnished with a conical leaden collar, adapted to a conical projection round the hole in the centre of the cover, to which it becomes so closely fitted by means of its rotatory motion, as to prevent the escape of the gas. The tube *l*, passing through the aperture *m*, to the bottom of the intermediate receiver nearly, which is two thirds full of water, deposits there the little sulphuric acid that may arise; while the oxigenated muriatic acid gas passes through the tube *n* into the wooden condenser *o o*. The agitator *p*, turned by its handle *t*, serves to accelerate the combination of the gas with the lime water, to which the horizontal pieces *q q*, projecting from the inside of the gas, likewise contribute. The cover of this receiver has a sloping groove *r*, to fit close on its edge, which is bevilled on each side; and a cock *s* serves to draw off the liquor.

Instead of this apparatus, which is peculiarly adapted for making a solution of hyperoxigenated muriat of lime, some employ a series of large barrels disposed in the manner of a Woulfe's apparatus, disengaging the oxigenated muriatic acid gas in one or more tubulated retorts, either of lead or stone, properly arranged for the purpose; or receive the gas thus disengaged into the vessels in which the goods are to be bleached. But whatever mode be adopted, every possible precaution should be employed, to prevent the escape of the gas into the air, to the injury of the workmen.

If the bleaching liquor be not made in the vessel in which it is to be used, it is proper to draw off the liquor from the cask as soon as it is prepared, because it acts upon the wood, and not only becomes by this means weaker, but likewise hastens the destruction of the cask: but when it is conveyed into a vessel in which cloths are properly placed, these speedily weaken it to such a degree, that it does not perceptibly act upon the wood.

The cloths are to be prepared by leaving them twenty-four hours in water, or still better in the old lixivium, to extract the dressing; after which they must be once or twice well washed in alkaline lixiviums, because all that part which can be extracted by the lixiviums would have neutralised a portion of the liquor, which requires to be carefully used. After this the cloth must be carefully washed, and disposed upon sticks in such a manner, that it may be impregnated with the liquor poured on it, without any part being compressed. The framing of the sticks, as well as the cask and vessel intended to contain the cloths, ought to be constructed without iron; because this metal becomes calcined by the oxigenated muriatic acid, and would produce iron-moulds, not to be taken out but by means of oxalic acid, or dilute sulphuric.

The first immersion must be longer than the following ones; it may last three hours: after which, the cloth is to be taken out,

, and then put into a shallow
er that new liquor may be
It is sufficient, that this im-
he following, should continue
of half an hour. The cloth is
, cleared of the liquor by pres-
iviated, and subjected to new
The same liquor may be used
austed; and when it is found
eakened, a proportion of the
has not been used may be

loth appears white, excepting
, and a few threads darker
it must be impregnated with
nd strongly rubbed; after
e lixiviated for the last time,
once more in the liquor.
r of lixiviations and immer-
re necessary cannot be deter-
e it varies according to the
loth: the limits of this num-
are between four and eight,
empen cloths. M. Berthollet
ability to point out the best
king the alkaline lixiviums;
being still a matter of mere
variously performed in differ-
t appeared advantageous to
the alkali caustic by mixing
ne; but in this case care must
the lixivium be strained
n, in order that the calcareous
mix itself with the linen, as
ight corrode or wear it by
. By this management the
rendered more active, it does
large a quantity of alkali;
s, if the quantity of alkali be
erable, it produces no damage
otwithstanding the contrary
ch is very general. He has
ked, that it was of no advan-
prejudicial, that the lixivia-
e of long duration; but it is
the fluid be very hot, and of
rength, otherwise the cloths
he oxigenated muriatic acid
coloured and ruddy when
ew lixiviations. Cottons are
ly and speedily bleached than
ixiviums, or at most three,
number of immersions in the
ficient; and as they are so
re readily bleached, it is ad-
hen linen, hemp, and cotton
ched, to reserve the liquors
which have been already
exerting their action on the
liquors as are so exhausted
act upon hemp or linen will
or cotton.
ast immersion in the liquor,
be plunged into sour milk,
dulated with sulphuric acid.
ortion is not well ascertained;
thinks, from his experiments,
of the acid by weight, with

fifty parts of water, may be employed successfully, and without danger. The cloths are to be kept about half an hour in this fluid, warmed; after which, they must be strongly pressed, or wrung, and immediately plunged into common water: for, if they were suffered to dry by evaporation, the sulphuric acid, becoming concentrated, would attack them. When the cloths are well washed, they must be passed through a weak alkaline lixivium, and rinsed a second time; after which nothing more is necessary than to dry and prepare them in the usual manner.

It is an obvious precaution, that this acid water be not too strong, as it would of course injure the texture of the stuffs: and soap must not be used after it as a lixivium, for this would render them yellow.

To avoid the inconveniences arising from the escape of the gas, which we have mentioned above, potash was added to the water in the receivers. But this was found to add considerably to the expense, and diminish the strength of the liquor. Mr. Tennant of Glasgow employed a cheaper material, quicklime, added to the water in the receiver, and kept in continual agitation. As lime is very little soluble in water, what is not saturated with the acid will subside to the bottom, if the liquor be left to stand after all the gas is come over. If thirty pounds each of manganese, salt, and sulphuric acid be used, Mr. Tennant puts sixty pounds of finely powdered quicklime into his receiver, which is capable of containing a hundred and forty wine gallons of water. He likewise previously dissolves thirty pounds of common salt in the water, but this does not appear to us to be necessary. Indeed by increasing the specific gravity of the water the lime does not subside in it so quickly, and probably a small portion of hyperoximuriat of potash is formed.

In bleaching with the oxigenated muriatic acid, it is of consequence to ascertain its relative strength, in order that the experiments may at all times be equally successful. Mr. de Croisille made use of a solution of indigo in the sulphuric acid; for which purpose he took one part of finely pulverized indigo, with eight parts of concentrated sulphuric acid This mixture is kept in a matrass for several hours on the water bath; and, when the solution is complete, it is diluted with a thousand parts of water. In order to ascertain the force of the oxigenated muriatic acid, one measure of this solution is put into a graduated tube of glass, and the liquor or impregnated water is added, until the colour of the indigo is completely destroyed. In this way it is ascertained, by means of the graduations, how many measures of any liquor, the goodness of which has been found by direct experiments upon linen or cotton, are necessary to destroy the colour of one measure of the solution of indigo; and this number will serve to ascertain the respective force of all the liquors, which are required to be compared together. Mr. Watt makes use of a decoction of cochineal for the same purpose.

All the colours of calicoes or printed goods may be discharged by the oxigenated muriatic acid, or hyperoxigenised muriat of potash. The blues, yellows, and blacks indeed require a previous bath of water acidulated with sulphuric acid; and according to their shade two or three immersions in the oxigenated muriatic acid, alternately with this bath, may be necessary. The Adrianople reds will always retain a ruddy tinge, on account of the oily matter that enters into their preparation, let them be immersed ever so often. All other colours require only a single immersion, without any previous lixiviation.

Silk too, and woollen dyed of certain colours, may thus be rendered white; but they must be exposed to the action of sulphurous acid gas, to remove the yellow colour left by the oxigenated muriatic acid.

The rags or other materials for making paper may be bleached in a similar manner: but it is best to reduce them first to the state of pulp, as then the acid acts more uniformly upon the whole substance.

For bleaching old printed paper, to be worked up again, Pajot des Charmes gives the following directions: Boil your printed paper for an instant in a solution of caustic soda. That from kelp may be used. Steep it in soap-suds, and then wash it; after which it may be reduced to pulp. The soap may be omitted without much inconvenience. For old written papers to be worked up again: steep it in water acidulated with sulphuric acid, and then wash it well before it is taken to the mill. If the water be heated it will be more effectual. To bleach printed paper, without destroying its texture. Steep the leaves in a caustic solution of soda, either hot or cold, and then in a solution of soap. Arrange them alternately between cloths, as papermakers do thin sheets of paper when delivered from the form, and subject them to the press. If one operation do not render them sufficiently white, it may be repeated as often as necessary. To bleach old written paper, without destroying its texture: steep the paper in water acidulated with sulphuric acid, either hot or cold; and then in a solution of oxigenated muriatic acid; after which immerge it in water, that none of the acid may remain behind. This paper, when pressed and dried, will be fit for use as before.

Blende. An ore of zinc, likewise known by the name of Mock Lead, False Galena, or Black Jack. There are several varieties of this ore. In general, they contain about half their weight of zinc, about one fourth sulphur, and the rest iron, copper, lead, and some earth in varied proportions. An ore of this kind lately found in one of the Gwennap mines in Cornwall, yielded on analysis ·66 oxide of zinc, ·23 sulphur, and a very minute portion of iron. 50 grains of this in powder being exposed to a moderate forge heat in a small platina crucible, enclosed in another of earthen ware, the platina when in contact with the mineral was completely fused, and the remaining part was covered with an iridescent pellicle, and made soft and brittle throughout its substance.

Blood. The fluid which first presents itself to observation, when the parts of living animals are divided or destroyed, is the blood, which circulates with considerable velocity through vessels, called veins and arteries, distributed into every part of the system. It can scarcely admit of doubt, that the component parts, or immediate principles, of the blood must differ in the various and exceedingly dissimilar genera and species of animals, which occupy the land and waters of the globe; and that there are likewise differences in the state or composition of this fluid in the same animal, according to its state of health. These differences can be ascertained only by the united efforts of the anatomist and the chemist. But as the difficulty and extent of the subject have hitherto prevented any considerable progress, it becomes an object of necessity, to confine our attention to the blood of man, or of such quadrupeds as afford this fluid in a state not obviously different from that of the human species.

Recent blood is uniformly fluid, and of a saline or slightly ferruginous taste. Under the microscope it appears to be composed of a prodigious number of red globules, swimming in a transparent fluid. After standing for a short time, its parts separate into a thick red matter, or crassamentum, and a fluid called serum. If it be agitated till cold, it continues fluid; but a consistent polypous matter adheres to the stirrer, which by repeated ablutions with water becomes white, and has a fibrous appearance: the crassamentum becomes white and fibrous by the same treatment. If blood be received from the vein into warm water, a similar filamentous matter subsides, while the other parts are dissolved. Alkalis prevent the blood from coagulating; acids, on the contrary, accelerate that effect. In the latter case, the fluid is found to contain neutral salts, consisting of the acid itself, united with soda, which consequently must exist in the blood, probably in a disengaged state. Alcohol coagulates blood. On the water bath, blood affords an aqueous fluid, neither acid nor alkaline, but of a faint smell, and easily becoming putrid. A stronger heat gradually dries it, and at the same time reduces it to a mass of about one eighth of its original weight. In this state it slightly attracts the humidity of the air, and effervesces with acids; but by a longer exposure

hs it becomes covered with an
of carbonated soda. By de-
lation, this animal fluid affords
or, holding in solution ammo-
and pungent vapour of car-
onia; a yellowish thick smoke,
d manifestly oily and inflam-
vard prussic acid, recognisable
; then phosphoric acid, an-
ome flames emitted from the
d hot matter; and lastly car-
a. The residue is a coal of
eration, containing oxide of
combined with a little iron;
me; and muriat of soda. Pro-
d of Copenhagen made some
n the blood of the horse to
roportion of carbon contained
und, that one ounce of venous
115½ grains of charcoal, and
terial only 87½.

of blood exhibits marks of a
aline salt, and is greatly dis-
efy. It unites with water in
s, and forms a milky fluid,
coagulated by acids, or alco-
rease of temperature causes
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, in the same manner as the
and it is accordingly used for
ose in clarifying liquids. From
xperiments it appears, that
consists of albumen and ge-
ed in a variable quantity of
mbined with soda; and that
riat of soda, and phosphats of
, and lime.

er the serum of blood more
agulate it, and exhibit the
ey would have produced by
ith mineral alkali.

agulated by alcohol, merely
part of its water. When ren-
by heat, and exposed to the
acid, it affords nitrogen gas
t, which is followed by ni-
nd the residue affords oxalic
with a small portion of

entum of blood, when treated
destructive distillation, be-
brittle, at the same time that
aline phlegm: this is followed
matic stinking oil, and con-
alkali. A spongy brilliant
which by treatment with sul-
found to contain soda and
rs by the production of Glau-
sulphat of iron: coaly matter
of lime are then left behind.

matter, which is obtained by
d part of the blood, resembles
many of its properties; though
it in not being soluble in wa-
ng hard by a very gentle heat,
mbining with alkalis. Acids
and in particular the nitric
it, and extricates nitrogen gas,

and nitrous oxide; while the residue, by evaporation, affords oxalic acid in crystals, a peculiar oil in flocks, and the phosphat of lime. Its volatile products, by destructive distillation, are nearly the same as those of serum: but its residue contains no salt, except the combination of lime and phosphoric acid; the other salts it might have contained having probably been carried off during the washing. Muriatic acid forms a green jelly with the fibrous part of the blood. It is among those animal substances, that furnish the greatest proportion of oil, and of ammonia.

Blood contains much iron. The experiments of Menghini, Bucquet, and Lorry prove, that this metal is capable of passing into the blood by the first passages, since patients who are under a course of martial medicines void it by the way of urine. When the coagulated part of the blood has been washed, if that part which has retained the colouring matter be burned, and the coal be lixiviated, the residue of this lixivium is in the state of saffron of Mars, of a fine colour, and usually obedient to the magnet.

The colour of blood has been attributed to this iron; and it is very true, that the colour appears to be entirely formed of it; for there exists no vestige of this metal in the washed and discoloured coagulum: but as, on the other hand, the blood does not become coloured without the concourse of air, and as oxigen alone is absorbed in respiration, it appears that the colour is owing to iron oxided by the air, and reduced to the state of red oxide.

Dr. Carbonel of Barcelona has employed serum of blood on an extensive scale in painting. Mixed with powdered quicklime, or slaked lime, to a proper consistence, it is easily applied on wood, to which it thus gives a coating of a stone colour, that dries quickly, without any bad smell, and resists the action of sun and rain. The wood should be first covered with a coating of plaster, the composition must be mixed as it is used, and the serum must not be stale. It may be used too as a cement for water-pipes, and for stones in building under water.

Blowpipe. This useful instrument will be described under the article Laboratory, which see. The present article will therefore consist of an account of the materials, or subjects, upon which experiments are made with it. The bodies intended to be heated by the blowpipe must not in general exceed the size of a pepper-corn, unless bellows and a very large flame be used. The proper supports are either a piece of smooth close-grained charcoal, for such bodies as are not subject to an alteration of their properties, from the inflammability of the coal, as might be contrary to the nature of the investigation. This support is therefore most frequently used; as it is properly adapted for saline, earthy, and many metallic bodies. The other support consists of a spoon, somewhat less than a quarter of an inch in diameter, made of a metal not subject to calcination; that is to say pure gold, silver, or platina, or such a mixture of these metals as might be found to be least deficient in the requisite degree of hardness, which gold or silver alone does not possess. Bergman advised to add one tenth of platina to a given mass of silver. I find, however, that this mixture, with picked grains of crude platina, forms a compound harder indeed than pure silver, but subject to blister at a low red heat, and perhaps more fusible than silver itself. There is, however, no very considerable inconvenience resulting from the use of a small spoon, either of gold, or of silver; and platina, purified to such a degree as to be perfectly malleable, and to exceed 21 in specific gravity, possesses every quality which can be wished for. The small metallic spoon must of course be properly fixed in a socket of metal, provided with a wooden handle.

Very small or pulverulent substances are apt to be carried away by the current of flame. These may be secured by making a small hole in the charcoal, into which the powder is to be put, and covered with another small piece of charcoal, which partly protects them from the flame. Some experiments of reduction are made by binding two small pieces of charcoal together, cutting a channel along the piece intended to be the undermost, and making a cavity in the middle of this channel to contain the subject matter of examination. With this apparatus the flame is urged through the channel between the two pieces of coal, and violently heats the substance in the cavity, which may be considered as a closed vessel.

A great number of mineral bodies are not fusible by mere flame, urged by common air through the blowpipe; though oxigen gas subdues most bodies. See GAS (OXIGEN).

Whenever therefore the fusion of any refractory substance is to be attempted, some other substance must be added which is more fusible, and capable of dissolving the former. These solvents in the dry way are distinguished by the name of fluxes, and, like the solvents used in the humid way, are mostly saline. It may easily be imagined, that the nature of the products will greatly vary, according to that of the flux which enters into combination with them; and accordingly they are varied in experiments as well as in operations in the large way. The blowpipe experiments, though conducted upon the same principles as those upon a larger scale, differ nevertheless from them in two particulars; namely, that the whole of the phænomena are visible throughout, and that the residues are of no value, otherwise than as they serve to indicate facts. For these reasons, every flux without exception might be used with the blowpipe, provided it were not of such a nature as to sink into the charcoal. We may therefore select a certain small number of the most convenient fluxes, and note the effects which they respectively produce upon the various mineral bodies; and these will serve as indications to enable the chemical inquirer to distinguish them again with a much greater degree of accuracy than by their external figures, not to mention, that he may also derive the greatest advantage with regard to the more extensive operations he might be disposed to undertake. A considerable part of this preliminary labour has already been performed by Engestrom, Bergman, Mongez, and others; and it is now become usual for chemists, among their other experiments on minerals, to mention their habitudes with the blowpipe. In the following general sketch, I shall chiefly recur to Bergman's Treatise on the Blowpipe, of which we have an English translation, in the second volume of his Essays. A good treatise on this subject by Engestrom may likewise be consulted at the end of the English edition of Cronstedt's Mineralogy; and the habitudes of a very great number of bodies with the blowpipe may be seen in the French edition of Bergman's Sciagraphia Regni Mineralis, by the abbé Mongez, under the title of Manuel du Minéralogiste.

The fluxes which have obtained the general sanction of chemists, on account of the extensive use they have been applied to by Bergman, are:

1. *The phosphoric acid*, or rather the microcosmic salt, as it is generally called, which contains that acid, partly saturated with mineral, partly with volatile alkali, and loaded besides with much water and a gelatinous fat. This salt, when exposed to the flame, boils and foams violently with a continual crackling noise, until the water and volatile alkali have flown off: afterward it is less agitated, sending forth somewhat like black scoriæ, arising from the burned gelatinous part: these are soon dispelled, and exhibit a pellucid spherule, encompassed by a beautiful green cloud, which is occasioned by the deflagration of the phosphorus arising from the extrication of the acid by means of the inflammable matter.

The clear globule, which remains upon the removal of the flame, continues longer soft than that formed by borax, and therefore is more fit for the addition of the matter to be dissolved. The volatile alkali is expelled by the fire, and leaves an excess of acid, which easily attracts moisture in a cool place.

2. *The mineral alkali*, or soda, which, when fused upon charcoal, melts superficially with a crackling noise, penetrates the charcoal, and disappears. This, in the spoon, yields a permanent spherule, so long as it is

by the blue apex of the flame;
he heat is diminished, it assumes
acity, and cannot be employed
oal. This alkali attacks several
particularly siliceous matters.

llized borax, exposed to the flame
coal, at first becomes opake,
l wonderfully intumescent; it
t branches and various protube-
t when the water is expelled, it
lected into a mass, which, when
yields a colourless spherule, and
ransparency even after cooling:
borax be employed, the clear
more speedily obtained. This
of mineral alkali, partially satu-
boracic acid; each of its princi-
ately fusible, and each dissolves
nber of other matters.

ts of these salts, when exposed
g once known, it will be easy to
the differences occasioned by
t additions.

tudes of the salts, according to
re as follows:

nic acid in the dry state, when
e blowpipe upon charcoal, be-
r disoxigenated as to generate
id, and emit the smell of garlic.
n it fuses, and does not smoke,
partial reduction from the flame,
llic support.

ybdic acid, when exposed to the
charcoal, is absorbed.

The crystallized vegetable alkali
es opake, and decrepitates long
tly, then melts into a globule,
ists in the spoon, but expands on
l, and is absorbed with a crack-

tile alkali liquefies a little, and is

alts. Several of the neutral salts
but, according to their different
ey exhibit different phænomena,
w examples will sufficiently il-

pitating salts. These are broken
ed by sudden heat: of this sort
ts of potash and ammonia, and
potash and soda.

alts, which have a base totally
d generally fly off; sulphated,
d muriated volatile alkali.

succinic acid, by the exterior
e charcoal, liquefies and smokes;
rior takes fire, and in burning
with a blue flame.

poon the same happens, except
id abounds with oil, which almost
pens; in this case, some coaly
main. The spurious succinic
according to the frauds used in
tion; it generally, in the begin-
s, smokes, and grows black, then
finally melts into a fixed white

ng salts. These salts, which always abound with nitric acid, liquefy in the spoon, and persist even on the charcoal, unless it take fire; for, when ignited, they immediately take fire on the contact of inflammable matter, sending forth a violent flame with a detonating noise. During this operation, the acid is dissipated, and the basis, if fixed, remains alone. If the base be volatile, scarce any detonation is excited; for the salt flies totally off.

Nitrat of potash shows a blue flame; but the nitrats of soda and ammonia a yellow one.

Carbonaceous salts. These, by the combustion of their acid, yield spongy coals, which when ignited soon grow white, leaving behind the alkaline base: such are, acid of tartar, crude tartar, sal acetosellæ, and tartarised vegetable and mineral alkali.

Sulphureous salts. These, exposed to the flame on the charcoal, flow, and yield a yellow or red mass, which diffuses an hepatic smell, especially when moistened by any acid. To this class belong all those fixed in the fire, containing sulphuric acid, which, when disoxigenated by the charcoal, generate sulphur: these are, sulphats of potash and soda.

Middle earthy salts. Of the middle earthy salts, few flow so perfectly as to be reduced to a globule; nor do they all fuse actually, though the water of crystallization in its departure excites a foam: those which contain sulphuric acid effervesce violently with borax and microcosmic salt, but are difficultly dissolved by soda.

Decrepitating earthy salts. Gypsum spathosum.

Intumescent earthy salts. Sulphat of magnesia swells, foams, and, when repeatedly exposed to the flame, may be fused.

Alum is somewhat different; for finally all ebullition ceases, and the mass remains immovably at rest, and it undergoes no other change than to split: when hot, it is variegated with blue spots.

Acetat of lime swells much like alum, but scarcely adheres to the charcoal.

Nitrat of magnesia swells with a crackling noise, but without any detonation.

Muriat of magnesia, in a dry state, belongs to this class.

Fusible salts. Although gypsum eluded the force of fire in Pott's furnace, yet it may be fused in a moment if a section of the lamella be exposed in the blue flame: though naturally pellucid, it instantly acquires an opacity; the water goes off without ebullition.

Carbonaceous earthy salts. Tartrits of lime and magnesia: nay, all the earths united with tartarous acid.

Soluble in borax and microcosmic salt, with effervescence. Lime, magnesia, sulphat of alumine, and acetat of lime.

Middle metallic salts. Some of the middle metallic salts, either containing a large quantity of water, or retaining pertinaciously the acid, flow in the fire; others only foam: most of them recover, at least partly, their metallic appearance, especially when they touch the coal, leaving at the same time an irregular scoria. By the addition of borax, the scoriæ are dissolved, and the metal better collected; but here we consider the salts alone: the fluxes are tinged in the same way as by the metallic oxides.

Decrepitating metallic salts. Nitrated lead, tartarized antimony.

Volatile metallic salts. To this belong the salts the base of which is mercury, as they are dissipated by fire: those which contain muriatic acid, in general, fly off more quickly than those which are loaded by any other menstruum.

Detonating metallic salts. Silver, mercury, lead, and bismuth, united with nitric acid.

Intumescent metallic salts. At the first approach of fire they swell with noise, and a certain ebullition, but then remain immovable. Sulphats of copper, iron, cobalt, and zinc; and nitrats of copper and zinc.

Fusible metallic salts. These are by the exterior flame easily reducible to globules. By this method, muriats of silver and lead, in the spoon, put on the corneous appearance; but by a long violent fusion they again put it off, the acid being too much diminished: hence it appears with what caution these metals are to be made horny in the crucible. Sulphats of silver and lead, muriats of copper and zinc.

Carbonaceous metallic salt. Tartarized antimony.

Metallic salts tinging the flame. Sulphat of copper, and also nitrat of copper, produce a greenness; but muriat of copper acts with far more efficacy. The green crystals of this first grow red by the exterior flame; they soon liquefy and grow black; they make the flame first of a deep blue, which afterward verges to a green. The flame, thus tinged, expands much, and remains so until the whole mass of the salt is dissipated: this green salt, added to microcosmic salt in fusion, immediately shows a beautiful flame; the clear globule is tinged green, and does not grow opake or brown, unless a large quantity of the microcosmic salt be added; a circumstance which takes place much sooner upon the addition of a smaller quantity of borax.

HABITUDES OF THE PRIMITIVE EARTHS.

Lime.

This (which by itself is infusible), by a sufficient degree of heat, loses its property of effervescing in acids; it acquires solubility in water, the power of generating heat with it, and of suffering spontaneous calcination. These last properties, however, it loses, if too much urged by heat. The heat it generates with water may easily be tried by a drop of water on the back of the hand, with the addition of a small piece of lime, just cooled after burning.

Carbonat of lime effervesces a little with soda, and is divided into small particles, but sparingly dissolved: when overburned, it seems not to be divided or diminished.

In borax the former dissolves with effervescence; the latter scarcely generates any bubbles.

In microcosmic salt the same phenomena appear; but the effervescence is somewhat greater.

It is also observable, that a very small piece of calcareous earth is easily dissolved in borax and microcosmic salt, yielding spherules altogether pellucid: but if more earth be gradually added, the flux, at length saturated, retains the dissolved matter, indeed, while in perfect fusion; but on removing the flame, the part, which was taken up by means of the heat alone, separates; hence clouds arise at first, and the whole globule becomes opake, and recovers its transparency again by fusion. This is entirely correspondent to what happens in the humid way; for warm water saturated with nitrat of potash, or sulphat of soda, upon cooling, is obliged to deposit that part which it had taken up in virtue of its warmth. If the fused pellucid globule (which would grow opake upon cooling) be quickly plunged into melting tallow, water, or any other substance hot (for cold generally cracks it), so as to grow suddenly hard, it retains its transparency; the particles being as it were fixed into that state which is necessary to transparency. This is a phenomenon highly worthy of observation, which cannot be seen in the crucible.

Barytes.

Barytes, exposed alone to the flame, becomes like calcareous earth, caustic, soluble in water, and noneffervescent in acids.

In carbonat of soda it effervesces only a little, but is sensibly diminished.

In borax it dissolves with slight effervescence, as also in microcosmic salt; but here it effervesces magnesia somewhat more violently.

The phenomena observed on saturation with calcareous earth have place here also. Carbonat of magnesia ignited alone loses its carbonic acid, together with the property of effervescing in acids; in carbonat of soda it effervesces a little, but is scarcely diminished.

Alumine.

Common argillaceous earth abounds with heterogeneous particles, and always contains a considerable quantity of siliceous earth, which generally amounts to half; hence, when clay is required pure, as in this instance, the earth of alum, digested in an alkaline lixivium and well washed, must be employed.

Exposed to the flame, it grows hard, contracts its bulk, but does not fuse.

In carbonat of soda it effervesces a little, but is sparingly dissolved.

it dissolves with remarkable
e.
cosmic salt, a still more violent
kes place.

Silex.

is not fused.
of soda dissolves it with violent
ce; and if the siliceous earth
ceeds the weight of the flux, it
llucid glass. This, and all the
ations with carbonat of soda,
formed in the spoon.
it dissolves slowly, without any
in microcosmic salt, very slowly,
effervescence.
ERIVATIVE EARTHS.
confusion from multiplicity, we
these into classes, according to
emarkable habits.

Decrepitating.

or. Tungsten. Fluat of lime.
arytes. The decrepitation may
ed without scattering in a glass
by the finger, and held over the

Infusible.

. Pure asbestos †. Refractory
acinth. Hydrophanous siliceous
ngsten. Pura mica †. Quartz.
phire. Flint. Steatite †. Topaz.
marked with a † are indurated

fusible, changing colour.

rths generally grow black; lime
carbonat of magnesia, black;
ned by subtile bitumen, white.
ems, some change or lose colour;
e crysolite, topaz, and sometimes
e.
and green jasper acquire a
ray colour.
black, and red steatite grow

sible without ebullition.

asbestos. Augites (aqua ma-
asaltes. * Crysolite †. Spath
nite. Marga. Petrosilex. Eme-
phat of barytes. (This corrodes
l, and acquires an hepatic taste.)
yromachum. Trapp.
hs marked with a † do not but
difficulty show any signs of

Fusible with ebullition.

rga. Schoerl. Tourmalin. The
ria quickly grows white, though
brown. Zeolite.

together in carbonat of soda, and with effervescence.

Chalcedony. Cornelian. Cos
Spath fluor †. Onyx. Opal.
Common flint. Sulphat of ba-

arked † effervesce but little.

Divisible with or without effervescence in carbonat of soda, but not entirely soluble.

Amianthus. Asbestos. Basaltes. Crysolite. Garnet †. Hornblende. Jasper. Tungsten. Lithomarga. Mica. Matrix of the alum of Tolfa. Petrosilex. Aluminous schist. Tegular schist, or roof slate of Helsing. Emerald. Spathum pyromachum. Steatites. Talc. Trapp. Trippel. Tourmalin.

Not fusible, or divisible by carbonat of soda.

Diamond. Hyacinth. Ruby. Sapphire. Topaz

Soluble in borax, with more or less effervescence.

Spath fluor †. Marga. Mica †. Ore of Tolfa. Aluminous schist. Tegular schist of Helsing † (roof slate). Sulphat of barytes. Schoerl. Talc. Tourmalin.

Those marked † effervesce but little.

Soluble in borax, without effervescence.

Agate. Diamond. Amianthus. Asbestos. Basaltes. Chalcedony. Cornelian. Crysolite. Cos Turcica. Garnet. Hyacinth. Hydrophanous siliceous jasper. Tungsten. (The flux grows hardly blue: on too much cooling it becomes white and opake.) Lithomarga. Onyx. Opal. Petrosilex. Quartz †. Ruby. Sapphire. Common flint †. Emerald. Steatites. Spathum pyromachum. Trapp. Trippel. Topaz †. Zeolite.

Those marked † require a greater quantity of flux and longer heat than the rest.

Soluble in microcosmic salt, with more or less effervescence.

Basaltes †. Cos Turcica. Spath fluor †. Tungsten. It effervesces at first, then scarcely dissolves: the flux acquires a fine blue tinge, without any mixture of redness. The colour is discharged by the exterior flame, or by a small quantity of nitre; but is restored by the interior flame: if the proportion of earth be large, it acquires a pellucid brown colour, not dischargeable either by nitre or the flame; if still larger, it grows black and opake. Marl. Mica †. Aluminous ore of Tolfa. Aluminous schistus. Tegular schistus of Helsing †. Schoerl. Sulphat of barytes. Tourmalin.

Those marked † effervesce but little.

Soluble in microcosmic salt, without effervescence.

Agate. Diamond. Amianthus. Asbestos. Chalcedony †. Cornelian †. Crysolite †. Granite. Hornblende. Hyacinth. Hydrophanous siliceous jasper †. Lithomarga. Onyx †. Opal †. Petrosilex. Quartz †. Ruby. Sapphire. Common flint. Emerald. Steatites. Spathum pyromachum. Talc. Topaz. Trapp. Trippel. Zeolite.

Those marked † are more difficultly dissolved than the rest, and scarce sensibly.

In general it is to be observed, 1. That when the effervescence is to be examined, only a very small piece of the matter is to

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ellowish crystalline matter which fills up the interstices of the native Siberian
ts the same properties with respect to fire as the crysolite.

be added to the flux, as the most subtile powder contains air, which, being expelled by the heat, forms the appearance of effervescence. 2. That the solution is often accelerated by lime, sulphat of barytes, gypsum, and other additaments, both in borax and microcosmic salt. 3. That gypsum alone is sometimes an excellent and very useful flux. This salt, with an equal portion of spath fluor, is easily reduced to a pellucid globule, which yet upon cooling grows white and opaque. The sulphat of barytes also unites with spath fluor, but the mass does not become pellucid.

Blue (Prussian). A combination of iron with an acid, distinguished by the name of the *prussic*. See Acid (Prussic), and Iron (Prussiat of).

A casual circumstance occasioned the discovery of this pigment. Diesbach, a chemist of Berlin, being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed a quantity of alkali of Dippel, from which he had several times distilled his animal oil; and as the decoction of cochineal contained sulphat of iron, a beautiful blue precipitate fell down. An account of Prussian blue was given in the Memoirs of the Academy of Berlin, in the year 1710, but with no intimation of the process. It was afterward rendered public by Woodward, in the Philosophical Transactions, who declared that he had received it from one of his friends in Germany.

To make Prussian blue, four ounces of alkali are mixed with an equal weight of dried bullock's blood, and the mixture is exposed to ignition in a covered crucible. By this treatment a coal is obtained, which is afterward lixiviated in water, filtered, and concentrated by evaporation. The liquor, formerly known by the name of the phlogisticated alkali, is now more properly termed prussiat of potash. On the other hand, two ounces of sulphat of iron and four ounces of alum are dissolved in a pint of water. The two solutions are then mixed, and a blueish deposition falls down, which is rendered still more intensely blue by washing it with muriatic acid.

This is the process used in chemical laboratories; but another method is followed in the manufactories. The raspings of horns, clippings of skins, or other animal substances, are converted into charcoal, by heating them in covered vessels. Thirty pounds of potash are then mixed with ten pounds of this coal, and the mixture calcined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered, and the solution mixed with another, consisting of three parts of alum, and one of sulphat of iron.

Blue (Saxon). The best Saxon blue colour may be given by the following composition:

Mix one ounce of the best powdered indigo with four ounces of sulphuric acid, in a glass body or matrass, and digest it for one hour with the heat of boiling water, shaking the mixture at different times: then add twelve ounces of water to it, and stir the whole well, and, when grown cold, filter it. This produces a very rich deep colour. If a paler blue be required, it may be obtained by the addition of more water. The heat of boiling water is sufficient for this operation, and can never spoil the colour: whereas a sand heat, which is commonly used, is often found to damage the colour. Indigo which has been digested with a large quantity of alcohol, and then dried, will produce a finer colour than the former, if treated in the same manner with sulphuric acid.

This colour, which was discovered by counsellor Barth, of Saxony, about 1740, is said to be very liable to fade. Bergman, however, affirms, that if 8 parts of sulphuric acid of the specific gravity of 1·9 be added to 1 of indigo, and digested with it at a heat of 100° or 120° F. for twenty hours, so as to form an opake black solution, this diluted with water will give various shades, the deepest of which will be as permanent as Coventry blue. Mr. Poerner makes the solution in the proportions directed above, but adds one ounce of good dry potash at the end of twenty-four hours, and lets this stand as much longer, before he dilutes it with water. The cloth should be prepared with alum and tartar.

Bog Ores. These are ores of iron, consisting of a calx of the metal in a state of greater or less purity, mixed with earth chiefly of the argillaceous kind. They appear to have been deposited by water, and are usually disposed in strata, separated into small prismatic parts by the contraction of the clay.

The chief of these are, the ætites, or eagle-stone, with other round pieces or pebbles; and the hæmatites, or blood-stone. See Ores.

Bole. Various indurated clays have been distinguished by this name, which was formerly much used: but, as it has been very little noticed, as a term, by the later improvers of mineralogical and chemical science, its present signification is very indeterminate. That commonly known by the name of *bole armenic*, or armenian bole, which is tinged red by an oxide of iron, was once much used. The French bole, which resembles it, but is paler coloured, is still retained in the materia medica of the London college.

Bolognian Stone. Lemery reports, that an Italian shoemaker, named Vincenzo Casciarolo, first discovered the phosphoric property of the Bolognian stone. It is the ponderous spar, or native sulphat of barytes. This man found it at the foot of mount Paterno; and, from its brilliancy and weight, was led to suppose that it contained silver. Having exposed it to the fire, doubtless with the intention of discovering that precious metal, he observed that it was luminous in the dark; a discovery which engaged his attention, and was frequently repeated with success. Many philosophers and chemists have since examined this phænomenon, and have varied the method of calcining the Bolognian stone in several respects. It seems as if the greatest degree of phosphorescence depended on a due application of the heat; but many trivial circumstances were noticed by the earlier chemists, which in all probability had little to do in producing this effect. An extreme degree of heat fuses this stone. If it be first heated to ignition, then finely powdered and made into a paste with mucilage; and this paste, divided into pieces a quarter of an inch thick, and dried in a moderate heat, be exposed to the heat of a wind furnace by placing them loose in the midst of the charcoal; a phosphorus will be obtained, which, after a few minutes exposure to the sun's rays, will give light enough in the dark to render the figures on the dial-plate of a watch visible. The fuel should be replenished when half consumed, the whole suffered to burn out, and the pieces of phosphorus, which may be separated by blowing away the ashes with a pair of bellows, should be kept in a phial closely stopped.

Bone. The bones of men and quadrupeds owe their great firmness and solidity to a considerable portion of the phosphat of lime which they contain. When these are rasped small, and boiled in water, they afford gelatinous matter, and a portion of fat or oil, which occupied their interstices. By destructive distillation they afford alkaline phlegm, a fetid oil, and much volatile alkali, leaving a coal not easily burned. In an open fire, bones are inflamed by virtue of their oil, and emit an offensive empyreumatic smell. The white, friable, and incombustible residue consists chiefly of lime and phosphoric acid in combination. It affords a small quantity of carbonat of soda by washing with water. This white matter is decomposable by fusion with mild fixed alkalis, which unite with the phosphoric acid at the same time that their carbonic acid converts the lime into chalk. Acids likewise disengage the phosphoric acid by uniting with the lime. The nitric or the sulphuric acid is most commonly used in this process. See Acid (Phosphoric). According to Mr. Accum, the bones of fishes contain upwards of one sixth more of phosphoric acid than those of quadrupeds.

It may be supposed, particularly when shells are included under the name, that bones differ considerably in the proportions of their ingredients, if not in the ingredients themselves. Merat-Guillot made a number of comparative analyses for the purpose of ascertaining this difference, the results of which he has tabulated; and we shall annex his table, as it gives a clear view of the subject.

Names of the substances.	Proportions of gelatinous matter.	Proportions of the phosphat of lime.	Proportions of the carbonat of lime.	Loss.
Human bones taken from a burying-ground	16	67	1·5	15·5
Dry human bones which had not been in the earth	23	63	2	2
Bones of an ox -	3	93	2	2
—— of a calf -	25	54	traces of it	21
—— of a horse -	9	67·5	1·25	22·25
Teeth of a horse -	12	85·5	0·25	2·25
—— of an elephant, or ivory - -	24	64	0·1	11·15
Bones of a sheep -	16	70	0·5	13·5
—— of an elk -	1·6	90	1	7·5
Horns of a stag -	27	57·5	1	14·5
Bones of a swine -	17	52	1	30
—— of a hare -	9	85	1	.5
—— of a hen -	6	72	1·5	20·5
Egg shells - -	3	2	72	23
Bones of a pike -	12	64	1	23
—— of a carp -	6	45	0·5	48·5
—— of a viper -	21·5	60·5	0·5	17·5
Lobster shells -	18	14	40	28
Mother of pearl -	2·5	0	66	31·5
Crab's eyes - -	2	12	60	26
White coral -	1·5	0	50	48·5
Red ditto - -	0·5	0	53·5	46
Articulated coralline	7·5	0	49	43·5
Cuttle fish bones -	8	0	68	24

The loss he ascribes chiefly to water; but in part to gelatine, and a small quantity of a saline substance, which he did not examine. He adds too, that what he has given as gelatine in the articulated coralline was not wholly that substance, and he suspects therefore was in part analogous to the matter that forms the polypi inhabiting the lithophytes.

Fourcroy and Vauquelin have farther discovered, that the bones of animals contain phosphat of magnesia. They found it in all the bones they examined, except human bones. Those of the ox, according to their analysis, contain dry gelatine ·51, phosphat of lime ·377, carbonat of lime ·1, phosphat of magnesia, ·13. The bones of the horse and sheep afford about 1-36th of phosphat of magnesia; those of fowls and fish nearly the same quantity as those of the ox. They account for this by observing, that phosphat of magnesia is found in the urine of man, but not in that of animals, though both equally take in a portion of magnesia with their food.

The experiments of Mr. Hatchett show, that the membranous or cartilaginous substance, which retains the earthy salts within its interstices, and appears to determine the shape of the bone, is albumen. This Merat-Guillot, in the table above given, has confounded with the gelatine of the bone under the head Gelatinous Matter. Mr. Hatchett too confirms the remark of John Hunter, that the enamel of tooth is altogether an earthy substance, not included in a membranous structure; and observes, that in this respect it is analogous to the porcellaneous shells, while mother of pearl approaches in its nature to the true bone.

A curious phænomenon with respect to bones is the circumstance of their acquiring a red tinge, when madder is given to animals with their food. The bones of young pigeons will thus be tinged of a rose colour in twenty-four hours, and of a deep scarlet in three days; but the bones of adult animals will be a fortnight in acquiring a rose colour. The bones most remote from the heart are the longest in acquiring this tinge. Mr. Gibson informs us, that extract of logwood too, in considerable quantity, will tinge the bones of young pigeons purple. On desisting from the use of this food, however, the colouring matter is again taken up into the circulation, and carried off, the bones regaining their natural hue in a short time. It was said by Du Hamel, that the bones would become coloured and colourless in concentric layers, if an animal were fed alternately one week with madder, and one week without; and hence he inferred, that the bones were formed in the same manner as the woody parts of trees. But he was mistaken in the fact; and indeed had it been true, with the inference he naturally draws from it, the bones of animals must have been out of all proportion larger than they are at present.

Bones are of extensive use in the arts. In their natural state, or dyed of various colours, they are made into handles of knives and forks, and numerous articles of turnery. We have already noticed the manufacture of volatile alkali from bones, the coal of which forms bone black; or, if they be afterward calcined to whiteness in the open air, they constitute the bone ashes, of which cupels are made, and which, finely levigated, are used for cleaning articles of paste and some other trinkets, by the name of burnt hartshorn. The shavings of hartshorn, which is a species of bone, afford an elegant jelly; and the shavings of other bones, of which those of the calf are the best, are often employed in their stead.

On this principle, Mr. Proust has recommended an œconomical use of bones, particularly with a view to improve the subsistence of the soldier. He first chops them into small pieces, throws them into a kettle of boiling water, and lets them boil about a quarter of an hour. When this has stood till it is cold, a quantity of fat, excellent for culinary purposes when fresh, and at any time fit for making candles, may be taken off the liquor. This in some instances amounted to an eighth, and in others even to a fourth, of the weight of the bones. After this the bones may be ground, and boiled in eight or ten times their weight of water, of which that already used may form a part, till about half is wasted, when a very nutritious jelly will be obtained. The boiler should not be of copper, as this metal is easily dissolved by the jelly; and the cover should fit very tight, so that the heat may be greater than that of boiling water, but not equal to that of Papin's digester, which would give it an empyreuma. The bones of meat that has been boiled are nearly as productive as fresh bones; but Dr. Young found those of meat that had been roasted afforded no jelly, at least by simmering, or gentle boiling.—*Annales de Chimie—Philos. Trans.—Manchester Memoirs—Gehlen's Journal—Journals of the Royal Institution.*

Boracite. The cubic quartz of many mineralogists. Magnesio-calcareous borat, or, according to Vauquelin, native borat of magnesia. See Acid (Boracic).

Borax. The origin of borax was for a long time unknown in Europe; and many chemists still continue to copy from each other, that its origin has not yet been ascertained. Mr. Grill Abrahamson, however, sent some to Sweden in the year 1772, in a crystalline form, as dug out of the earth in Thibet, where it is called Pounnxa, Mypoun, and Houipoun: it is said to have been also found in Saxony in some coal pits. But the most particular accounts we possess concerning the origin of borax, are found in the Philosophical Transactions for 1787. Mr. Blane, who had an opportunity of inquiring of some of the inhabitants of the place where the borax is made, gives the following account:

aline substance, called in the
f the country, Swagah, is brought
ostan from the mountains of Thi-
place where it is produced is in
om of Jumlate, distant from Be-
it thirty days journey north. Jum-
largest of the kingdoms in that
e Thibet mountains, and is con-
holding a superiority over all the

ce where the borax is produced is
to be in a small valley surround-
nowy mountains, in which is a
six miles in circumference, the
which is constantly hot, so much
e hand cannot be held in it for
The ground round the banks
e is perfectly barren, not pro-
en a blade of grass; and the
l of a saline matter in such plenty,
falls of rain or snow, it concretes
lakes upon the surface, like the
Hindostan. Upon the banks of
in the winter season, when the
ow begin, the earth is formed into
ervoirs, by raising it into banks
nches high: when these are filled
, the hot water from the lake is
on it, which, together with the
m the melted snow, remains in
oir, to be partly absorbed by the
d partly evaporated by the sun;
h there remains at the bottom a
etimes half an inch thick, of crude
ich is taken up, and reserved for
n only be made in the winter sea-
use the falls of snow are indis-
requisite, and also because the sa-
rances upon the earth are strong-
season. When once it has been
n any spot, in the manner above
it cannot be made again upon
lace, till the snow shall have fallen
d dissolved three or four times;
ch the saline efflorescence reap-
l it is again fit for the operation.
rax, in the state above described,
orted from hill to hill upon goats,
s through many different hands
reaches the plains; which increases
ulty of obtaining authentic infor-
garding the original manufacture.
ught down from the hills, it is re-
n the earth and gross impurities,
and crystallization. Mr. Blane
in no answers to any questions
the quality of the water, and the
roductions of the soil. All they
of the former was, that it was
very foul, and as it were greasy;
oils up in many places, and has a
sive smell: and the latter remark-
for the saline appearances above
That country, however, in ge-
duces considerable quantities of
per, and sulphur. After being
it sells in the market for about
oees per maund; and he was assured by many of the natives, that all the borax in India comes only from the place above mentioned.

The other account of borax, in the same volume of the Transactions, is contained in a letter from father Joseph de Rovato, father prefect of the mission in Thibet, who received the information from a native of the country where the borax is prepared, sent expressly for that purpose to him by the brother of the king of Nepal, a kingdom on the borders of Thibet.

This man, partly in the Nepalese, and partly in the Hindoo language, both which are understood by the prefect, gave the following account:—In the province or territory of Marmé, twenty-eight days journey to the north of Nepal, and twenty-five to the west of Lassa, the capital of Thibet, there is a vale about eight miles broad. In a part of this vale there are two villages or castles, the one named Scierugh, and the other Kanglé, the inhabitants of which are wholly employed in digging the borax, which they sell in Thibet and Nepal, they having no other means of subsistence, the soil being so barren as to produce nothing but a few rushes. Near the two above-mentioned castles there is a pool of moderate size, and some smaller ones, where the ground is hollow, in which the rain water collects. In these pools, after the water has been some time detained in them, the borax is formed naturally: the men wading into the water, feel a kind of pavement under their feet, which is a sure indication that borax is there formed, and there they accordingly dig it.

Where there is little water, the layer of borax is thin; and where it is deep, it is thicker; and over the latter there is always an inch or two of soft mud, which is probably a deposit of the water after it has been agitated by rain or wind. Thus is the borax produced merely by nature, without either boiling or distillation. The water in which it is formed is so bad, that the drinking a small quantity of it will occasion a swelling of the abdomen, and in a short time death itself. The earth that yields the borax is of a whitish colour; and in the same valley, about four miles from the pools, there are mines of salt, which is there dug in great abundance for the use of all the inhabitants of these mountains, who live at a distance from the sea. The natives, who have no other subsistence on account of the sterility of the soil, pay nothing for digging borax; but strangers must pay a certain retribution, and usually agree at so much a workman. This is paid to a Lama, named Pema Tupkan, who owns the pits in Marmé.

Ten days journey farther north there is another valley, named Tapré, where they dig borax, and another still farther, called Cioga; but of this latter the prefect did not mark the situation. Borax is, in the

Hindoo and Nepalese languages, called Soga. If it be not purified, it will easily deliquesce; and in order to preserve it any time till they have an opportunity of selling it, the people often mix it with earth and butter.

It does not appear that borax was known to the ancients, their chrysocolla being a very different substance, composed of the rust of copper, triturated with urine. The word borax is found for the first time in the works of Geber.

Borax is not only found in the East, but likewise in South America. Mr. Anthony Carera, a physician established at Potosi, informs us, that this salt is abundantly obtained at the mines of Riquintipa, and those in the neighbourhood of Escapa, where it is used by the natives in the fusion of copper ores.

The purification of borax by the Venetians and the Hollanders was for a long time among those secrets, which the want of a sufficient spirit of research prevented from becoming general; chemical writers have been satisfied in asserting, that the processes consisted of solution, filtration, crystallization, and calcination. Chaptal, however, informs us, from his own extensive experience, that the destruction of the oily part of borax by calcination is attended with considerable loss. He finds, after trying all the processes in the large way, that the simplest method consists in boiling the borax strongly, and for a long time, with water. This solution being filtered affords by evaporation crystals, which are somewhat foul, but may be purified by repeating the operation.

Purified borax is white, transparent, rather greasy in its fracture, affecting the form of six-sided prisms, terminating in three-sided or six-sided pyramids. Its taste is styptic; it converts sirup of violets to a green; and, when exposed to heat, it swells up, boils, loses its water of crystallization, and becomes converted into a porous, white, opaque mass, commonly called Calcined Borax. A stronger heat brings it into a state of quiet fusion: but the glassy substance thus afforded, which is transparent, and of a greenish yellow colour, is soluble in water, and effloresces in the air. It requires about eighteen times its weight of water to dissolve it at the temperature of sixty degrees of Fahrenheit; but water at the boiling heat dissolves three times this quantity. Its component parts, according to Kirwan, are, boracic acid ·34, soda ·17, water ·47. For an account of the neutral borat of soda, and other compounds of this acid, see Acid (Boracic).

Borax is used as an excellent flux in docimastic operations. It enters into the composition of reducing fluxes, and is of the greatest use in analyses by the blowpipe. It may be applied with advantage in glass manufactories; for when the fusion turns out bad, a small quantity of borax reestablishes it. It is more especially used in soldering: it assists the fusion of the solder, causes it to flow, and keeps the surface of the metals in a soft or clean state, which facilitates the operation. It is scarcely of any use in medicine. Its acid, called *Sedative Salt*, is used by some physicians; and its name sufficiently indicates its supposed effects. Mixed with shell lac, in the proportion of one part to five, it renders the lac soluble by digestion in water heated near boiling.

Borax has the inconvenience of swelling up, and requires the greatest attention on the part of the artist who uses it in delicate works, more especially when designs are to be formed with gold of different colours. It has been long a desideratum, to substitute some composition in the room of borax, which might possess its advantages without its defects.

Mr. Georgi has published the following process:—"Soda, mixed with muriat and sulphat of soda, is to be dissolved in lime water; and the crystals which separate by the cooling of the fluid may be set apart. The lixivium is then to be evaporated; and the salt afterward dissolved in milk. The evaporation affords scarcely one eighth of the soda employed; and the residue may be applied to the same uses as borax."

Messrs. Struve and Exchaquet have proved, that the combination of phosphoric acid and vegetable alkali, fused with a due proportion of phosphat of lime, forms an excellent glass for soldering metals.

Bovey Coal. Xylanthrax. This is of a brown or brownish black colour, and lamellar texture; the laminæ are frequently flexible when first dug, though generally they harden when exposed to the air. It consists of wood penetrated with petroleum or bitumen, and frequently contains pyrites, alum, and vitriol; its ashes afford a small quantity of fixed alkali, according to the German chemists; but according to Mr. Mills, they contain none. By distillation it yields an ill-smelling liquor, mixed with volatile alkali and oil, part of which is soluble in alcohol, and part insoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Iceland, &c.

Brain of Animals. The brain has long been known to anatomists; but it is only of late years that chemists have paid it any attention. It is a soft, white substance, of a pulpy, saponaceous feel, and little or no smell. Exposed to a gentle heat, it loses moisture, shrinks to about a fourth of its original bulk, and becomes a tenacious mass of a greenish brown colour. When completely dried, it becomes solid, and friable like old cheese. Exposed to a strong heat, it gives out ammonia, swells up, melts into a black pitchy mass, takes fire, burns with much flame and a thick pungent smoke, and leaves a coal difficult of incineration.

natural state, or moderately dried,
y forms an emulsion by trituration
ter, and is not separated by filtra-
his solution lathers like soap-suds,
not turn vegetable blue colours
Heat throws down the dissolved
a flocculent form, and leaves an al-
hosphat in solution. Acids separate
coagulum from it; and form salts
ses of lime, soda, and ammonia. Al-
o coagulates it.
ic fixed alkalies act very powerfully
in even cold, evolving much am-
and caloric. With heat they unite
nto a saponaceous substance.
ction of alcohol on brain is most
ble. When Fourcroy treated it
es in succession with twice its
of well rectified alcohol, boiling it
r of an hour each time, in a long-
matrass with a grooved stopple, the
st portions of alcohol, decanted
deposited by cooling brilliant la-
a yellowish white colour, diminish-
uantity each time. The fourth de-
ery little. The cerebral matter had
s of its weight; and by the spon-
deposition, and the subsequent eva-
of the alcohol, half of this was re-
in needly crystals, large scales, or
ed matter. The other half was lost
tilization. This crystallized sub-
of a fatty appearance, was aggluti-
to a paste under the finger; but
melt at the heat of boiling water,
erely softened. At a higher tem-
it suddenly acquired a blackish
olour, and exhaled during fusion
yreumatic and ammoniacal smell.
ws that it is not analogous to sper-
r to adipocere: but it seems more
le the fat lamellated crystals con-
biliary calculi, which however do
at a heat of 234° F., or become
cal and empyreumatic at this tem-
as the crystalline cerebral oil does.
tion of this concrete oil, separated
alcohol by evaporation in the sun,
granulated pellicle on its surface,
sistence resembling that of soft
was of a yellower colour than the
nd had a marked smell of animal
and a perceptible saline taste. It
sible in water, gave it a milky ap-
, reddened litmus paper, and did
me really oily, or fusible after the
f an oil, till it had given out am-
d deposited carbon, by the action
caustic alkalies.
ar action of alcohol on the brain,
d spinal marrow, is observed after
eration in it cold, when they are
natomical preparations.
ontaneous change that brain un-
n certain situations has already
ced under the article ADIPOCERE.
e Chimie.—Fourcroy.
Y. This well-known fluid is the
spirit distilled from wine. The greatest quantities are made in Languedoc, where this manufacture, upon the whole so pernicious to society, first commenced. It is obtained by distillation in the usual method, by a still, which contains five or six quintals of wine, and has a capital and worm tub applied. Its peculiar flavour depends, no doubt, on the nature of the volatile principles, or essential oil, which come over along with it, and likewise, in some measure, upon the management of the fire, the wood of the cask in which it is kept, &c. It is said, that our rectifiers imitate the flavour of brandy, by adding a small proportion of nitrous ether to the spirit of malt or melasses. See ALCOHOL.

BRASS. An elegant yellow-coloured compound metal, consisting of copper combined with about one third of its weight of zinc. The best brass is made by cementation of calamine, or the ore of zinc, with granulated copper. See COPPER.

BRASSICA RUBRA. Mr. Watt finds, that the red cabbage affords a very excellent test both for acids and alkalis; in which it is superior to litmus, being naturally blue, turning green with alkalis, and red with acids; beside which it possesses the advantage of not being affected by the fuming nitrous acid, any farther than as it acts as a real acid. The management of the leaves to procure this test is as follows:

To extract the colouring matter, take those leaves of the cabbage which are freshest, and have most colour; cut out the larger stems, and mince the thin parts of the leaves very small; then digest them in water, of about the heat of one hundred and twenty degrees, for a few hours, and they will yield a blue liquor, which, if used immediately as a test, will be found to possess great sensibility. But as this liquor is very apt to turn acid and putrid, and to lose its sensibility when it is wanted to be preserved for future use, the following processes succeed the best:

1. After having minced the leaves, spread them on paper, and dry them in a gentle heat; when perfectly dry, put them up in glass bottles well corked; and when you want to use them, acidulate some water with sulphuric acid, and digest or infuse the dry leaves in it until they give out their colour; then strain the liquor through a cloth, and add to it a quantity of fine whiting or chalk, stirring it frequently until it becomes of a true blue colour, neither inclining to green nor purple; as soon as you perceive that it has acquired this colour, filter it immediately, otherwise it will become greenish by long standing on the whiting.

This liquor will deposit a small quantity of gypsum, and by the addition of a little alcohol will keep good for some days, after which it will become a little putrid and reddish. If too much spirit be added, it destroys the colour. If the liquor be wanted to be kept longer, it may be neutralized by means of a fixed alkali instead of chalk.

2. But as none of these means will preserve the liquor long, without requiring it to be neutralized afresh, just before it is used; and as the putrid and acid fermentation which it undergoes, and perhaps the alkalis or spirit of wine mixed with it, seem to lessen its sensibility; in order to preserve its virtues while it is kept in a liquid state, some fresh leaves of the cabbage, minced as has been directed, may be infused in a mixture of sulphuric acid and water, of about the degree of the acidity of vinegar: and it may be neutralized, as it is wanted, either by means of chalk, or of the fixed or volatile alkali. But it is necessary to observe, that if the liquor have an excess of alkali, it will soon lose its colour, and become yellow, from which state it cannot be restored; therefore care should be taken to bring it very exactly to a blue, and not to let it verge towards a green. The infusions of red cabbages and of various flowers in water, acidulated by means of sulphuric acid, are apt to turn mouldy in the summer season, but the moulding is prevented by the addition of spirits of wine.

By the same process Mr. Watt made a red infusion of violets, which, on being neutralized, formed a very sensible test: but how long it will preserve its properties he had not determined. Probably the coloured infusions of other flowers may be preserved in the same manner, by the antiseptic power of the sulphuric acid, so as to lose little of their original sensibility. The petals of the scarlet rose, and those of the pink coloured lychnis, treated in this manner afford very sensible tests. Paper fresh stained with these tests in their neutral state, has sufficient sensibility for many experiments: but the alum and glue which enter into the preparation of writing-paper, seem in some degree to fix the colour; and paper which is not sized becomes somewhat transparent when wetted, which renders small changes of colour imperceptible; so that, where accuracy is required, the test should be used in a liquid state.

Brazil Wood. The tree that affords this wood, the Cæsalpina crista, is of the growth of the Brazils in South America, and also of the Isle of France, Japan, and elsewhere. It is chiefly used in the process of dyeing. The wood is considerably hard, is capable of a good polish, and is so heavy that it sinks in water. Its colour is pale when newly cut, but it becomes deeper by exposure to the air. The various specimens differ in the intensity of their colour; but the heaviest is reckoned the most valuable. It has a sweetish taste when chewed, and is distinguished from red sanders, or sandal, by its property of giving out its colour with water, which this last does not.

If the Brazil wood be boiled in water for a sufficient time, it communicates a fine red colour to that fluid. The residue is very dark-coloured, and gives out a considerable portion of colouring matter to a solution of alkali. Alcohol extracts the colour from Brazil wood, as does likewise the volatile alkali; and both these are deeper than the aqueous solution. The spirituous tincture, according to Dufay, stains warm marble of a purplish red, which on increasing the heat becomes violet: and if the stained marble be covered with wax, and considerably heated, it changes through all the shades of brown, and at last becomes fixed of a chocolate colour.

The recent decoction of Brazil wood, according to Berthollet, affords, by the addition of sulphuric acid, a precipitate, small in quantity, and of a red colour inclining to yellow; the liquor remaining transparent, and of a yellow colour. The nitric acid first converts the tincture to a yellow; but if the quantity of acid be increased, the liquor assumes a deep orange yellow, and becomes transparent, after depositing a precipitate of the same colour nearly as the foregoing, but more abundant. The muriatic acid has the same effect as the sulphuric. The oxalic acid affords an orange red, or almost ruddy precipitate, nearly as abundant as that thrown down by the nitric acid, and the liquor remains transparent and yellow. Distilled vinegar affords a very sparing precipitate of the same colour; the fluid continuing transparent, but rather of a deeper orange. Tartar affords still less precipitate; and the remaining liquor is turbid and more reddish than the last. Fixed alkali converts the colour of the decoction to a crimson or deep violet inclining to brown, and affords a precipitate of the same colour, though very small in quantity. Volatile alkali affords a brighter violet or purple, and a little precipitate of a fine purple. Alum throws down a red precipitate inclining to crimson, which is abundant and subsides very slowly; while the supernatant fluid preserves its fine red colour, like that of the recent decoction: this liquor affords another abundant precipitate, if the acid of the alum be saturated with an alkali. In this manner is prepared a kind of carmine, inferior in beauty to the common carmine, and likewise a liquid lake for miniature painters. Alum and tartar together afford a brownish red precipitate in small quantity, while the fluid remains of a bright orange red. Sulphat of iron gives the tincture a black colour, inclining to violet, at the same time that an abundant precipitate of the same colour falls down. Sulphat of copper likewise affords a plentiful brown precipitate, and converts the fluid to a transparent brownish red. Sulphat of zinc throws down a sparing brown precipitate, leaving the fluid of an amber colour. Solution of acetit of lead affords a precipitate of a deep red, of considerable beauty, and the liquor becomes of an orange red. The solution of tin in aqua regia occasions an abundant precipitate of a fine rose colour, and the fluid remains clear and quite colourless. Lastly, corrosive muriat of mercury occasions a slight brown precipitate; the liquor remaining transparent, and of a fine yellow colour.

The Journal de Physique, for February 1785, contains some curious experiments respecting the action of acids upon the colour of Brazil wood. If the aqueous tincture of this wood be first rendered yellow, by means of tartar and the acetous acid, and the solution of tin in aqua regia be then poured, a very abundant rose-coloured precipitate is obtained: if to the solution rendered yellow by an acid there be added a greater quantity of the same or a stronger acid, the red colour is restored; the sulphuric acid is best adapted to this effect. Several salts likewise cause the red colour of Brazil wood to appear again, after it has been destroyed by the action of acids.

It has been observed, that the recent decoction of Brazil wood is less proper for dyeing than that which is older, or even fermented; it assumes a yellowish red colour by age. Hellot recommends the hardest waters for making this decoction; but it must be observed, that such waters deepen the colour, by virtue of the earthy salts they contain. After boiling the chips of this wood for three hours, this first decoction is put into a cask. More water is then added to the wood, which is boiled for a second three hours, and the decoction added to the foregoing. In this, as in all decoctions of colouring, the wood is kept in a bag of porous cloth.

Wool plunged in the decoction of Brazil wood acquires a weak colour, which soon goes off. It therefore requires a preparation to render the dye permanent.

The wool must be boiled in a solution of alum, to which one fourth or even a less quantity of tartar has been added. A larger proportion of tartar would render the colour deeper. The impregnated wool is kept at least eight days in a cool place; after which it is dyed in the decoction of Brazil wood by a gentle boiling. As the colouring matter first deposited affords an inferior dye, it is proper to dip a coarser stuff first. In this way a lively red dye is obtained, which resists the air very well.

If the red colour of Brazil wood be destroyed by an acid, it communicates a very durable fawn colour to woollen stuffs.

Mr. Poerner prepares the stuff by boiling it in a solution of tin, alum, and a little tartar; and he makes his bath with the Brazil wood and a considerable proportion of alum. In the residue of this bath he dips another piece which has received the same preparation. The first piece receives a fine brick colour, and the second a dye approaching to scarlet. The shades may be greatly varied by altering the proportion of the ingredients.

By these means the dyes obtained from Brazil wood may be rendered considerably solid, but by no means comparable in this respect to those afforded by cochineal or madder. The dye afforded by this last substance is sometimes rendered brighter, by passing the dyed stuff through a decoction of Brazil; but the effect soon goes off.

Mr. Guhliche describes a process, which, as he affirms, is capable of affording more beautiful and more durable colours than those before used: he directs, that vinegar, or the aceto-citric [*] acid, or aqua regia, be poured upon the Brazil wood, reduced into powder, or thin shavings or chips, until it is covered to a certain depth. This mixture must be well agitated, then left at rest for twenty-four hours, and lastly decanted, filtered, and preserved for use. A vegetable acid, or simple water, is poured on the residue, and left to repose for a day or two, after which it is filtered; and in this manner the process is continued until no more colour is given out; the wood is then black: the several liquors are to be mixed together.

The stuff is prepared by a weak galling with sumach, or the white nut-gall: after this it is slightly alumed, simply rinsed, and immersed wet with the following bath:

The acid solution of Brazil wood is taken and diluted with a certain quantity of water, depending on the quantity of goods and the intensity of the colour intended to

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[*] This acid, so called by Mr. Berthollet, but distinguished by Mr. Guhliche by the name of the vegetable acid spirit, is much used by this last chemist in his dyeing processes, and is prepared as follows:

He takes lemons, not rejecting even those the skin of which is quite rotten; pares them, slices them into an earthen or metallic (but not a wooden) vessel; sprinkles them with good vinegar, of the strength which he judges to be equal to that of lemon-juice; expresses the juice from the lemons, exposed to the action of a press in a flannel bag; and lastly filters it through paper. In this state the liquor may be employed with success; but it has the inconvenience of becoming mouldy, and is aqueous. To remedy these defects, he recommends it to be purified and concentrated as follows: The liquor is left exposed to the sun until it has become clear, and deposited a sediment. It is then filtered and distilled on a sand bath. As soon as the drops which come over are perceived to be acid, the receiver is changed, and the distillation is continued until oily striæ are perceived in the neck of the retort. The acid which is thus obtained must be preserved for use.

be produced. It is then heated to such a degree, that the hand may be held in it; solution of tin is then poured in until it has acquired a fine colour; the bath being then agitated, the stuff is to be plunged in and kept immersed for half an hour, after which time it is to be taken out and washed. The remaining bath will serve for weaker shades, and the stuff must not be galled for these light tinges.

Brazil wood is used for dyeing silk of a crimson colour. This is called the false dye, to distinguish it from the crimson obtained by cochineal, which is much more durable.

The silk must be boiled with twenty pounds of soap for every hundred of silk, and afterward alumed. The aluming need not be so strong as for the fine crimson. It is then washed in a running stream, and immersed into a bath, more or less charged with the decoction of Brazil wood, according to the intended shade of colour. When water containing no earthy salt has been made use of, the colour is too red to imitate crimson. This quality, however, is given to the water by passing the silk through a slight alkaline solution, or by adding a little alkali to the bath. It might likewise be washed in hard water till it had obtained the required shade.

To make a deeper crimson of the false or red brown kind, the decoction of logwood is added to the bath of Brazil wood, after the silk is impregnated. A small quantity of alkali is likewise added, according to the shade intended to be produced.

To imitate the wild poppy, or fiery red, the silk must first receive a ground of rocou (better known in England by the name of ANNOTTO, which see), even deeper than when the dye with carthamus is intended; after which it is washed, alumed, and dyed with the decoction of Brazil wood, to which a little soap water is usually added.

The solution of tin cannot, as Mr. Berthollet observes, be employed with the decoction of Brazil wood, for dyeing silk in the same manner as with cochineal, because the colouring particles are too quickly separated to be able to fix themselves on the silk, which has not so strong an attraction for them as wool has. But, as Bergman remarks, in his notes upon Scheffer's Essay on the Art of Dyeing, it is possible to make great improvement in the colours afforded by the dyeing woods, by macerating the silk in a cold solution of tin. A strong decoction of Brazil wood gives to yellow silk a scarlet colour, inferior indeed to that of cochineal, but much more lively and solid than is had by mere maceration in alum, and capable of resisting the proof of vinegar, like the fine crimson and poppy colours. Instead of using the raw silk, it is requisite to give a yellow ground to boiled silk, or to mix a yellow substance with the decoction of Brazil wood. Several manufacturers have lately busied themselves with this process, and have produced a variety of effects, by applying it to different colouring matters, which afford colours of very little solidity, whether they be employed alone, or in forming different mixtures.

Mr. Guhliche, nevertheless, describes a process, in which he makes an immediate use of the solution of tin, to give a fire colour to silk. He directs, that it should be galled by a solution of nut-galls in white wine. He affirms, that this solution preserves much more of that brilliancy, so much in request in the colour of silk, than the solution made in water. He adds such a quantity of this solution to water as may give the whole a yellow colour; with this he carefully impregnates the silk, leaving it in the cold for twelve hours, after which he expresses the liquor very well, but without the action of washing. The silk being then dried is steeped in a solution of alum, in the proportion of four ounces of alum for every pound of the silk, where it remains for twelve hours. He then presses out the acid, and immerses the silk, wet as it is, into a bath prepared in the way already described, after having added an ounce of the solution of tin. The remaining force of the bath may be exhausted for lighter shades. If the fire colour be required more inclining to orange, he does not gall the silk, but alums it in a cold solution of two ounces of alum, of the strength of two ounces of the salt for every pound of the silk; after which he dyes it of an orange colour with annotto, without boiling, and plunges it still wet into the before-mentioned bath of Brazil wood. The author confesses, that these colours, more especially the last, do not possess much solidity. For rose colours he omits the galling, and uses no more than two ounces of alum. For light shades he recommends to decant the solution of alum from the deposition it may have made; and he prefers dyeing without heat, by employing a bath more highly charged with colour, out of which the silk may be taken when it has received the intended shade, and which may be afterward exhausted in producing other shades. He affirms that, by the assistance of these precautions, beautiful shades may be obtained of sufficient solidity.

Mr. Poerner has made a great number of essays on the methods which may be used to dye cotton by means of Brazil wood, with different mordants, such as alum, the solution of tin, sal ammoniac, alkali, &c., either in the bath or in the preparation of the stuff; but he could not produce colours capable of resisting the action of soap, though several among them withstood the action of the air and washing in water. He advises, that the cottons dyed with these colours should be dried in the shade.

The following process, used in some manufactories for dyeing cotton of a crimson

r, was communicated to M. Berthollet
r. Brown.

olution of tin is made in these propor-
of the ingredients: nitric acid two
ds, muriatic acid one pound, tin eight
es, water one pound; the fluids are
mixed, and the tin dissolved in the
ire by adding a little at a time.

r a piece of cotton velvet, weighing
n or sixteen pounds, the operation is
n by preparing a bath composed of four
boiling water, and two parts of a
g decoction of nut-galls. The bath is
stirred with the rake, the piece plunged
worked for half an hour, left immersed
vo hours, and afterward taken out and
ed. Another bath is also prepared
three parts of boiling water, and one
e decoction of Brazil wood likewise
g; this is raked, and the piece worked
or half an hour. The liquor is then
n out, and the vat filled with a de-
n of Brazil wood, unmixed and boil-
In this the piece is worked for half an
and then lifted out on a cross. A
of very clear river water is then pre-
, into which a pint of solution of tin
red; and when the bath has been well
, and the piece worked for half an
it is taken out on the cross, and carried
bath of the decoction of Brazil wood,
f which one sixth part of the whole
een taken, and replaced with an equal
ity of the boiling decoction. In this
the piece is worked for half an hour,
raised on the cross, and returned to the
which contains the solution of tin.
alternate operations are repeated six
ht times; taking care every time to
ut one sixth of the bath of the Brazil
and to replace it with an equal
ty of the boiling decoction of the
wood, to rake or stir the bath of the
sition every time, and to finish the
y the piece remaining in the latter
The piece is last of all to be washed
nty of water, or a stream, and it must
ed in a place inaccessible to the light.

e colouring particles of Brazil wood
asily affected and rendered yellow
ds, after which change they become
olours. But what distinguishes them
madder and kermes, and indicates a
blance to cochineal, is, that they ap-
again in their original colour, when
itated with alum or the oxide of tin.
two combinations appear the most
r to render the colour durable. It is
ary, therefore, to inquire after and
in the circumstances most proper to
their combinations, according to the
of the stuff.

astringent principle likewise appears
tribute to the solidity of the colouring
of Brazil wood: but this galling ren-
ie colour deeper, and cannot be used
ht shades.

The colouring parts of Brazil wood are very sensible to the action of alkalis, which give them a purple tinge; and there are many processes in which fixed or volatile alkalis are used to form violets and purples: but the colours, though obtained with ease in various shades by this method, are perishable, and possess only a transient brightness. Alkalis do not appear to injure the colours afforded by madder, but they hasten the destruction of most other colours.

It is usual in England to rasp or pulverize the dyeing woods in mills appropriated to that purpose. They are commonly kept moistened with urine; and when urine has not been used, a small quantity of alkali is added at the time of boiling. This method of proceeding, as M. Berthollet observes, is very advantageous; but the use of putrefied urine, or alkali, tends to deepen the colour, to render it less permanent, and may, on various occasions, be contrary to the nature of the processes intended to afford certain effects.

Mr. Julia has given a process for dyeing cottons of a beautiful amaranthine colour by means of Brazil. The cotton being cleansed by boiling in water till it sinks, rinsed, and wrung out, is to be saturated with the following mordant: Dissolve 10 pounds of Roman and 6 of English alum, 6 of acetat of lead, 1 of pure potash, and 24 ounces of Alicant soda, in 8 gallons of hot water; when cooled down to 104° F add 9 ounces of white arsenic in powder, and 13 of muriat of ammonia; and when these are dissolved, add a decoction of four ounces of Brazil in a gallon of water. This is to stand for four days, when the clear liquor is to be poured off, and the cotton well worked in it, slightly wrung out, and dried, turning it frequently. When dry, it is to be dipped several times into warm water, and wrung out. Twelve pounds of this cotton are next to be maddered in a bath of 50 gallons of water and 16 pounds of Dutch grape madder at a moderate heat, in which it is to be kept an hour and a half, toward the end increasing the heat so that the hand cannot be kept in the bath, but it must by no means be made to boil. The cotton, being taken out to drain, is to be rinsed two hours after in a stream of water till no more colour comes out, when it is to be wrung, passed through the mordant again, and well washed. Lastly, five pounds of rasped Brazil, enclosed in a coarse bag to which a stone is tied, are to be boiled for three hours and a half in 50 gallons of very hard water, and, after this decoction is drawn off, in a fresh quantity of water, till three fourths are wasted. The bag being taken out, and the first decoction poured into the boiler, the maddered cotton is to be put into it when hot, and the bath made to boil. Having boiled an hour, the cotton is to be taken out, and set to drain. When cold, it is to be washed and wrung till no more colour comes out, and then dried.

This colour, according to Messrs. Julia and Favier, is one of the most brilliant that can be conceived; and so fixed that nothing can injure it.

Bread. I am not acquainted with any set of experiments regularly instituted and carried into effect, for ascertaining what happens in the preparation of bread. Farinaceous vegetables are converted into meal by trituration, or grinding in a mill; and when the husk or bran has been separated by sifting or bolting, the powder is called flour. This is composed of a small quantity of mucilaginous saccharine matter, soluble in cold water, much starch, which is scarcely soluble in cold water, but combines with that fluid by heat, and an adhesive gray substance insoluble in water, alcohol, oil, or ether, and resembling an animal substance in many of its properties. See Wheat, Starch, Gluten (Vegetable), Mucilage.

When flour is kneaded together with water, it forms a tough paste, containing these principles very little altered, and not easily digested by the stomach. The action of heat produces a considerable change in the gluten, and probably in the starch, rendering the compound more easy to masticate, as well as to digest. Hence the first approaches towards the making of bread consisted in parching the corn, either for immediate use as food, or previous to its trituration into meal; or else in baking the flour into unleavened bread, or boiling it into masses more or less consistent; of all which we have sufficient indications in the histories of the earlier nations, as well as in the various practices of the moderns. It appears likewise from the Scriptures, that the practice of making leavened bread is of very considerable antiquity; but the addition of yeast, or the vinous ferment, now so generally used, seems to be of modern date.

Unleavened bread in the form of small cakes, or biscuit, is made for the use of shipping in large quantities; but most of the bread used on shore is made to undergo, previous to baking, a kind of fermentation, which appears to be of the same nature as the fermentation of saccharine substances; but is checked and modified by so many circumstances, as to render it not a little difficult to speak with certainty and precision respecting it. See Fermentation.

When dough or paste is left to undergo a spontaneous decomposition in an open vessel, the various parts of the mass are differently affected, according to the humidity, the thickness or thinness of the part, the vicinity or remoteness of fire, and other circumstances less easily investigated. The saccharine part is disposed to become converted into alcohol, the mucilage has a tendency to become sour and mouldy, while the gluten in all probability verges toward the putrid state. An entire change in the chemical attractions of the several component parts must then take place in a progressive manner, not altogether the same in the internal and more humid parts as in the external parts, which not only become dry by simple evaporation, but are acted upon by the surrounding air. The outside may therefore become mouldy or putrid, while the inner part may be only advanced to an acid state. Occasional admixture of the mass would of course not only produce some change in the rapidity of this alteration, but likewise render it more uniform throughout the whole. The effect of this commencing fermentation is found to be, that the mass is rendered more digestible and light; by which last expression it is understood, that it is rendered much more porous by the disengagement of elastic fluid, that separates its parts from each other, and greatly increases its bulk. The operation of baking puts a stop to this process, by evaporating great part of the moisture which is requisite to favour the chemical attraction, and probably also by still farther changing the nature of the component parts. It is then bread.

Bread made according to the preceding method will not possess the uniformity which is requisite; because some parts may be mouldy, while others are not yet sufficiently changed from the state of dough. The same means are used in this case as have been found effectual in promoting the uniform fermentation of large masses. This consists in the use of a leaven or ferment, which is a small portion of some matter of the same kind, but in a more advanced stage of the fermentation. After the leaven has been well incorporated by kneading into fresh dough, it not only brings on the fermentation with greater speed, but causes it to take place in the whole of the mass at the same time: and as soon as the dough has by this means acquired a due increase of bulk from the carbonic acid, which endeavours to escape, it is judged to be sufficiently fermented, and ready for the oven.

The fermentation by means of leaven or sour dough is thought to be of the acetous kind, because it is generally so managed that the bread has a sour flavour and taste. But it has not been ascertained that this acidity proceeds from true vinegar. Bread raised by leaven is usually made of a mixture of wheat and rye, not very accurately cleared of the bran. It is distinguished by the name of rye bread; and the mixture of these two kinds of grain is called bread-corn, or meslin, in many parts of the kingdom, where it is raised on one and the same piece of ground, and passes through all the s of reaping, thrashing, grinding, his mixed state.

or barm is used as the ferment for kinds of bread. This is the muci- froth, which rises to the surface of its first stage of fermentation When ed with dough, it produces a much peedy and effectual fermentation at obtained by leaven, and the bread dingly much lighter, and scarcely r. The fermentation by yeast seems lmost certainly of the vinous or spi- kind.

d is much more uniformly miscible ater than dough, and on this cir- ce its good qualities most probably great measure depend.

ry great number of processes are cooks, confectioners, and others, to kes, puddings, and other kinds of n which different qualities are re- Some cakes are rendered brittle, or called *short*, by an admixture of r of starch. Another kind of brit- s given by the addition of butter or hite of egg, gum-water, isinglass, ner adhesive substances are used, is intended that the effect of fer- on shall expand the dough into an ngly porous mass. Dr. Percival has nended the addition of salep, or the us powder of the orchis root. He at an ounce of salep, dissolved in a f water, and mixed with two pounds r, two ounces of yeast, and eighty of salt, produced a remarkably good eighing three pounds two ounces; loaf made of an equal quantity of ner ingredients, without the salep, d but two pounds twelve ounces. If p be in two large quantity, however, liar taste will be distinguishable in d. The farina of potatoes, likewise, with wheaten flour, makes very good The reflecting chemist will receive rable information on this subject n attentive inspection of the receipts met with in treatises of cooking and ionary.

CIA. An Italian term, frequently used mineralogical writers to denote such und stones as are composed of agglu- fragments of considerable size. the agglutinated parts are rounded, ne is called pudding-stone. Breccias ominated according to the nature r component parts. Thus we have ous breccias, or marbles, and silice- eccias, which are still more minutely according to their varieties. See neralogies of Cronstedt, Kirwan, and

WING. See BEER, also ALCOHOL.

K. Among the numerous branches general art of fashioning argillaceous into useful forms, and afterward ing them by fire, the art of making nd tiles is by no means one of the least useful. By this art we possess the advantage of obtaining the materials for constructing edifices at cheap rates, in almost every situation, without the expense of carrying stone from remote quarries; and this is so far from being the only advantage, that it is extremely probable, that these artificial compositions, if properly made, would prove superior in durability to every natural stone. The streets in Holland are every where paved with a hard kind of brick, known by us under the name of clinkers, and used in this country for paving stables and court-yards; and the houses in Amsterdam appear to be not at all decayed, but are perfectly fresh, as if new, though most of those in the vicinity of the Exchange have stood at least two centuries. The spirit of improvement may perhaps effect at some future period, in this country, what the stimulus of necessity has done on that naturally poor spot.

The art of brickmaking has for the most part been confined to the manufactories, no one having attended to it in a direct chemical way, except the celebrated Bergman. I shall therefore in the present article give an account of the leading facts and observations in his treatise.

The pottery made use of in the construction of edifices may be considered as of two forms; tiles for the roof, or bricks for the walls; to which may be added another kind of bricks for pavements. Softness and porosity are the greatest fault of tiles. The water retained in the pores of tiles becomes frozen in winter; and as ice occupies a larger space than water, the expansion of the water, at the instant of its congelation, does not fail to split and destroy such porous and brittle substances as tiles which are ill made. This has been remedied by covering them with a glaze, which adds considerably to the expense. Bergman is of opinion, that a stronger heat used in the baking would render them so close as to absorb very little moisture.

This illustrious chemist did not find that pure clay, or argillaceous earth, was fusible either alone or when mixed in any proportion with lime, though the addition of the smallest quantity of siliceous earth brought the mass into fusion. Neither was clay fusible with pure quartz alone. Spath fluor renders it fusible; as does likewise feld spar.

Common clay is scarcely ever found in a state approaching to purity on the surface of the earth. It usually contains a large proportion of siliceous earth. Bergman examined several clays in the neighbourhood of Upsal, and made bricks, which he baked with various degrees of heat, suffered them to cool, immersed them in water for a considerable time, and then exposed them to the open air for three years. They were formed of clay and sand. The hardest were those, into the composition of which a fourth part of sand had entered. Those which had been exposed for the shortest time to the fire were almost totally destroyed, and crumbled down by the action of the air: such as had been more thoroughly burned, suffered less damage; and in those which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole, he observes, that the proportion of sand to be used to any clay, in making bricks, must be greater, the more such clay is found to contract in burning; but that the best clays are those which need no sand. Bricks should be well burned; but no vitrification is necessary, when they can be rendered hard enough by the mere action of the heat. Where a vitreous crust might be deemed necessary, he recommends the projection of a due quantity of salt into the furnace, which would produce the effect in the same manner as is seen in the fabrication of the English pottery called stoneware.

It is of considerable importance to examine clay before it is made into tiles. This is done in a rough way by the manufacturers; but Bergman advises the following as the most expeditious process: Nitric acid poured upon unburned clay detects the presence of lime, by producing an effervescence. Calcareous clays, or marles, are often the fittest materials for making bricks. In the next place, a lump of clay, of a given weight, is to be diffused in water by agitation. The sand will subside, and the clay remain suspended. Other washings of the residue will carry off some clay, and by due management in this way, the sand, or quartzose matter, may be had separate. Nitric acid by digestion will take up the lime from a part of the clay, previously weighed, and this may be precipitated by volatile alkali. The clay, the sand, and the lime may thus be well enough ascertained by weight, so as to indicate the quantity of sand or other material requisite to be added in order to form that compound, which, from other experiments, may have been found best adapted to produce good tiles and bricks. An examination with the microscope will show whether the sand contain feld spar, or other stones of known figure.

The brickmakers in the vicinity of London collect the refuse cinders and ashes of the coal fires of that metropolis, and employ women to sift them. The cinders, called breeze, are used as fuel in the burning, and the smaller powder, or black ashes, enter into the composition of the bricks instead of sand. The proper management of the clay is of considerable importance with respect to the quality of the bricks; and various acts have been passed, to prohibit its use when recently dug. The clay is best if dug in the fall of the year, and exposed to the frosts during the winter, turning it over once or oftener during the time. Indeed the more it is turned and worked with the spade the better. When thus mellowed, it may be thrown into shallow pits in the spring, and left to soak in water some days. It is then to be tempered, and wrought into a smooth paste, with as little water as possible. This is usually done by a horsemill. All the stones ought to be picked out; but this is seldom done, except in the finer articles. When the materials are properly mixed and wrought, the bricks are fashioned in wooden moulds; and then piled up in long double rows to the height of four or five feet, the bricks being so arranged as to admit a free access of air between them, and covered at top with straw, to defend them from the rain. When sufficiently dried in this manner, they are commonly built up into large square heaps, called clamps, stratified with fuel between the rows, and leaving room for the fire to play between the bricks. Two or more arches likewise, according to the size of the clamp, are formed at the bottom, for holding the fuel, and kindling the fires. In this way it is obvious the bricks cannot be uniformly burnt; and to deficiencies in the management of this process, and negligences in tempering and working the materials, we may probably ascribe the bad qualities of too many bricks. A few of the finest kinds of bricks, for particular uses, as well as tiles, are burnt in kilns erected for the purpose, where the fire can be managed with much more regularity.

A kind of bricks called fire-bricks are made near Windsor, which are very hard, heavy, and contain a large proportion of sand. These are chiefly used in the construction of furnaces for steam-engines, or other large works, and in lining the ovens of glass-houses, as they will stand any degree of heat. Indeed they should always be employed where fires of any intensity are required.

Bricks (Floating). See Agaric (Mineral).

Bricks (Oil of). This oil, which once bore the imposing epithets of *sanctum*, *divinum*, *benedictum*, and *philosophorum*, is nothing more than common olive oil, rendered empyreumatic by quenching red-hot bricks in it, breaking these to pieces, and expelling the oil they had imbibed by distillation in a retort. It has long fallen into disuse.

Brimstone. See Sulphur.

Brocatello. A calcareous stone or marble, composed of fragments of four colours, white, gray, yellow, and red.

Bronze. A mixed metal, consisting chiefly of copper, with a small proportion of tin, and sometimes other metals. It is used for casting statues, cannon, bells, and other articles, in all which the proportions of the ingredients vary. The addition of tin to copper renders it brittle and hard, singularly augments its density, and makes it more fusible. The compound possesses likewise the advantage of being less subject to corrosion, or rust, by exposure to the air. Cannon and statues have less tin in their composition than bells; and in speculum metal the proportion of tin is greatest of all. See SPECULUM.

The operation by which large works of bronze are cast, as described by Macquer, is sufficiently simple. For this purpose a brick furnace is used, nearly in the shape of a baker's oven. The floor of this furnace is concave, and consists of a composition of sand and clay. In this hollow floor the metals are placed. The furnace has four openings. The first is a lateral mouth, at which the flame of the fuel enters, which is placed in a second furnace on one side of the first. The second opening is a chimney placed on the side opposite the mouth, by means of which the flame is drawn over the metal. The third opening is a hole, which can be shut or opened at pleasure, to inspect the state of the inside of the furnace and its contents. When the metal is in the state required, a fourth aperture is opened, communicating with the hollow floor, through which the melted metal flows by channels into the moulds prepared to receive it.

The recovery of copper from old bell metal is an object which is sometimes desirable. Chemistry affords various methods of doing this, an interesting detail of which may be seen in the ninth volume of the Annales de Chimie.

The ancients used bronze for many purposes, for which we employ steel and iron; as, for surgeons' instruments, swords, springs, and nails. According to Mongez, who has analysed several specimens, their bronze consisted of copper alloyed with tin in different proportions, as from four thousandth parts to thirteen hundredth parts. Traces of zinc too were found, but none of arsenic or iron, to which their hardness has been ascribed by some. Their cutting instruments of bronze, however, appear to have been hammer-hardened, as traces of this tool are found on them. The broad spring plate of the catapulta for throwing darts was formed of a bronze, according to Philo of Byzantium, consisting of copper alloyed with three hundredth parts of tin.

BRUNSWIC GREEN. This is an ammoniaco-muriat of copper, much used for paper-hangings, and on the continent in oil painting. See COPPER.

BUTTER. The oily inflammable part of milk, which is prepared in many countries as an article of food. This substance appears to be diffused through milk, either mechanically, or, which is more probable, by an imperfect chemical union; that is, by combination with the caseous, saccharine, and acid parts, which form the medium of its suspension in the aqueous fluid. When milk is suffered to remain at rest for several hours, a thick fluid rises to the top, well known by the name of cream, and consisting of the butter, together with a considerable mass of caseous and serous particles. It has not been ascertained whether this ascent of the cream be attended with any chemical change or ferment of the whole fluid, but it seems very probable that this is the case.

Butter as it exists in cream does not form continued masses, but has its parts separated by the interposition of the other principles. Some butter will however be separated without any operation, further than the mere continuance of standing undisturbed. But the common method of separating it consists in agitating the cream, for a certain time, in a vessel called a churn, the form of which is various, but its essential purpose the same. By this treatment it is collected in a uniform soft mass, possessing scarcely any smell; of a mild agreeable taste, easily fusible, and suffering no perceptible disengagement of any of its principles by any degree of heat not exceeding that of boiling water.

We do not possess any direct experiments to show what it is that occasions the difference between the obvious qualities of butter and those of other oils, distinguished by the name of fat or fixed oils, from their not rising by a low heat. It resembles them in its habitudes as nearly as they resemble each other respectively. By distillation on the water bath it gives out a portion of watery fluid, that either remained interposed between its parts from the first, or was taken up during the washing it undergoes in the making. A stronger heat, carefully managed, expels first a strong acid of a penetrating smell, which is followed by a concrete coloured oil possessing the same odour. Very little coal remains. The acid appears to be of the same nature as that distinguished by the name of the sebacic: and it may also be obtained from butter by means of lime or an alkali. See ACID (SEBACIC).

Butter becomes rancid sooner than most other fat oils, probably on account of the water, which may favour the development of its acid. Washing with water or alcohol restores it in some measure to its former state, by carrying off the disengaged part of the acid. The common mode of preserving it is by the addition of salt, which will keep it good a considerable time, if in sufficient quantity. Mr. Eton informs us, in his Survey of the Turkish Empire, that most of the butter used at Constantinople is brought from the Crimea and Kirban, and that it is kept sweet by melting it while fresh over a very slow fire, and removing the scum as it rises. He adds, that by melting butter in the Tartarian manner, and then salting it in ours, he kept it good and fine-tasted for two years; and that this melting, if carefully done, injures neither the taste nor colour. Thenard, too, recommends the Tartarian method. He directs the melting to be done on a water-bath, or at a heat not exceeding 180° F.; and to be continued till all the caseous matter has subsided to the bottom, and the butter is transparent. It is then to be decanted, or strained through a cloth, and cooled in a mixture of pounded ice and salt, or at least in cold spring water, otherwise it will become lumpy by crystallizing, and likewise not resist the action of the air so well. Kept in a close vessel, and in a cool place, it will thus remain six months or more nearly as good as at first, particularly after the top is taken off. If beaten up with one sixth of its weight of the cheesy matter when used, it will in some degree resemble fresh butter in appearance. The taste of rancid butter, he adds, may be much corrected by melting and cooling in this manner.

Dr. Anderson has recommended another mode of curing butter, which is as follows: Take one part of sugar, one of nitre, and two of the best Spanish great salt, and rub them together into a fine powder. This composition is to be mixed thoroughly with the butter, as soon as it is completely freed from the milk, in the proportion of one ounce to sixteen; and the butter thus prepared is to be pressed tight into the vessel prepared for it, so as to leave no vacuities. This butter does not taste well till it has stood at least a fortnight; it then has a rich marrowy flavour, that no other butter ever acquires; and with proper care may be kept for years in this climate, or carried to the East Indies, if packed so as not to melt.

In the interior parts of Africa, Mr. Park informs us, there is a tree much resembling the American oak, producing a nut in appearance somewhat like an olive. The kernel of this nut, by boiling in water, affords a kind of butter, which is whiter, firmer, and of a richer flavour, than any he ever tasted made from cows' milk, and will keep without salt the whole year. The natives call it *shea toulou*, or tree butter. Large quantities of it are made every season.

Butter of Antimony. The combination of oxide of antimony with the oxigenated muriatic acid. It is usually made by distilling a mixture of oxigenated muriat of mercury and antimony. See Antimony.

Butter of Arsenic. A combination of the oxide of arsenic with oxigenated muriatic acid; obtained by a process similar to that used in making the butter of antimony.

Butter of Cacao. An oily concrete white matter, of a firmer consistence than suet, obtained from the cacao nut, of which chocolate is made. The method of separating it consists in bruising the cacao and boiling it in water. The greater part of the superabundant and uncombined oil contained in the nut is by this means liquefied, and rises to the surface, where it swims, and is left to congeal, that it may be the more easily taken off. It is generally mixed with small pieces of the nut, from which it may be purified by keeping it in fusion without water in a pretty deep vessel, until the several matters have arranged themselves according to their specific gravities. By this treatment it becomes very pure and white.

Butter of cacao is without smell, and has a very mild taste, when fresh; and in all its general properties and habitudes it resembles fat oils; among which it must therefore be classed. It is used as an ingredient in pomatums.

Butter of Tin. When granulated tin, or an amalgam of tin and mercury, is distilled with corrosive muriat of mercury, the tin rises in combination with the oxigenated muriatic acid, partly in the form of a liquor, and partly in butyraceous flowers. The liquor is called the fuming liquor of Libavius, and is not essentially different from the flowers. Many chemists distinguish the whole product by the name of the fuming liquor of Libavius. See Tin.

Butter of Wax. Wax, though differing very considerably from fat oils, resembles them in affording an acid by distillation, while the remaining oleaginous part becomes more limpid, in proportion as the number of distillations is repeated. The first distillation leaves it of a butyraceous consistence, and this is called butter of wax. It has a strong smell, and is said by Macquer not to recover its consistence by long exposure to the air; in which particular he observes that it differs from resinous substances.

Button. The round mass of metal obtained in small reductions or other chemical experiments, and found at the bottom of the crucible or vessel wherein the operation is performed, is called the button by chemists.

Byssus. The asbestus, composed of parallel fibres, is distinguished by some under this name.

C.

CABBAGE (Red). See Brassica Rubra.

Cabochôn. The French use this word to denote the figure of precious stones when polished with a convex surface.

Cacao (Butter of). See Butter.

Cacholong. A very hard compact white agate. It is semitransparent, and in this respect differs from the moonstone, which has a milky white, with a few various shades of light proceeding from an internal blueish ground. The cacholong is vitrifiable and capable of a good polish. It is found in the river Cache in the Calmucks' country, whence in their language it takes its name.

Cadmia. A word scarcely met with in the writings of the later chemists. It has been given to various substances. The cadmia of the furnaces is matter that sublimes when ores containing zinc, like those of Rammelsberg, are smelted. This consists of the flowers of zinc, which rise by the violent heat of combustion, and adhere to the inside of the walls of the furnace; which being hot do not condense them immediately into the solid state, but cause them to pass through a state of fluidity intermediate between the elastic and the solid state. On this account they have a much less interrupted solidity than the flowers of zinc usually possess. The quantity collected at Rammelsberg is so considerable, as to form a very thick crust, requiring to be frequently removed. The name of cadmia has also been given to other sublimates that rise in the smelting of ores.

Calamine, or lapis calaminaris, which is an ore of zinc, has also been called native cadmia. This, as well as the cadmia of the furnaces, is used in the converting copper into brass. See Copper.

The ore of cobalt is sometimes, but very improperly, called fossil cadmia.

Cæruleum Montanum. An ore of copper classed by Cronstedt among the calcareous earths, as a combination of that earth with the metal, which is indeed occasionally contaminated with it. There are different varieties of it, containing from 66 to 70 per cent. of copper, 1 or 2 of water, and the remainder carbonic acid. It is found in Cornwall, as well as in different parts of Europe. It is most frequently found of a loose pulverulent form, though sometimes indurated and even crystallized, but it is then mixed with quartz. It may be analysed by solution in acids, and precipitation by immersing a piece of iron in the solution, which will throw down the copper in the metallic state.

Cæsalpinia. See Brazil.

Cajeput Oil. The volatile oil obtained from the leaves of the Cajeput tree. Cajeputa officinarum, the Melaleuca Leucadendron of Linn. The tree which furnishes the cajeput oil is frequent on the mountains of Amboyna, and other Molucca islands. It is obtained by distillation from the dried leaves of the smaller of two varieties. It is prepared in great quantities, especially in the island of Banda, and sent to Holland in copper flasks. As it comes to us it is of a green colour, very limpid, lighter than water, of a strong smell, resembling camphor, and a strong pungent taste, like that of cardamons. It burns entirely away, without leaving any residuum. It is often adulterated with other essential oils, coloured with the resin of milfoil. In the genuine oil, the green colour depends on the presence of copper; for when rectified it is colourless.

Calamine. An ore of zinc of a white, gray, yellow, brown, or red colour, of various hardness, though scarcely ever hard enough to strike fire with the steel. Its texture is either equable or cellular, and its form irregular, or crystallized, or in stalactites. It does not lose weight by calcination, unless mixed with charcoal; and then the zinc rises in flowers. Acids dissolve it, and with the sulphuric it affords sulphat of iron as well as of zinc. The specific gravity of the best sort, that is the gray, is 5·000; and 100 parts of this afforded Bergman 84 of oxide of zinc, 3 iron, 1 clay, and 12 siliceous earth; but in other specimens the proportions are very different. Most of the English calamines contain lead.

Mr. Smithson has lately analysed several specimens of calamine, chiefly with a view to confirm or refute the assertion of Haüy, that all calamines were simple oxides of zinc, without any carbonic acid. White calamine of Bleyburg, of the specific gravity of 3·59, afforded oxide of zinc ·714, carbonic acid ·135, water ·151: a very small portion of the carbonats of lead and of lime were present. Greenish yellow calamine, from Mendip in Somersetshire, of the sp. gr. of 4·336, oxide of zinc ·648, carbonic acid ·352. Pale yellow calamine in small crystals from Derbyshire, sp. gr. 4·333, oxide of zinc ·652, carbonic acid ·348. These crystals were not rendered electric by heat. Electrical calamine from Regbania in Hungary, sp. gr. 3·434, oxide of zinc ·683, quartz ·250, water ·044. This species is likewise found in Derbyshire, in small brown crystals.—*Phil. Trans.*

Calcareous Earth. See Earths.

Calces (Metallic). Metals which have undergone the process of calcination or combustion, or any other equivalent operation, now termed oxides.

Calcination. The fixed residues of such matters as have undergone combustion are called cinders in common language, and calces, or now more commonly oxides, by chemists; and the operation, when considered with regard to these residues, is termed calcination. In this general way it has likewise been applied to bodies not really combustible, but only deprived of some of their principles by heat. Thus we hear of the calcination of chalk, to convert it into lime, by driving off its carbonic acid and water; of gypsum or plaster stone, of alum, of borax, and other saline bodies, by which they are deprived of their water of crystallization; of bones, which lose their volatile parts by this treatment; and of various other bodies. See Combustion and Oxidation.

Calculus, or Stone. This name is generally given to all hard concretions, not bony, formed in the bodies of animals. Of these the most important, as giving rise to one of the most painful diseases incident to human nature, is the *urinary calculus*, or stone in the bladder. Different substances occasionally enter into the composition of this calculus, but the most usual is the lithic acid, under which article we have already given Scheele's analysis of the stone. The mulberry calculi, as they are called from the roughness of their coat, always contain oxalat of lime. Fourcroy enumerates twelve different substances, which he found in calculi of various kinds. The lithic acid already mentioned: Lithat of ammonia, which according to him sometimes forms the whole of a calculus: Phosphat of lime, which frequently occurs: Ammoniaco-magnesian phosphat, which, as was shown by Dr. Wollaston, forms projecting points on some urinary calculi, and the external strata of others, as well as of a great part of the intestinal bezoars of the elephant, horse, and larger mammalia: Oxalat of lime, found only in human urinary calculi: Silex, which occurred in very small quantity, in two out of six hundred calculi, and may be considered as accidental: Gelatine, which accompanies most of the other ingredients as a connecting medium: Superphosphat of lime, which is confined chiefly to the bezoars: Lithat of soda, discovered by Mr. Tennant in arthritic concretions: Carbonat of lime, which occurs in the urinary calculi of other mammalia, but not in those of man: Adipocere, found only in human biliary calculi: the animal resin of the bezoars.

Dr. Pearson, by dissolving urinary calculi in caustic alkali, and precipitating by acids, found a substance, which he thus characterizes:—It does not indicate acidity to the most sensible tests: it is inodorous, tasteless, and scarcely soluble in cold water: it does not unite with the alkali of carbonat of potash, soda, or ammonia, the oxide of mercury, or the lime of limewater: it does not decompound soap or prussiat of iron; and its combination with caustic soda more resembles a soap than a neutral salt: before the blowpipe it burns away without any sign of fusion, and stains the platina spoon black: distilled in close vessels it affords the distinguishing products of animal matter, particularly ammonia and prussic acid: it does not appear to be putrescible. Accordingly Dr. Pearson considers it as an animal oxide, which he thinks should be called *ouric* or *uric* oxide: and gives as its distinguishing characters, imputrescibility, facility of crystallization, insolubility in cold water, and above all the production of a pink or red matter on evaporation of its solution in nitric acid.

Out of 200 specimens, not more than six were wholly without this animal matter; but they contained it in different proportions, varying from $\frac{1}{200}$ to $\frac{188}{200}$, but commonly between $\frac{10}{200}$ and $\frac{140}{200}$.

The urinary calculus of a dog, examined by Dr. Pearson, was found to consist principally of the phosphats of lime and ammonia, with animal matter. Several taken from horses were of a similar composition. One of a rabbit consisted chiefly of carbonat of lime and animal matter, with perhaps a little phosphoric acid. A quantity of sabulous matter, neither crystallized nor concrete, is sometimes found in the bladder of the horse: in one instance there were nearly 45 pounds. These appear to consist of carbonat of lime and animal matter. A calculus of a cat gave Fourcroy three parts of carbonat, and one of phosphat of lime. That of a pig, according to Bertholdi, was phosphat of lime.

The renal calculus in man appears to be of the same nature as the urinary. In that of the horse Fourcroy found 3 parts of carbonat and one of phosphat of lime: Dr. Pearson, in one instance, carbonat of lime and animal matter; in two others, phosphats of lime and ammonia, with animal matter.

Arthritic calculi, or those formed in the joints of gouty persons, were once supposed to be carbonat of lime, whence they were called chalkstones; afterward it was supposed, that they were phosphat of lime; but Dr. Wollaston has shown, that they are lithiat of soda. The calculi found sometimes in the pineal, prostate, salivary, and bronchial glands, in the pancreas, in the corpora cavernosa penis, and between the muscles, as well as the tartar as it is called that encrusts the teeth, appear to be phosphat of lime. Dr. Crompton, however, examined a calculus taken from the lungs of a deceased soldier, which consisted of lime ·45, carbonic acid ·37, albumen and water ·18. It was very hard, irregularly spheroidal, and measured about 6½ inches in circumference.

For the biliary calculi, see Gall. Those called *bezoars* have been already noticed under that article.

It has been observed, that the lithic acid, which constitutes the chief part of most human urinary calculi, and abounds in the arthritic, has been found in no phytivorous animal; and hence has been deduced a practical inference, that abstinence from animal food would prevent their formation. But we are inclined to think this conclusion too hasty. The cat is carnivorous; but it appeared above, that the calculus of that animal is equally destitute of lithic acid, which indeed seems peculiar to man. If therefore we would form any deduction with respect to regimen, we must look for something used by man exclusively of all other animals; and this is obviously found in fermented liquors, but apparently in nothing else: and this practical inference is sanctioned by the most respectable medical authorities.

The property of forming calculi is observed likewise in vegetables. Several botanists have described these vegetable concretions, particularly in the cocoa, the palm, &c. Jussieu had many in his collection. They are called vegetable bezoars, and credulity has extolled them as powerful remedies. The concretion found in the joints of the bamboo cane, and known by the name of torbasheer, was shown by Mr. Macie to consist of siliceous earth.

It is well known that several fruits, more especially pears, are very subject to contain a quantity, sometimes considerable, of granulated, irregular, hard concretions, which are known by the name of Stones. Vauquelin has made a number of experiments on these, which prove, that they are of the same nature as wood.—*Phil. Trans.*—*Annal. de Chimie.*

Call. A word used by the miners to denote schoerl or cockle, and also other matters; but Da Costa says that, definitely speaking, it denotes the mineral called tungsten.

Calomel. The mild muriat of mercury. See Mercury.

Caloric. By this term is understood what has been usually called heat, and sometimes fire, by those philosophers who have considered it merely as a quality, or power of producing certain effects, inherent in bodies; and matter of heat, or igneous fluid, by those who have held it to be a peculiar substance. With a view to determine, whether caloric, or heat, be or be not a substance, attempts have been made to weigh it: but nothing satisfactory on this head is deducible from the experiments of Dr. Fordyce or Mr. Davy, Morveau or Lavoisier, Fontana or count Rumford. Indeed there is sufficient evidence, in the different states of bodies, that caloric renders them specifically lighter: but a mere repulsive power, enlarging their bulk without the addition of any substance, would have the same effect; this therefore proves nothing. All the phænomena, however, appear to admit of explanation in a simple manner, on the supposition, that caloric is a substance; except in the large quantity of heat that may be produced by friction or percussion. In the well-known practice of the smith, who kindles a fire by hammering a piece of iron till red hot, much more heat is evolved than the iron could possibly contain; but this may be derived from the surrounding substances. The same may be said of the experiment of count Rumford, in which he fixed a cylinder of brass in a trough filled with water, and adapted a borer to it, which was made to revolve in the usual manner at the rate of thirty-two times in a minute. The apparatus weighed 15 pounds, and the water 18. In an hour the temperature was raised from 60° to 107°, and in two hours and a half the water boiled. Boyle and Pictet, however, had found, that heat was equally produced by friction in an exhausted receiver; and Mr. Davy has shown the same. But neither is this a substantial objection; for the apparatus must have been in contact with other bodies: and beside, it has been shown that heat, like light, pervades even the Torricellian vacuum. This last-mentioned fact, and still more the radiation of caloric from heated bodies, which is capable of reflection and condensation, seem to show its materiality. We shall now proceed to the facts which illustrate its properties.

The most general and extensive property of caloric is its tendency to equilibrium, or to diffuse itself equally through all bodies; so that whatever substances, by direct or successive contact, communicate with each other, they must either have the same temperature, in other words the same relative proportion of caloric, or the hotter will communicate heat to the others, till a common temperature is produced among them.

The disposition or power of quickly transmitting heat in the production of a common temperature is not the same in different bodies. If a number of straight wires of equal sizes, but different metals, be covered each with a thin coat of wax, and their ends be plunged into the same heated fluid, for example, melted lead, the fusion of the coat of wax will show, that caloric is more quickly transmitted through some metals than others. Thus also it is found, that the end of a glass rod may be kept red-hot for a very long time, without any inconvenience to the hand that holds the other end; though a similar metallic rod, heated in the same manner, would very soon become too hot to be held. Bodies that quickly alter their temperature by communication, are said to be better conductors of caloric than such as alter more slowly. In general, the more dense a body is, the more rapidly it conducts caloric: but this does not hold true in all cases, so as to enable us to estimate the conducting power by the specific gravity.

Count Rumford has made many experiments on the transmission of caloric through fluids, from which he inferred, that they were absolute nonconductors; and that, when a body of fluid is heated throughout, it is owing to the ascent of the heated part, and the consequent successive action of the heating body on fresh portions of the fluid coming into contact with it; or to the transmission of caloric through the sides of the containing vessel. These conclusions, however, have been shown to be erroneous; though it is sufficiently proved that fluids are bad conductors of caloric; and therefore, that the heating body should be applied to the bottom of the fluid, in order that the heated part, ascending by its relative lightness, should make way for the colde and denser portions to come into contact with the body that communicates its caloric to it.

Beside the practical deduction just mentioned, the difference in the conducting power of bodies is of extensive application to various economical purposes. Hence we perceive the advantage of employing metals, when we wish to communicate heat quickly: and on the contrary their disadvantage, when heat is to be retained. Hence the utility of coating furnaces, to prevent the dissipation of heat; and glass vessels, in chemical operations, to prevent the sudden alterations of temperature, which would crack them. And hence the superiority of some articles of clothing over others, in defending us from the cold, or against the effects of sudden changes of temperature. In some experiments made by count Rumford on the following articles, hare's fur, eider down, beaver's fur, raw silk, wool, cotton, and fine lint, he found them to be in the order in which they here stand, with regard to the slowness with which they transmitted heat. But it is to be observed, that the looseness of their texture is of more importance than the nature of the substance itself in this respect.

The general effects of a change of temperature are these: a solid is rendered fluid by an increase of temperature, and a still greater increase converts it into elastic fluid, or vapour. If the body be composed of parts which become solid, fluid, or vapourous, at different temperatures; and the elective attraction, by which these parts are held together, be insufficient to prevent their assuming these states by the change of temperature, a separation will then take place: thus a diminished temperature separates salts from water, by their becoming solid; and an increased temperature separates water from salts, by causing the former to fly off in vapour. Lastly, if neither the change of temperature be considerable enough to alter the state of solidity, fluidity, or vapour, which the body under consideration may happen to possess, nor the body itself be of the nature to undergo a separation of its parts by the change, then an increase of temperature will cause an increase in the bulk or dimensions of the body, which will last no longer than during the time of the increase.

It has already been observed, that the temperature at which the different bodies change their form is various. Neither this property, nor the expansion of bodies by heat, has been observed to have any correspondence with their density, hardness, specific gravity, or other evident properties. There are, likewise, some irregularities in the contraction or expansion, which depend on circumstances not yet well ascertained, near the freezing point of water, and probably other substances. Pure water, when cooled, is observed to contract till within about eight degrees of the freezing temperature, where it begins to expand; and it may be cooled eleven degrees below that temperature, and still continue fluid. An adequate explanation of the circumstances that attend the conversion of bodies from their several states of solidity, fluidity, and vapour, seems to promise a more intimate acquaintance with the nature and properties of the particles of bodies, than has hitherto been obtained.

Permanently elastic fluids, or gases, appear to differ from vapour in the circumstance, that they take and retain the elastic form at a lower temperature. There are facts which render it probable, from analogy, that a great degree of cold would convert them into dense fluids.

It is a self-evident truth, that, if two bodies be perfectly equal and alike in all respects, and have the same temperature, they will possess equal quantities of caloric.

Thus, a pound of gold will possess an equal quantity of caloric with another pound of gold at the same temperature; a pound of water will possess an equal quantity of caloric with another pound of water at the same temperature, and so forth. From this it will also be clear, that two pounds of gold will possess twice as much caloric as one pound of gold, at the same temperature; and generally, that the quantities of caloric in bodies of the same kind, and at the same temperature, will be in proportion to their quantities of matter, or their weights.

If two such equal and similar bodies, that differ in temperature, be brought together, they will, by communication, acquire a common temperature, and their quantities of caloric will by this means be rendered equal. For this purpose, it is clear that the hotter of the two bodies must have communicated half its excess to the colder. The quantity of caloric in one of the two equal bodies will therefore be an arithmetical mean between the two quantities originally possessed by each of them; that is to say, its temperature, or the common temperature, will exceed that of the colder exactly as much as it falls short of the hotter body.

If the two bodies had been unequal, they would nevertheless have acquired a common temperature by communication; but the excess of caloric would not have been equally divided between them. For we have shown, that the quantities of caloric in such bodies, at the same temperature, are in proportion to the quantities of matter. If the surplus of caloric had been entirely taken away, it is obvious that their temperature would have been made equal, and their quantities of caloric would have been in that proportion; and there is no other way of adding the surplus to them, so as to preserve the same proportion, but by giving more to the larger than to the smaller body, according to its quantity. The common temperature that they acquire shows that this is done; and consequently that, when

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e changed by heating or cooling, the temperature, or power to heat or cool other bodies, will not follow the same proportion as the quantities of caloric; though it may be imagined, not without probability in this case, that correspondent irregularities in the expansions of the mercury may cause the thermometer to indicate the arithmetical means between the two expansions produced by an extreme temperature. But whatever irregularities may be supposed to counteract each other in these experiments with mercury and water, it is to the last degree improbable, that the same compensation would be found, when the mean temperature is obtained by other methods. With this view, the celebrated Dr. Crawford very carefully repeated and confirmed Mr. de Luc's experiments, made others with a like result, by using linseed oil instead of water, and also by producing the mean temperature permanently in air included in a cylinder formed of two equal parts, the upper of which was kept to the freezing point, by surrounding it with pounded ice, and the lower to the boiling water point, by surrounding it with a greater supply of steam than could be condensed by its contact. The near correspondence of these several methods shows, that the expansions of mercury in the thermometer are correspondent with the caloric it receives.

Thus far we have attended only to the communication of caloric between bodies of the same kind; but when two equal bodies of different kinds produce a common temperature by communication, it seldom happens that it proves to be an arithmetical mean between the two original temperatures. In such cases, it is evident, that the caloric, which was communicated from one to the other, has not altered their temperatures equally, but has raised or lowered that of the one more than it has lowered or raised that of the other. And as the proportion between the number of degrees through which one of the two bodies is thus raised, and the other lowered, is found, by experiment, to be the same, however different the two original temperatures may have been, provided no change of form or chemical combination has been produced in either of them; it is a general consequence, that the quantity of caloric required to alter the temperature of one of the bodies a single degree, or any other equal part, will be greater or less than would be required to produce the same change in the other body, in proportion as the changes produced by the communicated caloric were less or greater.

The whole of the caloric in each body, when they have the same temperature, must consist of the same number of degrees: the proportion between the whole quantities of caloric of the bodies will, therefore, be the same as between the quantities required to raise each of them a single degree: that is to say, the comparative quantities of caloric of bodies, at the same temperature, will be in the inverse proportion of the number of degrees their temperature is altered by the transmission of the same quantity of caloric.

To illustrate this by an example in round numbers: Suppose a pint of mercury, at the temperature of 136°, be mixed with a pint of water at 50°, the mean temperature will be 76°. The water, therefore, has been heated 26°, and the mercury has been cooled 60°, by the loss of the caloric it imparted to the water. The absolute caloric in one degree of the mercury will, consequently, be proportionally less than that of one degree of the water; because the very same caloric which has raised the water 26° in temperature, would raise the mercury 60°, if it could be returned again; and the whole of the caloric contained in the mercury will be to that of the water in the same proportion of 26 to 60. But in the present experiment, equal bulks were used; and mercury is about thirteen times as heavy as water; and equal weights of mercury would contain only one thirteenth part of the heat. Twenty-six, divided by 13, quotes 2. Whence, the comparative quantities of caloric, of mercury, and water, are in the proportion of about 2 to 60, or one to 30; that is to say, a pound of mercury, at the same temperature, contains no more than one thirtieth part of the caloric contained in a pound of water.

It may be observed, that the term comparative quantity of caloric is used to denote the proportion of the absolute quantity of caloric in one body to that of another equal mass of matter at the same temperature, considered as a standard. The standard made use of is pure water in a fluid state. Some writers call this specific heat. The disposition or property by which bodies severally require more or less caloric to produce equal changes in their temperature, is called their capacity for caloric, or for heat. These capacities are considered as the unknown cause of the difference in their comparative quantities of caloric, to which they are consequently proportional.

It is found by experiment, that the capacity of the same body for caloric is least when solid, greater when fused or fluid, and greatest of all when it becomes converted into vapour, or elastic fluid.

Also, when bodies unite by virtue of chemical attraction, their capacities are seldom the same as the sum of the capacities of the bodies, but almost always either greater or less.

As the experiments relating to the capacities of bodies cannot be here given at large, it will be proper to mention, by way of inference, some of the chief consequences of this most luminous doctrine; first premising, however, that these inductions have all been verified by experiment.

The capacities of ice and fluid water are found to be as 9 to 10. Ice cannot, therefore, be converted into water, unless it be supplied with as much caloric as is sufficient to answer the difference of capacity. Thus, if equal quantities of ice and water, both at the temperature of 32°, or the freezing point, be exposed in similar vessels, at the same distance from a fire, both will receive caloric alike, and the ice will be melted into water at 32°, while the water in the other vessel will have its temperature raised to 178°. Here it is obvious, that the same heat which raised the water 146°, was merely sufficient to supply the increased capacity of the ice; for which reason this last had not its temperature raised at all. If the experiment be more accurately made, by mixing equal weights of water at 178° and ice at 32°, the same consequence will follow; for the ice will be melted, and the common temperature will be 32°; because the ice in melting receives no augmentation of temperature by absorbing the whole 146° of heat from the water, by virtue of its increased capacity when it becomes fluid.

And so, likewise, when water is frozen by the loss of its caloric, communicated to a cold atmosphere or other contiguous bodies, the process of cooling goes on till ice begins to be formed; but during the whole time of the conversion of the water into ice, the temperature remains stationary, because the diminished capacity of the ice causes it to give out caloric, the continual evolution of which supplies the refrigerating bodies with as much as their energy of cooling might otherwise have taken to cause a diminution of the temperature. When the whole is frozen, this supply of extricated caloric ceases; and therefore the cause that cooled the water at first, goes on in cooling the ice, till the common temperature is produced.

In all experiments, wherein the capacities of the same bodies are changed, and the difference between the quantities of caloric in the same body, in both states, at one common temperature, is known in the degrees of the thermometer, we may derive the advantage of finding the absolute quantities of caloric in degrees of the thermometer, or the number of degrees which any particular point or temperature is remote from the true zero, or point of absolute privation of all caloric. To illustrate this curious position, the experiments on ice and water, just related, may be made use of. The whole quantities of caloric, in these two states, are as 9 to 10. It is plain, therefore, when water freezes, it must give out one tenth of its whole caloric; and this tenth part, by the experiment, is found to amount to 146° of Fahrenheit's thermometer; consequently its whole heat is ten times 146°, or 1460°, when its temperature is 32° above Fahrenheit's zero. Whence the natural zero is at 1428°.

No direct experiment has yet been made to show the capacity of steam with relation

.An indirect experiment of Dr.,
makes it as 15⅓ to 10. It is ac-
found, that steam, in its conden-
water, gives out as much caloric
raise the temperature of an equal
of non-evaporable matter, of the
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t a difficulty attends the produc-
am, in proportion as effective ob-
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ape. If the water be heated in a
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vill be formed; if there be a small
he steam to escape, there will be
l than if the whole surface of the
uncovered; and if the superin-
tmosphere be removed, as in the
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atest of all. In every case where
can escape, it will be produced,
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nd ether, being more evaporable,
stationary point of temperature lower than water in similar circumstances of exposure. The freezing of water by means of ether affords a striking instance of this effect. Water is included in a thin glass tube, and the outside of the tube is kept continually wetted with ether, by means of a bottle with a capillary tube in its neck, through which the ether is poured. The consequence of the speedy evaporation of this very volatile fluid is, that in a very short time the included water is suddenly converted into ice, even before a fire, or in the midst of summer.

There seems to be no difficulty in accounting for the cold produced by the evaporation of water from the surface of the hand; because it is perfectly analogous to the fact where a stationary temperature, or boiling point, is produced over a fire. But in the experiment of ether it may seem remarkable, that the refrigeration is carried to a point so far beneath that of every one of the surrounding bodies. This may, however, be explained from an attention to what is observed to happen with water. If water were enclosed in a strong metallic vessel, and surrounded on all sides with ignited coals, there is no doubt, from the general course of facts, but that it would become gradually hotter, until it either burst the vessel by its expansive force, or acquired a temperature equal to that of the coals. But if a hole be suddenly opened, after the temperature has increased beyond the common boiling-water point, it is found, that a sudden extrication of steam takes place, and the fluid immediately falls to the temperature of boiling water. Now the ether, being much more volatile than water, may be considered, when confined in a bottle, to be in a state similar to that of water in Papin's Digester; and the surrounding bodies act upon the bottle like the coals in the former instance. The included ether acquires the common temperature, because it is prevented from assuming the vaporous state, and has not elasticity enough to break the vessel. But as soon as this fluid is set at liberty, it evaporates readily, and becomes cooled down towards a stationary degree of temperature; at which, if acquired, the caloric carried off by the vapour would be accurately equal to that supplied by the surrounding bodies. This temperature, at the surface of ether exposed in our climate, is, on account of its volatility, considerably below the freezing point of water; and therefore, whenever a thin stratum of ether is made to surround a small vessel of water, it is no wonder it robs it of so much caloric as to congeal it in a short time.

The effect of freezing mixtures is another evident consequence of this doctrine of the change of capacities of bodies for caloric. When common salt is added to water, in as large a quantity as can be dissolved, the brine is much more difficult of congelation than mere water; so much so, that it does not acquire the solid state until it is cooled as low as 6° below 0° on Fahrenheit's scale; or 38° below the freezing point of water. Suppose now, that the salt be mixed, not with water, but with snow, or pounded ice. These two substances will be disposed to combine together as before, but much of the effect will depend on the temperature. If this be so low, as that the combination may preserve the solid state, the external parts in contact of each will indeed unite; but they will form a solid combination, that will effectually prevent the internal parts from approaching each other, and accordingly little or no perceptible progress will be made towards the union of the whole mass. But if, on the contrary, the temperature be higher than this, the combination will be the fluid brine, though the snow and ice were solid before; and this for the plain reason, that the brine requires less caloric to fuse it, than would have been requisite to fuse the ice alone. The assumption of the fluid state in these bodies will increase their capacity, and they will be disposed to deprive the surrounding bodies of caloric; that is to say, they will be colder than before. If the quantity of snow and salt be considerable, and there be no bodies at hand which can readily supply the caloric required, the brine first produced will cool the snow and salt in its vicinity; and these, when liquefied, will cool the rest of the snow and salt still more effectually. When the temperature of the whole is by this process reduced as low as —6°, or the freezing point of the brine, the liquefaction will stop, or it will proceed more slowly or faster, in proportion as the requisite caloric can be supplied. It may therefore be easily understood, that if a mixture of this kind be placed in a vessel, and a smaller vessel containing water be plunged into it, the cooling process will freeze the water. It is likewise evident, that such mixtures can descend in temperature no lower than a certain fixed degree, which is their own freezing point.

There are other freezing processes effected by the mere liquefaction or solution of salts in water, which also appear to depend on the increased capacity of the salt, or more probably of the water contained in them. Among a variety of processes of this kind the following may be selected, not as the most powerful, but because the materials are cheap, and well known. Equal parts of saltpetre and sal-ammoniac are to be reduced to a fine powder. If four ounces of water be poured on three ounces of this mixture, the solution will sink the thermometer 36 degrees: and as it is easy in this country to have pump water, at any season, as cool as 50°, this addition will cool it to 14°, which is therefore sufficient to freeze water in a phial plunged into it. If the water cooled in a first process be used to reduce other water and salts to the temperature of about 32°, and these be applied to the performance of a second process, the temperature will be much lower, viz. 4° below 0°. The table of freezing mixtures, at the conclusion of this article, shows the effects of most of the experiments of this kind that have been tried. It is observable, that deliquescent salts produce much more cold than such as are efflorescent: and they should possess the whole of their water of crystallization, for if deprived of this they produce heat instead of cold, according to Lowitz.

Without entering more largely into examples of the change of capacity for caloric in bodies which are changed in their form or state of chemical combination, it may be observed in general, that as the powers of gravity and projection, in continual opposition to each other, produce all the varied effects of position, and its consequences, in the great system to which they are essential, so among the actions of the minute parts of bodies, the cohesive attraction and the energy of caloric are in continual opposition, and are concerned in every process of change in their peculiar properties. It is certain, that the particles of bodies do not touch each other, but are held in equilibrio at a certain distance, which varies with the temperature, as is deduced from the expansions and contractions dependent on this cause. What might be the consequences of an extreme depression of temperature, we are not likely ever to discover, and conjecture leads us very little into the doctrine of caloric. It may be observed, that the changes of capacity in bodies, when they take the solid, fluid, or vaporous state, are greatly conducive to the preservation of a more equal temperature, than would otherwise be found in the districts around us. The cold produced by evaporation mitigates and conducts to other parts the strong heats of the torrid zone, and the heat developed on the freezing of water prevents the cold countries from being cooled as far below the freezing point as might otherwise happen. If the capacities of water and ice were equal, the freezing of immense bodies of water would scarcely be progressive, but would take place the instant the whole was cooled to 32°; and so likewise the thawing of immense bodies of snow, and of mountains of ice, would be performed in the short time of the transmission of caloric requisite to elevate its temperature the minutest portion of a degree above the temperature of solidity.

There are various methods used to increase the temperature of bodies. The friction of two pieces of wood against each other in a turner's lath produces heat and flame. A nail may be made red hot by quickly hammering it, or by the action of a dry grindstone; and when flint and steel are struck together, small particles of the steel are separated, which are in a strong

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t a distance from each other, that
s may coincide, and an iron heated
nition be placed in the focus (of parallel rays) of one mirror, there will be an image of the iron formed in the focus of the other; at which if a thermometer be applied, its temperature will be raised. Whence it follows, that the caloric radiating invisibly from the iron, is governed by the same laws as the light which forms the image. Even hot water will have a similar effect. It is likewise found, that a freezing mixture, placed in the same situation, will depress the thermometer by the action of its focal image. This has been thought to evince the material nature of cold, which has in every theory been supposed to be the mere negation of heat. It does not, however, appear to prove any thing more, than that, in the present constitution of the world, caloric is emitted in all directions by all bodies; and that the freezing mixture intercepts a portion, which would have passed through the focus of one mirror, and proceeded to the other. The freezing mixture does the same thing as to the caloric, which a black substance would have effected with regard to light. A black substance in one focus would have been visible in the other; not by the emission of rays of darkness, but by the interruption and privation of as much light as would else have proceeded from its apparent place. See Light.

The separation of compounds by the action of caloric is among the most common of its applications to chemical purposes, and the modification of this action by pressure is well known. Sir James Hall has lately applied this to illustrate the Huttonian theory of geology; and to prove, that compounds, which are readily decomposed in our fires under the pressure of the atmosphere alone, may be made to undergo very great heat, without having their combination destroyed. Thus pounded chalk, exposed to 21° or 22° of Wedgwood's pyrometer, was consolidated into limestone, or a semitransparent marble, without having its carbonic acid separated from it. His experiments may be seen at length in the Edinburgh Transactions, or in Nicholson's Journal.

I. *Table of Capacities of different Substances for Caloric.*

ble, the authorities are marked by the initials of the respective authors' names.
awford: K. Kirwan: Ir. Irvine: G. Gadolin: L. Lavoisier: W. Wilcke: M.
r.

GASSES.

gen gas	21·4000	C.	4. Aqueous vapour	1·5500	C.
n gas	4·7490	—	5. Carbonic acid gas	1·6454	—
pheric air	1·7900	—	6. Nitrogen gas	·7936	—

LIQUIDS.

on of carbonat of am-			10. Arterial blood	1·0300	C.
ia	1·8510	K.	11. Water	1·0000	
on of brown sugar	1·0860	—	12. Cows milk	·9999	C.
ol (15·44)	1·0860	—	13. Sulphuret of ammonia	·9940	K.

I. *Table of Capacities of different Substances for Caloric* (Continued).

LIQUIDS.

14.	Solution of muriat of soda, 1 in 10 of water	·9360	G.
15.	Alcohol (9·44)	·9300	Ir.
16.	Sulphuric acid, diluted with 10 of water	·9250	G.
17.	Solution of muriat of soda in 6·4 of water	·9050	G.
18.	Venous blood	·8928	C.
19.	Sulphuric acid, with 5 parts of water	·8760	G.
20.	Solution of muriat of soda in 5 of water	·8680	G.
21.	Nitric acid (39)	·8440	K.
22.	Solution of sulphat of magnesia in 2 of water	·8440	—
23.	Solution of muriat of soda in 8 of water	·8320	—
24.	Solution of muriat of soda in 3·33 of water	·8200	G.
25.	Solution of nitrat of potassa in 8 of water	·8167	L.
26.	Solution of muriat of soda in 2·8 of water	·8020	G.
27.	Solution of muriat of ammonia in 1·5 of water	·7980	K.
28.	Solution of muriat of soda saturated, or in 2·69 of water	·7930	G.
29.	Solution of supertartrit of potassa in 237·3 of water	·7650	K.
30.	Solution of carbonat of potassa	·7590	—
31.	Colourless sulphuric acid (51·55,56,57)	·7580	—
32.	Sulphuric acid with 2 parts of water	·7490	G.
33.	Solution of sulphat of iron in 2·5 of water	·7340	K.
34.	Solution of sulphat of soda in 2·9 of water	·7280	—
35.	Olive oil	·7100	—
36.	Water of ammonia, specific gravity 0·997	·7080	K.
37.	Muriatic acid, specific gravity 1·122	·6800	—
38.	Sulphuric acid, 4 parts with 5 of water	·6631	L.
39.	Nitric acid, specific gravity 1·29895	·6613	—
40.	Solution of alum in 4·45 of water	·6490	M.
41.	Mixture of nitric acid with lime, 9⅓ to 1	·6189	L.
42.	Sulphuric acid, with an equal weight of water	·6050	G.
43.	Sulphuric acid 4 parts with 3 of water	·6031	L.
44.	Alcohol (9·15)	·6021	C.
45.	Nitrous acid, specific gravity 1·354	·5760	K.
46.	Linseed oil	·5280	—
47.	Spermaceti oil (53)	·5000	C.
48.	Sulphuric acid, with ½ of water	·5000	G.
49.	Oil of turpentine (52)	·4720	K.
50.	Sulphuric acid, with ¼ of water	·4420	G.
51.	Sulphuric acid (31·55,56,57)	·4290	C.
52.	Oil of turpentine (49)	·4000	Ir.
53.	Spermaceti oil (47)	·3990	K.
54.	Red wine vinegar	3870	—
55.	Sulphuric acid, concentrated, and colourless (31)	·3390	G.
56.	Sulphuric acid, specific gravity 1.87058	·3345	L.
57.	Sulphuric acid (31·51)	·3330	Ir.
58.	Spermaceti melted	·3200	—
59.	Quicksilver, specific gravity 13·30	·0330	K.
60.	Quicksilver	·0290	L.
61.	————	·0290	W.
62.	————	·0280	Ir.

SOLIDS.

63.	Ice	·9000	K.
64.	—	·8000	Ir.
65.	Ox hide, with the hair	·7870	C.
66.	Sheep's lungs	·7690	—
67.	Beef of an ox	·7400	—
68.	Scotch fir wood	·6500	M.
69.	Lime tree wood	·2600	—
70.	Spruce fir wood	·6000	—
71.	Pitch pine wood	·5800	—
72.	Apple tree wood	·5700	—
73.	Alder wood	·5300	—
74.	Sessile-leaved oak	·5100	—
75.	Ash wood	·5100	—
76.	Pear-tree wood	·5000	—
77.	Rice	·5060	C.
78.	Horse-beans	·5020	—
79.	Dust of the pine tree	·5000	—
80.	Pease	·4920	—
81.	Beech	·4900	M.
82.	Hornbean wood	·4800	—
83.	Birch wood	·4800	—
84.	Wheat	·4770	C.
85.	Elm	·4700	M.
86.	White wax	·4500	G.
87.	Pedunculated oak wood	·4500	M.
88.	Prune tree	·4400	—
89.	Ebony wood	·4300	—
90.	Quicklime, with water, in the proportion of 16 to 9	·4391	L.
91.	Barley	·4210	C.
92.	Oats	·4160	—
93.	Charcoal of birch wood (99)	·3950	G.
94.	Carbonat of magnesia	·3790	—
95.	Prussian blue	·3300	—

able of Capacities of different Substances for Caloric (Continued).

LIQUIDS.

cklime saturated with ater and dried	·2800	G.
coal	·2777	C.
ificial gypsum	·2640	G.
rcoal (93)	·2631	C.
lk (108)	·2564	—
t of iron	·2500	—
te clay	·2410	G.
te oxide of antimony shed	·2272	C.
e of copper	·2272	—
klime (107)	·2239	—
iat of soda in crystals	·2260	G.
klime (105)	·2168	L.
k (100)	·2070	G.
vn glass	·2000	Ir.
e, specific gravity 2648	·1950	W.
nen ware	·1950	K.
tal glass without lead	·1929	L.
ers	·1923	C.
hur	·1890	Ir.
s of cinders	·1855	C.
e glass, specific gra- y 2·386	·1870	W.
e clay burnt	·1850	G.
lead	·1830	—
hur	·1830	K.
e of antimony, nearly e of air	·1666	C.
of iron, ditto, ditto	·1666	—
s of elm wood	·1402	—
(125·127,128·132)	·1450	Ir.
of zinc, nearly freed n air	·1369	C.
e cast iron	·1320	G.
e oxide of arsenic	·1260	—
123·132)	·1269	C.
pecific gravity 7876	·1260	W.
iron abounding in nbago	·1240	G.
ened steel	·1230	—

131. Steel softened by fire	·1200	G.
132. Soft bar iron, specific gravity 7·724	·1190	—
133. Brass, specific gravity 8356 (135)	·1160	W.
134. Copper, specific gravity 8·785 (136)	·1140	W.
135. Brass (133)	·1123	C.
136. Copper (133)	·1111	—
137. Sheet iron	·1099	L.
138. Zinc, specific gravity 7154 (143)	·1020	W.
139. White oxide of tin, nearly free of air	·990	C.
140. Cast pure copper, heated between charcoal, and cooled slowly, specific gravity 7907	·990	G.
141. Hammered copper, specific gravity 9150	·970	G.
142. Oxide of tin	·960	K.
143. Zinc (198)	·943	C.
144. Ashes of charcoal	·909	—
145. Sublimated arsenic	·840	G.
146. Silver, specific gravity 10·001	·820	W.
147. Tin (152)	·704	C.
148. Yellow oxide of lead	680	—
149. White lead	·670	G.
150. Antimony	·645	—
151. Antimony, specific gravity 6107	·630	W.
152. Tin, specific gravity 7380 (147)	·600	—
153. Red oxide of lead	·590	G.
154. Gold, specific gravity 1904	·500	W.
155. Vitrified oxide of lead	·590	G.
156. Bismuth, specific gravity 9861	·430	W.
157. Lead, specific gravity 1145	·420	—
158. ——	·352	C

II. *Table of Freezing Mixtures.*

ixtures.	Thermometer sinks	
	From	To
mmonia 5 parts, water 16	50°	10°
mmonia 5, nitre t of soda 8, wa-	50	4
nmonia 1, water	50	4
nmonia 1, car- soda 1, water 1	50	7
oda 3, diluted ni-	50	3
oda 6, muriat of 4, nitre 2, di- ic acid 4	50	10

Mixtures.	Thermometer sinks	
	From	To
Sulphat of soda 6, nitrat of ammonia 5, diluted nitric acid 4	50	14
Phosphat of soda 9, diluted nitric acid 4	50°	12°
Phosphat of soda 9, nitrat of ammonia 6, diluted nitric acid 4	50	21
Sulphat of soda 8, muriatic acid 5	50	0
Sulphat of soda 5, diluted sulphuric acid 4	50	3
Snow 1, common salt 1	32	0
Muriat of lime 3, snow 2	30	—50
Potash 4, snow 3	32	—51

II. *Table of Freezing Mixtures* (Continued).

Mixtures.	Thermometer sinks From	Thermometer sinks To
Snow 1, diluted sulphuric acid 1	20	—60
Snow, or pounded ice, 2, common salt 1	0	—5
Snow and diluted nitric acid	0	—46
Muriat of lime 2, snow 1	0	—66
Snow, or pounded ice, 1, common salt 5, muriat of ammonia and nitre 5	—5	—18
Snow 2, diluted sulphuric acid 1, diluted nitric acid 1	—10	—56
Snow, or pounded ice, 12, common salt 5, nitrat of ammonia 5	—18	—25
Muriat of lime 3, snow 1	—40	—73
Diluted sulphuric acid 10, snow 8	—68	—91

III. *Table of the Freezing Points of Liquids.*

Oil of aniseeds (50° Thomson)	64°
Sulphuric acid, specific gravity (1·78 Keir)	46
Olive oil	36
Oximuriatic acid. Water	32
Milk	30
Vinegar	28
Human blood	25
Fluoric acid. Oils of cinnamon and bergamot	23
Strong wines	20°
Oil of turpentine (Macquer)	16
Strongest sulphuric acid (Cavendish)	1
Brandy	—7
Alcohol 2 parts, water 1	—11
Acetous acid	—22
Sulphuric acid (Thomson)	—36
Mercury	—39
Ether and liquid ammonia	—46
Strongest nitric acid (Cavendish)	—55

IV. *Table of the Boiling Points of Liquids.*

Ether boils	98°
Liquid ammonia boils	140
Alcohol boils (174 Black)	176
Water and essential oils boil	212
Nitrous acid boils	242
Nitric acid boils	248
Oil of turpentine boils	560°
Sulphuric acid boils (Dalton) (546 Black)	590
Linseed oil boils	600
Mercury boils (Dalton (660) (Crichton 656) (Second at 644) (Black)	600

V. *Table of the Melting Points of Solids.*

Sulphur and phosphorus, equal parts	40°
Adipocere of muscle	82
Lard	97
Phosphorus (Pelletier)	99
Resin of bile	104
Myrtle wax (Cadet)	109
Spermaceti (Bostock)	112
Tallow (92 Thomson)	127
Bees wax	149
Ambergris (La Grange)	145
Bleached wax	155
Bismuth 5 parts, tin 3, lead 2	212
Sulphur (212 Fourcroy) (185 Kirwan Hope)	234
Adipocere of biliary calculi (Fourcroy)	235
Tin and bismuth equal parts	283
Camphor	303
Tin 3, lead 2, or tin 2, bismuth 1	334
Tin (413 Irvine) (Crichton)	442
Tin 1, lead 4	460
Bismuth (Irvine)	476
Lead (594 Irvine) (540 Newton) Crichton	612
Zinc	700
Antimony	809

	Wedgwood.	Fahr.
Brass	21	3809
Copper	27	4587
Silver	28	4717
Gold	32	5237
Cobalt	130	17977
Nickel	150	20577
Soft nails	154	21097
Iron	158	21637
Manganese	160	21877
Platina, tungsten, molybdena, uranium, titanium, &c.	*170	23177

VI. *Table of the Points at which certain Solids are volatilized.*

Camphor sublimes (Venturi)	145
Sulphur evaporates (Kirwan)	170
Phosphorus distils (Pelletier)	219
White arsenic sublimes	283
Metallic arsenic sublimes	540
Sulphur sublimes (Davy)	600

Calorimeter. An instrument contrived by Lavoisier and La Place, to measure the heat given out by a body in cooling by the quantity of ice it melts. It consists of two vessels, one to be placed within the other, so as to leave a cavity between them; and a frame of iron network, to be suspended in the middle of the inner vessel. This network is to hold the heated body, and is to be surrounded with ice broken to pieces so as to fill the rest of the inner vessel. As the ice melts, the water runs off through the bottom of the inner vessel, which is grated, and terminates in the shape of a funnel, with a stopcock. The space between the two vessels is filled with pounded ice, to prevent the access of caloric from the external air; and the cover is made double so as to contain ice for the same purpose, with a perforation to let any water that may be formed drop into the cavity.

Two sources of fallacy in this instrument have been pointed out by Mr. Wedgwood. One, that water is retained among the broken ice by capillary attraction: the other, that the water formed by the thawing of the ice in the upper portions of the vessel is again frozen in part as it filters through the lower, so as even to endanger stopping up the passage.—*Mem. de l'Acad. des Sciences.—Phil. Trans.*

Cameleon Mineral. The combination of fixed alkali and oxide of manganese has been so called, on account of the changes of colour it is subject to when dissolved in water.

Camomile. A small quantity of blue essential oil resides in the cup of the flowers. This colour changes to a brownish green by age, and that more readily in half filled or imperfectly closed vessels than in such as are entirely full. Camomile flowers boiled in wine give it a manifestly saline taste, and the decoction precipitates silver and mercury from nitric acid. But as the precipitates were different from those afforded by common salt, Neumann is justly of opinion, that the precipitating salt was afforded by the wine. They afford half their weight of watery extract, and three eighths of spirituous.

Berthollet observes, that as a dye they afford a weak yellow colour, of a tolerably pleasant hue, but without durability. Mordants give it a little, the best of which are alum, tartar, and sulphat of lime.

Sir John Pringle finds, by his experiments, that the soluble part of camomile flowers is one hundred and twenty times as antiseptic as common salt.

Campan Marble. The green campan from the Pyrenean mountains is slightly magnetic, and contains, according to Mr. Bayen, in the centenary sixty-five parts of carbonat of lime, thirty-two of alumine, and three of iron partially oxided. The red campan is not magnetic, and contains eighty-two parts of carbonat of lime, eleven of alumine, and seven of oxide of iron.

Campeachy Wood. See Logwood.

Camphor. This singular vegetable substance comes to us from China. There are two kinds grow in the East, the one produced in the islands of Sumatra and Borneo, and the other produced in Japan and China. The Sumatran camphor, which the Europeans obtain, is carried to the China market, where it bears a better price than the Japanese. This has given rise to an opinion, that the Chinese buy it, to convert it, by some manipulation, into the other. The properties of the camphor we receive render this in the highest degree improbable.

Camphor is extracted from the roots, wood, and leaves of two species of laurus, the roots affording by far the greatest abundance. The method consists in distilling with water in large iron pots, serving as the body of a still, with earthen heads adapted, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water. It is said by some to be sublimed without water; but Neumann thinks, perhaps without foundation, that such treatment would give an empyreumatic smell to the camphor. The rough camphor, as imported, resembles crude nitre or bay salt. It is imported in canisters.

The refining of camphor was long a secret in the hands of the Venetians, at the time when most of the commodities of the East were brought into Europe by that people. The Hollanders have since appropriated to themselves this, with various other manufactures dependent on chemistry; and I do not find that it is purified in large quantities elsewhere. Neumann mentions one of the largest refineries at Amsterdam, in which were fifty furnaces, all managed by women. He was permitted to see the whole operation, except the charging of the vessels. The sublimation was performed in low flat-bottomed glass vessels placed in sand; and the camphor became concrete in a pure state against the upper part, whence it was afterward separated with a knife, after breaking the glass. Lewis, in a note on this passage, asserts, that no addition is requisite in the purification of camphor; but that the chief point consists in managing the fire so that the upper part of the vessel may be hot enough to bake the sublimate together into a kind of cake. He thinks it more commodious to dissolve the crude camphor in alcohol, and, after decantation or filtration, to distil off the spirit, and fuse the camphor into a cake in a glass vessel. This is practised to advantage. Chaptal says the Hollanders mix an ounce of quicklime with every pound of camphor previous to the distillation.

Purified camphor is a white concrete crystalline substance, not brittle, but easily crumbled, having a peculiar consistence resembling that of spermaceti, but harder. It has a strong lively smell, and an acrid taste; is so volatile as totally to exhale when left exposed in a warm air; is light enough to swim on water; and is very inflammable, burning with a very white flame and smoke, without any residue.

The roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemony, the pasque flower or pulsatilla, and other vegetables, afford camphor by distillation. It is observable, that all these plants afford a much larger quantity of camphor, when the sap has been suffered to pass to the concrete state by several months drying. Thyme and peppermint, slowly dried, afford much camphor; and Mr. Achard has observed, that a smell of camphor is disengaged when volatile oil of fennel is treated with acids. The combination of diluted nitric acid with the volatile oil of anise afforded him a large quantity of crystals, that possessed most of the properties of camphor; and he obtained a similar precipitate by pouring the vegetable alkali upon vinegar saturated with the volatile oil of angelica.

From all these facts, Chaptal concludes, that the base of camphor forms one of the constituent parts of some volatile oils, in which it exists in the liquid state, and does not become concrete but by combining with oxigen.

Mr. Kind, a German chemist, endeavouring to incorporate muriatic acid gas with oil of turpentine, by putting this oil into the vessels in which the gas was received when extricated, found the oil change first yellow, then brown, and lastly to be almost wholly coagulated into a crystalline mass, which comported itself in every respect like camphor. Tromsdorff and Boullay confirm this. A small quantity of camphor may be obtained from oil of turpentine by simple distillation at a very gentle heat. Other essential oils however afford more. By evaporation in shallow vessels at a heat not exceeding 57° F. Mr. Proust obtained from oil of lavender ·25, of sage ·21, of marjoram ·1014, of rosemary ·0625. He conducted the operation on a pretty large scale.

Camphor is not soluble in water in any perceptible degree, though it communicates its smell to that fluid, and may be burned as it floats on its surface. It is said, however, that a surgeon at Madrid has effected its solution in water by means of the carbonic acid.

Camphor may be powdered by moistening it with alcohol, and triturating it till dry. It may be formed into an emulsion by previous grinding with near three times its weight of almonds, and afterward gradually adding the water. Yolk of egg and mucilages are also effectual for this purpose; but sugar does not answer well.

It has been observed by Romieu, that small pieces of camphor floating on water have a rotatory motion, which he ascribes to electricity.

Alcohol, ethers and oils, dissolve camphor very plentifully. The former of these dissolves much more by heat, though when cold it takes up three fourths of its own weight. The surplus taken up by heat is separated, in crystals of a plumose form, by cooling.

Nitric acid, which acts so violently on essential oils as to cause inflammation, dissolves camphor without producing heat or agitation. The camphor becomes fluid, and floats on the surface of the acid like oil, and has been called oil of camphor. Neumann says, it combines with the most concentrated part of the acid. Other acids also dissolve it. Alkalis precipitate it heavier, harder, and much less combustible.

The addition of water to the spirituous or acid solutions of camphor instantly separates it.

When equal parts, by weight, of a saturated solution of camphor in alcohol and of dense sulphuric acid are distilled on a sand bath, a camphorated ether comes over, which does not deposit camphor when agitated with water; and a black tenacious bitumen remains behind, which becomes more firm and solid by washing in water. Mr. Mounet, the author of the experiment, thinks the camphor is decomposed. Mr. Hatchett has particularly examined the action of sulphuric acid on camphor. A hundred grains of camphor were digested in an ounce of concentrated sulphuric acid for two days. A gentle heat was then applied, and the digestion continued for two days longer. Six ounces of water were then added, and the whole distilled to dryness. Three grains of an essential oil, having a mixed odour of lavender and peppermint came over with the water. The residuum being treated twice with two ounces of alcohol each time, fifty-three grains of a compact coal in small fragments remained undissolved. The alcohol being evaporated in a water bath yielded forty-nine grains of a blackish brown substance, which was bitter, astringent, had the smell of caramel, and formed a dark brown solution with water. This solution threw down very dark brown precipitates with sulphat of iron, acetit of lead, muriat of tin, and nitrat of lime. It precipitated gold in the metallic state. Isinglass threw down the whole of what was dissolved in a nearly black precipitate.

When nitric acid is distilled repeatedly in large quantities from camphor, it converts it into a peculiar acid. See ACID (CAMPHORIC).

Camphor is much used in medicine, parernally as a discutient. Discetic acid, with some essential ns the aromatic vinegar, for re indebted to the elder Mr. remarkably promotes the solu- l. Its effluvia are very noxious to which account it is much used ubjects of natural history from s.—*Journ. de Phys.*—*Van Mons's nales de Chimie.*—*Phil. Trans.*

. See LIGHT.

COAL. A coal which burns with e, much smoke, and a smell re- tch. It probably owes its name a substitute for candles in many r families in the north of Eng- n their store of coals take care ded with a separate portion of d on the fire at night. Kirwan breaks easily in any direction, racture presents a smooth con- ace, if broken transversely. Its ity is about 1·27.

IDES. A well known fly with , very common in hot countries, sed as an article of the materia he powder of this insect applied causes blisters, excites urine, ever. They produce the same taken in a small dose internally. es have occasioned priapisms, blood, and lastly death. The ve formerly administered this o excite venereal emotions, but ut much danger.

venel has made some valuable on cantharides. Water extracts dant principle, which gives it llow colour, and also separates oily principle. Ether takes up ery acrid oil, wherein the virtue arides most eminently resides. f cantharides afforded

	grains.
yellow bitter extract -	216
ly matter - -	12
y substance analogous to - - - -	60
ma, soluble neither in r nor alcohol - -	288
The French ounce,	576

has since attempted to analyse more accurately, and he gives ponent parts of the French k matter 74 grs. yellow matter natter 80; parenchyma 324; lime 12; carbonat of lime 2; muriat of lime 4; oxide of iron leterminate quantity of an acid, d not ascertained. He informs queous extract produces nearly ects as the insects themselves, r doses. His researches, how- appear to be completed.

it extracts, by digestion, a tinc- antharides, which possesses all f the insects themselves. When this tincture is distilled, the spirit which comes over has the smell of the cantharides.

Alcohol takes up the caustic part only; whence it follows, that the intensity of the tincture may be varied, as well by varying the strength as the quantity of the spirit to a given dose of the insects. This tincture has the character of warming and increasing the circulation of the parts to which it may be applied in rheumatic pains, sciatica, the wandering gout, &c.

Neumann was acquainted with the resinous substance of cantharides, and that the virtue of this medicament resided in it.

CAOUTCHOUC. This substance, which has been improperly termed *elastic gum*, and vulgarly, from its common application to rub out pencil marks on paper, *India rubber*, is obtained from the milky juice of different plants in hot countries. The chief of these are the *Jatropha elastica*, and *Urceola elastica*. The juice is applied in successive coatings on a mould of clay, and dried by the fire or in the sun; and when of a sufficient thickness the mould is crushed, and the pieces shaken out. Acids separate the caoutchouc from the thinner part of the juice at once by coagulating it. The juice of old plants yields nearly two thirds of its weight; that of younger plants less. Its colour, when fresh, is yellowish white, but it grows darker by exposure to the air.

The elasticity of this substance is its most remarkable property: when warmed, as by immersion in hot water, slips of it may be drawn out to seven or eight times their original length, and will return to their former dimensions nearly. Cold renders it stiff and rigid, but warmth restores its original elasticity. Exposed to the fire it softens, swells up, and burns with a bright flame. In Cayenne it is used to give light as a candle. Its solvents are ether, volatile oils, and petroleum. The ether, however, requires to be washed with water repeatedly, and in this state it dissolves it completely. Pelletier recommends to boil the caoutchouc in water for an hour; then to cut it into slender threads; to boil it again about an hour; and then to put it into rectified sulphuric ether in a vessel close stopped. In this way he says it will be totally dissolved in a few days, without heat, except the impurities, which will fall to the bottom, if ether enough be employed. Berniard says the nitrous ether dissolves it better than the sulphuric. If this solution be spread on any substance, the ether evaporates very quickly, and leaves a coating of caoutchouc unaltered in its properties. Naphtha, or petroleum, rectified into a colourless liquid, dissolves it, and likewise leaves it unchanged by evaporation. Oil of turpentine softens it, and forms a pasty mass, that may be spread as a varnish, but is very long drying. A mixture of volatile oil and alcohol dissolves it better, and dries more speedily. Of the essential oils that called cajeput appears to dissolve it best; and from this it may be separated by washing with alcohol and exposure to the air. Oil of spike is said to act upon it in a similar manner. The expressed vegetable oils, wax, butter, and animal oil, by the assistance of a boiling heat, form with it viscid inelastic compounds. A solution of caoutchouc in five times its weight of oil of turpentine, and this solution dissolved in eight times its weight of drying linseed oil by boiling, is said to form the varnish of air-balloons Alkalis act upon it so as in time to destroy its elasticity. Sulphuric acid is decomposed by it; sulphurous acid being evolved, and the caoutchouc converted into charcoal. Nitric acid acts upon it with heat; nitrous oxide being given out, and oxalic acid crystallizing from the residuum. On distillation it gives out ammonia, and carburetted hidrogen.

Caoutchouc may be formed into various articles without undergoing the process of solution. If it be cut into a uniform slip of a proper thickness, and wound spirally round a glass or metal rod, so that the edges shall be in close contact, and in this state be boiled for some time, the edges will adhere so as to form a tube. Pieces of it may be readily joined by touching the edges with the solution in ether: but this is not absolutely necessary, for, if they be merely softened by heat, and then pressed together, they will unite very firmly.

If linseed oil be rendered very drying by digesting it upon an oxide of lead, and afterward applied with a small brush on any surface, and dried by the sun or in the smoke, it will afford a pellicle of considerable firmness, transparent, burning like caoutchouc, and wonderfully elastic. A pound of this oil, spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of caoutchouc: it was used to make catheters and bougies, to varnish balloons, and for other purposes.

If mastic be digested in alcohol, about one fifth remains undissolved; and this, though somewhat glutinous, possesses properties similar to those of caoutchouc when chemically examined.

Humboldt found a kind of caoutchouc in the earth, in some parts of South America. It occurred, however, only at the roots of certain trees, from which it was an exudation; and differs therefore from what is extracted from some of the mines in Derbyshire, the only place whence the *mineral caoutchouc*, or *elastic bitumen*, has yet been obtained.

Of the mineral caoutchouc there are several varities: 1. Of a blackish brown inclining to olive, soft, exceedingly compressible, unctuous, with a slightly aromatic smell. It burns with a bright flame, leaving a black oily residuum, which does not bethe come dry. 2. Black, dry, and cracked on surface, but, when cut into, of a yellowish white. A fluid resembling pyrolignic acid exudes from it when recently cut. It is pellucid on the edges, and nearly of a hyacinthine red colour. 3. Similar to the preceding, but of a somewhat firmer texture, and ligneous appearance, from having acquired consistency in repeated layers. 4. Resembling the first variety, but of a darker colour, and adhering to gray calcareous spar with some grains of galana. 5. Of a liver-brown colour, having the aspect of the vegetable caoutchouc, but passing by gradual transition into a brittle bitumen, of vitreous lustre, and a yellowish colour. 6. Dull reddish brown, of a spongy or corklike texture, containing blackish gray nuclei of impure caoutchouc. Many more varieties are enumerated.

One specimen of this caoutchouc has been found in a petrified marine shell enclosed in a rock, and another enclosed in crystallized fluor spar.

The mineral caoutchouc resists the action of solvents still more than the vegetable. The rectified oil of petroleum affects it most, particularly when by partial burning it is resolved into a pitchy viscous substance. A hundred grains of a specimen analysed in the dry way by Klaproth afforded carburetted hidrogen gas 38 cubic inches, carbonic acid gas 4, bituminous oil 73 grains, acidulous phlegm 1·5, charcoal 6·25, lime 2, silex 1·5, oxide of iron ·75, sulphat of lime ·5, alumine ·25.—*Journal de l'Institut. Nat. et du Muscum Nat.—Asiatic Researches.—Nich. Journal.—Klaproth's Analyses.*

Cap. The piece which terminates the top of a melting furnace is called the cap. It has the figure of an oblong dome, with a large oval door on one side for the introduction of fuel, of which this furnace requires a quick and large supply. The upper part terminates in a tube or chimney, which may be lengthened accordingly as a greater or less draught is required.

Capacity. See Caloric.

Capital. The upper part of an alembic, likewise called the head. See Laboratory.

Caput Mortuum. A fanciful term much used by the old chemists, but now entirely rejected. It denoted the fixed residue of operations. As the earlier chemists did not examine these, they did not find any inconvenience in one general term to denote them; but the most slender acquaintance with modern chemistry must show, that it is utterly impracticable to denote, by one general term, all the various matters that remain fixed in certain degrees of heat.

Carat. See Karat.

Carbon. When vegetable matter, particularly the more solid, as wood, is exposed to heat in close vessels, the volatile parts fly off, and leave behind a black porous substance, which is charcoal. If this be suffered to undergo combustion in contact with oxigen, or with atmospheric air, much the greater part of it will combine with the oxigen, and escape in the form of gas; leaving about a two-hundredth part, which consists chiefly of different saline and metallic substances. This pure inflammable part of the charcoal is what is commonly called *carbon*; and if the gas be received into proper vessels, the carbon will be found to have been converted by the oxigen into an acid, called the carbonic. See ACID (CARBONIC).

From the circumstance, that inflammable substances refract light in a ratio greater than that of their densities, Newton inferred, that the diamond was inflammable. Experiments afterward proved this to be the fact; and as the diamond is completely dissipated by combustion in oxigen gas in a close vessel, and the product is carbonic acid, it is inferred, that the diamond is perfectly pure carbon. The quantity of the inflammable part of charcoal requisite to form a hundred parts of carbonic acid was calculated by Lavoisier to be twenty-eight parts, though by subsequent experiments he found it to be but twenty-four. From a careful experiment of Mr. Tennant, 27·6 parts of diamond, and 72·4 of oxigen formed 100 of carbonic acid: and hence, as the proportions of Lavoisier first given were then supposed to be true, he inferred the identity of diamond and the inflammable part of charcoal. Guyton-Morveau has since made experiments on some diamonds taken on board a ship from Senegal, which were deemed by the jewellers unfit to be cut, and according to him 17·88 of diamond produce 100 parts of carbonic acid. He found it become black, and apparently charred on its surface at 18° or 20° of Wedgwood, and require a heat of 30° to burn with a feeble flame. In an experiment by Mr. Francillon, too, a diamond partly consumed was found to be studded over with a substance of a metallic brilliancy, which appeared through a magnifier to be plumbago.

Thus according to Guyton diamond is the only pure carbon; and the combustible part of charcoal is an oxide of carbon, containing 36 per cent. or rather 25·5, of oxigen. Plumbago, or black lead, exclusive of the iron it contains amounting to 5 or 10 per cent., he considers as an oxide of carbon likewise, but with a very small portion of oxigen. And the coaly matter of mineral carbon, anthracite, or anthracolite, is according to him an oxide of carbon, approaching to that of plumbago.

From a number of experiments Mr. Biot has made on the refraction of different substances he has been led to form a still different opinion. According to him, if the elements of which a substance is composed be known, their proportions may be calculated with the greatest accuracy from their refractive power. Thus he finds, that the diamond cannot be pure carbon, but requires at least one fourth of hidrogen, which has the greatest refractive power of any substance, to make its refraction commensurate to its density. This assumption accounts for one of the facts advanced by Guyton-Morveau, that the diamond consumes more oxigen in combustion than charcoal.

Berthollet, on the contrary, considers charcoal as a compound of carbon with hidrogen, and containing a small quantity of oxigen. The action of heat alone expels this oxigen, with a certain portion of the hidrogen, and also of the carbon; after which, he says it ought to be deemed a combination of carbon with a small proportion of hidrogen, so retained by its affinity to the carbon, that the action of heat cannot separate it without the addition of oxigen.

From the apparently discordant facts adduced by various chemists of high authority, it cannot yet be considered as decided whether pure carbon, or the base of carbonic acid, has ever been obtained in a separate state: but as without all dispute it exists abundantly in charcoal, the mode of preparing and economical uses of which will be given under that article, and charcoal is the substance almost always employed in chemistry when carbon is wanted, we shall proceed to consider it in this form.

Well-burned charcoal is a conductor of electricity, though wood simply deprived of its moisture by baking is a nonconductor: it is likewise an excellent conductor of galvanism, but a very bad conductor of caloric, a property of considerable use on many occasions, as in lining crucibles.

It is insoluble in water, and hence the utility of charring the surface of wood exposed to that element, in order to preserve it; a circumstance not unknown to the ancients, who sometimes availed themselves of it. This preparation of timber has been proposed as an effectual preventive of what is commonly called the dry rot. It has an attraction, however, for a certain portion of water, which it retains very forcibly. Heated red-hot, or nearly so, it decomposes water; forming with its oxigen carbonic acid, or carbonous oxide, according to the quantity present; and with the hidrogen a gaseous carburet, sometimes called hidrocarbonat, and heavy inflammable air.

Charcoal is infusible by any heat. If exposed to a very high temperature in close vessels it loses little or nothing of its weight, but shrinks, becomes more compact, and acquires a deeper black colour.

Recently prepared charcoal has a remarkable property of absorbing different gasses, and condensing them in its pores, without any alteration of their properties or its own. If charcoal heated to ignition be allowed to cool without exposure to air, and the gas be then admitted to it, it will absorb it in the following proportion: one part of charcoal will absorb 2·25 times its bulk of atmospheric air immediately, and ·75 more in four or five hours. of oxigen gas about 1·8 immediately, and slowly 1 more: of nitrogen gas 1·65 immediately: of nitric oxide 8·5 very slowly: of hidrogen gas about 1·9 immediately: carbonic acid gas 14·3 immediately: a low temperature promotes the absorption. The greater part of the gas thus absorbed may be expelled unaltered by a heat below 212°, and a portion of it even by immersing the charcoal in water. If charcoal thus saturated with oxigen gas be introduced into hidrogen gas, or the contrary, water is formed, with an increase of temperature; and other affinities between the condensed bases of different gasses may be made to take place.

Charcoal has a powerful affinity for oxigen, whence its use in disoxigenating metallic oxides, and restoring their base to its original metallic state, or reviving the metal. Thus too it decomposes several of the acids, as the phosphoric and sulphuric, from which it abstracts their oxigen, and leaves the phosphorus and sulphur free. A pleasing experiment is shown by throwing finely powdered charcoal into recently prepared oximuriatic acid gas, as thus it takes fire, and falls to the bottom of the vessel in a burning shower. The alkaline and earthy salts with decomposable acids are remarkably altered by charcoal at a red heat. The sulphats are thus converted into sulphurets, the nitrats into carbonats: while others, as the muriats and fluats, remain unchanged.

Carbon is capable of combining with sulphur, and with hidrogen. With iron it forms steel; and it unites with copper into a carburet, as observed by Dr. Priestley, who called it charcoal of copper.

A singular and important property of charcoal is that of destroying the smell, colour, and taste of various substances: for the first accurate experiments on which we are chiefly indebted to Mr. Lowitz of Petersburgh, though it had been long before recommended to correct the fœtor of foul ulcers, and as an antiseptic. On this account it is certainly not a bad dentifrice. Water that has become putrid by long keeping in wooden casks is rendered sweet by filtering through charcoal powder, or by agitation with it; particularly if a few drops of sulphuric acid be added. Common vinegar boiled with charcoal powder becomes perfectly limpid. Saline solutions, that are tinged yellow or brown, are rendered colourless in the same way, so as to afford perfectly white crystals. The impure carbonat of ammonia obtained from bones is deprived both of its colour and fetid smell by sublimation with an equal weight of charcoal powder. Malt spirit is freed from its disagreeable flavour by distillation from charcoal; but if too much be used part of the spirit is decomposed. Simple maceration, for eight or ten days, in the proportion of about $\frac{1}{150}$ of the weight of the spirit, improves the flavour much. It is necessary, that the charcoal be well burned, brought to a red heat before it is used, and used as soon as may be, or at least be carefully excluded from the air. The proper proportion too should be ascertained by experiment on a small scale. The charcoal may be used repeatedly, by exposing it for some time to a red heat before it is again employed.

Charcoal is used on particular occasions as fuel, on account of its giving a strong and steady heat without smoke. It is employed to convert iron into steel by cementation. It enters into the composition of gunpowder. In its finer states, as in ivory black, lamp black, &c., it forms the basis of black paints, Indian ink, and printers' ink.—*Phil. Trans.*—*Mem. de l'Instit. Nat.*—*An. de Chim.*—*Journ. de Phys.*—*Phil. Mag.*—*Trans. of Soc. of Arts.*—*Murray's Chem.*

Carbuncle. The ancients called all red gems by this name; but the carbunculus of Pliny was the same as the oriental ruby of our jewellers. Its colour is of a deep red inclining to purple. See Ruby.

Cardamom. Neumann examined the lesser cardamom. One ounce yielded a scruple of essential oil, containing the whole of their pungency and smell, with fourteen or fifteen grains of resinous, and forty-five grains of mucilaginous extract. The spirituous tincture and extract are both grateful aromatics.

The greater cardamoms, or grains of Paradise, are more pungent, but less agreeably aromatic, and rarely if ever used, except by farriers.

Carduus Benedictus. Centaurea benedicta. Four ounces of the leaves afforded four drachms and a half of extract to alcohol: the same quantity gave out six drachms and a half of mucilaginous extract with water. The expressed juice, depurated and evaporated to the consistence of a sirup, afforded Neumann saline crystals, approaching to the nature of tartar.

Carica Papaya. Papaw tree. Every part of the papaw tree, except the ripe fruit, affords a milky juice, which is used in the Isle of France as an effectual remedy for the tape worm. In Europe, however, whither it has been sent in the concrete state, it has not answered, perhaps from some change it had undergone, or not having been given in a sufficient dose. It has been analysed by Vauquelin, and by C. L. Cadet. The concrete juice may be dried so as to be pulverable, but it attracts the moisture of the air very powerfully. It dissolves in the mouth, and excites a peculiar sensation, with a considerable discharge of saliva. It is very soluble in water, but coagulates on boiling, and is precipitated by alcohol. On distillation it gives out a great deal of carbonat of ammonia, a black fetid oil, carbonic acid gas, and carburetted hidrogen. A light,

y coal is left behind, resembling
nimal matters, and containing
osphat of lime. The juice it-
es spontaneous decomposition,
bstance separates from it, and
ears to be formed in it by de-
. This acid, according to Vau-
e acetous: but Cadet and Che-
the malic acid in the juice they
-*An. de Chimie.*

Thistle. A prickly thistle,
iefly in Switzerland. Neumann
he roots as brought in bundles
ngia. They have a bitter pun-
and are chiefly used in the dis-
ttle. In his method of treatment,
by distillation about one ninth
veight of essential oil. Alcohol
ore than one fourth of resinous
ich possessed the flavour and
the root. Water extracted a
ter.

. A red pigment prepared by
ochineal in an alkaline lixivium,
itating by alum. It consists,
f the colouring matter of cochi-
ned with the argillaceous earth
. See Lake.

ecipitates are also called by this
vis asserts, that he has often re-
n success an experiment, first
the Acta Naturæ Curiosorum,
fine precipitate, little inferior in
armine, is afforded by adding
olution of tin to a decoction of
l.

ian. A stone of the siliceous
ifferent shades of brownish red
our. The several specimens vary
ir hardness and transparency.
steemed is of an orange or yel-
and gives fire with steel. The
softer and less valued. Ignition
e red colour to an opake white.
gravity is from 2·6 to 2·7.

thi. A name given by writers
such stones as represent fruit.
s a martial jasper, in which no-
unded calcareous spar and ser-
e included. Denominations of
re at present little regarded.

mus, Safflower, or Bastard
In some of the deep reddish, yel-
nge-coloured flowers, the yellow
ns to be of the same kind with
pure yellow flowers; but the red
different kind from the pure red
ery menstrua take up only the
d leave the red, which may after-
tracted by alcohol, or by a weak
alkali. Such particularly are
-coloured flowers of carthamus.
er the yellow matter has been
y water, are said to give a tinc-
; from which, on standing at
e time, a deep red fecula sub-
l safflower, and, from the coun-
e it is commonly brought to us,

Spanish red and China lake. This pigment impregnates alcohol with a beautiful red tincture; but communicates no colour to water.

Rouge is prepared from carthamus. For this purpose the red colour is extracted by a solution of the subcarbonat of soda, and precipitated by lemon juice, previously depurated by standing. This precipitate is dried on earthen plates, mixed with talc, or French chalk, reduced to a powder by means of the leaves of shave-grass, triturated with it till they are both very fine, and then sifted. The fineness of the powder and proportion of the precipitate constitute the difference between the finer and cheaper rouge. It is likewise spread very thin on saucers, and sold in this state for dyeing.

Carthamus has lately been analysed by Mr. Dufour, who was led to it from the difficulty he found in preparing rouge according to the directions generally given. He operated on 16 ounces troy of carthamus of Alexandria, and its products were, per cent. of moisture, 6·2; dust and sand, 3·4; vegetable albumen of a greenish yellow colour, 5·5; extract soluble only in water, consisting of yellow colouring matser, sulphat of lime, and sulphat of potash, 26·8; extract soluble both in water and alcohol, mixed with yellow colouring matter, and muriat and acetit of potash, 4·2; resin, ·3; wax of a particular kind, ·9; red colouring matter, ·5; ligneous substance, 49·6; alumine and magnesia, ·5; red oxide of iron, ·2; sand, 1·2; loss, ·7. There is great difficulty in separating the last portions of yellow matter, and the mixture of albumen occasions the red to precipitate in a flocculent form. Mr. Dufour tried various expedients to remedy this, but succeeded only by macerating carthamus, deprived of as much as possible of its yellow matter by washing in cold water, in an equal weight of water, and ·15 of carbonat of soda, for one hour only. The feculencies having subsided, he decanted the liquor, put into it some pieces of cotton, and added as much lemon juice as gave it a fine cherry colour. At the end of twenty four hours, the cotton, having taken up all the colouring matter, was rinsed in warm water three or four times; and then lixiviated for an hour in twenty times its weight of water, and a tenth of their weight of carbonat of soda. This lixivium was precipitated by lemon juice, and gave very fine red feculæ, which subsided very slowly. It is probable, that the manufacturers use acid of tartar instead of lemon juice.

Carthamus is used for dyeing silk of a poppy, cherry, rose, or bright orange red. After the yellow matter is extracted as above, and the cakes opened, it is put into a deal trough, and sprinkled at different times with pearl ashes, or rather soda well powdered and sifted, in the proportion of six pounds to a hundred, mixing the alkali well as it is put in. The alkali should be saturated with carbonic acid. The carthamus is then put on a cloth in a trough with a grated bottom, placed on a larger trough, and cold water poured on, till the large trough is filled. And this is repeated, with the addition of a little more alkali toward the end, till the carthamus is exhausted and become yellow. Lemon juice is then poured into the bath, till it is turned of a fine cherry colour, and after it is well stirred the silk is immersed in it. The silk is wrung, drained, and passed through fresh baths, washing and drying after every operation, till it is of a proper colour; when it is brightened in hot water and lemon juice. For a poppy or fire colour a slight annotta ground is first given; but the silk should not be alumed. For a pale carnation a little soap should be put into the bath. All these baths must be used as soon as they are made; and cold, because heat destroys the colour of the red feculæ.

Caryophylloides. A name given to a specimen of mica, the scales of which are concentric and perpendicular.—*Cronstedt.*

Case-Hardening. Steel when hardened is brittle, and iron alone is not capable of receiving the hardness steel may be brought to possess. There is nevertheless a variety of articles in which it is desirable to possess all the hardness of steel, together with the firmness of iron. These requisites are united in the art of case-hardening, which does not differ from the making of steel, except in the shorter duration of the process. Tools, utensils, or ornaments intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter, than when the whole is intended to be made into steel. Immersion of the heated pieces into water hardens the surface, which is afterward polished by the usual methods. Moxon's Mechanic Exercises, p. 56, gives the following receipt:—Cow's horn or hoof is to be baked or thoroughly dried, and pulverized. To this add an equal quantity of bay salt: mix them with stale chamberley, or white wine vinegar: cover the iron with this mixture, and bed it in the same in loam, or enclose it in an iron box: lay it then on the hearth of the forge to dry and harden: then put it into the fire, and blow till the lump have a blood red heat, and no higher, lest the mixture be burned too much. Take the iron out, and immerse it in water to harden.

Cassia Fistularis. The fruit of a tree growing in Egypt and in the East Indies. It is a large cylindrical pod or cane, containing, under a hard rind, a soft pulp lodged in a number of transverse cells, with a flat roundish seed in each. Out of four drams of the dried pulp Neumann found water take up three drams fifteen grains. Alcohol took up as much, or nearly so, but acted more slowly. It is a mild purgative, and forms the basis of an electuary of the London college. It also enters into the electuary of senna, formerly called lenitive electuary.

Cassia Lignea. The bark of a tree of the same kind as the cinnamon tree. It contains an essential oil of the same flavour and qualities as that of cinnamon; but much less in quantity. Cassia is very commonly sold under the name of cinnamon, from which however its external appearance is sufficient to distinguish it. The cassia is thick, rough, and breaks crosswise without splitting; but the cinnamon is smoother, thinner, and cannot easily be broken crosswise without causing it to split into many thin fragments.

Castor. A soft grayish yellow or light brown substance found in four bags in the inguinal region of the beaver. In a warm air it grows by degrees hard and brittle, and of a darker colour, especially when dried in chimneys, as is usually done. According to Bouillon La Grange it consists of a mucilage, a bitter extract, a resin, an essential oil, in which its peculiar smell appears to reside, and a flaky crystalline matter, much resembling the adipocere of biliary calculi.

Castor is regarded as a powerful antispasmodic.

Castor Oil. An oil extracted from the seeds of the *ricinus communis*, or *palma Christi*, which contain a third or fourth of their weight of it. The oil is extracted by expression, or by gentle boiling in water. That by expression is said to become in some degree acrimonious, in consequence of the mucilage it contains. It is commonly thick and viscid, of a light amber colour, and with little smell or taste. That which has least smell, taste, and colour, is the mildest and best. If it have become acrimonious by keeping, shaking it in a bottle with a little warm water, and then pouring it off, will improve it.

Castor oil is a very useful purgative in doses of half an ounce or an ounce, operating in general very gently and speedily, if good. It should be taken floating unmixed in a glass of water.

Catechu. A brown astringent substance formerly known by the name of *Japan earth*. It is a dry extract, prepared from the wood of a species of sensitive plant, the *mimosa catechu*. It is imported into this country from Bombay and Bengal. According to Mr. Davy, who has lately analysed it, that from Bombay is of a uniform texture, red brown colour, and specific gravity 1·39: that from Bengal is more friable and less consistent, of a chocolate colour externally, but internally chocolate streaked with red brown, and gravity 1·28. The catechu from both places differs little in its properties. Its taste is astringent, leaving behind a sensation of sweetness. It is almost wholly soluble in water. Eighteen ounces of water at 52° dissolve 100 grains, leaving about $\frac{1}{14}$ of earthy matter, which was mixed with it either accidentally or by design. A considerable portion is soluble in alcohol, but this leaves behind a mucilaginous matter soluble in water. When a small quantity of water is put to a large quantity of catechu, it takes up much more of the tannin contained in it, than of the extractive matter. The extractive matter is softened by heat; and at a temperature below ignition gives out carbonic acid, carburetted hidrogen, and water holding in solution acetous acid and a little extractive matter. A light and very porous coal is left behind.

Two hundred grains of picked catechu from Bombay afforded 109 grains of tannin, 68 extractive matter, 13 mucilage, 10 residuum, chiefly sand and calcareous earth. The same quantity from Bengal, tannin 97 grains, extractive matter 73, mucilage 16, residual matter, being sand, with a small quantity of calcareous and aluminous earths, 14. Of the latter the darkest parts appeared to afford most tannin, the lightest most extractive matter. The Hindoos prefer the lightest coloured, which has probably most sweetness, to chew with the betel nut.

Of all the astringent substances we know, catechu appears to contain the largest proportion of tannin, and Mr. Purkis found, that one pound was equivalent to seven or eight of oak bark for the purpose of tanning leather.

As a medicine it has been recommended as a powerful astringent, and a tincture of it is used for this purpose, but its aqueous solution is less irritating. Made into torches with gum arabic and sugar it is an elegant preparation, and in this way is said much to assist the clearness of the voice, and to be remarkably serviceable in disorders of the throat.—*Phil. Trans.*—*Red. Obs.*

Cat's Eye. Pseudopalus. A semi-opake stone of the siliceous order, and reckoned among the gems. It is whitish, and reflects green and yellowish rays, varying according to the position of the observer. It is very hard, and is usually cut by jewellers of the figure of a plano-convex lens, and set with the convex side outwards. The best of these stones are very scarce. Bomare informs us that there was one in the cabinet of the Grand Duke of Tuscany, of one inch diameter.

Caustic (Common). A fixed alkali deprived of carbonic acid and most of its water. If the lixivium of the soap-boilers be evaporated to dryness in a silver or copper vessel, then fused in a crucible, poured out into a basin, and, when solid, cut into small pieces, it forms the common caustic. This must be kept in a close bottle, to prevent its deliquescing. When a piece of this alkali is applied to the skin, for the space of three quarters of an hour, it corrodes it, no doubt by forming a saponaceous compound with its fat parts. It was much used in making issues, before that practice was laid aside. See **Alkali.**

Caustic (Lunar). This is likewise, though improperly, called lapis infernalis. It consists of the crystals of silver obtained by solution in nitric acid, and afterward fused in a crucible. To make this preparation, very pure silver must be dissolved to saturation in nitric acid, and the crystals separated by evaporation and cooling. These are to be fused in an earthen crucible, sufficiently large to admit of the frothing and swelling that happen at the commencement of the fusion. The heat must be gentle, because the crystals are very fusible, and the acid easily decomposed and driven off. It requires, however, to be somewhat raised after the ebullition has ceased. As soon as the matter is in quiet fusion, it is to be poured into a mould, consisting of five or six small cylindrical cavities, by which it acquires the form of small pencils, and may conveniently be held in a case instead of touching it with the fingers.

Lunar caustic is black, which seems to arise from part of the acid being driven off, and a portion of the silver revived. Its causticity or action on animal substances appears to depend on the strong disposition of the silver to recover its metallic state, and consequently is a true combustion.

Causticity. All substances which have so strong a tendency to combine with the principles of organized substances, as to destroy their texture, are said to be caustic. The chief of these are the concentrated acids, pure alkalis, and the metallic salts.

Cawk. A term by which the miners distinguish the opake specimens of sulphat of barytes, or marmor metallicum.

Cement. Whatever is employed to unite or cement together things of the same or different kinds may be called a *cement*. In this sense it includes **lutes**, **glues**, and **solders** of every kind, which see; but it is more commonly employed to signify those of which the basis is an earth or earthy salt. See **Lime.** We shall here enumerate, chiefly from the Philosophical Magazine, some cements that are used for particular purposes.

Seven or eight parts of resin, and one of wax, melted together, and mixed with a small quantity of plaster of Paris, is a very good cement to unite pieces of Derbyshire spar, or other stone. The stone should be made hot enough to melt the cement, and the pieces should be pressed together as closely as possible, so as to leave as little as may be of the cement between them. This is a general rule in cementing, as the thinner the stratum of cement interposed, the firmer it will hold.

Melted brimstone used in the same way will answer sufficiently well, if the joining be not required to be very strong.

It sometimes happens, that jewellers, in setting precious stones, break off pieces by accident: in this case they join them so that it cannot easily be seen, with gum mastic, the stone being previously made hot enough to melt it. By the same medium cameos of white enamel or coloured glass are often joined to a real stone as a ground, to produce the appearance of an onyx. Mastic is likewise used to cement false backs, or doublets, to stones, to alter their hue.

The jewellers in Turkey, who are generally Armenians, ornament watch-cases and other trinkets with gems by glueing them on. The stone is set in silver or gold, and the back of the setting made flat to correspond with the part to which it is to be applied. It is then fixed on with the following cement. Isinglass, soaked in water till it swells up and becomes soft, is dissolved in French brandy, or in rum, so as to form a strong glue. Two small bits of gum galbanum, or gum ammoniacum, are dissolved in two ounces of this by trituration: and five or six bits of mastic, as big as pease, being dissolved in as much alcohol as will render them fluid, are to be mixed with this by means of a gentle heat. This cement is to be kept in a phial closely stopped; and when used, it is to be liquefied by immersing the phial in hot water. This cement resists moisture.

A solution of shell lac in alcohol added to a solution of isinglass in proof spirit makes another cement that will resist moisture.

So does common glue melted without water with half its weight of resin, with the addition of a little red ochre to give it a body. This is particularly useful for cementing hones to their frames.

If clay and oxide of iron be mixed with oil, according to Mr. Gad of Stockholm they will form a cement, that will harden under water.

A strong cement, insoluble in water, may be made from cheese. The cheese should be that of skimmed milk, cut into slices, throwing away the rind, and boiled till it becomes a strong glue, which however does not dissolve in the water. This water being poured off, it is to be washed in cold water, and then kneaded in warm water. This process is to be repeated several times. The glue is then to be put warm on a levigating stone, and kneaded with quicklime. This cement may be used cold, but it is better to warm it; and it will join marble, stone, or earthen-ware, so that the joining is scarcely to be discovered.

Boiled linseed oil, litharge, red lead, and white lead, mixed together to a proper consistence, and applied on each side of a piece of flannel, or even linen or paper, and put between two pieces of metal before they are brought home, or close together, will make a close and durable joint, that will resist boiling water, or even a considerable pressure of steam. The proportions of the ingredients is not material, but the more the red lead predominates the sooner the cement will dry, and the more the white lead the contrary. This cement answers well for joining stones of any dimensions.

The following is an excellent cement for iron, as in time it unites with it into one mass. Take 2 ounces of muriat of ammonia, 1 of flowers of sulphur, and 16 of cast iron filings or borings. Mix them well in a mortar, and keep the powder dry. When the cement is wanted for use, take one part of this mixture, twenty parts of clear iron borings or filings, grind them together in a mortar, mix them with water to a proper consistence, and apply them between the joints.

Powdered quicklime mixed with bullock's blood is often used by coppersmiths, to lay over the rivets and edges of the sheets of copper in large boilers, as a security to the junctures, and also to prevent cocks from leaking.

Six parts of clay, one of iron filings, and linseed oil sufficient to form a tough paste, make a good cement for stopping cracks in iron boilers.

Temporary cements are wanted in cutting, grinding, or polishing optical glasses, stones, and various small articles of jewellery, which it is necessary to fix on blocks, or handles, for the purpose. Four ounces of resin, a quarter of an ounce of wax, and four ounces of whiting made previously red hot, is a good cement of this kind; as any of the above articles may be fastened to it by heating them, and removed at pleasure in the same manner, though they adhere very firmly to it when cold. Pitch, resin, and a small quantity of tallow, thickened with brick-dust, is much used at Birmingham for these purposes. Four parts of resin, one of bees wax, and one of brick-dust, likewise make a good cement. This answers extremely well for fixing knives and forks in their hafts; but the manufacturers of cheap articles of this kind too commonly use resin and brick dust alone. On some occasions, on which a very tough cement is requisite, that will not crack though exposed to repeated blows; as in fastening to a block metallic articles, that are to be cut with a hammer and punch; workmen usually mix some tow with the cement, the fibres of which hold its parts together.

Cement Copper. Copper precipitated from vitriolic waters by iron. The name is said to be derived from a vitriolic water in Hungary called Ziment.

Cementation. A chemical process, which consists in surrounding a body in the solid state with the powder of some other bodies, and exposing the whole, for a time, in a closed vessel, to a degree of heat not sufficient to fuse the contents. Thus iron is converted into steel by cementation with charcoal: green bottle glass is converted into porcelain by cementation with sand, &c. See Iron (Porcelain).

The effects of cementation appear to be chiefly produced by one or more of the bodies being converted into vapour, and acting upon the others. The change in the solid is chiefly attended to. The powder is called by the name of a cement.

Centaury. The leaves of the lesser centaury contain a bitter substance, soluble in water and in alcohol. The green colour of the plant resides in the resinous part, being extracted by alcohol, but not by water. It affords nearly ½ of spirituous and ⅔ of watery extract.

Cerite. Messrs Hisinger and Berzelius, analysing the pseudotungsten of Bastnas, discovered in it a new metallic substance; and their discovery has been fully confirmed by Vauquelin, who has since examined it in company with Tassaert and Bergman. The discovery of a new planet, which has received the name of Ceres, about the same time, induced Messrs. H. and B. to give the metal the name of *cerium*, and to alter that of the mineral in which it was found to *cerite*.

Cerite is semitransparent, or nearly opake, of a slight rosy, or carnation tinge, and sometimes, though rarely, yellowish. It is in some specimens sufficiently hard to scratch glass, strikes fire with difficulty, is of no determinate crystalline figure, and in specific gravity 4·530. Its fracture is compact, unequal, angular, and a little shining. Its powder is grayish, becomes yellow by calcination, and loses from six to twelve per cent. Its component parts, as given by Messrs. H. and B. are silex 23, carbonat of lime 5·5, oxide of iron 22, and oxide is of cerium after calcination more than 50. The increase of weight they ascribe to the oxigen absorbed. The purest specimens analysed by Vauquelin gave oxide of cerium 63, silex 17·5, oxide of iron 2, lime 3 or 4, water 12. Other specimens he found mixed with green actinote, and cupreous pyrites.

To obtain the oxide of the new metal the cerite is calcined, pulverized, and dissolved in nitromuriatic acid. The filtered solution, being neutralized with pure potash, is to be precipitated by tartrit of potash; and the precipitate, well washed and afterward calcined, is oxide of cerium.

Cerium is susceptible of two stages of oxidation: in the first it is white, and this by calcination becomes of a fallow red.

The white oxide exposed to the blowpipe soon becomes red, but does not melt, or even agglutinate. With a large proportion of borax it fuses into a transparent globule.

The white oxide becomes yellowish in the open air, but never so red as by calcination, because it absorbs carbonic acid, which prevents its saturating itself with oxigen, and retains a portion of water, which diminishes its colour.

Alkalis do not act on it: but caustic potash in the dry way takes part of the oxigen from the red oxide, so as to convert it into the white without altering its nature.

Equal parts of the sulphuric acid and red oxide, with four parts of water, unite by the assistance of heat into a crystalline mass; which may be completely dissolved by adding more acid, and heating them together a long time. This solution yields by gentle evaporation small crystals, some of an orange, others of a lemon colour. The sulphat of cerium is soluble in water only with an excess of acid. Its taste is acid and saccharine. The sulphuric acid combines readily with the white oxide, particularly in the state of carbonat. The solution has a saccharine taste, and readily affords white crystals.

Nitric acid does not readily dissolve the red oxide without heat. With an excess of acid white deliquescent crystals are formed, which are decomposable by heat. Their taste is at first pungent, afterward very sugary. The white oxide unites more readily with the acid.

Muriatic acid dissolves the red oxide with effervescence. The solution crystallizes confusedly. The salt is deliquescent, soluble in an equal weight of cold water, and in three or four times its weight of alcohol. The flame of this solution, if concentrated, is yellow and sparkling; if not, colourless; but on agitation emits white, red, and purple sparks.

The oxigenated muriatic acid does not dissolve the red oxide, but does the white, without parting with any of its oxigen.

Carbonic acid readily unites with the oxide. This is best done by adding carbonat of potash to the nitric or muriatic solution of the white oxide, when a light precipitate will be thrown down, which on drying assumes a shining silvery appearance.

Sulphuretted hidrogen does not combine with cerium; but hidrosulphurets will precipitate from its solutions any iron that may be mixed with it.

The white oxide unites directly with tartarous acid, but requires an excess to render it soluble.

Vauquelin made several unsuccessful attempts to reduce the metal: however, having mixed tartrit of cerium with a very small quantity of oil and lampblack, he put it into a crucible of charcoal bedded in sand in an earthen crucible, and heated it for an hour and a half in a forge furnace. A metallic globule scarcely as big as a pin's head was left in the coal, but no other trace of cerium could be discovered, though the sand was examined with the utmost care.

None of the simple acids acted on this globule; but it dissolved, though with extreme difficulty, in aqua regia, after being triturated. The solution was reddish, and exhibited unequivocal marks of iron; but it likewise gave evident signs of the existence of cerium, both by its saccharine taste, and by the white precipitates which tartrit of potash and oxalat of ammonia threw down. The metallic globule too was harder, whiter, much more fragile, and more scaly in its fracture, than pure cast iron.

As from these experiments cerium appeared to be volatile, Vauquelin attempted to sublime it. With this view he heated a similar mixture, with the addition of borax, in a porcelain retort, to the neck of which a porcelain tube was adapted. But whether the heat were insufficient, or the metal were volatilized without adhering to the neck of the retort, no trace of sublimate was found. Several very small metallic globules remained in the retort, adhering to a black varnish formed by the borax; and there were some about the upper part of the vessel, to which they had been raised apparently by the fire: but all together would not have amounted to a fiftieth part of the cerium employed.—*Annal. de Chim.* —*Van Mons's Journ.*

Cerium. A metal lately discovered in the pseudotungsten of Bastnas, or cerite. See the preceding article.

Ceruse, or White Lead. An oxide of lead produced by exposing this metal to the vapours of vinegar. To prepare this colour, the lead is cast into plates about one twentieth part of an inch thick, four or five inches wide, and two feet long. These are rolled up in a spiral form, in such a manner that the space of half an inch is left between each revolution. They are then placed in earthen pots, which have three projections within, to prevent them from resting on the bottom. Some good vinegar is then poured in, so as to reach no higher than the lower edge of the leaden spiral, and the pots are then buried in dung beneath sheds. A great number of these are disposed beside each other, each pot being covered with a leaden plate and boards, by which contrivance the number of pots is multiplied by placing them above each other in strata. At the expiration of a month or six weeks they are taken out, and the white lead separated by unrolling the coils. It is then ground in mills, and dried in the shade for use.

Some writers distinguish this oxide by the name of white lead, and apply the term ceruse to denote a mixture of white lead and chalk.

Lead is found native in the form of ceruse, or the white oxide.

Ceruse of Antimony. A white oxide of this semimetal, which separates from the water in which diaphoretic antimony has been washed.

Chalcedony, or White Agate. A flint of a white colour, resembling milk diluted with water, and more or less opake, with veins, circles, or spots. It is said to be softer than the onyx, but much harder than the agates of the same colour as the onyx. Bergman observes, that it varies greatly in specific gravity; from 2·5 to 4·6. He found the chalcedony of Ferro to contain 84 parts silex, and 16 alumine.

Chalk. A very common species of calcareous earth, of an opake white colour, very soft, and without the least appearance of a polish in its fracture. Its specific gravity is from 2·4 to 2·6, according to Kirwan, who likewise informs us that this substance contains more carbonic acid than any other variety of the calcareous class; generally about forty per cent. It contains a little siliceous earth, and about two per cent. of clay. Some specimens, and perhaps most, contain a little iron, and Bergman affirms that muriat of lime, or magnesia, is often found in it; for which reason he directs the powder of chalk to be several times boiled in distilled water, before it is dissolved for the purpose of obtaining pure calcareous earth.—*Sciag. Regni Min.* § 92.

Chalk (Red). This is a clay coloured by the oxide of iron, of which it contains from 16 to 18 parts in the hundred, according to Rinman.

Chalk (Spanish). The soap rock, or lapis ollaris, is frequently distinguished by this name.

Characters (Chemical). Language in its usual construction is very far from being capable of expressing our conceptions with the rapidity and perspicuity necessary for the adequate communication of ideas. Writing is still slower and less perfect. But as the language and the writing we possess are capable of supplying our grosser and more immediate wants, it is much to be feared, that neither the one nor the other will ever be carried to those degrees of perfection, of which they are certainly susceptible. A few attempts have nevertheless been made from time to time; but they have in general been frustrated by the indolence of the multitude, who are at all times more disposed to use a bad instrument, than take the trouble to learn the use of a good one. The chemical characters are, in some measure, an instance of this. They were invented by the earlier chemists, probably with no other view than to save time in writing the names of substances that frequently occurred, in the same manner as we avoid repetitions by the use of pronouns. But the moderns seem to have considered them as relics of alchemistical obscurity, and have almost totally rejected their use, without inquiring whether they may not possess advantages far superior to those of the common literal enunciation.

We need not have recourse to the remote field of Chinese literature, to show how admirably the simplicity, relative position, and connection of characters are calculated to expreſs ideas at one glance of the eye, with a degree of accuracy and precision not to be obtained by the use of many written words. Neither need we recur to the science of algebra, where by the use of characters the mind receives the proof, and assents to propositions almost instantaneously, which would have required a long series of verbal deductions in any other way. Our own science, chemistry, will afford us instances of the most striking nature. The tables at the end of Bergman's Essay on the Affinities exhibit, in the most speedy and intelligible manner, the greater part of many volumes of chemical results; and I know, from my own experience, that it is easy, by a simple combination of chemical and algebraical characters, to write the whole contents of any chemical work in the small margin usually left by the printer; and that in a manner so full, clear, and perspicuous, that whole pages may be read and understood in a few seconds. This will be readily allowed by any chemist, who will make the trial, and will be done with ease by those who are acquainted with the characters and methods of the two sciences; for which reason I hope to be acquitted of the contemptible spirit of reserve, when I say, that the limits of the present work, and a wish to pursue the subject a little further, prevent me from entering into it at present.

Characters are either entirely arbitrary, or they have some resemblance to the idea they represent. The latter property is naturally aimed at, where it can be obtained, because it cannot but tend to assist the memory. Thus a number of dots were used to denote sand or powder; the figure of a retort, to denote the retort, &c.; and the combination of characters is used to denote similar combinations of the substances they represent. Very little of system appears in the ancient characters of chemists: the characters of Bergman are chiefly grounded on the ancient characters, with additions and improvements. But the characters of Hassenfratz and Adet are systematical throughout. The two former are exhibited in Plate III, and the latter in Plate IV.

Charcoal. When vegetable substances are exposed to a strong heat in the apparatus for distillation, the volatile principles fly off, but combustion does not take place for want of air. The fixed residue is the inflammable substance called charcoal. For general purposes, wood is converted into charcoal by building it up in a pyramidal form, covering the pile with clay or earth, and leaving a few air-holes, which are closed as soon as the mass is well lighted; and by this means the combustion is carried on in an imperfect manner. In the forest of Benon, near Rochelle, great attention is paid to the manufacture, so that the charcoal made there fetches 25 or 30 per cent. more than any other. The wood is that of th black oak. It is taken from ten to fifteen years old, the trunk as well as the branches cut into billets about four feet long, and not split. The largest pieces, however, seldom exceed six or seven inches in diameter. The end that rests on the ground is cut a little sloping, so as to touch it merely with an edge, and they are piled nearly upright, but never in more than one story. The wood is covered all over about four inches thick with dry grass or fern, before it is enclosed in the usual manner with clay; and when the wood is charred half a barrel of water is thrown over the pile, and earth to the thickness of five or six inches is thrown on, after which it is left four-and-twenty hours to cool. The wood is always used in the year in which it is cut.

In charring wood it has been conjectured, that a portion of it is sometimes converted into a pyrophorus, and that the explosions that happen in powder-mills are sometimes owing to this.

Charcoal is black, sonorous, and brittle, and in general retains the figure of the vegetable it was obtained from. If, however, the vegetable consist for the most part of water or other fluids, these in their extrication will destroy the connection of the more fixed parts. In this case the quantity of charcoal is much less than in the former. The charcoal of oily or bituminous substances is of a light pulverulent form, and rises in soot. This charcoal of oils is called lamp-black. A very fine kind is obtained from burning alcohol.

Turf or peat has been charred lately in France, it is said, by a peculiar process, and, according to the account given in Sonnini's Journal, is superior to wood for this purpose. Charcoal of turf kindles slower than that of wood, but emits more flame, and burns longer. It boiled a given quantity of water four times, while an equal weight of wood charcoal boiled the same quantity but once. In a goldsmith's furnace it fused eleven ounces of gold in eight minutes, while wood charcoal required sixteen. The malleability of the gold, too, was preserved in the former instance, but not in the latter. Iron heated red-hot by it in a forge was rendered more malleable.

From the scarcity of wood in this country pitcoal is charred, and much used instead of charcoal by the name of Coak.

The residue of charcoal burned in the open air consists of a small quantity of ashes, which contain alkaline and neutral salts. The vegetable alkali is found in the ashes of various plants, and is known under the names of pot-ash, pearl-ash, cendres gravelées, &c. It is not easy to purify it by a cheap process from the neutral salts it may be contaminated with. Soda is found in the ashes of none but marine plants. The neutral salts found in the ashes of vegetables are sulphats of potash, soda, and lime, muriat of soda, and acetat of potash. Oxides of iron and manganese, with an earthy substance, compose the insoluble residue. For the chemical properties of charcoal, see CARBON.

CHATOYANT. A term applied, by the French, to denote that affection of semitransparent stones, by which their colours vary according to the position of the eye of the observer. We have not a correspondent English word; for which good reason this word has been adopted by several writers on mineralogy.

CHAY, OR CHAYA-ROOT. This is the root of the *Oldenlandia umbellata*, which grows wild on the coast of Coromandel, and is likewise cultivated there for the use of the dyers and calico-printers. It is used for the same purposes as madder with us, to which it is said to be far superior, giving the beautiful red so much admired in the Madras cottons. The Indian method of using it is very operose: but a piece of cotton being prepared by a species of galling, or boiling in a decoction of powdered *hurr*, the astringent fruit of the *myrobolana citrona*; then washed and dried; a design pencilled on it with acetit of alumine in a solution of gum arabic; the cloth again rinsed in cold water, and lastly boiled with two ounces of the chay root coarsely powdered, in a quart of water, about half an hour; after it was well rinsed in cold water and dried, the design appeared of a good bright red, which was much improved by washing with soap and water, and drying in the sun.—*Trans. of Soc. of Arts.*

CHEESE. It is a well known fact, that milk consists of butter, cheese, a saccharine matter called sugar of milk, and a small quantity of common salt, together with much water. Our chemical knowledge of this fluid, before the time of Scheele, consisted of little more than the common operations of the dairy, and the results of the inaccurate method of decomposition by fire.

If any vegetable or mineral acid be mixed with milk, the cheese separates, and, if assisted by heat, coagulates into a mass. The quantity of cheese is less when a mineral acid is used. Neutral salts, and likewise all earthy and metallic salts, separate the cheese from the whey. Sugar and gum arabic produce the same effect. Caustic alkalis will dissolve the curd by the assistance of a boiling heat, and acids occasion a precipitation again. It does not appear, however, that the cheesy part is dissolved in milk by means of an alkali, as was ascertained by adding an acid to milk, which ought to have produced a neutral salt, if this had been the case, but did not. The true reason why acids cause the cheesy matter to separate is, that they combine with it, and form a compound much less soluble in water than the cheese itself. Eight parts of water dissolved one part of the curd precipitated by a mineral acid; so much of the acid having been previously mixed with the water as to give it a sour taste. Vegetable acids have very little solvent power upon curd. This accounts for a greater quantity of curd being obtained when a vegetable acid is used. But what answers best is rennet, which is made by macerating in water a piece of the last stomach of a calf, salted and dried for this purpose.

Scheele thinks that neutral salts, gums, and sugar produce a coagulation of curd by virtue of their stronger attraction for the water.

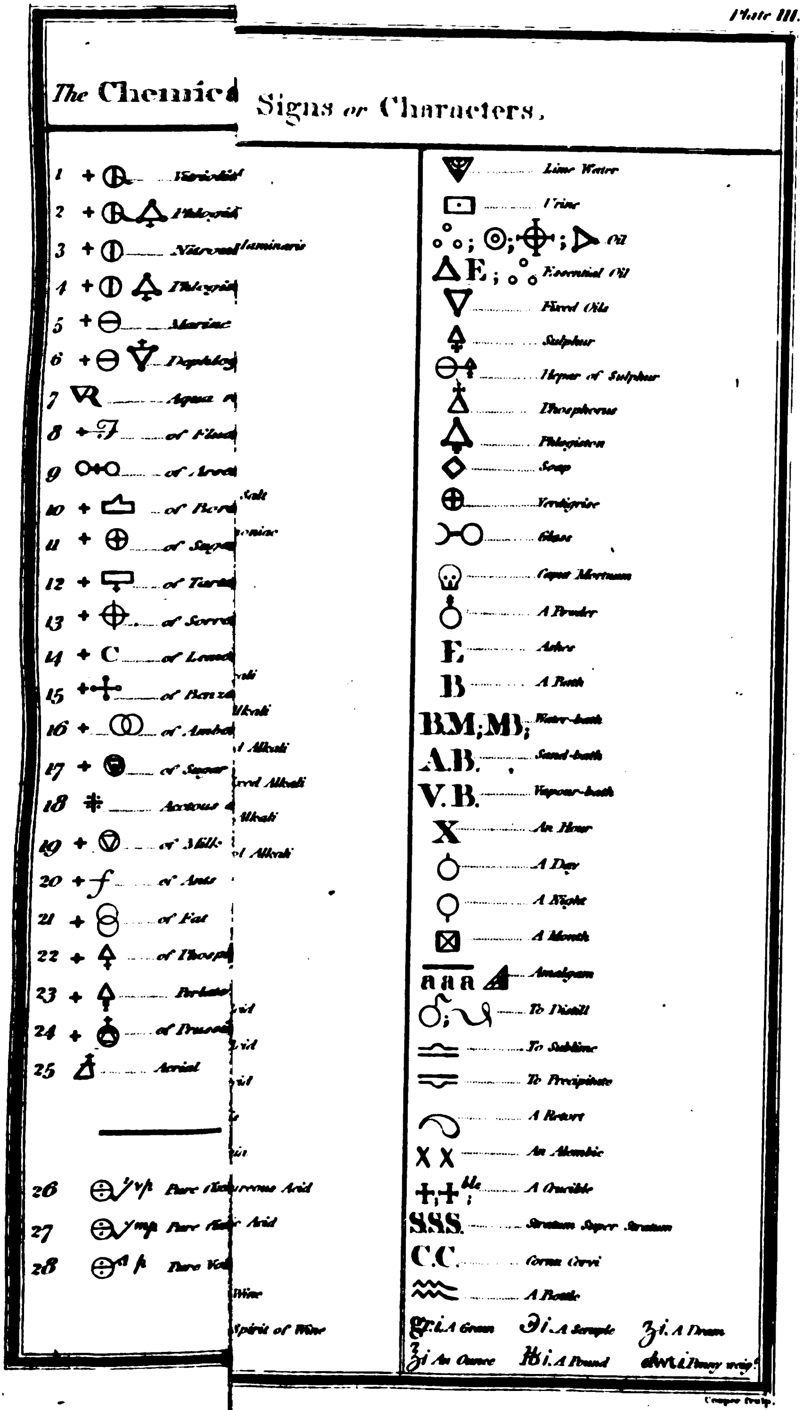
He observed, that cheese has a considerable analogy to albumen, which it resembles in being coagulable by fire and acids, soluble in ammonia, and affording the same products by distillation or treatment with nitric acid. There are however certain differences between them. Rouelle observed likewise a striking analogy between cheese and the gluten of wheat, and that found in the feculæ of green vegetables. By kneading the gluten of wheat with a little salt and a small portion of a solution of starch, he gave it the taste, smell, and unctuosity of cheese, so that after it had been kept a certain time, it was not to be distinguished from the celebrated Rochefort cheese, of which it had all the pungency. This caseous substance from gluten, as well as the cheese of milk, appears to contain acetit of ammonia, after it has been kept long enough to have undergone the requisite fermentation, as may be proved by examining it with sulphuric acid, and with potash. The pungency of strong cheese, too, is destroyed by alcohol.

Darcet has recommended cheese as a substitute for glue, or size, in distemper painting. He takes 144 parts of new cheese, or curd well drained, and beats it in a mortar to the consistence of an ointment; with this he mixes 7 parts of fine powder of lime just slaked with as little water as possible: and to these he adds 280 parts of whiting and 2 of finely powdered charcoal, previously mixed with 80 parts of water. When it is used, about 210 parts more of water must be added, or as much as will dilute it sufficiently for working. Red or yellow ochre, or lamp-black, may be mixed with the curd and lime instead of the whiting and charcoal directed above, but of these only 200 parts should be taken.

With quicklime, and perhaps still better with calcined barytes or strontian, cheese makes an excellent cement for porcelain. See CEMENT.

CHEMISTRY. It is usual with writers to define the science of chemistry, before they proceed to treat on it. It seldom happens, however, that descriptions of very complicated objects can possess that neatness and precision, which are essential to a good definition. Chemistry was formerly consi-

The Chemic Signs or Characters.



Cooper sculp.

Plate IV.

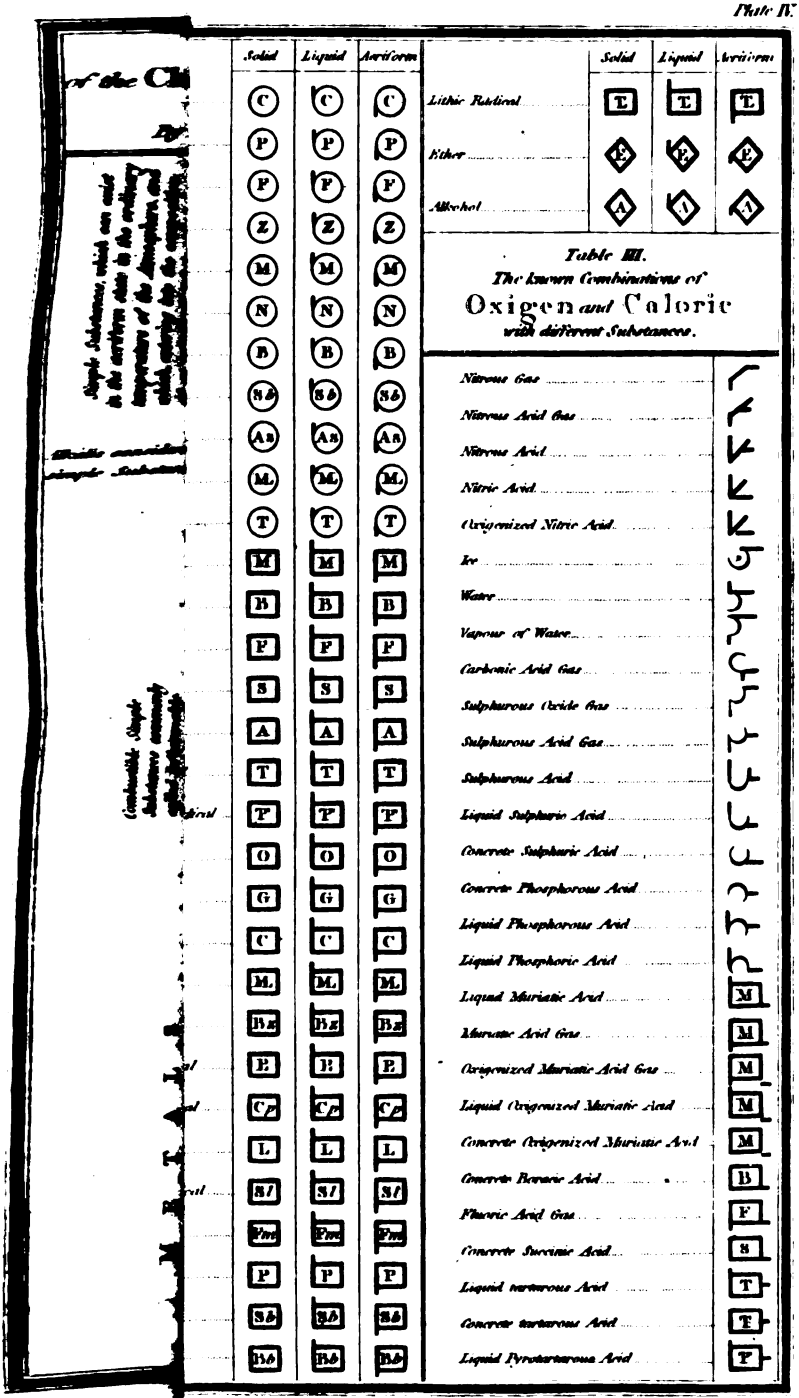
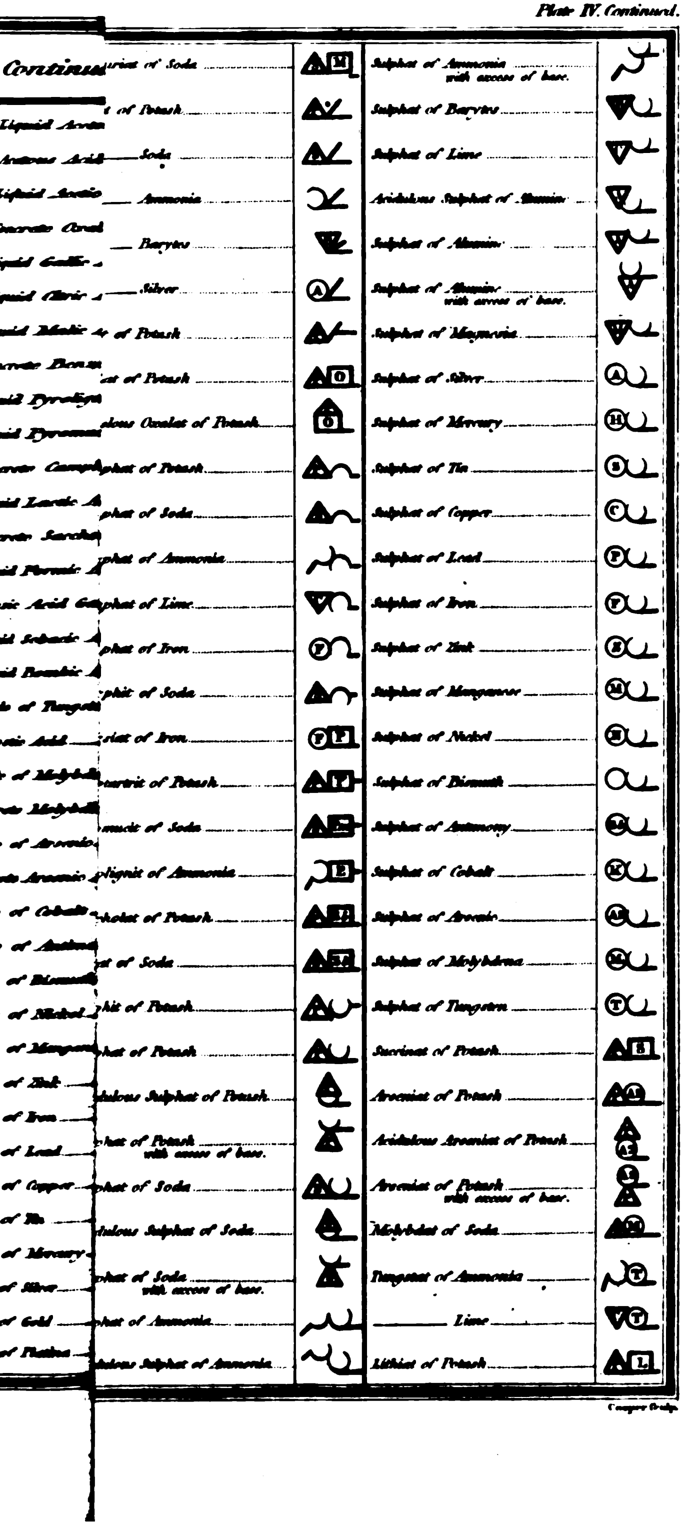


Table III.
The known Combinations of
Oxigen and Caloric
with different Substances.

Cooper sculp.

Plate IV. Continued.



Continu

Liquid Aceto
Acetous Acid
Liquid Acetic
Concrete Oxal
Liquid Gallic
Liquid Citric
Liquid Malic
Concrete Benzo
Liquid Pyrolign
Liquid Pyromuc
Concrete Campho
Liquid Lactic
Concrete Saccha
Liquid Formic
sic Acid Ga
Liquid Sebacic
Liquid Bombic
de of Tungst
stic Acid
de of Molybd
ate Molybd
e of Arsenic
ite Arsenic
of Cobalt
of Antimon
of Bismuth
of Nickel
of Mangan
of Zink
of Iron
of Lead
of Copper
of Tin
of Mercury
of Silver
of Gold
of Platina

uriat of Soda	Sulphat of Ammonia with excess of base.
t of Potash	Sulphat of Barytes
—— Soda	Sulphat of Lime
—— Ammonia	Acidulous Sulphat of Alumine
—— Barytes	Sulphat of Alumine
—— Silver	Sulphat of Alumine with excess of base.
of Potash	Sulphat of Magnesia
at of Potash	Sulphat of Silver
dous Oxalat of Potash	Sulphat of Mercury
phat of Potash	Sulphat of Tin
phat of Soda	Sulphat of Copper
phat of Ammonia	Sulphat of Lead
phat of Lime	Sulphat of Iron
phat of Iron	Sulphat of Zink
phit of Soda	Sulphat of Manganese
riat of Iron	Sulphat of Nickel
artrit of Potash	Sulphat of Bismuth
mucit of Soda	Sulphat of Antimony
olignit of Ammonia	Sulphat of Cobalt
holat of Potash	Sulphat of Arsenic
at of Soda	Sulphat of Molybdena
hit of Potash	Sulphat of Tungsten
hat of Potash	Succinat of Potash
dulous Sulphat of Potash	Arseniat of Potash
hat of Potash with excess of base.	Acidulous Arseniat of Potash
phat of Soda	Arseniat of Potash with excess of base.
dulous Sulphat of Soda	Molybdat of Soda
phat of Soda with excess of base.	Tungstat of Ammonia
phat of Ammonia	—— Lime
dulous Sulphat of Ammonia	Lithiat of Potash

Cooper Sculp.

nere art, at present it is justly
one of the most sublime and
f the sciences. In its object it
e whole of natural phænomena,
g few changes, comparatively
which are not attended with
that comes under the considera-
s science. We might define it
by affirming, that every effect,
ot purely mechanical, is chemical;
suance of this view of the subject,
say that chemistry, as a science,
e methods of estimating and ac-
or the changes produced in bo-
otions of their parts among each
ch are too minute to affect the
idually; and as an art, we should
t it consists in the application of
each other, in such situations
t calculated to produce those

or CHERTZ. Petrosilex semipel-
pis corneus, hornstein of the
Chert is a semitransparent stone
ceous kind. It is generally less
of a coarser texture than common
rge quantities of chert are found
limestone, as flints are found in
chalk; with this difference, that
s of loose nodules, and chert often
e masses of the rock. They are
nding-stones for grinding calcined
other hard substances, but have
h and close a texture for the
of corn.

TE. The greenish talky earth of
his is sometimes crystallized in
l prisms, but chiefly amorphous.
l in Scotland of a slaty texture,
mountain green colour, thickly
ed with garnets: in small scales,
hering, of a pale mountain green:
indurated earthy texture, and pale
green: and in Cornwall of a simi-
e, and dark mountain green co-
rspersed with minute crystals of
iron ore. It melts into a dull,
ompact slag, and then becomes
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caly, analysed by Mr. Hœpfner,
gnesia 39·47, silex 41·5, alumine
e 1·5, iron 10·15, air and water
e indurated differed in containing
t less magnesia, and more silex.

naceous specimen examined by
n gave oxide of iron 43·3, silex 26,
15·5, magnesia 8·2, muriat of pot-
ater 4.

IE. An acidifiable metal, first dis-
n the red lead ore of Siberia by
n in 1797, and so named from the
colours it affords. In this ore it
the acid state, forming chromat of
romat of alumine is the colouring
f the spinel ruby; as the green
chrome is of the Peruvian emerald:
green oxide is united with lead in the green crystals commonly found with the red lead ore of Siberia. Beside these it has been found in the stones called meteoric by Laugier and Thenard, and combined with iron in an ore dug near Toulon.

If the red lead ore be treated with muriatic acid it will be totally dissolved, forming a fine deep red solution. On evaporating the liquor the muriat of lead will fall to the bottom, till the supernatant liquor contains only the oxide of chrome, which gives it a fine green colour, and may be obtained by further evaporation. By heating either this oxide, or the chromic acid, for the mode of obtaining which see ACID (CHROMIC), with charcoal, the metal will be reduced, and found in a grayish white mass, formed of a number of needles crossing each other. It is very hard, very brittle, and extremely difficult of fusion. With oxigen it unites in three different proportions: in its first stage of oxidation it is green, in the second brown, and in the third it is the ruby-coloured acid.

Gmelin precipitated the green oxide from its solution in muriatic acid by means of zinc, prussic acid, sulphat of potash, carbonat of potash, and potash alone. The latter threw it down of a mountain blue colour; and this precipitate fused with saline substances into a green mass. As it is very soluble in saline fluxes, he found it difficult to fuse into a metallic button by their means, without precipitating it, while in fusion by means of zinc. The button thus obtained, when fused with borax, rendered it green.—*Annales de Chimie.—Philos. Mag.—Fourcroy.*

CHRYSOCOLLA. The Greek name for Borax; which see. The ancients likewise used it to denote Mountain Green, Viride Montanum.

CHRYSOLITE. The oriental chrysolite and peridot are the same gem. It becomes electric by being rubbed: its form is prismatic, of six and sometimes of five striated faces. It is found in the East Indies, Brazil, Bohemia, Saxony, and Spain; in Bourbon and Auvergne in France; and in Derbyshire in England. Some are likewise found with volcanic lavas, as in the Vivarais, where some large lumps have been seen of twenty and thirty pounds weight. But it is remarkable, that some of these chrysolites are partly decomposed into an argillaceous substance.

However, all chrysolites are far from being of the same kind: the oriental ones differ only on account of their green hue, from those sapphires, topazes, and rubies of the same denomination. These do not lose their colour or their transparency in the fire: but the chrysolite either becomes opake by a strong heat, or is entirely fusible; and it phosphorises in the instant it melts, like the basis of alum and gypseous spar: with borax it produces a thin colourless glass.

Its specific gravity is between 3·600 and 3·700, according to Brisson; and that of the Spanish chrysolite 3·0989.

Its substance is lamellated in the direction of the axis of its primitive form; but the chrysolite from Saxony is foliated in a perpendicular position to the same axis.

The chrysolite of the ancients was the same gem which is now called topaz. The name of itself indicates, that it must have been so; and Pliny very plainly says, (b. 37. c. 9.) that the colour of the chrysolite is yellow like gold.

Chrysoprase. Mr. Achard has made the analysis of chrysoprase from Koseinitz in Silesia, which lost its colour and transparency in the fire, becoming cracked and white in its surface, but without melting. Its powder, either with carbonat of potash or soda, nitre, or borax, gave a diaphanous glass; and with other substances produced opake masses of different colours.

The chrysoprase is of a green colour, deeper than the chrysolite, but with a yellowish tinge, inclining to blue, like the green leek, as Pliny says (b. 37. c. 8). Mr. Achard says, that it never is found crystallized, and that it is semitransparent. Mr. Romé de Lisle reckons it among the quartz; and says, that its colour is owing to the mixture of cobalt, as it gives a fine blue glass when fused with borax, or with fixed alkali. But Mr. Achard found the glass of a deep yellow, when the fusion was made with borax; and that it really contains some oxide of copper instead of cobalt. Mr. Dutens says, that some gold has been found in this kind of stone: but this last, in all probability, belongs to some other class of substances, viz. to the vitreous spars.

Cimolite, or Cimolian Earth. The *cimolia* of Pliny, which was used both medicinally and for cleaning cloths by the ancients, and which has been confounded with fuller's earth and tobaccopipe clay, has lately been brought from Argentiera, the ancient Cimolus, by Mr. Hawkins, and examined by Klaproth.

It is of a light grayish white colour, acquiring superficially a reddish tint by exposure to the air; massive; of an earthy, uneven, more or less slaty fracture; opake; when shaved with a knife, smooth and of a greasy lustre; tenacious, so as not without difficulty to be powdered or broken; and adhering pretty firmly to the tongue. Its specific gravity is 2. It is immediately penetrated by water, and develops itself into thin laminæ of a curved slaty form. Triturated with water it forms a pappy mass; and 100 grains will give three ounces of water the appearance and consistence of a thickish cream. If left to dry after thus ground, it detaches itself in hard bands, somewhat flexible, and still more difficult to pulverise than before.

It appeared on analysis to consist of silex 63, alumine 23, oxide of iron 1·25, water 12.

Ground with water, and applied to silk and woollen greased with oil of almonds; the oil was completely discharged by a slight washing in water, after the stuffs had been hung up a day to dry, without the least injury to the beauty of the colour. Mr. Klaproth considers it as superior to our best fuller's earth; and attributes its properties to the minutely divided state of the silex, and its intimate combination with the alumine. It is still used by the natives of Argentiera for the same purposes as of old.

According to Olivier the island of Argentiera is entirely volcanic, and the cimolian earth is produced by a slow and gradual decomposition of the porphyries, occasioned by subterranean fires. He adds, that he collected specimens of it in all the states through which it passes.—*Klaproth's Essays.* —*Mem. de l'Institut.*

Cinchona. Peruvian Bark. The cinchona officinalis Linn. which furnishes this bark, is generally about fifteen feet high and six inches thick, somewhat resembles our cherry-tree, grows promiscuously in forests, particularly in the hilly parts of Quito in Peru, and is spontaneously propagated from its seeds.

The bark has some odour, to most people not unpleasant; and very perceptible in the distilled water, in which floating globules, like essential oil, have been observed. Its taste is bitter and astringent, accompanied with a degree of pungency, and leaving a considerable lasting impression on the tongue.

Two species are mentioned, viz. the coloured and the white. The coloured includes the pale, the red, the yellow, and the knotty; their bark being coloured, having the cinchona taste and smell, and the trees having very smooth leaves and purplish flowers. The white includes four varieties, their bark being of a whitish colour, with very little taste or smell: the trees have broad hairy leaves, and very fragrant flowers with hairs on the inside.

The proper red bark and one of the white kind have been found in the province of Santa Fé.

The cinchona Caribbæa Linn., cinchona Jamaicensis Phil. Trans. vol. lxxvii. p. 11, is called the seaside beech in Jamaica, and grows from 20 to 40 feet high. The white, furrowed, thick outer bark is not used; the dark brown inner bark has the common flavour, with a mixed kind of taste, at first of horseradish and ginger, becoming at last bitter and astringent. It seems to give more extractive matter than the cinchona officinalis. Some of it was imported from St. Lucia, in consequence of its having been used with advantage in the army and navy during the last war. The fresh bark is found to be considerably emetic and ca-

which properties it is said to lose
g.
pale, the red, and the yellow, are
n use. The pale is brought to us in
different sizes, either flat or quilled,
powder is rather paler than that of
n. The red is generally in much
hicker, flattish pieces, but sometimes
form of quills, and its powder is
like that of Armenian bolé. It is
ore resinous, and possesses the sen-
alities of the cinchona in a much
egree: but the yellow bark is con-
as stronger than either of the
o.
eruvian bark yields its virtues both
nd boiling water; but the decoction
r, gives out its taste more readily,
ns an ink with a chalybeate more
than the fresh cold infusion. This
however contains at least as much
e matter, but in a state of more
olution; and its colour, on stand-
time with the chalybeate, becomes
while that of the decoction becomes
nt. When they are of a certain
addition of a chalybeate renders
en; and when this is the case, they
l to be in a state of fermentation,
e. Mild or pure alkalis or lime
te the extractive matter, which in
of the pure alkali is redissolved by
addition of the alkali. Lime water
ates less from a fresh infusion than
resh decoction; and in the precipi-
is last, some mild earth is percep-
he infusion is by age reduced to
state with the fresh decoction; and
deposit nearly an equal quantity
arth and extractive matter; so that
er, as well as a chalybeate, may be
test of the relative strength and
e nature of the different prepara-
l of different barks. Accordingly
sions are found by experiments to
perishable than decoctions; infu-
decoctions of the red bark, than
the pale; those of the red bark,
are found by length of time to
more mild earth with the lime-
d more extractive matter. Lime-
precipitating the extractive mat-
ars an equally improper and dis-
menstruum.
ing to the experiments of Dr. Ir-
powers of different menstrua on
bark are in the following order:
vitriolic ether; solution of pure
rench brandy; Rhenish wine; soft
negar and water; spirit of nitrous
lution of carbonat of ammonia;
solution of carbonat of potash;
r. The antiseptic powers of vine-
ark united are double the sum of
rately. The astringent power of
ona is increased by the addition of
acid; and its bitter taste destroyed

According to Deschamps of Lyons, cinchona contains a considerable quantity of a calcareous salt, which he calls cinchonat of lime. From 12 lbs. of yellow bark, which affords the most, he obtained regularly eleven drachms of this salt. He obtained it by simply infusing this quantity of bark 24 hours first in 50 quarts of water, then in 30, and afterward in 20; mixing and filtering these infusions; evaporating to about half, filtering again, and washing out any salt that may have remained on the filters; and then evaporating the filtered liquor and washings to 6 or 7 quarts. The filtering, washing, and evaporation were then repeated, till the liquor acquired a sirupy consistence; and this being left to stand in a cool place for a fortnight, the salt was found crystallized among the extractive matter. Being purified by washing, dissolving and recrystallizing, it will be obtained in white laminæ, truncated at their extremities, and adhering obliquely to one another. This salt is not soluble in alcohol, and therefore may be obtained, perhaps with less difficulty, from cinchona of which the resin has been extracted.

Mr. Seguin has found in cinchona a principle that precipitates solution of tannin, but neither that of gelatine, nor of sulphat of iron. This he considers as pure gelatine, and ascribes to it the febrifuge properties of bark. To confirm this opinion, he adds, that he has cured thirty-seven patients, and a committee of physicians at Paris have cured a great many more, with gelatine alone. It was given in somewhat larger doses, however, than could have been contained in any reasonable quantity of cinchona, namely from 2 drams to 32, according to the age and circumstances of the patient, dissolved in water, and taken at once when the fit was coming on.

Dr. And. Duncan, jun. however, has made experiments tending to show, that cinchona does not contain any gelatine; though he found in it a principle, which like gelatine indeed precipitates tannin, but does not form a jelly with water, is not precipitated from it by carbonat of potash, and is soluble in alcohol. Considering it as a peculiar substance, he calls it cinchona.—*Ann. de Chim.—Bulletin des Sciences.—Nich. Journal.*

Cinchonin. See the preceding article.

Cinis. According to Dr. Mitchill of New York, the greater part of the residuum of lixiviated wood ashes consists of a peculiar earth, which he would distinguish by this name. In America it is much esteemed as a manure, thrown over barren land at the rate of twelve loads to an acre and ploughed in, as its fertilizing effects both for grass and corn are very great, and perceptible from seven to twenty years.—*Trans. of the Board of Agriculture.—Phil. Mag.*

Cinnabar. An ore of mercury, consisting of that metal united with sulphur.

This combination is also made by art. The native cinnabar is of different shades, from yellowish to a deep red, and even black. It is found either in hard or friable masses, irregularly figured or crystallized in cubes, sometimes though rarely transparent, and its texture is either radiated, striated, scaly, or granular. One hundred parts contain pretty regularly eighty parts mercury and twenty sulphur. In closed vessels it sublimes by heat, but in open vessels it is decomposed.

The principal cinnabar mines which are wrought in Europe are those of the Palatinate, and those of Spain. In the Palatinate the ore is decomposed by mixing it with one third of its weight of lime, and distillation in iron cucurbits one inch thick, three feet nine inches long, one foot wide, with an aperture of five inches. These vessels are disposed in a gallery; forty-eight being arranged in two parallel lines, a second row above the first. An earthen pot is one third part filled with water, adapted to the neck of each cucurbit, and accurately luted on. The gallery is heated by a fire lighted at the two ends, and several apertures, formed in the upper part, serve the purpose of chimneys. The heat is kept up for ten or twelve hours before the process is finished.

The above process was also followed at Almaden in Spain, till the year 1647, when the following was adopted on account of its greater simplicity and economy. The furnace is twelve feet high, and four feet and a half diameter within. At the distance of five feet and a half from the ground is an arched floor, upon which the ore is deposited, and a fire is kindled in the ash-hole. The sublimed mercury escapes through twelve apertures, formed in the upper part of the laboratory. To these apertures rows of aludels inserted one in the other are adjusted, and disposed parallel upon a terrace, which terminates in a small building separated into as many chambers as there are files of aludels. Each chamber has a cavity in the middle, to receive the small quantity of mercury which may arrive to that distance.

Every furnace contains two hundred quintals of cinnabar, and the fire is kept up for three days. The sulphur which burns is disengaged in the form of sulphureous acid, and escapes through small chimneys made in each chamber. Every repetition of the process affords from twenty-five to sixty quintals of mercury.

The mine of Almaden has been wrought from time immemorial. Its veins are from three to fourteen feet in breadth; and their breadth is even larger where they join.

Artificial cinnabar is known in commerce by the name of vermilion, and ought to be used in all cases wherein this compound is meant to be applied to medical purposes, on account of its greater purity. The manufacture of this pigment has long been in the hands of the Hollanders, who kept it a secret; and as there is some difficulty in perfectly succeeding in the process, chemical writers have given various methods of performing it, most of which, according to Mr. Tuckert, are inaccurate. This gentleman has given a full account of the method used at Amsterdam, which I find extracted from Crell's Chemical Journal, and inserted in the fourth volume of the Annales de Chimie. It is as follows:

The manufactory, at which Mr. Tuckert several times assisted in the preparation of artificial cinnabar, is without the Utrecht port at Amsterdam, and is one of the most considerable in Holland. Forty-eight thousand pounds of vermilion are annually made in three furnaces by four workmen, beside other mercurial preparations.

The ethiops mineral is first prepared by mixing together 150 pounds of sulphur with 1080 pounds of pure mercury, and then exposing the mixture to a moderate heat in a flat-bottomed polished iron vessel, one foot in depth, and two feet and a half in diameter: its form is that of a chocolate machine. Mr Tuckert does not enter into the particular manipulations of the Hollanders in this part of the process, because the methods of producing the black combination of mercury with sulphur are well known.

The mercurial ethiops thus prepared is in the next place pounded, in order that it may more readily be put into small earthen bottles, capable of holding each about 24 ounces of water. Thirty or forty of these bottles are filled to be in readiness for the subsequent operation.

In the next place three large pots, or sublimatory vessels, made of clay and very pure sand, are taken. These vessels are previously covered with a coating of lute, which is suffered to become perfectly solid and dry before the vessel is used. Mr. Tuckert refers to a German translation of a work of Mr. Machy for the figure of these vessels, as well as for the composition of the lute. As we have not that translation, it is impossible for us to give any further information on these heads than may be gathered from the rest of his memoir. These pots are placed over three furnaces, upon iron circles. The sublimatory vessels may be of different sizes, and the furnaces are constructed in such a manner as that the flame circulates freely round the vessels to two thirds of their height.

When the vessels are duly placed in their furnaces, a moderate fire is first lighted, which is gradually raised until they become red hot. The fuel is turf, or rather peat, commonly used throughout the United Provinces. As soon as the vessels are red hot, a bottle of the ethiops is poured into the first, another into the second, and another into the third. In the subsequent progress of the operation, two, three, and perhaps more bottles may be poured in at a time; but this depends on the strength of the inflammation exhibited by the ethiops after its introduction, the flame of which sometimes rises to the height of four, and even six feet. When this is a little diminished, the mouth of the vessel is covered with a plate of iron, one foot square, and an inch and a half thick, which perfectly closes it. In this way, during thirty-four hours, the whole of the prepared matter is introduced into the three pots; that is to say, for each pot three hundred and sixty pounds of mercury, and fifty of sulphur.

After all the ethiops has been introduced, the fire is duly kept up; and when the whole sublimation has taken place, it is suffered to go out; which requires thirty-six hours from first to last. The workmen know when the fire is too strong or too weak by the appearance of the flame when the iron cover is taken off: if too strong, the flame rises to the height of several feet; if, on the contrary, it be too weak, the flame barely appears playing about the edges of the pot The proper degree of heat is when, upon taking off the cover, a brisk flame appears, but does not rise more than three or four inches above the opening.

In the last thirty-six hours, the mass was stirred every quarter or half hour with an iron rod, to accelerate the sublimation. The workmen do this with so much courage, that Mr. Tuckert was every time apprehensive they would fall into the vessels.

When the whole is cool, the vessels are taken out by means of the iron circles, which prevent their breaking. The cinnabar is taken out by breaking the vessel. Each vessel constantly affords four hundred pounds of cinnabar, the loss of original weight in each being ten pounds.

The cinnabar does not attach itself to the plates of iron, because they are so frequently taken off, excepting towards the end, when the vessels were left untouched. These plates are not in the least corroded.

Cinnamon is the bark of a tree of the bay kind, the laurus cinnamomum, growing in the island Ceylon. Though the bark is one of the most grateful spices, the wood is insipid and inodorous, and used only as firewood: the root is impregnated with aromatic matter, and yields in distillation not only an essential oil, but a portion of camphor. The bark is taken off twice a year; in the spring, before the tree begins to blossom, and in autumn, after the fruit has fallen. It is taken only from young trees, that of the old being woody and bitterish.

It has been observed that the thin membrane, which invests the internal surface of the bark, is much stronger in smell and taste than the bark itself. Some suppose, that the aromatic matter is originally confined wholly to this membrane, and thence communicated to the exterior parts in drying.

Cinnamon has a very agreeable pungent, somewhat astringent taste, and a delightful smell. Its essential oil is extremely pungent and fiery, but in small quantity, sixteen ounces of the very best cinnamon scarcely yielding two scruples and a half. The distilled water appears milky, and retains in it greatest part of the oil, which on long standing it deposits to the bottom, and then becomes clear. Oftentimes, though several pounds of cinnamon be committed to distillation, we shall scarcely be able to separate any oil till the water has been kept for some months. Mr. Stoll of Leipsick pretends to have a method of collecting all the oil from the water in a very little time; how justly, I cannot determine. If this should be found practicable, it would be a very useful discovery, provided the oil received no injury. The Dutch are the only persons who prepare the oil of cinnamon in quantity; but it never comes from their hands unadulterated. We seldom meet with oil of cinnamon that holds less than half its weight either of expressed oil or of alcohol.

The oil of this spice does not arise in distillation with alcohol: on distilling pure spirit from cinnamon, it received no sensible impregnation; on drawing it over repeatedly from fresh parcels of the spice, it smelt and tasted a little, but very weakly. An extract made by spirit contains the whole of the taste and flavour of the cinnamon. The watery extract has nothing valuable; sixteen ounces yield two or more of spirituous extract, and about one and a half of watery.

Cipolin. The cipolin from Rome is a green marble with white zones: it gives fire with steel, though difficultly. One hundred parts of it contains 67·8 of carbonat of lime, 25 of quartz, 8 of schistus, 0·2 of iron, beside the iron contained in the schistus. The cipolin from Autun, 83 parts carbonat of lime, 12 of green mica, and one of iron.

Circumcision-Stone. A variety of the jade or jaspachates, which comes from the Amazon river. It melts by the solar heat into a brown opake glass, less hard than the stone itself.

Civet is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped met with in China and the East and West Indies, called a civet-cat, but bearing a greater resemblance to a fox or marten than a cat.

Several of these animals have been brought into Holland, and afford a considerable branch of commerce, particularly at Amsterdam. The civet is squeezed out, in summer every other day, in winter twice a week; the quantity procured at once is from two scruples to a drachm or more. The juice thus collected is much purer and finer than that which the animal sheds against shrubs or stones in its native climates.

Good civet is of a clear yellowish or

brownish colour, not fluid, nor hard, but about the consistence of butter or honey, and uniform throughout; of a very strong smell, quite offensive when undiluted, but agreeable when only a small portion of civet is mixed with a large one of other substances.

This commodity is rarely or never to be met with genuine, notwithstanding the sealed bottles in which it is purchased at Amsterdam. Nor have we any certain criteria for distinguishing its adulteration. Some look upon it as genuine, if when rubbed upon paper it sinks in, without leaving any thing upon the surface; and if, when melted in hot water, it totally swims at top: but lard and butter, the substances principally mixed with it, have both these properties equally with the civet itself.

Civet unites easily with oils, both expressed and distilled, but not at all with alcohol or with water: nor is it rendered miscible with water by the mediation of sugar. Boecler relates, that sugar and alcohol are its two best menstrua; but he has certainly never made the experiment with either. The yolk of an egg seems to dispose it to unite with water; but in a very little while the civet separates from the liquor, and falls to the bottom, though it does not prove of such a resinous tenacity as when treated with sugar and alcohol.

It communicates, however, some share of its smell both to watery and spirituous liquors; hence a small portion of it is often added in odoriferous waters and spirits; as those of lilies of the valley, roses, rhodium wood, orange flowers, orange peel, yellow sanders, &c. The Italians make it an ingredient in perfumed oils, and thus obtain the whole of its scent; for oils dissolve the whole substance of the civet.—*Neumann.*

CLARIFICATION. The process of freeing a fluid from heterogeneous matter or feculencies, though the term is seldom applied to the mere mechanical process of straining, for which see FILTRATION.

Albumen, gelatine, acids, certain salts, lime, blood, and alcohol, in many cases serve to clarify fluids, that cannot be freed from their impurities by simple percolation.

Albumen or gelatine, dissolved in a small portion of water, is commonly used for fining vinous liquors, as it inviscates the feculent matter, and gradually subsides with it to the bottom. Albumen is particularly used for fluids, with which it will combine when cold, as sirups; it being coagulated by the heat, and then rising in a scum with the dregs. Isinglass is commonly employed for wine, either dissolved as mentioned above, or put in without dissolving, in the proportion of about a quarter of an ounce to a cask. Care should be taken, however, that the whole of the isinglass is separated from the wine before it is drunk, otherwise it may excite nausea, vomiting, and giddiness, even in small quantity.

One or two spoonfuls of fresh cream will clarify a quart of spirit in a few hours, but it requires to be filtered afterward.

Heat alone clarifies some fluids, as the juices of plants, in which however the albumen they contain is probably the agent.

A couple of handfuls of marle, thrown into the press, will clarify cider, or water-cider.

One thing must be observed with respect to clarification, that the medium employed seldom unites with the feculencies alone, but frequently carries off more or less of what is essential to the liquor, particularly in medicinal preparations. Care must be taken too, when albumen is used, that the clarified liquor is not left to stand upon the feculent matter, otherwise it will render it more foul than before, and perhaps noxious, from undergoing the putrid fermentation.—*Neumann.—Ann. de Chim.*

CLAY. See EARTHS, ALUMINE.

CLOVES. The pungency of cloves resides in their resin, or rather in a combination of resin with essential oil, for the spirituous extract is very pungent; but if the oil and the resin contained in this extract be separated from each other by distillation, the oil will be very mild; and any pungency which it does retain proceeds from some small portion of adhering resin, and the remaining resin will be insipid. No plant, or part of any plant, contains so large a portion of essential oil as cloves. From sixteen ounces Neumann obtained by distillation two ounces and two drachms; and Hoffman obtained from the same quantity an ounce and a half. The oil is specifically heavier than water.

CLYSSUS. A word formerly used to denote the vapour produced by the detonation of nitre with any inflammable substance.

Other clyssi were also produced, which had their names from the inflammable substance made use of; such as the clyssus of antimony and the clyssus of sulphur.

COAK. Coal charred in the same manner as wood is to convert it into charcoal. An oblong square hearth is prepared by beating the earth to a firm flat surface, and puddling it over with clay. On this the pieces of coal are piled up, inclining toward one another, and those of the lower strata are set up on their acutest angle, so as to touch the ground with the least surface possible. The piles are usually from thirty to fifty inches high, from nine to sixteen feet broad, and contain from 40 to 100 tons of coal. A number of vents are left, reaching from top to bottom, into which the burning fuel is thrown, and they are then immediately closed with small pieces of coal beaten hard in. Thus the kindled fire is forced to creep along the bottom, and when that of all the vents is united, it rises gradually, and bursts out on every side at once. If the coal contain pyrites, the combustion is allowed to continue a considerable time

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flowers on the surface: if it con-
the fire is covered up soon after
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50, 60, or 70 hours the fire is in
ompletely covered with the ashes
ormerly made, and in 12 or 14
coak may be removed for use. In
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to 1100 pounds of coak.
way the volatile products of the
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a range of 18 or 20 stoves, with
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conducting the smoke, through
rizontal tunnels, to a capacious
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brick, supported on brick arches,
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the bitumen is condensed in the
ar: 120 tons of coal yield about
though some coals are said to be
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—*Soc. of Arts.*—*Nich. Journ.*
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ly said to belong to it, but have
orated in the bodies of animals
or vegetables. From the turf that is pared from the surface of the earth, and owes its inflammability to the roots of vegetables which are mixed with it, we may descend to the peat, or black earth, of the moors, in many specimens of which vegetable remains are still perceptible; though in most they appear to be deprived of every appearance of their organic texture, their oily and inflammable nature only remaining; and thence the transition to pit-coal is easy. For if we reflect on the vast revolutions which the earth has certainly undergone through a long course of ages, by means of which its surface has been broken, displaced and inverted, from the actions of floods, earthquakes, and the great convulsions of nature caused by volcanic eruptions, it will be no improbable inference, that the thin, though extensive strata of pit-coal, as well as the exsudations of naphtha, petroleum, and their modifications, have all arisen from the burying of extensive woody tracts of the surface, such as are common in all uncultivated countries. And this probability will be reduced to a certainty, when we advert to the natural history of pit-coal, which is met with in all the various states of transformation. Whole trees are converted into pit-coal, in such quantities together as to exhibit entire forests; in which the roots, trunks, branches, bark, and even species, are discernible. The experiments of Mr. Hatchett on the action of acids on vegetable substances, and those of Sir James Hall on the action of heat on vegetable and animal matter under great pressure, tend greatly to confirm this opinion.

Coal pits and slate quarries exhibit innumerable marks of impressions of leaves, and other indications of their vegetable origin; and the analysis of this combustible substance tends still further to confirm this truth. On the other hand, if we attend to such inferences as chemical theory might point out from the facts around us, we shall see how small the probability is, that the mineral kingdom should, after a certain limited time, contain inflammable bodies, if they were not occasionally thrown into it, in consequence of the operations carried on within organised substances. For all inflammable substances, tending to decompose the oxigen of the atmosphere, would, in process of time, revert to the class of uninflammable bodies, if the operation of organised bodies, particularly of the vegetable kind, did not tend to disengage the oxigen again, and render bodies combustible, which were not so when they became parts of those substances.

COATING, *or* LORICATION. Glass being a brittle substance, and at the same time a bad conductor of heat, is always liable to be broken by the expansion of its outer surface, where heat is so suddenly applied, that the expansion of the inner part does not immediately take place. To prevent this, and also to obviate the same inconvenience arising from variations in the intensity of the fire, it is usual to have recourse either to a sand-bath, or to coating the vessel.

Retorts may be coated in the following manner: Take of sand and clay equal parts; make them into a thin paste with fresh blood prevented from coagulating by agitation till it is cold, and diluted with water; add to this paste some hair, and powdered glass; with a brush dipped in this mass besmear the retort; and when this first layer is dry, let the same operation be repeated twice or oftener, till the coat applied is about one third part of an inch thick.

Chaptal recommends a soft mixture of marly earth, first soaked in water, and then kneaded with fresh horse-dung, as a very excellent coating.

The valuable method used by Mr. Willis of Wapping to secure or repair his retorts used in the distillation of phosphorus deserves to be mentioned here. The retorts are smeared with a solution of borax, to which some slaked lime has been added, and when dry, they are again smeared with a thin paste of slaked lime and linseed oil. This paste being made somewhat thicker, is applied with success, during the distillation, to mend such retorts as crack by the fire.

Cobalt is a semimetal, of a whitish gray or steel colour, hard and brittle; of a dull, close-grained fracture, and moderate specific gravity. It is rather more difficult of fusion than copper; does not easily become calcined; and its oxide is of so deep a blue colour as to appear black. The most remarkable and most valuable property of this metallic substance is, that its oxide, when fused with borax, or with alkali and sand, produces a blue glass, known by the name of smalt. The action of air soon tarnishes cobalt; but water has little or no effect upon it. When reduced into thin plates it is said to be capable of being rendered magnetic, but many suspect this to be owing to the presence of iron.

To obtain the metal pure, Tromsdorff recommends to mix eight parts of finely pulverized zaffre with two of dry nitrat of potash, and one of charcoal powder, and project them by small quantities into an ignited crucible: to repeat this process three times with the detonated residuum and fresh quantities of nitre and charcoal: to mix the mass with an equal weight of black flux, and keep this mixture at a red heat for an hour. The metal thus obtained is to be pulverized, mixed with three times its weight of nitrat of potash, and detonated as before. This being powdered and washed to separate the arseniat of potash, the filtered residue is to be digested in nitric acid, which will dissolve the cobalt, and leave the highly oxidized iron untouched. Then evaporate the solution to dryness, redissolve in nitric acid, refilter lest some oxide of iron should have been retained, decompose the nitrat of cobalt by potash, wash the precipitate, and reduce it by heat.

Brugnatelli supposed he had discovered an acid in zaffre, which he called the cobaltic, but it appears to have been only arseniat of cobalt.

Concentrated and boiling sulphuric acid, distilled nearly to dryness, combines with this semimetal. Much sulphurous acid gas flies off; and the cobalt is in part calcined, and in part conveyed into a crystallizable salt, soluble in water, and precipitable by lime and by alkalis in the form of a rose-coloured powder or oxide. Diluted sulphuric acid acts upon the oxide of cobalt, and forms the same salt.

Nitric acid dissolves cobalt by the assistance of a moderate heat. Nitrous oxide is disengaged, and the solution affords deliquescent crystals by evaporation, which do not detonate on ignited coals, but boil up and leave a red oxide. Lime and the alkalis precipitate the solution; and, if the alkali be added in excess, it dissolves the precipitate.

The muriatic acid has scarcely any action on cobalt, unless it is boiling; in which case it dissolves a small portion. It dissolves the oxide more readily, with which it forms a red brown fluid, that becomes green when heated. This solution affords deliquescent crystals by evaporation.

Aqua regia dissolves cobalt more easily than the muriatic acid, though not so readily as the nitric. This solution is well known as one of the most celebrated sympathetic inks afforded by chemistry.

The acid of borax does not act immediately on cobalt, in the humid way: but borax itself, added to either of the foregoing solutions, effects a decomposition by double affinity; the alkali uniting with the solvent acid, while the acid of borax seizes the cobalt, and forms a scarcely soluble compound, which falls down.

The oxalic acid precipitates cobalt from its solutions, in the form of a pale rose-coloured powder.

Whether alkalis or earths combine with this metal directly, by the intervention of water, has not been determined.

Cobalt does not act on neutral salts in general. It detonates feebly with nitre, when projected into a red hot crucible, with twice or thrice its weight of that salt.

Sulphur does not unite with cobalt but with difficulty. Alkaline sulphurets combine more readily with it. Phosphuret of cobalt may be formed by fusing equal parts of glacial phosphoric acid and cobalt with an eighth of their weight of charcoal powder: or by projecting small bits of phosphorus on cobalt ignited in small fragments in a crucible.

This semimetal unites by fusion with most of the metals and semimetals, as has before been noticed. Silver, lead, and bismuth, do not mix with it; and zinc does not but

t difficulty. It debases the colour
nd renders it brittle.
is found native in alloy with ar-
iron, and of a steel-grained ap-
when broken; or in the state of
a black colour, either pulverulent
ated; or combined with arsenic
he flowers of cobalt, of a red co-
lastly, united to sulphur and iron,
without arsenic, of various shades
s. Bismuth, nickel, and other sub-
re contained in these ores. They
neral be distinguished by solution
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tive cobalt, and its calciform or
us ores, may be examined by so-
aqua regia, and evaporation to
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rains for every hundred and sixty
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nay be ascertained by the usual
The red arsenical cobalt ore,
tains arsenic acid, may be decom-
ulphuric acid; and the disengaged
id will be taken up by alcohol;
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n water, and precipitated by mild
the ore itself may be dissolved in
rpened by an acid; and the oxide
ecipitated by the alkali.
dry way, the ores of cobalt, after
pounding, washing, and roasting,
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ower of cobalt ores may be assay-
on with three parts of fixed alkali,
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reduced, this semimetal usually
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or at least by eliquation, or melt-
count of its greater fusibility.
s found in several parts of Europe,
plentifully on the southern border
and in Saxony. A very rich vein
been discovered in Cornwall.
usually broken into pieces about
a hen's egg, and the stony parts
t. The sorted mineral is then
n mills, and sifted through wire
By washing in water, the lighter
arried off; and the remainder is
a furnace resembling an oven,
is heated by the action of the
ed flame of wood which plays
In this situation, it is occasionally
th long iron rakes; and emits
nsisting chiefly of arsenic, which
is collected in a long horizontal chimney, built for that purpose. If the ore contain bismuth, this fusible semimetal is collected at the bottom of the furnace. The cobalt, after a sufficient torrefaction, remains in the form of a dark gray oxide, called zaffre. The zaffre of commerce always contains twice or thrice its weight of powdered flints. The flint is pulverized for this and other purposes by means of previous ignition, and quenching in water, which renders it friable. Smalt is a blue glass, composed of one part of the calcined cobalt, fused with two of the flint powder, and one of potash.

The use of this metallic substance is confined chiefly to the production of the blue glass for enamels, and other purposes. The powder blue, and a bad sort of stone blue, used by laundresses, is a preparation made by the Dutch from the coarse smalt.

Coccus. A genus of insects, among which are the *cochineal*, c. cacti; *kermes*, c. ilicis; the *lac* insect, c. lacca; and Polish scarlet grain, c. polonicus, which is now scarcely used in Europe, being superseded by the c. cacti. See Cochineal, Kermes, and Lac.

Cochineal was at first supposed to be a grain, which name it still retains by way of eminence among dyers, but naturalists soon discovered that it was an insect. It is brought to us from Mexico, where the insect lives upon different species of the opuntia.

Two sorts of cochineal are gathered at Mexico, the sylvestris, there known by the Spanish name grana sylvestra, and the fine, or grana fina, called also mesteque, from the name of a province in Mexico, and which are bred upon the nopal. The first is smaller, and covered with a cottony down, which increases its weight with a substance useless in dyeing: an equal weight of it therefore gives less colour, and is of a lower price than the fine cochineal; but these disadvantages are perhaps compensated by its being reared with greater facility, and at less expense, and even by the effects of its down, which enables it better to resist rain and storms.

Both the nopal and the cochineal have been introduced into some of the West India islands, and even into the *Jardin des Plantes* at Paris, so that the French expect to raise enough for their own consumption in the neighbourhood of their metropolis.

Fine cochineal, which has been well dried and properly kept, ought to be of a gray colour inclining to purple. The gray is owing to a powder which covers it naturally, a part of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed. Cochineal will keep a long time in a dry place. Hellot says, that he tried some one hundred and thirty years old, and found it produce the same effect as new.

The decoction of cochineal is of a crimson colour, inclining to violet. A small quantity of sulphuric acid made this liquor assume a red colour, inclining to yellow, and a small quantity of a beautiful red precipitate was formed. Muriatic acid produced nearly the same change in the colour, but no precipitate. Solution of tartar changed the liquor to a yellowish red. A little precipitate of a pale red colour formed slowly: the supernatant liquor remained yellow; but, on pouring in a little alkali, it became purple. The small quantity of precipitate was quickly dissolved by the alkali, and the solution was purple. Solution of tin formed a rose-coloured precipitate with the yellow liquor. Solution of alum brightened the colour of the infusion, and gave it a redder hue; a crimson precipitate was formed, and the supernatant liquor retained a crimson colour, somewhat reddish. Alum and tartar mixed produced a brighter colour, more lively, and inclining to a yellowish red. A precipitate was formed, but much less abundant, and much more pale than in the preceding experiment. Solution of tin produced a copious sediment of a beautiful red. The liquor remaining above it was as clear as water, and suffered no change of colour on adding alkali. Having poured in a solution of tartar, and after that a solution of tin, a precipitate of a rose colour, inclining to black, was formed more quickly than in the foregoing experiment; and, though solution of tin in excess was added, the supernatant liquor remained a little yellow. Solution of common salt rendered the colour somewhat deeper, but did not make the liquor turbid. Sal ammoniac gave a purple tinge, without occasioning any precipitate. Sulphat of soda produced no perceptible change in the liquor. Having boiled a little cochineal with half its weight of tartar, the liquor was more inclining to red, and had a colour much less deep than that obtained from an equal quantity of cochineal without tartar; but the former gave a more abundant precipitate with solution of tin, and its colour was more rosy; so that tartar favours the solution of the colouring part of the cochineal; for, though the colour of the solution is less deep, the precipitate produced from it by solution of tin is of a deeper and more rosy hue. This experiment deserves notice, in judging of the influence of tartar in dyeing scarlet.

Sulphat of iron formed a brown violet precipitate. The supernatant liquor remained clear, with a tinge of feuille-mort. Sulphat of zinc formed a deep violet precipitate. The supernatant liquor remained clear and colourless. Acetit of lead produced a purple violet precipitate, less deep than the preceding. The supernatant liquor remained limpid. Sulphat of copper produced a violet sediment, which formed slowly. The liquor remained clear, and of a violet colour.

If the extract which decoction of cochineal affords on evaporation be digested in alcohol, the colouring part dissolves, and leaves a residuum of the colour of wine lees, of which fresh alcohol cannot deprive it. This residuum, analysed by fire, affords the common products of animal substances.

The alcoholic tincture of cochineal leaves on evaporation a transparent residuum of a deep red, which when dry has the appearance of a resin. This also, if distilled, yields the product of animal substances; which shows, that the colouring matter is an animal production.

Yet the decoction of cochineal does not easily putrefy. Berthollet has kept some of it more than two months, both in an open vessel, and in a bottle corked. At the end of that time the former showed no signs of putrefaction, the latter had a slight putrid smell. The first grew turbid in a few days, and left a brown violet sediment on the filter: the second preserved its transparency a long time, and probably lost it only from the effect of an incipient putrefaction, or rather of a slight combustion, produced by means of a little oxigen, probably united with the red particles of the cochineal. The colour of each had become crimson; but that of the former was more weak, because a greater part of the colouring matter had precipitated, in consequence of the effects produced on it by the air.

In some experiments by Hermbstaedt, muriat of barytes, used as a mordant in kerseymere, gave a pleasing violet with cochineal: the nitrat of barytes, a very pleasing poppy red: the acetit of barytes, a deep but bright poppy colour: muriat of strontian, a crimson: nitrat of strontian, a bright reddish brown: acetit of strontian, a bright poppy. He likewise found, that a solution of fine English tin in pure muriatic acid being exposed to the air in an open vessel for a month, a piece of kerseymere boiled in it, and then immersed in a warm cochineal bath, took a bright scarlet colour.

A distinguishing characteristic between cochineal and madder may be observed in the manner in which they are acted upon by the reagents. Both receive a yellow colour from acids; but if the colouring matter of cochineal be separated by a substance which precipitates it from the acid liquor, it reappears with its natural colour little altered; while that of madder, treated in the same manner, retains a yellow or fawn tinge. Hence mordants abounding in acid, as solution of tin, are much more successfully employed with cochineal than with madder. The cause of this probably is, that the colouring matter of madder united with oxide of tin retains a portion of acid, while that of cochineal combined with it retains none, or a much smaller quantity.—*Berthollet on Dyeing.—Scherer's Journal.*

Cockle. A Cornish mineral term applied to various substances, but most generally to the substance called schorl or shrill, from the German; which see.

Coffee. Neumann obtained from one pound of coffee by distillation five ounces five drachms and a half of water, six ounces and half a drachm of a fœtid oil, and four ounces two drachms of coal. It afforded him $\frac{5}{16}$ of watery extract, and $\frac{7}{32}$ of spirituous.

According to Seguin it consists of albumen, oil, a peculiar principle which he calls the bitter principle, and a green matter which is a combination of this principle with albumen. He found the proportions of these variable in different specimens: that torrefaction augmented the bitter principle by destroying the albumen: that both these contain nitrogen: and that the bitter principle is antiseptic. The oil is white, congealable, and without smell. He has found albumen in many other vegetables, most of which contain a bitter principle in many respects similar to that of coffee.

Mr. Chenevix discovered this bitter principle, and examined it more minutely. He obtained it by heating water on raw coffee in a close vessel, filtering, and evaporating. or by precipitating a decoction of raw coffee with muriat of tin, and separating the tin from the filtered precipitate by putting it into water, and passing a current of sulphuretted hidrogen slowly through the liquor, which Mr. Chenevix conceived afforded this principle in still greater purity.

It is of a pale yellow colour, transparent like horn, bitter but not unpleasant, and neither acid nor alkaline. Its solution is turned red by alkalis, and by nitric acid: alkaline carbonats do not precipitate it; neither does gelatine: it cannot therefore be tannin. Sulphuric acid merely changes its colour to a dirty brown. Solution of iron gives a fine green precipitate; muriat of tin, a yellowish; water of barytes, a fawn coloured. Neither lime water nor strontian precipitated it.

As a decoction of well roasted coffee evidently contains tannin, as is shown by the addition of gelatine, Mr. Chenevix conjectures, that this principle is converted into tannin by the action of heat, though he did not find this to be the case after it was separated from the coffee.

Coffee is diuretic, sedative, and a corrector of opium. It should be given as a medicine in a strong infusion, and is best cold. In spasmodic asthma it has been particularly serviceable: and it has been recommended in gangrene of the extremities arising from hard drinking.—*Bulletin des Sciences.*—*Nich. Journ.*—*Percival's Essays.*

Cohesion. The power by which the parts of bodies become attached to each other, and form consistent masses. We know scarcely any thing concerning attraction but its effects, there being very few instances indeed wherein we can consider ourselves as authorised to refer this property to any more remote cause deducible by our researches. The various kinds of attraction have been classed relative to their effects, and considered as distinct, and in a certain sense independent properties. It has however been made a question by chemists of undoubted sagacity, whether all attractions, and more particularly the cohesive and chemical attractions, ought not to be referred to one general property of matter, modified by variations in the figures, relative distances, &c. of bodies. See Attraction.

Cohobation. It is frequently required in chemical operations, that a substance should be for a long time boiled, or digested in a volatile fluid considerably heated. This necessarily supposes a great loss of the fluid, if the operation be performed in an open vessel. To prevent this, the ancient chemists employed a kind of still, called a pelican. The head of this vessel was provided with two beaks, which by a gradual incurvation returned into the body, and conveyed thither whatever volatile matter had risen into the head, and there became condensed. The views and practices of the moderns do not require these long digestions; but many valuable experiments of Priestley and others, of the nature of repeated distillation, have been made by a simpler apparatus. A glass tube, three or four feet in length, supplies the place of the pelican. A mineral acid, water, or any other requisite fluid, is put into the tube, in such a quantity as to occupy an inch or more of its lower end; the upper end is then hermetically sealed, and heat applied to the lower by a sand bath. The fluid partly rises, and is partly changed in other respects by the heat. The vapours as they arrive towards the upper part of the tube become condensed, and return again to the lower in a kind of circulation down the cooler side of the vessel. In this way Scheele has shown, that the pretended conversion of water into earth by repeated distillation is in fact nothing more than an abrasion or decomposition of the glass vessels; and Priestley has made a variety of experiments on the mineral acids.

Colcothar. The brown red oxide of iron, which remains after the distillation of the acid from sulphat of iron: it is used for polishing glass and other substances by artists, who call it crocus, or crocus martis.

Cold. The privation of heat. See Caloric.

Colophony. Colophony, or black resin, is the resinous residuum after the distillation of the light oil, and thick dark reddish balsam, from turpentine.

Columbium. A mineral in the British Museum, sent to Sir Hans Sloane with some iron ores from Massachusetts, was lately examined by Mr. Hatchett, and a new metallic substance discovered in it, to which he has given the name of columbium.

The mineral is heavy, of a dark gray nearly black, and in some measure like the

Siberian chromat of iron. The mineral acids act on it very feebly: the sulphuric rust dissolving some iron. Melted with five or six parts of carbonat of potash it is partly decomposed; but to effect a complete decomposition the ore must be alternately melted with potash and digested with muriatic acid, which takes up the iron. During the fusion carbonic acid is expelled, and the potash is partly neutralized by a metallic acid, which may be separated after solution in water by adding nitric acid to excess, when it will appear in the form of a copious white flocculent precipitate.

The ore consists of more than three fourths of this substance combined with iron. When recently separated it is soluble in muriatic or sulphuric acid with heat. Alkalis precipitate it white; prussiat of potash, olive green; tincture of galls, a deep orange. If the sulphuric solution be copiously diluted, it falls down in the state of a sulphat, which as it dies changes from white to blue, and lastly to gray. Zinc precipitates it white. Hidrosulphuret of ammonia forms a chocolate-coloured precipitate with its alkaline solutions.

The white precipitate combines with potash and soda, both in the dry and humid way, and expels the carbonic acid from them. With potash it forms a glittering scaly salt, which has much the appearance of the boracic acid. With phosphat of ammonia it forms a purplish blue glass. It is extremely difficult to reduce: and it reddens litmus paper.—*Nich. Journal.*

Combination. When two bodies unite together in such a manner as that most of the original properties of the bodies respectively disappear, and the compound exhibits new properties not immediately deducible from those before existing, the bodies are said to be combined together. Combination is therefore the most intimate union of bodies, and is to be distinguished from the grosser union called mixture.

Combustion. There is a remarkable distinction in bodies with regard to the effects of heat upon them. Some bodies will admit of being heated to such a degree as even to become luminous or red hot without any permanent or considerable change of their properties or component parts; and as soon as the communication of heat ceases, the bodies immediately begin to cool. On the other hand, there are a great number of bodies, which, when heated with access of oxigen to such a degree as to become luminous, undergo a change in their properties, insomuch that their temperature even increases, and they continue to give out heat until the general state of the combination of their parts is changed. These bodies are distinguished by the name of combustible bodies, and the alteration produced by this apparently spontaneous production of heat is called combustion.

It must always have been a problem of the first importance in natural philosophy, to ascertain what happens in combustion. The division of substances into combustible and incombustible is as striking and distinct as any we are acquainted with; and it is a natural inference, that the one class of bodies must possess some general property, or identical substance, not to be found in the other. The philosophy of the middle ages, probably in consequence of their logical classifications, was much more disposed to attach itself to substances than habitudes or properties. It is less to be wondered at, therefore, that Beccher and Stahl should have assigned a substance eminently combustible, or fire itself, as resident in all combustible bodies, and occasioning the difference between them and other bodies, instead of inquiring whether the general effect might not have arisen from some effect of the chemical affinities. Modern chemists have however very amply and successfully maintained this last doctrine. Still it will be proper to give a short statement of the two doctrines as applied to combustion in general.

The modern maintainers of phlogiston, or the principle of inflammability, do not teach exactly the same doctrine as Stahl. This chemist supposed combustion to consist in the escape of fire from bodies. Various facts have compelled the moderns to modify this position. The most generally received statement is, that a substance called phlogiston and very strongly attractive of oxigen, resides in all combustible bodies; that a certain degree of heat weakens the adherence between phlogiston and the combustible substance, and consequently disposes it to a more speedy union with the oxigen of the atmosphere; that the capacity of oxigen for heat is diminished by this union, and consequently an increase of temperature follows, which serves to accelerate the disengagement of more of the phlogiston; and in this way heat continues to be extricated until the body has become dephlogisticated, or incombustible.

The modern or antiphlogistic theory is exactly the same, excepting that instead of supposing combustible bodies to contain a principle of inflammability, which attracts the oxigen of the atmosphere, it infers, that the body itself attracts and combines with oxigen; and as no difficulty ensues from this statement, it seems clear that the phlogiston is redundant and unnecessary in accounting for the effects.

The consideration of these doctrines and their consequences embraces nearly the whole science of Chemistry; but the reader may more especially recur to the articles Acids, Metals, and Caloric.

Combustion, as already observed, is commonly occasioned by the application of a body already ignited to the combustible; and when this is not the case it has been termed *spontaneous.* But this would include the mechanical means, as friction, and the concentration of the solar rays, which cannot with propriety be called spontaneous; we would confine it therefore to combustions that arise simply from the play of chemical affinities. Such of these as have hitherto been observed we shall proceed to enumerate, as they lead to cautions of importance for preventing serious accidents.

If quicklime in any quantity be laid in contact with any combustible, as wood, and be wetted by accident, or to make it into mortar, a sufficient quantity of heat may be extricated to set fire to the wood. Animal or vegetable substances laid together damp in large heaps undergo a fermentation, which often excites combustion, as in the case of hay-ricks. Woollen cloth, not freed from the oil used in dressing it, and laid up damp in large heaps, has been known to take fire; and so has painted canvass. Flowers and herbs boiled in oil, as is done by druggists, and then laid in heaps, sometimes do the same. The mixture of linseed oil and lampblack, or of linseed oil and black wadd, is very liable to inflame. Torrefied vegetables, as malt, coffee, or bran, put while hot into coarse bags, are apt to take fire. The spontaneous combustion of phosphorus, and various pyrophori, is well known. It is suspected to be owing to the presence of one or other of these, that charcoal sometimes takes fire without any apparent cause; and the charcoal of peat is said to be particularly liable to this. Hyperoxigenated muriat of potash mixed with sulphur, or with sulphur and charcoal, is apt to detonate spontaneously.

Many cases of spontaneous combustion taking place in the human body too are on record: and it has been observed, that all the persons, who thus suffered, were much addicted to the use of spirituous liquors.

Concentration. This term is used to denote the privation of a part of the water usually contained in certain fluids, more particularly saline solutions. Thus, by evaporation of part of the water of a solution of sea salt, we obtain a concentrated brine; by evaporation in a nearly closed vessel, or by distillation, part of the water of sulphuric acid is driven off, and the remainder is concentrated sulphuric acid. Thus, again, if vinegar be exposed to freeze, the aqueous part congeals first, leaving the concentrated vinegar behind.

Condensation. The approach of the particles of a body to each other, so as to cause the whole to occupy less space than before. It is most commonly applied in chemistry to denote the transition from the vaporous or aërial to the solid state, as happens in distillation, sublimation, &c.

Congelation. The formation of ice. The term is applied in general to every transition from the fluid to the solid state. Thus we say the congelation of sulphuric acid, of oils, of metals, &c. It appears to be owing to the abstraction of caloric. See Caloric.

Cone (Melting). This is a hollow cone formed of copper or of brass, with a handle, and with a flat bottom adjoining to the apex of the cone, upon which it is intended to rest. Its use is to receive a mass of one or more metals melted together and poured into it. This mass, when cold, may be easily shaken out of the cone from the figure of the vessel. Also if a melted mass, consisting of two or more metals, or other substances not combined together, be poured into this vessel, the conical figure facilitates the separation of these substances according to their respective densities. The cone ought to be well heated before the melted mass is poured into it, that no moisture may be contained, by which a dangerous explosion might be occasioned. It ought also to be greased internally with tallow, to prevent the adhesion of the fluid matter.

Contrayerva. The leaves of this plant are said to afford a poison employed by Indians for poisoning arrows, to which poison the root of the said plant is said to be an antidote. From an ounce of the root Neumann extracted with water three drams and half a scruple; and from the same quantity with alcohol five scruples and two grains.

Copal, improperly called gum copal, is a hard, shining, transparent, citron-coloured, odoriferous, concrete juice of an American tree, but which has neither the solubility in water common to gums, nor the solubility in alcohol common to resins, at least in any considerable degree. By these properties it resembles amber. It may be dissolved by digestion in linseed oil with a heat very little less than sufficient to boil or decompose the oil. This solution, diluted with oil of turpentine, forms a beautiful transparent varnish, which, when properly applied and slowly dried, is very hard, and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colours of old pictures by filling up the cracks and rendering the surfaces capable of reflecting light more uniformly.

In Gehlen's Journal we are informed, that copal may easily be dissolved either in alcohol, or in oil of turpentine, by suspending bits of copal by threads over either of these in an alembic, and then boiling the fluid. The vapour liquefies the copal, which drops into the liquor beneath, and when cold the limpid and colourless solution is to be decanted from the undissolved part of the copal.

Mr. Tim. Sheldrake has found, that camphor has a powerful action on copal; for if powdered copal be triturated with a little camphor, it softens, and becomes a coherent mass; and camphor added either to alcohol or oil of turpentine, renders it a solvent of copal. Half an ounce of camphor is sufficient for a quart of oil of turpentine, which should be of the best quality; and the copal, about the quantity of a large walnut, should be broken into very small pieces, but not reduced to a fine powder. The mixture should be set on a fire so brisk as to make the mixture boil almost immediately: and the vessel Mr. S. recommends to be of tin or other metal, strong, shaped like a wine-bottle with a long neck, and capable of holding two quarts. The mouth should be stopped with a cork, in which a notch is cut to prevent the vessel from bursting. It is probably owing to the quantity of camphor it contains, that oil of lavender is a solvent of copal. Camphor and alcohol dissolve copal still more readily than camphor and oil of turpentine.

Lewis had observed, that solution of ammonia enabled oil of turpentine to dissolve copal: and Mr. Sheldrake found it did, when added in the proportion of an eighth part. But it requires such nice management of the fire, as the mixture must be kept boiling, yet so that the bubbles may be counted as they rise, that it seldom succeeds completely.

Copper is a metal of a peculiar reddish brown colour; hard, sonorous, very malleable and ductile; of considerable tenacity, and of a moderate specific gravity. At a degree of heat far below ignition the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest the end which has been most heated; an effect which must doubtless be attributed to oxidation, the stratum of oxide being thickest where the heat is greatest, and growing gradually thinner and thinner towards the colder part. A greater degree of heat oxides it more rapidly, so that it contracts thin powdery scales on its surface, which may be easily rubbed off; the flame of the fuel becoming at the same time of a beautiful blueish green colour. In a strong white heat, nearly the same as is necessary to melt gold or silver, it melts, and exhibits a blueish green flame; by a violent heat it boils, and is volatilized partly in the metallic state.

Copper rusts in the air; but the corroded part is very thin, and preserves the metal beneath from further corrosion.

The sulphuric acid, when concentrated and boiling, dissolves copper. A brown thick fluid, containing oxide of copper and a portion of the oxide combined with sulphuric acid, is found at the bottom of the solvent. If water be added to this, it forms a blue solution of copper, which by evaporation affords blue crystals, that require about four times their weight of water to dissolve them. This solution lets fall an oxide of copper of a green colour by long exposure to the air.

The solutions of copper in sulphuric acid are slightly caustic. Magnesia, lime, and the fixed alkalis, precipitate the metal from them in the form of oxide. Volatile alkali precipitates all the solution of copper; but redissolves the oxide and produces a deep blue colour. Copper is precipitable from most of its solutions, in the metallic state, by the addition of iron: a clean plate of iron soon becomes covered with a coating of copper, when immersed in the solution: hence the volatile alkali and the application of iron are considered as the tests of the presence of copper. There are certain mineral waters in Hungary, Sweden, Ireland, and in various parts of England, which contain sulphat of copper, and from which it is precipitated by the addition of pieces of old iron. Gay-Lussac however has observed, that iron very much oxided is precipitated by oxide of copper; and that thus sulphat of copper may be freed from an iron with which it is contaminated by strongly oxiding the iron, either with nitric acid, or with the oxigenated muriatic, which is preferable.

Nitric acid dissolves copper with great rapidity, and disengages a large quantity of nitrous gas. Part of the metal falls down in the form of an oxide; and the filtrated or decanted solution, which is of a much deeper blue colour than the sulphuric solution, affords crystals by slow evaporation. This salt is deliquescent, very soluble in water, but most plentifully when the fluid is heated. Its solution, exposed to the air in shallow vessels, deposits an oxide of a green colour. Lime precipitates the metal of a pale blue; fixed alkalis of a blueish white. Volatile alkali throws down blueish flocks, which are quickly redissolved, and produce a lively blue colour in the fluid.

Muriatic acid does not readily dissolve copper, unless it be concentrated and boiling. The solution is of a deep brown colour; but on standing for some time it deposits a sediment, and becomes green. By careful evaporation it yields crystals; or when inspissated, it affords a greenish mass, which deliquesces in the air, is readily dissolved in water, gives a green tincture to alcohol, melts in a gentle heat, takes fire from a candle, and burns with a blue flame. The muriatic acid dissolves the oxides of copper more readily than the metal itself; but the solution does not differ from the foregoing.

Vegetable acids dissolve copper slowly; but in considerable quantity, if oxigen be present. In this, as in a number of other metallic solutions, it appears, that the disposition of the air to oxide the metal is greatly assisted by the elective attraction of the acid for the metallic oxide. Vinegar does not dissolve copper when boiling, because the steam prevents the access of the air; but the same acid standing for a day in a copper vessel will contract a dangerous metallic impregnation. This circumstance accounts for the unhappy consequences produced in some instances by copper vessels, which in other cases have produced no noxious effects. Confectioners boil pickles, and even lemon-juice, in clean copper vessels, without observing any bad taste or noxious consequence to follow. We cannot however avoid heartily concurring in the general opinion which now prevails, in the rejection of copper vessels for culinary purposes.

Verdigris is an oxide of copper, prepared in large quantities near Montpellier in France, by stratifying copper-plates with the husks of grapes which remain after the juice has been pressed out. These soon become acid, and corrode the copper. A solution of this oxide in distilled vinegar affords permanent crystals of acetat of copper, improperly called distilled verdigris. At Grenoble, verdigris, which is considered somewhat superior in quality, particularly for dyeing, is prepared by sprinkling plates of copper repeatedly with distilled vinegar. The component parts of this verdigris, as analysed by Chaptal, were, copper 20·9, carbonic acid 9·1, water slightly acidulated 13·05, strong coloured acid 53·95, carbon 3.

Prussic acid unites with the oxide of copper, and forms a brown paint, superior both in oil and water, as Mr. Hatchett informs us, to any other in use. It has also a purple tinge, so as to form various shades of bloom or lilac when mixed with white, which are not so liable to fade as those made with lake. The best mode of preparing the prussiat of copper is to dissolve the green muriat in ten parts of distilled water, and precipitate with prussiat of lime. It may be prepared also from sulphat of copper and prussiat of potash.

Fixed alkalis have some action on copper, with which they form a light blue solution. This, as well as the ammoniacal solution, appears to succeed better in the cold than by the assistance of heat, for the same reason as the cold acetous acid acts upon copper; namely, the facility with which the metal is calcined by the access of air.

Ammonia dissolves copper with much greater rapidity than fixed alkalis, whether it be in the metallic or oxided state, and forms a beautiful blue solution. This fluid has long attracted the notice of chemists, on account of its becoming colourless in closed vessels; and recovering its colour, which gradually extends from the surface downwards, when the vessel is opened. This effect is explained by the supposition, that the perfect solution of oxide of copper in ammonia is colourless when the alkali is in excess; but that it is blue when it abounds with oxide of copper: and accordingly it is found, that the loss of colour on keeping the vessel closed for some time, and its reappearance on opening the vessel, do not succeed with old solutions, which are permanently blue.

The air oxides more perfectly a portion of the suspended copper, which gives a blue colour to the fluid until it has more intimately combined with the alkali. If this combination be made in the closed vessel, the colour disappears; if it be made in the open vessel, the oxidation of another portion goes on, and continues until the alkali is saturated, and can combine with no more: so that the last portion of perfect oxide, which causes the blue colour, does not seem to have entered into so intimate a combination, for want of an excess of alkali. The alkali does not take up any considerable quantity, when applied to copper filings; but it dissolves much more of the oxides of copper. The solution does not very readily afford crystals.

Oils do not seem to act upon copper until they become rancid, in which case their disengaged acid corrodes the copper, and the oil assumes a blueish green colour. Verdigris is soluble in alcohol. Copper, in the metallic state, does not unite with earths or alkalis in the dry way. Its oxides enter into the composition of glass. In general it does not act on the neutral salts by fusion. Nitre detonates with it but difficultly. Filings of copper are thrown upon red hot nitre; and the residue is a brownish gray oxide, mixed and partly combined with vegetable alkali. If this be washed with water, the remaining oxide may be fused without other addition into a deep opake brown glass, used by enamellers.

Muriate of ammonia is decomposed by copper filings. The produce which comes over consists of ammonia, rendered blue by a small portion of copper, together with pure ammonia, hidrogen, and nitrogen: the residue consists partly of muriat of copper and oxide. In the wet way Brunswic or Friezland green is prepared by pouring a saturated solution of muriat of ammonia over copper filings or shreds in a close vessel, keeping the mixture in a warm place, and adding more of the solution from time to time, till 3 parts of muriat to 2 of copper have been used. After standing a few weeks, the pigment is to be separated from the unoxided copper by washing through a sieve; and then it is to be well washed, and dried slowly in the shade. This green is almost always adulterated with ceruse.

A solution of alum boiled in a copper vessel deposits some earth, and the fluid exhibits signs of the presence of copper by the test of ammonia. This does not seem to be a perfect decomposition of the alum; but appears to be effected by virtue of the acid, which that salt contains in excess. The neutral salt or alum saturated with its own basis falls down, because less soluble; while the excess of acid, forming sulphat of copper, exhibits the blue tinge when ammonia is added.

Copper unites very readily with sulphur. If copper filings be mixed with flowers of sulphur and a little water, the combination takes place; but it is much more readily effected in the dry way. This cannot be done by direct fusion, because the sulphur is burned at a much less heat than is required to fuse the copper. It may be prepared by mixing equal parts of sulphur and copper filings together, and exposing them to heat gradually raised to ignition: or plates of copper may be stratified in a crucible with sulphur, and gradually heated as before. This compound is a blackish gray mass, and is used by dyers and calico-printers: it is distinguished by the name of æs veneris. Alkaline sulphurets dissolve copper both in the humid and dry way.

Phosphorus unites with the oxide of copper; or if the glacial phosphoric acid be exposed to heat in a crucible, together with its weight of copper filings and about one quarter of its weight of charcoal, the phosphorus which is formed combines with the copper, and forms a kind of pyrites, which changes by exposure to air. It loses its metallic state, and assumes a black colour. Mr. Sage took one part of copper chips, and put it into a crucible in alternate layers with two parts of the glacial acid powdered and mixed with a twelfth of a part of charcoal. On breaking the crucible after cooling, a button of phosphuret of copper, of the hardness, grain, and colour of steel, was found at the bottom. It was easily turned in a lathe, took a beautiful polish, and did not appear to be changed by contact with fat bodies, or to be tarnished after fifteen years exposure to the air in his laboratory. It is more fusible than copper; may be melted several times under charcoal powder without losing its properties; and exposed for a long time under a muffle parts with its phosphorus with difficulty. Over the button was a deep red enamel, that did not change colour in the fire.

This metal combines very readily with gold, silver, and mercury. It unites imperfectly with iron in the way of fusion. Tin combines with copper, at a temperature much lower than is necessary to fuse the copper alone. On this is grounded the method of tinning copper vessels. For this purpose, they are first scraped or scoured; after which they are rubbed with sal ammoniac. They are then heated, and sprinkled with powdered resin, which defends the clean surface of the copper from acquiring the slight film of oxide, that would prevent the adhesion of the tin to its surface. The melted tin is then poured in, and spread about. An extremely small quantity adheres to the copper; which may, with great justice, be supposed insufficient to prevent the noxious effects of the copper as perfectly as might be wished.

When tin is melted with copper it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The uses of this hard, sonorous and durable composition in the fabrication of cannon, bells, statues, and other articles, are well known. Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. See SPECULUM. The ancients made cutting instruments of this alloy. A dagger analysed by Mr. Hielm consisted of 83¾ copper, and 16¼ tin.

Copper unites with bismuth, and forms a reddish white alloy. With arsenic it forms a white brittle compound, called tombac. With zinc it forms the compound called brass, and distinguished by various other names, according to the proportions of the two ingredients. It is not easy to unite these two metals in considerable proportions by fusion, because the zinc is burned or volatilized at a heat inferior to that which is required to melt copper; but they unite very well in the way of cementation. In the brass works, copper is granulated by pouring it through a plate of iron, perforated with small holes and luted with clay, into a quantity of water about four feet deep and continually renewed: to prevent the dangerous explosions of this metal, it is necessary to pour but a small quantity at a time. There are various methods of combining this granulated copper, or other small pieces of copper, with the vapour of zinc. Calamine, which is an ore of zinc, is pounded, calcined, and mixed with the divided copper, together with a portion of charcoal. These being exposed to the heat of a wind furnace, the zinc becomes revived, rises in vapour, and combines with the copper, which it converts into brass. The heat must be continued for a greater or less number of hours, according to the thickness of the pieces of copper, and other circumstances; and at the end of the process, the heat being suddenly raised causes the brass to melt, and occupy the lower part of the crucible. The most scientific method of making brass seems to be that mentioned by Cramer. The powdered calamine, being mixed with an equal quantity of charcoal and a portion of clay, is to be rammed into a melting vessel, and a quantity of copper, amounting to two thirds of the weight of the calamine, must be placed on the top, and covered with charcoal. By this management the volatile zinc ascends, and converts the copper into brass, which flows upon the rammed clay: consequently, if the calamine contain lead, or any other metal, it will not enter into the brass, the zinc alone being raised by the heat.

A fine kind of brass, which is supposed

to be made by cementation of copper-plates with calamine, is hammered out into leaves, in Germany; and is sold very cheap in this country, under the name of Dutch gold, or Dutch metal. It is about five times as thick as gold leaf; that is to say, it is about one sixty-thousandth of an inch thick.

Mr. Sage says, that fifty parts of oxide of copper, left after distilling acetic acid from verdigris, 100 of calamine, 400 of black flux, and 30 of charcoal powder, mixed together, and kept in fusion till no blue flame appears round the top of the crucible, will give a very fine brass, consisting of 6 parts copper and 1 zinc, which he esteems the best proportions. Some fine Geneva brass, however, used for the finer parts of watch-work, analysed by Dize, gave 3 parts copper only to one of zinc. The common French brass contains about 13 per cent. only of zinc.

The readiest mode of analysing brass is by dissolving it in sulphuric acid diluted with 20 parts of water, and immersing a plate of zinc in the solution, which will precipitate the copper.

Copper may be coated with platina, as well as with tin. Mr. Strauss precipitated a solution of platina by muriat of ammonia; washed, dried, and exposed the precipitate to a graduated red heat for half an hour in a covered crucible; and triturated it with 5 parts of mercury in a warm mortar into an amalgam, to which he added 2 parts more of mercury. A plate of copper coated with this, and then ignited to drive off the mercury, was covered with the platina. Mr. Strauss then mixed a little of the amalgam with chalk, sprinkled it with water, coated the plate of copper a second time, and again ignited it. The coating was now very perfect, and assumed a shining colour under the burnisher.

Copper unites readily with antimony, and affords a compound of a beautiful violet colour. It does not readily unite with manganese. With tungsten it forms a dark brown spongy alloy, which is somewhat ductile.

Copper is either found native, mostly in an impure state, or in the form of an oxide, of a red, green, or blue colour. The native solutions of copper frequently impregnate calcareous earths, in which they deposit the metal. Phosphat of copper has been found native: and likewise arseniat and carbonat. Many ores of copper contain sulphur. Among these, the vitreous copper ore is of a red, brown, blue, or violet colour; sometimes crystallized, but usually soft enough to be cut with a knife. Some of the pyrites contain a considerable proportion of copper, together with iron, sulphur, and clay. The gray copper ore is a sulphureous combination containing arsenic; it is of a white, gray, or brown colour, heavy, and difficult of fusion. Blendose copper ore is of a brown colour, hard, solid, compact, and granulated: it contains the metal, with sulphur, arsenic, zinc, and iron. Some slates, and one species of coal, afford copper; and several waters contain this metal, dissolved in sulphuric or muriatic acid.

Native copper may be assayed, in the humid way, by solution in nitric acid. If it contain gold, this metal falls untouched to the bottom, in the form of a black powder; if silver, it is soon precipitated by more copper; if iron, by boiling the solution for some time, it is gradually oxided, and falls to the bottom.

The calciform copper ores are soluble in acids, and may be precipitated either by iron, which affords the copper in the metallic state, or by mild alkali, which throws down 194 grains of precipitate for every 100 grains of copper.

Sulphureous copper ores may be powdered, and gently boiled to dryness in five times their weight of concentrated sulphuric acid. The whole, or most part of the sulphur, flies off by this heat. The sulphat of copper requires at least four times its weight of water to dissolve it. A sufficient quantity being therefore added, and a polished iron plate boiled in the solution, the copper will be precipitated. If iron be found to be mixed with the precipitate, it must be again dissolved, to obtain a richer solution. This will deposit pure copper, if the operation be conducted as before. If it contain other metals, they may be easily separated by solution in nitric acid.

In the dry way, the sulphureous ores of copper must be first pulverized, and separated as much as possible from the earthy and stony particles, then roasted, to separate the sulphur and arsenic; and lastly, melted with an equal weight of Tillet's flux, which consists of two parts pounded glass, one calcined borax, and one eighth of charcoal. More borax may be added if the ore be poor. Alkaline fluxes are hurtful in the fusion of copper ores, because the salt combines with the sulphur, and forms a sulphuret, which dissolves part of the copper.

In the large way copper is roasted in a close furnace, by a slow fire, to scorify the mixtures of iron and other substances. By repeated fusions with sulphur and charcoal, the scorified metal rises to the top, and is scummed off. The copper, in the great Hungarian mines, is said to undergo fusion fourteen times before it is fit for sale. The roasted ore in the isle of Anglesey is deprived of its sulphat by washing, and the copper is precipitated by means of old iron immersed in the water. This precipitated copper is, however, but small in proportion to the whole produce.

Copper is found in various parts of the world; in Spain, France, England, Norway, Hungary, Sweden, and elsewhere. The Japan copper is said to be purer, and has a greater specific gravity, than any other copper. The wire-drawers, who require copper of extraordinary ductility, use the Swedish copper. Fine Swedish copper is much used by jewellers for alloying gold: it is of a pale colour, and sells as high as six shillings a pound. The copper mines in England are exceedingly numerous and productive. Paris Mountain, on the isle of Anglesey, contains a bed of ore forty feet in thickness, and is said to produce upwards of four thousand tons of copper annually.

It is of importance in many cases, as for alloying gold, to have copper very pure: and for this perhaps Pelletier's method is the best. He fuses the copper, and projects upon it black oxide of manganese in powder, frequently stirring the metal, so as to oxidate the metals usually combined with it, without proceeding so far as to oxidate the copper itself.

The uses of this metal are too numerous to be distinctly specified. It has for some years past been applied with great success and advantage for sheathing the bottoms of ships; and several builders have lately endeavoured to introduce it as a covering for houses. It is the lightest of all coverings; but whether it be more durable than slate, which is nearly as light, has not yet been ascertained by experience.

Copperas. Sulphat of iron is called green copperas in commerce. The sulphat of copper is called blue copperas, or frequently blue vitriol; and the sulphat of zinc is called white copperas.

Coral and **Coralline** are shells of marine animals of the polypus kind, and possess the same chemical properties as the shells of oysters and other fish; that is, they consist of calcareous earth combined with mucilage and other animal matter.

Cork is a bark of a tree of the oak kind, very common in Spain and the other southern parts of Europe. By boiling in water Neumann obtained from cork one twelfth part of its weight of extract, and by digestion in alcohol he obtained rather a larger quantity of resinous matter.

Mr. Brugnatelli has examined this substance in the more accurate methods of modern chemistry. The cork upon which he made his experiments was white and very smooth. In the focus of the burning glass it was quickly burned with a white brilliant flame, leaving a light spongy coal, easily and almost totally consumed in a crucible, the residue of ashes being scarcely perceptible. Cork, when treated in the way of destructive distillation, was entirely or very nearly converted into hidrogen. Boiling water only softened it. The action of the sulphuric and also of the muriatic acid, even when assisted by heat, was scarcely sensible. By the action of the nitric acid it was found to be acidified. See **Acid** (**Suberic**).

Cork (**Fossil**), Suber Montanum. This name is given to a stone which is a species of amianthus, consisting of flexible fibres loosely interwoven, and somewhat resembling vegetable cork. It is the lightest of all stones. By fire it is fusible, and forms a black glass. It possesses the general properties of amianthus.

Coro-Shut Marle. A kind of marle of a brown colour mixed with chalk and blue veins.

Corrosive Sublimate. A combination of oxide of mercury with muriatic acid. See **Mercury.**

Corundum, or **Corrindon.** The name of a stone brought from the East Indies, and commonly called **Adamantine Spar**, which see. Some make it a genus, including, beside the adamantine spar, the ruby and the sapphire.

Countries. An English mine term for the sides or enclosures of a vein or load of ore: *e. g.* the country of lead is limestone, killas, &c.

Cream of Lime. When lime water is exposed to the air, a portion of carbonic acid combines with the lime near the surface, and converts it into chalk, which first forms a pellicle at the top, and afterward falls down. This substance, which is either not at all soluble in water, or much less so than lime, is separated on that account. The term is at present seldom met with.

Cream of Milk. A portion of milk which rises to the surface of the fluid by repose: most probably in consequence of an incipient fermentation. It contains all the butter, some of the cheese, together with a portion of the other principles of the milk. See **Butter** and **Milk.**

Cream of Tartar. The supertartrit of potash in its purified state. See **Acid** (**Tartarous**).

Crimson. See **Dyeing.**

Crocus. The yellow or saffron-coloured oxides of iron and copper were formerly called crocus martis and crocus veneris. That of iron is still called crocus simply by the workers in metal who use it.

Crucible. A pot or vessel formed either of earth, of plumbago, or of some suitable metal. It is used for fusions, cementations, and other operations in the dry way. See **Laboratory.**

Cryolite. A triple salt, consisting of soda 36, alumine 24, fluoric acid and water of crystallization 40. It was found in Greenland: is of a bright whitish gray colour, semitransparent, soft to the touch, and very fragile; breaks into cubic fragments with a vitreous splendour; and its mean specific gravity is 2·95. It fuses at first before the blowpipe, but afterward loses this property, and resembles an earth strongly calcined.—*Klaproth's Analyses.*

Crystal. This word is used extensively to denote those portions of bodies which have assumed a symmetrical form at the time of acquiring the solid state. Thus we have crystals of salts, of metals, of earths, and of every other substance that possesses a considerable degree of simplicity in its composition. It is likewise used as the name of various substances to which we shall proceed.

Crystal (Factitious). The very fine clear glasses made in imitation of precious stones are sometimes called factitious crystals, but much more commonly pastes. Our opticians and other artists distinguish the dense white glass, which contains much calx of lead, by the name of crystal glass, and frequently enough by that of white flint. See Glass.

Crystal (Mineral). In the ancient dispensatories we find a formula for making a salt under this name, by fusing nitre, projecting a little sulphur thereon, and afterward casting it into cakes.

Crystal (Rock). The purest specimen of siliceous earth. This is either colourless and crystallized in hexagonal pyramids, and then called mountain crystal, or in various other forms. Its specific gravity is from 2·65 to 2·7. Its texture lamellated, and frequently shattered. The application of heat, unless extremely gradual, causes it to crack and lose its transparency. Some of these crystals have been found to consist of pure siliceous earth. Bergman extracted about six of argillaceous and one of calcareous earth from 100 parts of these crystals. The most violent heat of a furnace has not been found to diminish the weight or hardness of rock crystal; but professor Errhmann fused it by flame, urged with a stream of oxigen gas; and by the same means Mr. Francillon fused two pieces into one, but on cooling they flew to pieces, and in part even to a white powder.

The formation of crystal has much engaged the attention of chemists. There seems to be little doubt that this earth is suspended in water, most probably by a true solution, and afterward deposited in the same manner as other soluble bodies are: the only peculiarity appears to be, that so very large a quantity of the water is required to suspend a small quantity of the earth, that this last has eluded the attention of philosophers. The effects of water in the extensive operations of nature, relative to this earth, are however very considerable. The vast basin chiefly composed of siliceous materials deposited by the water of the prodigious fountain of Geyser, in Iceland, described by Von Troil, affords a proof that hot water suspends siliceous earth, and points out a series of experiments to be made with Papin's digester, though not yet undertaken by any one. And the observations of Mr. Genssane, quoted by Chaptal in his Elements of Chemistry, with others of the professor himself, prove that rock crystal is formed in a way not at all differing from that of calcareous spars. Mr. Genssane shows, that a quartzose gurh is formed by simple transudation upon ferruginous rocks; and the same naturalist has taken notice, that when the gurh is worn and deposited by water, rock crystals are formed. The waters which work their way through the quartzose rocks of the mine of Chamillat, near Planche les Mines in Franche Comté, form quartzose stalactites to the roof of the works, and even upon wood. The extremities of these stalactites, which have not assumed a solid consistence, are of a granulated and crystalline substance, easily crushed between the fingers.

In these cavities, called craques by the miners, a fluid gurh is often found, and still oftener crystals ready formed. Chaptal observed at Saint Sauveur, in the work of Laboissiere near Bramebiaou, several incrustations of gurh on the side of the gallery; and these spreading incrustations were terminated by well-formed crystals, whereever the wall overhung, or deviated from the perpendicular. This gurh, when handled, and minutely examined, had no other appearance than that of a siliceous paste of considerable purity.

Bergman obtained crystals resembling rock crystal, but not so hard, by dissolving siliceous earth in the fluoric acid, and leaving it to spontaneous evaporation. Chaptal has observed a fact of the same nature. Mr. Achard obtained a crystal as hard and as transparent as rock crystal, by dissolving the earth of alum in water impregnated with carbonic acid, the fluid filtrating very slowly through the bottom of a porous vessel of baked clay. A crystal of this kind was sent by him to my late friend Mr. Magellan, who exhibited it to the Royal Academy of Sciences at Paris, in the year 1778; and from whom I received it, and still retain it in my possession. Others have since attempted to repeat the experiment, though without success; and there have not been wanting several writers who have questioned the validity of the fact, though in my opinion very rashly; the character of this chemist, and the obscurity of the subject, in which so many unheeded circumstances might have conspired either to produce or vary the results, being amply sufficient to defend him from any imputation of so degrading a nature. It has been thought in particular, that a very perfect state of repose is necessary for the success of this experiment of a crystallization so extremely slow; and indeed if it be considered how greatly the phænomena of crystallization are influenced by the slightest agitation, and at the same time how considerable the agitations of the grounds and buildings are in great towns, it will not appear at all wonderful, that the Parisian chemists should not have succeeded in attempting to repeat this experiment. Any one may satisfy himself as to these vibrations, by observing the reflection of objects in a basin of mercury, which, however defended from the impressions of the external air, does not remain a moment in tranquillity, unless at a very great distance from all workshops or roads where carriages pass.

Since that time Guyton-Morveau, having enclosed rock crystals with a bar of iron in a bottle filled with carbonated water, perceived a vitreous point fixed to the iron, which he supposed to be a rock crystal formed by this operation; so that he considers iron as a necessary intermedium to enable the carbonic acid to dissolve quartz.

Rock crystal, though the softest among transparent stones, is harder than most of the opake stones, and much harder than glass.

Crystallization. Whenever the parts of bodies are separated from each other, and suspended in a medium or solvent, in which they can freely move, they either remain at a distance from each other by virtue of their attraction to the solvent, or they come together by their own mutual attraction, and form consistent masses. See Attraction.

From the facts there appears to be just ground to conclude that the particles of bodies demand certain relative positions at like distances, in order that the energy of their attraction may be the greatest possible; in a manner similar to what we observe in the attractions of magnetism and electricity. This polarity of the particles deducible by mathematical reasoning from their supposed figures, but no doubt in a great measure dependent on their component parts likewise, will cause the aggregate masses to assume some determinate figure, in similar circumstances or situations, and this figure will be modified in a great variety of ways accordingly as those circumstances are changed. If the particles be suspended or kept fluid, either by a due quantity of solvent, or by heat, or by both of these agents, a separation or deposition will ensue, whenever the quantity of the solvent or of the heat is sufficiently diminished. If this diminution be sudden, the particles will suddenly come together, with their sides or faces presented to each other in the order they happened to possess at the instant or short time of coagulation; subject likewise to all the accidental irregularities of agitation in the mass of the fluid. In such cases the particles will form a solid, possessing little or no symmetry in its figure. This is called confused crystallization.

On the other hand it may happen, that by gradual evaporation, or cooling, the diminution of the quantities of solvent, or of heat, may take place so slowly as to occasion a degree of motion altogether inconsiderable among the parts of the fluid. In this case, the particles which are about to separate will approach each other with extreme slowness, and no circumstance will interfere to prevent their applying such sides or faces towards each other as are best adapted to the governing laws of attraction. As soon as the particles have arrived to a distance less than is sufficient for their mutual attraction to overcome the power of the fluid which suspends them, they will rush together, and form symmetrical bodies possessing figures originating in, and dependent on the properties or nature of the particles which form them, and the symmetry will be more perfect the less the crystallization is influenced by disturbing causes. This is called regular crystallization, and the symmetrical bodies are called crystals.

As the agitation arising from the causes just mentioned is sufficient to prevent the regular formation of crystals, so likewise it is found, that mechanical agitation is still more destructive of their regularity. Slow crystallization produces sugar candy; a quicker crystallization affords loaf sugar. When a balloon some years ago was inflated at Moorfields by inflammable air, extricated by the action of sulphuric acid upon zinc, the white vitriol of commerce was afforded in beautiful transparent crystals, which the shops refused to purchase; but when by subsequent solution and mechanical agitation a white mass of confused crystals was obtained, the shop-keepers recognised the *white copperas* they had been used to deal in. The presence or absence of external impulse is of so much consequence in crystallization, that it may be doubted whether the action of light, which considerably impedes the formation of regular crystals, may not be attributed to this cause. The electric state of the atmosphere is said to influence crystallization: and the contact of air appears to be necessary, as salts that will not shoot in a fluid covered with a pellicle, begin to form crystals as soon as the pellicle is broken.

In a paper in the Journal de Physique Mr. Leblanc gives instructions for obtaining crystals of large size. His method is to employ flat glass or china vessels: to pour into these the solutions boiled down to the point of crystallization: to select the neatest of the small crystals formed, and put them into vessels with more of the motherwater of a solution that has been brought to crystallize confusedly: to turn the crystals at least once a day: and to supply them from time to time with fresh motherwater. If the crystals be laid on their sides they will increase most in length: if on their ends, most in breadth. When they have ceased to grow larger, they must be taken out of the liquor, or they will soon begin to diminish. It may be observed in general, that very large crystals are less transparent than those that are small.

The permanent texture of bodies, their fracture, and other circumstances, appear to depend upon the state of crystallization at the time of assuming the solid form. In metals, for example, the crystals are smaller and more confused the hastier the cooling. Thus steel suddenly cooled breaks with a r fracture, possesses a diminished gravity, and is very hard, whereas e steel, more slowly cooled, will be softer, difficult to be broken asunder, hen broken exhibits a very different l texture. The crystals of other me- y be obtained by fusing them in a e with a hole in its bottom closed by er, which is to be drawn out after sel has been removed from the fire, e surface of the metal has begun to l. The same effect may be observed metal be poured into a plate or dish, inclined, which is to be suddenly in- n the opposite direction, as soon as al begins to congeal round its edges. first method, the fluid part of the uns out of the hole, leaving a kind lined with crystals: in the latter e superior part, which is fluid, runs leaves a plate of metal studded over ystals.

e is scarcely any experiment in che- which does not afford some appear- a curious nature, referable to cry- tion.

n bodies dissolved in any fluid are ed by crystallization, they are always o retain a part of the fluid. The thus retained by saline crystals is the water of crystallization. This appears to be essential to the trans- crystalline form of salts, and is no retained by virtue of their attraction t fluid. From some experiments, in a much greater degree of cooling oduced by the solution of crystallized an of such as had lost its water of lization, it may be inferred, that this xists in crystals in the congealed or ate, and perhaps much denser than ce. Most salts may be deprived of ater of crystallization by mere heat. ose it in the common temperature of nosphere, and fall into a pulverulent called an efflorescence. Other salts water so strongly, that they draw it he atmosphere, and gradually become a phænomenon distinguished by the of deliquescence. Mr. Baumé affirms, e water of crystallization in all neu- ts with bases of fixed alkali is pure, ey are not capable of taking up a re- cy of either principle in their cry- This however may be doubted.

crystallization of salts is usually d by evaporating part of the water; may likewise be made to take place traction of the water in the way of al affinity. Thus if alcohol be added qual volume of a strong solution of he spirit combines with the water, nost the whole of the nitre separates stant in the crystalline form. There oubt but appearances of this kind ration have misled chemists on vari- asions.

operation of crystallizing, or crystallization, is of great utility in the purifying of various saline substances. Most salts are suspended in water in greater quantities at more elevated temperatures, and separate more or less by cooling. In this property, and likewise in the quantity of salt capable of being suspended in a given quantity of water, they differ greatly from each other. It is therefore practicable in general to separate salts by due management of the temperature and evaporation. For example, if a solution of nitre and common salt be evaporated over the fire, and a small quantity be now and then taken out for trial, it will be found, at a certain period of the concentration, that a considerable portion of salt will separate by cooling, and that this salt is for the most part pure nitre. When this is seen, the whole fluid may be cooled to separate part of the nitre, after which, evaporation may be proceeded upon as before. This manipulation depends upon the different properties of the two salts with regard to their solubility and crystallization in like circumstances. For nitre is considerably more soluble in hot than in cold water, while common salt is scarcely more soluble in the one case than in the other. The common salt consequently separates in crystals as the evaporation of the heated fluid goes on, and is taken out with a ladle from time to time, whereas the nitre is separated by successive coolings at proper periods.

Those chemists who consider heat as a peculiar substance, and not a modification of matter, are in general inclined to reckon the fluid state a solution in this matter; and the crystallization of bodies merely fused is by them accounted for by the abstraction of this supposed solvent.

It was natural for the earlier mineralogists and chemists to distinguish bodies by their symmetrical figures. Subsequent experience has however shown, that the crystallization of bodies is variable by so many and such minute circumstances, that a considerable dependance on this single attribute must necessarily be productive of error. Modern chemists, as the methods of analysis became more perfect, seem to have adopted a prejudice of the contrary nature, by almost totally rejecting the external figures of bodies as indications of their component parts. Romé de Lisle in his Crystallographie, Bergman in one of his Essays, and the abbe Haüy, have treated expressly and scientifically upon the formation of those geometrical figures which constitute crystals; but the subject is very far from being enough simplified to admit of any ready application. The miner, the mineralogist, and the chemist will perceive a number of circumstances in natural and artificial bodies relative to their configuration, grouping, colour, fracture, specific gravity, &c., by means of which he may form very probable conjectures as to their contents, and the experiments requisite to be instituted upon them: but in the present state of science there is no method, which can be substituted instead of actual inspection, and the attentive consideration of minerals and chemical products, the contents of which are previously known.

An ingenious and handy graphometer, or instrument for measuring the angles of crystals, by Mr. Bancks in the Strand, is described in my Journal, vol. xii. p. 374.

Culm. A term exclusively applied by dealers in pit-coal, to denote such coal as does not cake, or adhere together, when heated. Small pieces of coal of this kind are of much less value than larger pieces; and on this account the duties on culm are less than upon coal. See Coal.

Cupel. A shallow earthen vessel somewhat resembling a cup, from which it derives its name. It is made of phosphat of lime, or the residue of burned bones rammed into a mould, which gives it its figure. This vessel is used in assays wherein the precious metals are fused with lead, which becomes converted into glass, and carries the impure alloy with it. See Assay.

Cupellation. The refining of gold by scorification with lead, upon the cupel is called cupellation. See Assay.

Curd. The coagulum which separates from milk upon the addition of acid or other substances. See Milk, also Cheese.

D.

DAMPS. The permanently elastic fluids which are extricated in mines, and are destructive to animal life, are called damps by the miners. The chief distinctions made by the miners, are choak-damp, which extinguishes their candles, hovers about the bottom of the mine, and consists for the most part of carbonic acid gas; and fire-damp, or hidrogen gas, which occupies the superior spaces, and does great mischief by exploding whenever it comes in contact with their lights. The stithe, or styth, a kind of choak-damp not unfrequent in our coalmines in the north, is said by some to be nitrogen gas. The history of the effects of these fluids is very curious, and has been given much in detail by various writers. But the general properties of elastic fluids having of late years been much elucidated by the experiments of Dr. Priestley and others, it is at present found as easy to account, in a general way, for the wonderful effects of these fluids, as for any other appearances that take place in chemistry. See Gas.

Daurite. A rose-coloured stone, crystallized in hexaëdra, with a triangular apex, so called by Delametherie because it came from Dauria. Like the tourmalin it is rendered electric by heat. It consists of alumine 48 parts, silex 36, lime 3·5, oxide of manganese 9.—*Journ. de Physique.*

Daze, or Glimmer. A mine term applied to micaceous substances.

Decantation. The action of pouring off the clearer part of a fluid by gently inclining the vessel after the grosser parts have been suffered to subside. Some chemists avoid the use of the filter altogether, and separate solids from fluids by decantation. But there are situations, in which either method may be preferable to the other.

Decoction. The operation of boiling. This term is likewise used to denote the fluid itself which has been made to take up certain soluble principles by boiling. Thus we say a decoction of the bark, or other parts of vegetables, of flesh, &c.

Decoction is chiefly applied to organised substances, and is rather a culinary or pharmaceutical than a chemical operation. It serves to soften and considerably alter the parts of vegetables and animals; but its effects in general are too gross and complicated, to afford satisfactory theoretical results. In this process the volatile parts, if any be present, fly away and are lost; and it is attended with other inconveniences, which the chemical practitioner will very readily perceive.

Decomposition. This word was formerly used in a sense almost opposite to that which universally prevails at present. Newton, Boyle, and other earlier English writers, as the annotator on Macquer's Chemical Dictionary observes, used it to denote the composition or junction of two or more bodies which were previously compounded of other parts. But it is now understood to imply the separation of the component parts or principles of bodies from each other.

It is distinguishable from division, because this last may consist in the separation of parts of the same nature as the body itself, which decomposition does not. Thus common salt may be divided by pulverizing or otherwise, into parts of extreme minuteness, which still continue to be common salt: but it cannot be said to be decomposed, until its alkali and acid are separated from each other.

The decomposition of bodies forms a very large part of chemical science. It seems probable from the operations we are acquainted with, that it seldom takes place but in consequence of some combination or composition having been effected. It would be difficult to point out an instance of the separation of any of the principles of bodies which has been effected, unless in consequence of some new combination. The only exceptions seem to consist in those separations which are made by mere heat; and these cannot be admitted as exceptions, if we attend to the means by which the temperature was originally raised, or if we admit heat to be a peculiar substance.

DECREPITATION. The small and successive explosions afforded in many chemical operations are distinguished by this name. They are either produced by heating metallic substances with nitre, which take fire and explode, or else by suddenly heating crystallized bodies. Thus common salt, which has been deprived of its water of crystallization by heat, is called decrepitated. See SALT.

DELFT WARE. A kind of pottery made at Delft in Holland, which formerly supplied all Europe, until it was supplanted by a yellow pottery made in France, which has since given place to the queen's ware, and various kinds of china fabricated in Great Britain.

Pottery may be distinguished into two kinds; namely, that which has a transparent varnish or glaze, and that which has an opake glaze. The queen's ware, the stone ware, and various kinds of china are of the former sort. The Delft ware and other kinds of china ware are of the latter kind. In every kind of pottery it is an object of great importance, that the expansions and contractions of the glaze and the body should be nearly the same at like temperatures: but this desirable property is seldom found in vessels covered with an opake glaze or enamel.

As the Delft pottery has fallen into disuse, it seems of less consequence to inquire into its composition, more especially as this disuse has been occasioned by the production of better potteries.

DELIQUESCENCE. The spontaneous assumption of the fluid state by certain saline substances, when left exposed to the air, in consequence of the water they attract from it.

We know of no criterions to determine, à priori, whether any combination shall be consistent, efflorescent, or deliquescent in the air. It appears, that, whenever any salt attracts moisture more strongly than the air is disposed to retain it, it is deliquescent; and, on the contrary, if the air be more attractive of moisture, it will cause the salt to effloresce. Salts, which are not commonly deliquescent, will be liquefied in a very humid air, and other salts strongly attractive of humidity may be dried in proper situations.

Generally speaking, the simpler substances are more deliquescent than such as are compounded. So the acids and pure alkalis are all strongly attractive of water; most of the former being disposed to rise in distillation, long before they are deprived of the last portions of water, and consequently they are constantly in the fluid state, unless when congealed by cold.

DELIQUIUM. Deliquescent salts are by some writers said to fall into a deliquium.

DEMIMETAL. A word sometimes used for semimetal, which see.

DEPHLEGMATION. Any method by which bodies are deprived of water. The term is nearly synonymous with concentration. It is effected either by evaporation or congelation, and was chiefly used in speaking of very aqueous fluids, whereas the word concentration is usually applied to the extreme dephlegmation of acids.

DEPHLOGISTICATED. A term of the old chemistry implying deprived of phlogiston, or the inflammable principle, and nearly synonymous with what is now expressed by *oxigenated*, or *oxided*.

DEPHLOGISTICATED AIR. The same with oxigen gas.

DERBYSHIRE SPAR. A combination of calcareous earth with a peculiar acid called the FLUORIC, which see.

DESTRUCTIVE DISTILLATION. When organised substances or their products are exposed to distillation until the whole has suffered all that the furnace can effect, the process is called destructive distillation. As this method decomposes bodies so as to separate their component parts from each other into a state of considerable simplicity: and as the original principles of organised bodies seem to be few, the products of substances of the vegetable kingdom, though much differing from each other at first, are found to possess characters so similar as to render the method of no great use, unless in conjunction with other processes. The same may be observed of the destructive distillation of animal substances.

DETONATION. A sudden combustion and explosion. The detonations observed in chemical experiments are mostly caused by the destruction of the acid of nitre in contact with some combustible substance. This acid takes fire spontaneously, when applied to charcoal or to volatile oils (see ACID, NITRIC): but the sudden explosion called detonation requires, that the acid should be in a state nearly or completely dry, and the inflammable substance of considerable fixity.

Various theories of detonation exhibiting considerable ingenuity have been maintained by the earlier chemists, in which the facts are accurately stated and plausibly accounted for. The discoveries of the moderns were however wanting to elucidate this subject. Nitrats are decomposable by mere heat, the acid being separated into its component parts, nitrogen and oxigen. It is this oxigen which so strongly and suddenly destroys combustible substances in the way of detonation. The detonation of common nitre and charcoal is one of the most common, and is seen in the effects of *gunpowder* (which see). In experiments of this kind it is remarkable, that the combustion is maintained by oxigen, which is not in the elastic state, but fixed in the nitre: whence it should follow, that either the oxigen or the combustible body, even in the fixed state, has a great capacity for caloric, of which they contain a large quantity.

The oxigenated muriatic acid, being much more ready to part with its oxigen than the nitric, is found to afford a much more sudden and stronger detonation. A new kind of gunpowder has accordingly been made out of the salt produced by the combination of this acid and potash, for which recourse may be had to the article Gunpowder.

The most remarkable detonations in chemistry are afforded by *gunpowder*, *fulminating powder*, certain metallic oxides, and the *gunpowder* of oxigenated muriatic acid. See Fulminating Powders, and Gunpowder.

Dew. Formerly this name was given to the phlegm that rose first in the distillation of several substances: thus the dew of vitriol, the dew of honey, were the watery liquors, which rise first when these substances are distilled.

Diamond. The diamond is a mineral, which was long considered as a stone, but has since been proved to be an inflammable substance, and is now classed accordingly. See Carbon. It is found in a sandy earth in the hither peninsula of India, in the island of Borneo, and in the Brazils. The form of the diamond, when perfect, is that of an eight-sided prism. There are also cubical diamonds, which are suspected to be of a different nature from the others. Diamonds are of a lamellated texture, and may be easily split by a blow in a proper direction. The consent of mankind has fixed an immense value upon this stone. The inimitable qualities, to which this preference is attached, are its hardness, which is such that it easily cuts all other substances, and takes an exquisite and lasting polish; and its very great refracting power, which is so considerable, as to occasion all the light to be reflected that falls on any of its interior surfaces at a greater angle of incidence than 24¼ degrees. Hence its lustre, when cut into the form of a regular solid, is very great. This may be easily understood, when it is considered, that an artificial gem does not reflect the light from its hinder surface, until that surface is inclined in an angle of 41 degrees. The diamond therefore will not only throw back all the light which an artificial gem would reflect, but likewise half as much more; which, falling between the angles of 41 degrees and 24¼, would have been suffered to pass through by the false gem. It is not surprising, therefore, that the effect of the diamond should be so much greater; more especially when we attend to its extreme transparency, and the accuracy of its polish.

No solvent but the sulphuric acid has any effect on this gem; in which if diamond powder be triturated, and evaporation carried on nearly to dryness, the acid grows black, and deposits pellicles that burn, and are entirely consumed.

Diamonds are of all colours: the clear transparent stones are the most esteemed; and, next to them, those of a deeper tinge. Whether these coloured stones be really of the same nature as the clear diamond, has not been ascertained. The lapidaries reckon them to be diamonds from their hardness and lustre. Those that are tinged throughout are said to draw colour. Some acquire an appearance of being coloured, from having cavities in them filled with red, yellow, or brown earths, which are called fouls, or specks: and the defect in these may be cured by exposure to heat, which changes the earth black, after which the diamond plays colourless.

The value of diamonds is reckoned by weight, at so much the carat. The carat used in this valuation is divided into four parts, called grains; but less than troy grains by one fifth; for 150 carats are equal to the troy ounce of 480 grains. Rough diamonds, without any flaw or blemish, are valued at two pounds sterling the single carat; and the expense of cutting amounts to 3¼ pounds the carat. The value is greatly diminished if the diamond be imperfect, or of a bad figure; and it increases rapidly with the size. To find the worth of a rough diamond, its weight in carats must be squared, and multiplied by two, and the product will be pounds sterling. A cut or finished diamond is worth four times as much as one that is still rough. Those of the greatest brilliancy are sometimes valued at a higher rate; but this value has never been applied to stones of excessive magnitude. It does not appear, that any sum exceeding one hundred and fifty thousand pounds has been given for a diamond. See Magellan's improved edition of Cronstedt's Mineralogy, for a considerable mass of entertaining information on this subject.

Diaphoretic Antimony. This is a white oxide of antimony, made by calcining antimony with thrice its weight of nitre. See Antimony.

Diaspore. An aluminous stone containing according to Vauquelin nearly 80 parts of alumine, 3 of oxide of iron, and 16 or 17 of water, of which it may be deprived by heating it to ignition.

Digestion. The slow action of a solvent upon any substance for a length of time is called digestion by chemists. In this operation the action of the solvent is frequently assisted by heat, in some instances stronger than in others, but seldom equal to that of boiling water. Chemical writers frequently mention a digesting heat. No definite application is made of these terms, but they usually signify a degree of heat exceeding that of living animals, and less than that of boiling water, such as may be produced by a vessel in hot ashes. It may re be taken to be somewhere about rees.

stive Salt. Muriat of potash.

ster. The digester is an instrument d by Mr. Papin about the beginning last century, and usually called digester. It is a strong vessel of or iron, with a cover adapted to on with pieces of felt or paper inter- In some vessels of this kind the s made of an elliptical form, and is l through an opening of the same which it completely closes by appli- of its upper surface to the internal of the vessel. A valve with a small e is made in the cover, the stopper h valve may be more or less loaded by actual weights, or by pressure a apparatus on the principle of the d. Instead of the common valve N. Edelcrantz employs a cylinder in er, with a steam-tight piston. This nay be loaded with any weight, and inder is perforated with small holes rent heights, and a larger hole near , to allow an exit to the steam re- to the pressure it exerts.

purpose of this vessel is to prevent of heat by evaporation. The solvent of water when heated in this vessel is increased, chiefly no doubt on ac- of its increased temperature, and like- a all probability on account of the re exerted by the reaction of the water or steam which is upon the of being generated.

not hear of many experiments made s engine. The inventor proposed it ulinary utensil, by which the grisly ny parts of animals might be com- with water in the form of a jelly, as ct the case. But whether a food so with the phosphoric salt of lime be wholesome may perhaps admit of doubts: it is likewise very liable to e an empyreuma, if the heat be car- ittle too high. See Bones.

rman thought that the digester might a considerable solvent power of upon the pure earths, and he consi- he deposition of siliceous earth from water of the stupendous fountain of in Iceland, mentioned by Von Troil, oof of such a solution.

illation. The separation of a vo- uid from other substances, which are atile, by applying a due degree of the mixture, and afterward con- the vapours in another part of the us by cooling. The older chemical distinguished three kinds of distilla- er ascensum, per descensum, and per

distillation per ascensum is performed alembic: here the elastic vapours rpendicularly, and are condensed in d of the vessel, from which they run into the receiver through the beak. Large stills are constructed on this principle. The chief advantage it seems to possess consists in the facility with which the residues of the distillation may be come at; and in those few instances wherein considerable quantities of flowers or pulverulent matter rise along with other vapours which are condensed into the fluid form, it may perhaps afford some facility in separating them.

The distillation formerly denominated per descensum consisted in placing certain herbs or other substances in a shallow tray or cullender, which was applied like a cover to a tall cylindrical glass vessel. Another cover was then laid over this cullender, which consisted of a pan containing lighted charcoal. The heat was therefore applied above the materials, and the volatile parts were forced to descend, and became condensed against the sides of the vessel. Philosophical chemists at present consider this method as entirely useless; but there are several instances of its convenient and advantageous application in large works, as in the distillation of zinc, of pit-coal, and other substances.

The distillation per latus is the simplest and most extensively used: a retort and a receiver are the fewest vessels which can be used; and where the heat is properly managed, every operation of the other methods may be performed in this way with great facility. It has accordingly happened, that most of the improvements of distillation for philosophical purposes have been made in this method. See Laboratory.

The general rule for performing all distillations in the most safe, accurate, and perfect manner, consists in applying no more heat than is necessary to raise the volatile matter, and in keeping the receiving apparatus sufficiently cool, either by surrounding it with wet cloths, immersing it in water, occasionally renewed or kept cold by putting ice or snow into it, &c., that the whole of what rises may be condensed, and not escape into the air in the state of vapour.

Dittany of Crete. Sixteen ounces of the leaves of this plant yield about half a drachm of a strong, aromatic, essential oil, which coagulates by cold, resembling camphor. From an ounce of this plant Neumann obtained with water two drachms and a scruple of extract; and from the same quantity, with alcohol, he obtained a drachm and a half of resinous extract. He observes, that the green colour of the leaves resides in the resin, and is extractible by alcohol, especially after water had previously extracted the gummy part, some of which, being also soluble by alcohol along with the resin, alters the colour of the spirituous tincture.

Division. Some writers use this word as a term to denote every mechanical separation of the parts of bodies. According to this notion, clipping, pounding, trituration, levigation, and the like, are methods of division.

Docimastic Art. This name is given to the art of assaying, or determining, by experiments, in the small way, the quantities and nature of the component parts of bodies intended to be used in commerce. See Assay, Blowpipe, Analysis, and the several metals.

Dolomite. The elastic marble, or supercarbonat of lime, first analysed by Dolomieu. Its colour is grayish or yellowish white, or light red, with little lustre or transparency: fracture conchoidal or granularly foliated: gravity 2·85 or 2·86. Some varieties are phosphorescent. It consists of lime 44·29, carbonic acid 46·1, alumine 5·86, magnesia 1·4, iron ·074. It effervesces slowly with acids.

Dome. A hemispherical covering of forged iron, with a tube or chimney proceeding from its upper part. The cavity between the dome and the fuel, and likewise the internal space in the chimney, being filled with air much rarefied by heat, produce a strong draught, and greatly increase the intensity of the fire. It has also been supposed to reflect the heat or flame upon the vessels, and on this account a furnace with a cover of this form is called a reverberatory furnace.

Doronicum. From two ounces of the dry root were obtained by water fourteen drachms of extract; and from the same quantity, with alcohol, four drachms and a half. This root is supposed by some to be poisonous, especially when fresh.—*Neumann.*

Dragon's Blood is a red-coloured, inodorous, and insipid resin, insoluble in water, soluble in alcohol and in oils, to both which liquors it communicates a red colour. By fire it is fusible, inflammable, and it emits an acid vapour, like that of benzoin. A solution of dragon's blood in alcohol is used for staining marble, to which it gives a red tinge, which penetrates more or less deeply according to the heat of the marble during the application. But as it spreads at the same time that it sinks deep, for fine designs the marble should be cold. Mr. du Fay says, that, by adding pitch to this solution, the colour may be rendered deeper.

Drake- or Druse-Hol. A Swedish denomination used to express a cluster of crystals which line a cavity in any mineral.

Drying Oil. Fat oils require a very long time to become consistent by exposure to the atmosphere; but painters render them more disposed to dry, by boiling them with oxides of lead. Linseed oil holding oxide of lead in solution, which it takes up by boiling with litharge, is called drying oil, from this property.

Ductility. That property or texture of bodies, which renders it practicable to draw them out in length, while their thickness is diminished without any actual fracture of their parts. This term is almost exclusively applied to metals, and implies that they are capable of being made into wire, by drawing a portion of the metal through a hole in a plate of steel or other proper composition. The ductility of a metal depends therefore on two circumstances, namely, its malleability or property of extending by pressure, and its tenacity or power of resisting an actual separation of its parts. If the metal be not malleable enough, it will resist the action of the wire-drawer's plate, and not change its figure to a sufficiently small diameter to come through: if, on the other hand, it be very malleable, but at the same time deficient in tenacity, the part which has been put through the hole may not be strong enough to bear, without breaking, that pull which is necessary to form the wire.

Gold, silver, platina, copper, and iron have tenacity and malleability enough to afford very fine wire. Lead and tin have not tenacity enough to be wrought in this way to any advantage, though the hammer and the laminating rollers are capable of extending them to extreme thinness. Zinc laminates very well, but scarcely supports the sudden action of the hammer without breaking, and is altogether unfit to be drawn into wire.

Most authors confound the words malleability, laminability, and ductility together, and use them in a loose indiscriminate way; but they are very different. Malleability is the property of a body which enlarges one or two of its three dimensions, by a blow or pressure very suddenly applied. Laminability belongs to bodies extensible in dimension by a gradually applied pressure. And ductility is properly to be attributed to such bodies as can be rendered longer and thinner by drawing them through a hole of less area than the transverse section of the body so drawn.

Duckstein. The duckstein of the Germans is a white calcareous stone, formed by the deposition of chalk from water, in which it is diffused. It is generally formed on branches or roots of trees, and stones of different kinds, and differs from the stalactites in its mode of formation, this last being deposited by water in the act of evaporation as it transudes through the roofs of caverns.

Dulcification. A medical process consisting in combining the mineral acids with alcohol by digestion, or more frequently by distillation. The processes for this purpose are not in general very scientific. When ether is made, the first produce is very pure alcohol, little altered, or slightly combined with some acid; next the ether, then partly decomposed acid, with some vinegar, according to the management of the operation. The dulcified acids of the dispensatories consist of an admixture of these products, which in all probability is seldom the same.

t laboratories, where the degrees ie time of charging the receiver, essential circumstances, are liable ed.

g. The art of dyeing is considered t importance to society, according sent habits and usages. It consists upon cloths of various kinds any hich may be required, in such a s that they shall not be easily al- those agents, to which the cloth probably be exposed during its wear.

re can be no probable cause by y colouring matter can adhere to , except an attraction subsisting he two substances, it must follow, e will be few tingeing matters f indelibly or strongly attaching s by simple application. For such nent would imply, that the elec- tion by which it was effected was han all or most others; a circum- the order of events not likely to ften. On this account it is, that he dyeing processes appear to con- lying some substance or principle th, which forms a colouring mat- y insoluble, by combining with er principle applied to it in its dhesion to the cloth.

g is therefore a chemical art; and erations were no more complicated ere expressed, it would be easy, not cquire a perfect theory of its pro- ut likewise to bring many of them ction, which at present constitute st reproach. But the effects and tions produced in this way being to all appearance dependent on d actions of chemical affinity, but n general produced by means dis- by mere and almost casual trial, it that no small degree of sagacity uous research is necessary, to de- the uses and advantages of the ngredients. In addition to these ents, the theory of dyeing has been mpeded in its progress, by the little men of science have found in at- to repeat its manipulations, and usy of manufacturers, who, with tice, are inclined to estimate their in their own gainful discoveries as ion which they have a right to ze by keeping them secret. It has gly happened from these causes, ing has been merely a practical ery lately, that it has been culti- a few eminent chemists.

earlier theories of dyeing, like nencements of the other branches l philosophy, have been deduced s apparently too remote for our neans of investigation, namely, the tion of the particles of bodies. from observations on the colours by light reflected from, or transmitted through, thin transparent bodies, as exhibited in experiments too few and imperfect to have afforded satisfactory conclusions in the hands of a philosopher of less sagacity, formed a general inference, that the colours of all bodies are governed by the magnitude of their particles. He likewise brought their densities into consideration, as a modifying circumstance, but this only in a conjectural way, and he altogether overlooked that property, which on another occasion he had noticed as increasing their refracting power, namely their combustibility. Mr. Delaval, in his Treatise on Light and Colours, and a subsequent paper in the Manchester Memoirs, has displayed this doctrine very much at large, with many valuable improvements and discoveries. It is evident, however, that much remains to be done before any clear and practical application of this theory can take place. If we suppose, that a due magnitude and refractive power be all that is necessary for the particles of bodies to exhibit a determinate colour in white light, which indeed seems to be nearly proved, we shall find no data among our present acquisitions sufficient to afford any determination of these requisites. To produce a green colour there will be no constant thickness or magnitude of particles required; for this will vary with the reflective power. We know, that the reflective and refractive powers are the same, and are not governed by the mere density, but are greatest in combustible bodies. And when, in addition to these difficulties with grosser bodies, we observe, that there is no possibility of determining either the magnitude, figure, density, or other obvious properties of indiscernible particles, we may justly conclude, that it will be a long time before we shall be able to apply the Newtonian theory to the art of dyeing.

The theory of the celebrated Hellot supposed, that the pores of bodies are opened by the heat used in dyeing, that the colouring matter was deposited in these interstices, and there firmly held by the subsequent contraction of cooling, assisted by a kind of varnish or covering deposited by the salts used. This theory has not met with much success, though, like other hypothetical speculations on obscure objects, it may not be difficult to apply it to most of the known facts. It is moreover contradicted not only by the circumstance, that the stuff does not in all instances take the colour of the dyer's bath, but some other colour; and that it sometimes happens that the bath, instead of sharing its colour with the stuff, as it ought to do, is rendered as clear as water by an entire privation of all its tingeing matter: both which circumstances evidently prove, that a chemical combination takes place in consequence of an attraction exerted between the stuff and the colouring matter.

The attention of philosophers is not therefore at present much directed toward the mechanism of the particles of bodies used in dyeing, but to the elective attractions exercised between them, and the nature of the compounds they form. In this inquiry they have naturally endeavoured to extend their researches by endeavouring to generalize particular facts. Some have supposed the various colours of bodies to be in a very great measure owing to the presence of iron; a body the most universally diffused, and susceptible of a great variety of shades of colour, according to the degree of oxidation it may have undergone. It does not however appear, that this metal, though so widely diffused, is found in sufficient quantity to be admitted as the efficient cause of the tinges induced upon bodies. But the more modern chemists have with no small degree of probability applied the doctrines of combustion and revivification, or the combination and disengagement of oxigen, to the fixation and discharging of colours.

The most remarkable general fact in the art of dyeing consists in the different degrees of facility, with which animal and vegetable substances attract and retain colouring matter; or rather the degree of facility, with which the dyer finds he can tinge them with any intended colour. The chief materials of stuff to be dyed are wool, silk, cotton, and linen, of which the former two are more easily dyed than the latter. This has been usually attributed to their greater attraction to the tingeing matter; though it does not appear to be true in all cases, because the stuffs more difficult to be dyed will absorb a greater quantity of that matter, before they acquire the requisite intensity of colour obtainable in the former by a less proportion of the same drug. In every attempt to deduce the causes of these different effects, it is proper to inquire into the properties of these bodies by experiment.

Wool, silk, cotton, and linen, though in various respects similar to each other, are nevertheless found to differ exceedingly in others. In the method of destructive distillation, wool yields much impure volatile alkali, a portion of empyreumatic oil, leaving about one fifth of incombustible fixed residue. Silk affords less volatile alkali and oil, and more residue. Cotton affords no volatile alkali and little oil, but some acid, leaving little coal, which may for the most part be burned by calcination in the air. Here we observe a very considerable difference in the habitudes and products of the several substances; but the scientific experiments of Berthollet show it still more evidently. He distilled nitric acid from silk, and obtained oxalic acid, with a greasy matter, which, though it at first congealed on the surface of the liquor in the receiver, was afterward dissolved in it by means of heat, even though diluted with water with which it passed through the filter. Wool also afforded the same greasy matter, and oxalic acid; the last of which was more abundant in quantity than he obtained by the same treatment from any other substance. But the oily part of vegetables was totally destroyed by similar treatment, no greasy matter being afforded; and on analysing cotton, he obtained oxalic acid, but no other product, and the quantity was far inferior to that yielded by animal substances. It was remarkable, that the cotton left no residue, but was entirely converted into elastic fluid and oxalic acid, which last is likewise easily convertible into carbonic acid and charcoal.

Mr. Henry, in his remarks on these experiments, appears to think, that the chief difference between the animal and vegetable substances consists in the former containing a more abundant greasy principle, soluble in a watery menstruum, which the more sparing portion of oil in the latter is not; and likewise in the animal substance containing alkali, or at least one of its component parts: whereas the vegetable affords acid. On these circumstances indeed the different modes of treatment evidently depend. So that it is remarkable, that vegetable substances, the oil of which is wholly destroyed by nitric acid, and to the texture of which the mineral acids are in general injurious, will bear steeping in solutions of caustic alkali of such strength as would prove totally destructive to wool.

Wool is naturally so much disposed to combine with colouring matter, that it requires but little preparation for the immediate processes of dyeing; nothing more being required than to cleanse it, by scouring, from a fatty substance, called the yolk, which is contained in the fleece. For this purpose an alkaline liquor is necessary; but as alkalis injure the texture of the wool, a very weak solution may be used. For if more alkali were present than is sufficient to convert the yolk into soap, it would attack the wool itself. Putrid urine is therefore generally used, as being cheap, and containing a volatile alkali, which, uniting with the grease, renders it soluble in water.

Silk when taken from the cocoon is covered with a kind of varnish, which, because it does not easily yield either to water or alcohol, is usually said to be soluble in neither. It is therefore usual to boil the silk with an alkali, to disengage this matter. Much care is necessary in this operation, because the silk itself is easily corroded or discoloured. Fine soap is commonly used, but even this is said to be detrimental; and the white China silk, which is supposed to be prepared without soap, has a lustre superior to that of Europe. It is however more than probable that the Chinese have a different kind of silk-worm beside that cultivated in Europe. A weak solution of car-

soda has been used with success
gaut in clearing silk of its varnish,
Abbé Coulomb has performed the
g by boiling silk for nine hours in
ilk loses about one fourth of its
being deprived of its varnish.

iteness and softness of silk are con-
improved by clearing it of its var-
it receives a still farther degree
cy by exposing to the fumes of
sublimed or set on fire in a close
loset. What happens in this ope-
s not been well explained. Silk
ed has a crisp feel, as if flowers of
ere enclosed between its threads,
robably the case. It seems as if a
the sulphur entered into combi-
th the colouring principle of the
ormed a colourless or transparent
: and accordingly it is found less
in general, of being easily dyed,
ilk which has not been scoured
ured.

and linen are cleared of a tingeing
which Mr. Kirwan finds in the
e neither gummy nor resinous, but
embling lac. Alkalis act upon this
d dissolve it after it has suffered a
ombustion by exposure to air and
light in the bleach ground. See
NG.

tention of the previous prepara-
ns to be of two kinds. The first to
e stuff or material to be dyed as
ossible, in order that the aqueous
e afterward applied, may be im-
d its contents adhere to the minute
urfaces. The second is, that the
be rendered whiter and more ca-
reflecting the light, and conse-
nabling the colouring matter to
ore brilliant tints.

of the preparations, however,
onsidered merely as preparative,
constitute part of the dyeing
themselves. In many instances
l is applied to the stuff, to which
s; and when another suitable ma-
applied, the result is some colour
Thus we might dye a piece of
ack, by immersing it in ink; but
r would be neither good nor
because the particles of precipitat-
, formed of the oxide of iron and
galls, are already coagulated in
o gross either to enter the cotton,
ere to it with any considerable
strength. But if the cotton be
an infusion of galls, then dried,
ward immersed in a solution of
iron (or other more proper fer-
salt), the acid of galls, being every
fused through the body of the
ll receive the particles of oxide of
e very instant of their transition
fluid or dissolved to the precipi-
olid state; by which means a per-
ring of the black inky matter will
be applied in close contact with the surface of the most minute fibres of the cotton. This dye will therefore not only be more intense, but likewise more adherent and durable.

The French dyers, and after them the English, have given the name of *mordant* to those substances which are previously applied to piece goods, in order that they may afterward take a required tinge or dye.

It is evident, that, if the mordant be universally applied over the whole of a piece of goods, and this be afterward immersed in the dye, it will receive a tinge over all its surface; but if it be applied only in parts, the dye will strike in those parts only. The former process constitutes the art of dyeing, properly so called; and the latter, the act of painting, staining, or printing, woollens, cottons, or linens.

In the art of printing piece goods, the mordant is usually mixed with gum seneca, and applied by means of blocks or wooden engravings in relief, or from copper plates, and the colours are brought out by immersion in vessels filled with suitable compositions. Dyers call the latter fluid the bath. The art of printing affords many processes, in which the effect of mordants, both simple and compound, is exhibited. The following is taken from Berthollet.

The mordant employed for linens, intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum, and one pound of acetit of lead, to which two ounces of potash, and afterward two ounces of powdered chalk, are added.

In this mixture the sulphuric acid combines with the lead of the acetit and falls down, because unsoluble, while the argillaceous earth of the alum unites with the acetous acid disengaged from the acetit of lead. The mordant therefore consists of an argillaceous acetous salt, and the small quantities of alkali and chalk serve to neutralize any disengaged acid, which might be contained in the liquid.

Several advantages are obtained by thus changing the acid of the alum. First, the argillaceous earth is more easily disengaged from the acetous acid, in the subsequent processes, than it would have been from the sulphuric. Secondly, this weak acid does less harm when it comes to be disengaged by depriving it of its earth. And thirdly, the acetit of alumine not being crystallizable like the sulphat, does not separate or curdle by drying on the face of the blocks for printing, when it is mixed with gum or starch.

When the design has been impressed by transferring the mordant from the face of the wooden blocks to the cloth, it is then put into a bath of madder, with proper attention, that the whole shall be equally exposed to this fluid. Here the piece becomes of a red colour, but deeper in those places where the mordant was applied. For some of the argillaceous earth had before quitted the acetous acid, to combine with the cloth; and this serves as an intermedium to fix the colouring matter of the madder, in the same manner as the acid of galls, in the former instance, fixed the particles of oxide of iron. With the piece in this state, the calico-printer has only therefore to avail himself of the difference between a fixed and a fugitive colour. He therefore boils the piece with bran, and spreads it on the grass. The fecula of the bran takes up part of the colour, and the action of the sun and air renders more of it combinable with the same substance. The operations of boiling with bran and exposure in the field are alternately repeated, till the ground becomes white, and the design only remains. It seems evident, that this discharge of the colour is performed nearly in the same way as bleaching, the bran being substituted instead of the alkali, because this last would act upon the printed colour and partly discharge it.

In the foregoing instance the mordant was completely formed by the effect of the double elective attraction of the principles of the acetit of lead and of the alum. In other cases however the elective attraction of the stuff to be dyed has a more marked agency. A very common mordant for woollens is made by dissolving alum and tartar together; neither of which is decomposed, but may be recovered by crystallization upon evaporating the liquor. Wool is found to be capable of decomposing a solution of alum, and combining with its earth: but it seems as if the presence of disengaged sulphuric acid served to injure the wool, which is rendered harsh by this method of treatment, though cottons and linens are not, which have less attraction for the earth. Wool also decomposes the alum, in a mixture of alum and tartar: but in this case there can be no disengagement of sulphuric acid, as it is immediately neutralized by the alkali of the tartar.

Alum is an exceedingly useful agent in dyeing processes, and Mr. Berthollet has satisfactorily proved, by a variety of experiments, that its earth has a strong tendency to unite with animal matters, and that its attraction for vegetable substances is very weak, excepting to their colouring parts.

Metallic oxides have so great an attraction for many colouring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them. These oxides are also found by experiment to be strongly disposed to combine with animal substances; whence in many instances they serve as mordants, or the medium of union between the colouring particles and animal bodies. But it has not been shown, that any considerable attraction is exerted between these oxides and vegetable substances.

A considerable progress has been made of late years in the investigation of such facts as tend to afford a theory of the art of dyeing. The following general abstract of this theory is taken from Berthollet.

Metallic colours must be distinguished from those which are peculiar to vegetable and animal substances.

The colours of metals are modified and changed by oxidation, according to the degree to which it is carried.

Vegetable and animal substances may themselves possess a peculiar colour, which varies in the different states through which they pass; or they may owe their colours to tingeing particles, either combined or simply mixed with them. These are the particles extracted from different substances, and which undergo different preparations, to fit them for the purposes of dyeing.

The colouring particles have chemical properties, which distinguish them from all other substances: the attractions which they have for acids, alkalis, earths, metallic oxides, oxigen, wool, silk, cotton, and linen, constitute the chief of these properties.

According to the attraction which the colouring particles have for wool, silk, cotton and linen, they unite more or less readily, and more or less intimately with each of these substances; and thence arises the first cause of variation in the processes employed, according to the nature of the stuff and of the colouring substance.

By the attraction which the colouring particles have for argillaceous earth and metallic oxides, they form compounds with these substances, in which their colour is more or less modified, becomes more fixed, and more difficultly affected by external agents, than before. This compound being formed of principles, which have separately the power of uniting with vegetable substances, and more especially with animal substances, preserves this property, and forms a triple compound with the stuff; and the colour which has been again modified by the formation of this triple union acquires a greater degree of fixity, and of indestructibility by external agents.

The colouring particles have frequently so great an attraction for alumine and metallic oxides, that they separate them from acids which held them in solution, and fall down with them; but the attraction of the stuff is sometimes necessary, in order to produce this separation.

The metallic oxides which combine with the colouring particles modify their colours, not only by their own, but also by acting upon their composition by means of their oxigen. The change which the colouring particles thereby suffer is similar to that occasioned by the air, which injures all colours more or less.

Of the two principles which compose the air of the atmosphere it is only the oxigen which acts upon the colouring particles:

ines with them, weakens their co-
d renders it paler; but its action is
lly exerted on the hidrogen, which
nto their composition, and it then
ater. This effect ought to be consi-
s a true combustion, whereby the
l which enters into the composition
colouring particles becomes predo-
and the colour commonly changes
w, fawn colour, or brown; or the
part, by uniting with what remains
original colour, produces other ap-
es.

favours the combination of the
g particles, which frequently cau-
place without its aid; and it is thus
ontributes to the destruction of co-
Heat promotes it also, but less
lly than light, unless it has a certain
f intensity.

similar combustion are to be attri-
e effects of the pale nitric acid, of
enated muriatic acid, and even of
huric acid, when they make the co-
the substances upon which they act
yellow, and even to a black.

effects of combustion may however
aled by the oxigen combining with
uring particles, without acting par-
on the hidrogen.

rs are more or less durable, or more
xed, according to the greater or less
on of the colouring particles to un-
ombustion, and to allow it to go on
re or less advanced stage.

substances are also capable of acting
olour of stuffs by a superiority of
n, or by a solvent power; and in
sists the action of acids, alkalis, and
A small quantity of these agents,
, may sometimes form supracom-
with the stuff, and thereby change
r.

lic oxides produce, in the colouring
with which they unite, a degree
ustion proportioned to the quantity
n which can be taken from them by
rticles.

colours which the compounds of
oxides and colouring particles as-
en, are the product of the colour
to the colouring particles, and of
liar to the metallic oxide; but the
particles and metallic oxides must
dered in that state to which they
n reduced by the diminution of
the oxide, and the diminution of
in the colouring particles.

it follows: First, that the metallic
which the oxigen is only slightly
are not fit to serve as connecting
for the colouring particles, because
duce in them too great a degree of
on; such are the oxides of silver,
mercury.

t the oxides which undergo con-
changes of colour, by giving off more or less of their oxigen, are also bad intermediums, especially for light shades, because they produce changeable colours; such are the oxides of copper, of lead, and of bismuth.

3d. That the oxides which strongly retain their oxigen, and suffer very little change of colour by the loss of a part of it, are best fitted to answer this purpose: such is particularly the oxide of tin, which quits its menstruum easily, which has a strong attraction for the colouring particles, and which affords them a basis that is very white, and proper for giving a brightness to their shades, without altering them by the admixture of another colour. The oxide of zinc possesses some of these qualities.

In order to account for the colours which result from the union of the colouring particles with the basis which a mordant gives them, we must attend to the proportion in which the colouring particles unite to that basis; thus the solution of tin, which produces a very copious precipitate with a solution of colouring particles, and thereby proves that the oxide of tin enters in a large proportion into the precipitate, has a much greater influence on the colour of the precipitate, by the whiteness of its basis, than the solution of zinc, or that of alum, both of which generally produce much less copious precipitates. The precipitates produced by these two last substances retain very nearly the natural tint of the colouring particles.

We must then distinguish, in the action of mordants, the combinations that may take place by their means between the colouring particles, the stuff, and the intermedium; the proportions of the colouring substance and intermedium; the modifications of colour, which may arise from the mixture of the colour of the colouring particles, and of that of the basis to which they are united; and finally, the changes which the colouring particles may suffer from the combustion that may be produced by the intermedium.

Astringents do not derive their characteristic property from an acid, or from any other individual principle which is always the same, but from the property which they possess of uniting with the oxide of iron, of reducing it to the state of black oxide, and of acquiring themselves a dark colour, by the combustion they experience. Galls, which are to be considered as the representatives of all astringents, readily undergo a slight combustion, which gives them a deep brown colour; but this combustion, which requires but a small quantity of oxigen, soon ceases without injuring their properties.

Galls owe their stability to the large proportion of carbon they contain; and as they have the property of combining with some vegetable substances, with several colouring matters, and particularly with am-mal substances, they serve as an intermedium for them, and impart to them their own firmness of colour.

For the modes of using the different articles used in dyeing, see them under their respective names in the order of the alphabet.

E.

EAGLE STONE. See ÆTITES.

EARTH. Chemists have sometimes in a gross and inaccurate way called those substances earths, which remain after the volatile products of distillation have arisen, and which are not soluble in water. This is not however sufficiently exact, though it is difficult to exhibit a good positive definition. Earths are bodies simple with respect to the present powers of chemical analysis, brittle, incombustible, infusible by the heat of furnaces, and destitute of that opake brilliancy which characterizes metals.

We are at present acquainted with at least nine distinct substances, that are classed as earths: alumine, barytes, glucine, lime, magnesia, silex, strontia, yttria, and zircon, which we shall here describe in this order, after some general remarks. The agustine earth, which Trommsdorf imagined he had discovered in the Saxon beryl, Vauquelin has shown to be phosphat of lime: and the ochroit, which Klaproth supposed he had found in the tungsten of Bastnas, appears to be a metal. See CERITE. As four of these earths, barytes, lime, magnesia, and strontian, have some affinity to alkalis, certain chemists have proposed to class them as alkalis; while others distinguish them by the term alkaline earths.

The attention of the chemical world was once strongly excited by some experiments of Mess. Ruprecht and Tondi, who affirmed, that they had reduced alumine, lime, barytes, and magnesia to the metallic state, by strongly heating them with charcoal. But however probable it may be from analogy, that such reductions may be within the limits of possibility, it is now universally admitted, that the metal obtained in these experiments consisted of iron from the crucibles used.

In some systems a distinction is made between earths and stones; but this is of no utility in the chemical inquiry respecting their component parts and properties. A stone is nothing more than a hard earthy mass, and an earth in powder is an aggregate of very minute stones.

Earths appear to have an affinity for each other in the humid way, which has not yet however been sufficiently examined. The affinity of alumine for magnesia is the most powerful. It has also an affinity for silex and lime. Scheele was the first who observed this; and Chenevix and Darracq have made farther experiments on the subject. So has Guyton-Morveau; but Mr. Chenevix observes, that he was led into errours probably by using earths precipitated from sulphuric acid, of which they still retained a little.

Alumine, or *Argillaceous Earth*. The principal natural specimens of this earth are, clays, properly so called, marles, boles, slates or schistus, and mica. In none of these, except the flag stone, does the alumine amount to so much as half their weight, though their predominating qualities appear to depend upon it. A fossil has been found in Devonshire, however, containing 70 per cent. of alumine. See HIDRARGILLITE. The most obvious characters of this earth are, an adhesion to the tongue, or any wet and soft body, in the more solid specimens; and a remarkable tenacity, ductility, or kneadability serve to distinguish moistened clays in a very eminent degree. It is soluble in acids; but alkalis act much less upon it, either in the dry or moist way, than they do on silex. Alum is a combination of this earth with sulphuric acid. If the concrete volatile alkali be added to a solution of pure alum, the alkali and acid unite, while the alumine falls to the bottom, united only with a small quantity of carbonic acid. The fluid must be abstracted by decantation, and the precipitate washed with distilled water, and dried. If we would have it very pure, alum may be dissolved in four times its weight of boiling water, and precipitated by liquid ammonia. Heat the mixture nearly to the boiling point for a few minutes, and pour it into a filter. As the water runs off add more, till it passes without taste. Transfer the precipitate while still wet to a basin, and add muriatic acid in small quantities till the whole is dissolved. Evaporate the solution, till a drop cooled on a plate of glass yields crystals. Let the solution cool; remove the crystals that form; and evaporate again, till no more crystals can be obtained by cooling. Dilute this solution, which contains nearly pure muriat of alumine; precipitate by liquid ammonia, adding this in excess; and the precipitate, when well washed, will be alumine white as snow, without taste or smell, somewhat unctuous to the touch, and affording no sulphuretted hidrogen when heated with charcoal powder. As this method is operose, a more ready way is to procure it from such of the natural clays as contain only silex and alumine, by solution in muriatic acid, and precipitation by ammonia.

Alumine has a considerable affinity for metallic oxides, particularly that of iron;

for vegetable or animal colouring matter; and for the extractive matter of vegetables: hence its uses as a mordant in dyeing, and as the bases of the pigments termed lakes.

Clays may be easily diffused and suspended in water, but are not soluble in any sensible degree. The sudden application of strong heat hardens their external parts, which afterward burst by the explosion of the moisture within. By a more gradual heat pure clay contracts very much, becomes hard, and full of cracks or fissures. The presence of siliceous earth in common clays, where it usually constitutes above half the weight, renders the contraction more uniform throughout, and prevents the cracks; probably in no other way than by rendering them more numerous, and too small to be perceived. When thus baked, it constitutes all the varieties of bricks, pottery, and porcelain. These, if baked in a strong heat, give fire with steel; a property that may be attributed to the siliceous earth they contain, which cannot act on the steel unless firmly set in the hardened clay. The dimensions of pottery are less, the greater the heat to which the article has been subjected. On this property is constructed a thermometer for measuring the heat of furnaces, by igniting a small brick of known dimensions therein, and afterward measuring its contraction. Baked clay is no longer kneadable with water, though as finely pulverized as mechanical means can go. Hence it has been inferred, that clays owe their ductility to a kind of gluten, which is supposed to be dissipated by heat. They recover that property, however, by solution in an acid and precipitation; whence it should seem to depend either on a minute portion of acid contained in clays, or the smallness of the particles when precipitated.

For the habitudes of clay with acids, see the several acids.—See also BRICKS, POTTERY, PYROMETER.

Barytes. This earth, which derives its name from the weight of its compounds, whence it has been called likewise *heavy* or *ponderous* earth, has never been found native in a pure state. Its sulphat is most common, and has long been known by the names of *heavy spar* and *marmor metallicum*. At a mine at Anglezark, near Chorly, in Lancashire, the carbonat of barytes is found in large quantity. This may be decomposed by intense heat. Mr. Henry gives the following process, which is nearly the same with Pelletier's, for procuring the pure earth.

Let the native carbonat be powdered and sifted through a fine sieve; mix it with an equal bulk of wheaten flour; and make it into a ball with water. Put this ball into a crucible one third full of charcoal powder; cover it and surround it with more of the powder; lute on a cover; and expose it for two hours to the most violent heat that can be raised in a wind furnace. When cold, take out the ball, and on adding water to it great heat will be emitted, and the barytes dissolved. The filtered solution on cooling will shoot into beautiful crystals.

Barytes has a sharp caustic taste, changes vegetable blues to green, forms a soap with oils, and combines with sulphur, like the fixed alkalis. It unites with phosphorus also. When recently prepared, it absorbs water rapidly, and gives out much heat. If the water be small in quantity it hardens into a solid mass; a little more water converts it into a light powder; and if the water be sufficient to cover it completely, the barytes will dissolve, and shoot into crystals on cooling. These are flat hexagonal prisms, terminated by quadrangular pyramids.

The crystals are soluble by heat in their own water of crystallization, which amounts to 53 per cent., and may be expelled by continuing the heat, leaving a white powder. They are efflorescent, and require 17½ parts of water at 60° to dissolve them. They communicate a yellow colour to the flame of alcohol.

In the dry way three parts of barytes and one of silex mixed and fused together produce a yellowish green mass, entirely soluble in nitric, muriatic, or acetous acid, from which the silex may be precipitated. In the humid way with alumine it forms a compound insoluble in water, but readily soluble if an additional portion of barytes be added. It likewise dissolves certain metallic oxides, especially those of lead.

Barytic water, like limewater, abstracts carbonic acid from the air, till the whole of the earth is converted into carbonat, and precipitated.

Barytes is an active poison, as are most of its salts, particularly the carbonat.

Glucine. This earth was discovered by Vauquelin, first in the aqua marina, and afterward in the emerald, in the winter of 1798. Its name is derived from its distinguishing character of forming with acids salts that are sweet to the taste. The following is his method of obtaining it:

Let 100 parts of beryl, or emerald, be reduced to a fine powder, and fused in a silver crucible with 300 of pure potash. Let the mass be diffused in water, and dissolved by adding muriatic acid. Evaporate the solution, taking care to stir it toward the end: mix the residuum with a large quantity of water, and filter, to separate the silex. Precipitate the filtered liquor, which contains the muriats of alumine and glucine, with carbonat of potash; wash the precipitate, and dissolve it in sulphuric acid. Add a certain quantity of sulphat of potash, evaporate, and crystals of alum will be obtained. When no more alum is afforded by adding sulphat of potash and evaporating, add solution of carbonat of ammonia in excess, shake the mixture well, and let it stand some hours, till the glucine is redissolved by the excess of carbonat of ammonia, and nothing but the alumine remains at the bottom of the vessel. Filter the solution, evaporate to dryness, and expel the acid from the carbonat of glucine by slight ignition in a crucible. Thus 15 or 16 per cent. of pure glucine will be obtained.

Glucine thus obtained is a white, soft powder, light, insipid, and adhering to the tongue. It does not change vegetable blues. It does not harden, shrink, or agglutinate by heat; and is infusible. It is insoluble in water, but forms with it a slightly ductile paste. It is dissolved by potash, soda, and carbonat of ammonia; but not by pure ammonia. It unites with sulphuretted hidrogen. Its salts have a saccharine taste, with somewhat of astringency.

Lime, or calcareous earth, predominates in most stones which are soft enough to be scratched with a knife. These are chalk, limestone, marble, spars, gypsum, or plasterstone, and various others. As the lime is most frequently combined with carbonic acid, it is usual for mineralogists to drop a small quantity of nitric acid upon the stones they are desirous of classing; and if they froth by the escape of the acid, they conclude that lime enters into the composition. To obtain pure calcareous earth, powdered chalk must be repeatedly boiled in water, which will deprive it of the saline impurities it frequently contains. It must then be dissolved in distilled vinegar, and precipitated by the addition of concrete volatile alkali. The precipitate, when well washed and dried, will consist of lime united to carbonic acid; the latter of which may be driven off by heat, if necessary.

If chalk, marble, limestone, spar, or any other specimens of this earth, containing carbonic acid, be exposed to continued ignition, they give out carbonic acid and water, to the amount of near half their weight. The remainder, consisting chiefly of lime, has a strong tendency to combination, and attracts water very powerfully. The addition of water to lime produces a very considerable heat, attended with noise, and agitation of the parts, which break asunder; a considerable vapour arises, which carries up with it part of the lime; and a phosphoric light is seen, if the experiment be made in the dark. Lime thus saturated with water is said to be slaked. Water dissolves about one five-hundredth part of its weight of lime, and is then called lime-water. This solution has an acrid taste, and turns sirup of violets to a green colour. If lime-water be exposed to the open air, the lime attracts carbonic acid, and is by this means converted into chalk; which, not being soluble in water, forms a crust on the surface, formerly called cream of lime, which, when of a certain thickness, breaks, and falls to the bottom: and in this way the whole of the lime will in time be separated. If the fire have been too violent in the burning of lime, the stone becomes hard, sonorous, and incapable of absorbing water with the requisite degree of avidity. This effect seems to arise from part of the calcareous earth having entered into fusion with the clay, flint, or other contaminating earths, with which it forms a glass that covers and defends the rest.

The paste of lime and water, called mortar, has a degree of adhesion and ductility, though much less than clay. When dry, it is more or less friable, like chalk. A mixture of sand, or broken earthen vessels, greatly increases its firmness, which it seems to effect by rendering it more difficult for the parts to be removed with respect to each other. When mortar is left to dry by the gradual evaporation of its superfluous water, it is very long before it obtains its utmost degree of firmness. But if dry quick-lime be mixed with mortar, it gradually absorbs the superfluous water, and the mass becomes solid in a very short time.

Lime has an affinity for tannin, whence it is probable that a portion of it is retained in tanned leather, perhaps not to the improvement of its quality. It has an edulcorative power with respect to animal oils, by combining with the putrid gelatine in them; but its coagulative action on them is too strong to admit of its being used for this purpose with advantage, unless in small quantity. Feathers, however, may be very conveniently cleaned by steeping three or four days in strong lime-water, and afterward washing and drying them.

Though infusible in the strongest heats of our furnaces, it is nevertheless a very powerful flux with regard to mixtures of the other earths. These are all fusible by a proper addition of lime. Compounds are still more fusible; for any three of the five well-known earths may be fused into perfect glass, if they be mixed together in equal portions, provided the calcareous be one of them.

The earthy part of animals is chiefly, if not altogether, calcareous: in most cases it is united with phosphoric acid, but frequently with the carbonic.

Magnesia. This earth is of modern discovery. Bergman has written a treatise upon it in his usual masterly manner. It first began to be known at Rome under the name of Count Palma's powder, where it was offered by a regular canon as a remedy for all disorders. Its resemblance in many respects to calcareous earth induced many to consider it at first as the same thing; but Mr. F. Hoffman first proved it to be essentially different. This was afterward discovered by Dr. Black of Edinburgh, and Margraaf of Berlin, unknown to each other.

Magnesia is a white powder, perfectly void of taste or smell. It is very little soluble, water taking up about a two thousandth part only: yet it appears to have some affinity for water, as, if it be moistened with water, and then dried, it gains about 18 per cent. It changes sirup of violets green, but its filtered solution does not. With the acids it forms very soluble and bitter salts. It is not soluble in caustic alkalis. It has a great affinity for alumine.

No effervescence or loss of weight should ensue on adding dilute sulphuric acid to pure magnesia; it should dissolve entirely in the acid; and, when largely diluted, oxalat of ammonia should occasion no precipitate in the solution. For the mode of preparing it see Ammonia.

The carbonat of magnesia shows signs of fusion in a strong heat; but pure magnesia resists the most powerful focus of the burning glass, without either contracting in its dimensions, or undergoing any other change. It flows easily with borax and the microcosmic salt: with equal parts of flint and borax it assumes the form of a beautiful coloured glass, resembling the topaz. With equal parts of flint and fluor spar it affords a glass resembling the chrysolite: and with an equal portion of fluor alone it corrodes and runs through the crucible. Almost any proportion of lime, pure clay, and flint is made by it to flow in the fire; and with four times its weight of green glass it affords a mass resembling porcelain, and hard enough to give fire with steel. It will not flow with an equal weight singly, either of flint, quicklime, barytes, glass, lead, potash, or sulphat of potash: but common clay runs with it into a hard mass.

Magnesia combines very sparingly with sulphur in the dry as well as in the humid way, and the combination possesses the characters of sulphurets.

Though this earth appears to be very extensively diffused over the surface of the globe, yet it is undoubtedly less plentiful than the calcareous, siliceous, or aluminous earths. Most of the native specimens of the magnesian genus are remarkable for a certain soapy or greasy feel. Of these the most common are steatites of a greenish colour, and soft enough to be scraped with the nail; soap rock, lapis ollaris, or Spanish chalk, of a yellow or whitish colour, or black, though rarely, rather harder than steatites, and so easily wrought and turned that pots are made of it. Asbestos, amianthus, and the Venetian and Muscovy talc are included in this genus.

In the state of phosphat it is said by Fourcroy and Vauquelin to exist in the bones of all the animals they examined, those of man excepted. Giobert has found, that a white earth employed near Turin in the fabrication of porcelain, and considered as pure alumine, contains 80 per cent. of subcarbonat of magnesia, and sometimes 90, without a grain of alumine. According to him it contains, on an average, magnesia 68, carbonic acid 12, silex 15·6, sulphat of lime 1·6, water. It is said to be of extraordinary good quality for making pottery. This is dug at Baudissero, and a somewhat similar earth is found at Castellamonte, in the same neighbourhood.

Under the name of calcined magnesia the pure earth is much used in medicine, where absorbents are indicated, and the carbonic acid might be detrimental.

Silex. The most eminent characters of this earth are its hardness and insolubility in almost every acid. It exists nearly in a state of purity in rock-crystal, and abounds in all natural bodies which are hard enough to strike fire with the steel. In the pulverulent form it possesses a singular degree of asperity to the touch, and has not the least disposition to adhere and become kneadable by the addition of water. It has been thought, however, by Bergman and others, that water may dissolve a minute proportion of it. See Crystal (Rock). No acid dissolves it but that of the fluor spar, which suspends it abundantly while in the aëriform state, less so when dissolved in hot water, and very sparingly when cold. The fixed alkalis dissolve it both in the humid and the dry way. In the humid way they combine with about one sixth part of their weight, when the siliceous earth is in a state of extreme division. And in the dry way they take up a very large proportion, according to the degree of heat made use of. From one to two parts of alkali, with one part of silex, form hard permanent glass; but if the salt exceed this proportion, the compound will attract humidity from the air, and assume the liquid state. This fluid, or combination of silex with water by the medium of alkali, is known by the name of the liquor of flints. The addition of an acid will seize the alkali, and throw down the siliceous earth in a state of purity; and accordingly this is the process by which it is to be obtained in a disengaged state. That is to say, let rock crystal be dissolved by strong fusion in four times its weight of fixed alkali, and the mass dissolved in water: let muriatic acid be then added in excess; this will seize the alkali, and form soluble salts with any other earths that may be present; but the siliceous earth will fall to the bottom. Repeated ablutions in distilled water will separate all the extraneous saline fluid, which may be interposed between these particles after decantation, and the dried powder will consist of pure silex.

When a solution of silex in potash is mixed with a solution of barytes, strontia, or lime, in water, or of alumine in alkali, a precipitation ensues, whence silex may be inferred to have an affinity for all these earths in the humid way.

Pure silex has not been fused either by the heat of a furnace or of the burning mirror; but rock crystal was fused by Professor Errhmann, by means of a flame urged by a stream of oxigen. With borax it is easily fused; but requires a longer time with microcosmic salt. With metallic oxides, more especially those of lead, it combines by fusion, and forms glass of a dense texture and strong refractive power. See Glass.

Rock crystal, quartz, flint, gritstone, jasper, and most of the precious stones or gems, owe their distinguishing qualities to siliceous earth, and are therefore considered as specimens of this genus. The respective titles of these may be consulted for accounts of their component parts and habitudes.

Strontia. About twenty years ago a mineral was brought to Edinburgh by a dealer in fossils from a lead-mine at Strontian in Argyleshire, which was generally considered as a carbonat of barytes. It has since been found near Bristol, in France, in Sicily, and in Pennsylvania. Dr. Crawford first observed some differences between its solution in muriatic acid, and that obtained from the carbonat of barytes of Anglezark, and thence supposed it to be a new earth. Dr. Hope of Edinburgh had entertained the same opinion, and confirmed it by experiments in 1791. Kirwan, Klaproth, Pelletier, and Sulzer did the same. The carbonic acid may be expelled by a heat of 140° of Wedgwood, leaving the strontia behind: or by dissolving in the nitric acid, and driving this off by heat.

Pure strontia is of a grayish white colour; a pungent, acrid taste; and when powdered in a mortar the dust that rises irritates the lungs and nostrils. Its specific gravity approaches that of barytes. It requires rather more than 160 parts of water at 60° to dissolve it; but of boiling water much less. On cooling it crystallizes in thin, transparent, quadrangular plates, generally parallelograms, seldom exceeding a quarter of an inch in length, and frequently adhering together. The edges are most frequently bevilled from each side. Sometimes they assume a cubic form. These crystals contain about ·68 of water; are soluble in 51·4 times their weight of water at 60°, and in little more than twice their weight of boiling water. They give a blood red colour to the flame of burning alcohol. The solution of strontia changes vegetable blues to a green. Strontia combines with sulphur either in the wet or dry way, and its sulphuret is soluble in water.

In its properties strontia has a considerable affinity to barytes. It differs from it chiefly in being infusible, much less soluble, of a different form, weaker in its affinities, and not poisonous. Its saline compounds afford differences more marked.—*Edinburgh Trans.*—*Crawford on the Mur. of Barytes.*—*Kirwan.*—*Klaproth.*—*Mem. of the Nat. Instit.*

Yttria. This also is a new earth, discovered in 1794 by Prof. Gadolin in a stone from Ytterby in Sweden: see Gadolinite.

It may be obtained most readily by fusing the gadolinite with two parts of caustic potash, washing the mass with boiling water, and filtering the liquor, which is of a fine green. This liquor is to be evaporated, till no more oxide of manganese falls down from it in a black powder; after which the liquid is to be saturated with nitric acid. At the same time digest the sediment, that was not dissolved, in very dilute nitric acid, which will dissolve the earth with much heat, leaving the silex, and the highly oxided iron, undissolved. Mix the two liquors, evaporate them to dryness, redissolve, and filter, which will separate any silex or oxide of iron that may have been left. A few drops of a solution of carbonat of potash will separate any lime that may be present, and a cautious addition of hidrosulphuret of potash will throw down the oxide of manganese that may have been left; but if too much be employed it will throw down the yttria likewise. Lastly, the yttria is to be precipitated by pure ammonia, well washed, and dried.

Yttria is perfectly white, when not contaminated with oxide of manganese, from which it is not easily freed. Its specific gravity is 4·842. It has neither taste nor smell. It is infusible alone; but with borax melts into a transparent glass, or opake white if the borax were in excess. It is insoluble in water, and in caustic fixed alkalis: but it dissolves in carbonat of ammonia, though it requires five or six times as much as glucine. It is soluble in most of the acids. The oxalic acid, or oxalat of ammonia, forms precipitates in its solutions perfectly resembling the muriat of silver. Prussiat of potash, crystallized and redissolved in water, throws it down in white grains; phosphat of soda, in white gelatinous flakes; infusion of galls, in brown flocks.

Some chemists are inclined to consider yttria rather as a metallic than as an earthy substance; their reasons are its specific gravity, its forming coloured salts, and its property of oxigenizing muriatic acid after it has undergone a long calcination.—*Crell's Chem. An.*—*Scherer's Journ.*—*Annales de Chimie.*

Zircon—was first discovered in the jargon of Ceylon by Klaproth, in 1789, and it has since been found in the jacinth. To obtain it the stone should be calcined and thrown into cold water, to render it friable, and then powdered in an agate mortar. Mix the powder with nine parts of pure potash, and project the mixture by spoonfuls into a redhot crucible, taking care that each portion is fused before another is added. Keep the whole in fusion, with an increased heat, for an hour and half. When cold, break the crucible, separate its contents, powder, and boil in water, to dissolve the alkali. Wash the insoluble part; dissolve in muriatic acid; heat the solution, that the silex may fall down; and precipitate the zircon by caustic fixed alkali. Or the zircon may be precipitated by carbonat of soda, and the carbonic acid expelled by heat.

on is a fine white powder, without smell, but somewhat harsh to the It is insoluble in water; yet if slowly it coalesces into a semitransparent sh mass, like gum arabic, which re- one third its weight of water. It with all the acids. It is insoluble in lkalis; but the alkaline carbonats e it. Heated with the blowpipe it ot melt, but emits a yellowish phos- light. Heated in a crucible of char- edded in charcoal powder, placed in e crucible, and exposed to a good ire for some hours, it undergoes a usion, which unites its particles into opake mass, not truly vitreous, but esembling porcelain. In this state it ciently hard to strike fire with steel, ratch glass; and is of the specific gra- f 4·3.—*Journn. de Phys.*—*Fourcroy.*—

TH (FULLERS). Among the useful hes, for which we are indebted to the ous Bergman, we find one upon narga, or stone marle; which seems r from common marle in its compo- chiefly in possessing a much larger n of siliceous and less of calcareous Fullers earth is one of the most use- ieties of Lithomarge.

nstedt describes Lithomarge under the ing general characters: First, When t is smooth and slippery like hard Secondly, It is not perfectly diffusi- water; but when immersed in that it falls into pieces of greater or less tude, or in such a manner as to as- he appearance of curds. Thirdly, In e it easily melts into a white or red- othy slag, which is considerably larger efore, in consequence of its porosity. ly, Its fracture is irregularly convex cave.

author describes only the Litho- e of Osmund, of Tartary, and of Lem- he Hampshire fullers earth not having to his hands, probably on account of vere penalties imposed by the English ture on its exportation. Bergman ned them all, except the second, which Keffekil of the Crim Tartars, who are o use it instead of soap, and of which s not provided with a sample. Wieg- n Crell's Journal, quoted by Kirwan, that it consists of equal parts magne- d silex.

e Lemnian earth, highly esteemed for centuries for its supposed medical s, and till lately sold in Europe under eal of the Grand Signior, has the ex- appearance of clay with a smooth e, resembling agate, especially in its fractures, which are usually either ve or convex. It may be scraped with ail, is composed of impalpable parti- though a little gritty between the under which it feels like tallow. immersed in water, it is spontaneously divided into small pieces with a slight crackling noise, but they do not become so small as to be invisible or impalpable. Pulverization and boiling in water diffuse it in the fluid, which passes almost perfectly clear through doubled filtering paper. The water examined by the usual tests is found to be neither acid nor alkaline, but exhibits the presence of muriatic acid in combination.

This earth removes impurities like soap, though it affords no froth. When urged by the blowpipe, it does not decrepitate, but turns black, melts with ebullition, and becomes converted into a dark frothy slag. With microcosmic salt there is a commencement of solution with effervescence; but the remainder is scarcely affected. Borax acts more effectually, though slowly, on the residuum. Soda occasions a considerable effervescence with noise. By the humid analysis, Bergman found it to contain forty-seven parts in the hundred of silex, $5\frac{4}{10}$ of carbonat of lime, $6\frac{2}{10}$ of carbonat of magnesia, 10 of alumine, $5\frac{4}{10}$ oxide of iron, and 17 of moist volatile matter expellable by drying.

The Osmundic earth comes from mount Osmund, in the parish of Ratwick in East Dalecarlia. Its colour is gray, like cinders, its surface rough, and as if greased. It is harder than the Lemnian earth, breaks into angular pieces, adheres strongly to the lip, and is more gritty between the teeth than that earth. In water it separates into smaller particles, and is detergent.

This earth decrepitates before the blowpipe, turns black, and melts with ebullition, leaving a white frothy slag. It exhibits the same phenomena as the Lemnian earth with the blowpipe; but a grain of it thrown into the solution becomes white. It effervesces less with soda.

From the humid analysis, Bergman found one hundred parts of the Osmundic earth to contain 60 parts white siliceous powder, $5\frac{7}{10}$ lime, $0\frac{5}{10}$ magnesia, $11\frac{1}{10}$ alumine, $4\frac{7}{10}$ oxide of iron, and 18 of moist volatile matter.

The Hampshire fullers earth, examined by Bergman, was of a dark colour, a little inclined to green, and faintly marked with yellowish veins, less hard than the Osmundic and Lemnian earths, capable of being polished with the nail, of a rough fracture with dark pointed eminences, adhering to the lip, and a little siliceous between the teeth. When immersed in water, it fell to pieces like the other earths. It produced no froth when rubbed with water, but was exceedingly detergent.

Water in which pulverized fullers earth was boiled passed still turbid through several folds of paper, and the water indicated the presence of combined muriatic acid. Before the blowpipe it decrepitated, but less than the Osmundic earth; after which it turned black, was fused with ebullition into a dark-coloured spongy mass. Its habitudes with borax, microcosmic salt, and soda, were the same as those of the Lemnian earth.

Bergman's method of analysing this and the two preceding earths was the following: A hundred parts or docimastic pounds of the earth were pulverized, and inserted into a small glass cucurbit with twice its weight of highly concentrated sulphuric acid; after which a capital and receiver being adapted, the distillation was performed on a sand bath. An acid vapour arose by the first gentle heat, which was found to be muriatic acid; doubtless, says Bergman, arising from decomposed sea-salt. A greater heat did not exhibit any signs of volatile alkali. He then decanted off the superfluous acid, washed the residuum in distilled water, dried it, and found its weight. This was found to be siliceous earth contaminated with iron.

The next object consisted in ascertaining the contents of the acid which had been decanted off. For this purpose he divided it into two parts. To one part, made very warm, he gradually added finely pulverized chalk, taking great care not to exceed the due quantity. The chalk precipitated whatever clay or iron might be present; but left the magnesia in solution, because the sum of the quiescent attractions of lime to carbonic acid, and of sulphuric acid to magnesia, are greater than the divellent attractions of the carbonic acid to magnesia, and sulphuric acid to lime; so that the presence of the carbonic acid prevented that decomposition of sulphat of magnesia, which would have taken place if mere lime had been used.

After the precipitation of clay and iron from the solution, he evaporated the liquor, which occasioned the separation of sulphat of lime, and sulphat of magnesia; the latter of which, on account of its much greater solubility, was taken up by a little warm water. Another evaporation and solution of the sulphat of magnesia was made, to clear it entirely of the sulphat of lime. Mild fixed alkali was used to precipitate the earths from the respective solutions of these two salts, and the remaining liquors were subjected to ebullition for a quarter of an hour, to throw down the small portion of earth which might be suspended by the redundant fixed air. In this way, consequently, the true quantities by weight of magnesia and of lime, contained in half the centenary, were ascertained, taking care to deduct the weight of chalk made use of in the precipitation.

In the foregoing process the iron and clay were precipitated, that they might be no impediment to an examination of the quantities of lime and magnesia. The separation of the clay from the iron not being a very direct operation, the other half of the original solution was reserved for the purpose of determining their weights. Prussiat of potash was therefore added to this half of the solution; in consequence of which the iron fell down in the form of Prussian blue, leaving the earths suspended. The quantity of iron was determined by allowing ten grains of iron, for each fifty-nine grains of blue precipitate.

In the next place the solution was filtered, now containing clay, magnesia, and lime, all combined with sulphuric acid; out of which the quantity of the first only was required to be found. The solution was therefore concentrated by evaporation, and the excess of acid then saturated, by the addition of carbonat of magnesia, till paper stained with litmus was not affected by it. An excess of magnesia was guarded against, by suffering each small portion to be entirely dissolved before any more was added. After half an hour's boiling, the neutral combination of alumine and sulphuric acid fell down, it being well known, that the solubility and other properties of alum depend on its excess of acid: and this combination being digested with alkaline carbonat afforded the pure alumine.

By this management he found, that the Hampshire fullers earth contained of silex $51\frac{8}{10}$ parts; of carbonat of lime $3\frac{1}{10}$; of carbonat of magnesia $0\frac{7}{10}$; of alumine 25; of oxide of iron $3\frac{7}{10}$; and of moist volatile matter $15\frac{1}{2}$ parts.

The properties required in a good fullers earth are, that it should contribute to the washing away all impurities, and promote that curling and intermixture of the hairs of the woollen cloth, which thicken its texture, and give it the desired firmness. Both probably depend on its detergent quality, that clears away all the unctuous matter of the wool, and renders its parts capable of becoming more perfectly entangled together by the mechanical action of fulling; an effect not so likely to take place when the fibres or hairs are disposed by grease to slide easily over each other. The detergent power resides in all clays, but is doubtless greatly increased by the siliceous earth, which may be considered as the brush, while the clay serves as the soap. This is familiarly shown, by the common practice of adding sand to soap, which renders it much more detergent; but at the same time more capable of injuring the substances to which it is applied, and that more especially when the sand is coarse. Fullers earth is bad, if the sand be not exceedingly fine; and the superior excellence of the Hampshire fullers earth seems to depend more on the fineness of its parts, than on their proportions, as is shown by the experiment of boiling it in water; after which it passes more plentifully through the filter than any of the other lithomargæ.

EARTH (LEMNIAN), or TERRA LEMNIA. A bolar earth from the island of Lemnos, formerly in great esteem for its supposed medical qualities. Cronstedt reckons it among the lithomargæ or stone marrow. Bergman has given a good analysis of it; for which see Earth (Fullers).

Earth (Mercurial). A substance which, according to Becher and other alchemical philosophers, is a common principle of metals and some other bodies. In conformity with this obscure theory, we find frequent mention of the mercuries of gold, of silver, or of other metals. The facts and discoveries subsequent to the time of the illustrious Becher have not afforded any foundation to conclude, that any such common principle as the mercurial earth exists; and it was so far from being satisfactorily exhibited by Becher himself, that his disciple, the great Stahl, did not include it in his modification of the Becherian system.

Earth (Vegetable). This appellation has been given to the insoluble residue which remains after the incineration of vegetables, and likewise to the mould or soil best suited to the propagation and growth of these organized beings.

Vegetables contain but a small proportion of earth of any kind, the much greater part of their substance being found by experiment to consist of oxigen, hidrogen, nitrogen, and carbon, in the concrete or combined state, as remote principles; a small portion of fixed alkali, usually either neutralized by the vegetable acids or combined with the oils or mucilage, and a few other neutral salts.

The earth of vegetables is for the most part either calcareous, or a mixture of various earths, and sometimes of the oxides of iron and manganese, in different proportions, according to the species of the vegetable. These earths may be obtained either by incineration or putrefaction, and are not therefore the product of the fire.

Vegetable mould or earth, as far as the same may consist of fixed parts, appears therefore, from these analytical facts, to be merely the vehicle, by which the aqueous or aërial substances are conveyed into the vessels of plants. Other synthetical experiments of plants supported and nourished by the mere immersion in water, and some which thrive, though their roots and branches have no other body in contact with them but the air of the atmosphere, are sufficiently strong in confirmation of this truth.

Chaptal has treated this subject in a manner so singularly perspicuous and concise, that I shall follow him in the remainder of the present article.

Although it is well proved, that pure water is sufficient for the support of plants, it must not be concluded, that the soil or earth is of no utility. Its use is similar to that of the placenta, which of itself affords no support to the fœtus, but prepares and disposes the blood of the mother to become a suitable nutriment; or it resembles, in its useful application, the various receptacles which are placed in the human body, to preserve the several humours, and emit them when required. The earth imbibes and retains water. It is the reservoir destined by nature to preserve the elementary fluid, which the plant continually requires, and to supply it in proportion to its wants, without exposing it to the equally fatal alternatives of being either inundated or dried up.

We may even observe, that the young plant or embryo of a vegetable is not intrusted by nature with the labour of digestion. The seed is formed of a parenchyma, which imbibes water, elaborates it, and does not transmit it to the germen, until it is converted into a humour of a suitable quality. By insensible gradations this seed is destroyed; and the plant, having become sufficiently strong, is left to perform the digestive function without farther assistance. So likewise it is, that we observe the fœtus supported in the womb by the fluids of the mother herself; but when it has seen the light, it receives for its nourishment a fluid less animalized; its organs are gradually strengthened, and at length become capable of digesting a stronger and less assimilated nutriment.

But on this very account, namely, that the earth is destined to afford a due supply of water to the plant, the nature of the soil cannot be a matter of indifference, but must be varied accordingly as the plant requires a more or less considerable quantity of that fluid in a given time, in proportion to the magnitude and extent of its roots.

A proper soil is that, 1st, which affords a support to the plant, of sufficient firmness to prevent its being too much agitated, or overthrown, by the winds or other causes; 2d, which is capable of admitting the roots to be easily extended; 3d, which is suited to receive and absorb moisture, that the plant may on no occasion suffer from the want of this essential requisite. To answer these conditions, it is necessary to make a due mixture of the primitive earths, because no one in particular is equal to the accomplishment of them. Siliceous and calcareous earths may be considered as hot and drying, the argillaceous as moist and cold, and the magnesian as possessing intermediate properties. Each in particular has its imperfections, that render it unfit for culture. Clay absorbs water, but does not communicate it; calcareous earth receives and gives it too quickly; but the properties of these earths are so happily opposed, that they correct each other by mixture. Accordingly we find, that by adding lime to an argillaceous earth, this last is divided; and the drying quality of the lime is mitigated, while the stiffness of the clay is diminished. On these accounts also it is, that any single earth cannot constitute manure to be applied in all cases; but the character of the soil intended to be meliorated ought first to be examined and considered, before any decision is made concerning the manure to be applied. Mr. Tillet has ascertained, that the best proportions of a fertile earth for corn are three-eighths clay, two-eighths sand, and three-eighths fragments of hard stone.

The advantage of labour or cultivation consists in dividing the earth, impregnating it with air, destroying useless and noxious plants, and converting them into manure by facilitating their decomposition. See Arable Land, and Soils.

Earth (Vitrifiable). Every earth is in fact vitrifiable with proper additions, and none without. But siliceous earth has been generally distinguished by this name, on account of the superior facility with which it is converted into a good glass by fusion with an alkali. See Earths, Silex, also Glass.

Earthen-ware. See Pottery.

Earthworms are plentifully found in moist fat grounds, but rarely, if ever, in dry sands. Mr. Reaumur proposed collecting them as a cheap substitute for grain in feeding domestic poultry. The physicians, who appear to have overlooked scarcely any produce of the three kingdoms of nature, have used these creatures, under the notion of their possessing an antispasmodic and diuretic virtue. Neumann relates several experiments made with them. They are cleansed by washing, and suffering them to creep through dry woollen cloths. Unless hastily dried by the heat of the sun or a fire, they are very apt to putrefy. Moistened with wine or vinous spirit, to prevent their putrefaction, and set in a cellar in a wide-mouthed glass, they are almost wholly resolved in a few days into a slimy liquor. When this liquamen or solution is mixed with a little fixed alkali, and after due evaporation set by to shoot, the crystals are no other than saltpetre. Neumann did not in direct terms assert, that he himself made this experiment, and from the context there seems to be some slight reason to suspect he had it from Stahl.

He made however his usual set of experiments with them by digestion in water and alcohol, and by destructive distillation. When repeated digestion with the spirit was used first, the quantity of extract from four ounces of the dried worms, and the residuum treated with water, yielded three drachms and a scruple. But the same quantity treated first with water afforded one ounce, six drachms, and a scruple, after which rectified spirit extracted two scruples.

Thirty-two ounces of dried earthworms yielded, by destructive distillation, thirteen ounces and a half of an alkaline fluid, one ounce of concrete volatile alkali, and four ounces and a half of empyreumatic oil. The remainder, burned in the open air, afforded, by lixiviation, one ounce and a half of fixed alkali. The earthy residuum weighed six ounces and a half, which, at that early period of chemistry, Neumann did not possess the methods of examining. If the worms were putrefied, by distillation the volatile product was scarcely any thing but mere water, with very little oil and volatile alkali.

Eau de Luce. The smell of the volatile alkali is rendered considerably more grateful by an imperfect combination with oil. Eau de luce is a compound of this nature, consisting chiefly of the essential oil of amber and the volatile alkali. There is some difficulty in compounding this fluid, so that it shall possess the desired quality of a beautiful milky whiteness. For if the combination be too perfect by a due proportion of the materials, it will approach to transparency; and if it be less perfect by a redundancy of oil, this last will separate in the form of globules, or in a kind of cream. See Ammonia.

Echini. Calcareous petrifactions of the echinus, or sea hedgehog.

Edulcoration. This word imports the same thing as dulcification, properly speaking; namely, the rendering things more mild: but chemists use the terms very differently. Dulcification consists in the obtunding of acids by combination with alcohol (see the word). Edulcoration consists in carrying off superfluous acid, or other saline matter, by one or more washings with water. Metallic oxides and other insoluble precipitates are usually edulcorated previous to drying them.

Effervescence. According to its derivation, this term implies the boiling over of any fluid by heat. In chemistry it is appropriated to the commotion and increase of volume produced in fluids by some part of the mass suddenly taking the elastic form, and escaping in numerous bubbles. Thus, when any other acid is poured on chalk, the carbonic is disengaged in the elastic state with bubbles, vapour, and a hissing noise.

Effervescences are more or less violent, according to circumstances, and are usually attended with a change of the temperature. If the capacity of the mixture or new combination for heat be diminished by the change the bodies have undergone, in a greater degree than that of the elastic fluid is enlarged, the temperature will be increased: but if, on the contrary, the mixture retain its original or acquire an increased capacity, the elastic fluid will carry off so much of the heat, as to produce a greater or less degree of cold in the remainder. Chemistry affords many instances of both effects taking place.

Efflorescence is the effect which takes place when solid or consistent bodies gradually and spontaneously become converted into a powder. It is almost always occa-

by the loss of the water of crystalli-
in saline bodies. Thus carbonat and
of soda, and many other salts, are
cent; that is, they become dry and
lent when left exposed to the air.
efflorescences are occasioned not sim-
the loss of moisture, but by pro-
of a more compounded nature, such
efflorescence of alum-slate by the
sion of its sulphur into sulphuric
y roasting and exposure to the air;
efflorescence of the martial pyrites,
by the same treatment become con-
into sulphat of iron, though origi-
omposed of iron and sulphur.

. The eggs of hens and of birds in
are composed of several distinct
ces. 1. The shell or external coat-
ich is composed of carbonat of lime
osphat of lime ·2, gelatine ·3. The
ing ·23 are perhaps water. 2. A thin
nd strong membrane, possessing the
aracters of animal substances. 3. The
f the egg, for which see ALBUMEN.
yolk, which appears to consist of an
he nature of fat oils, united with a
of serous matter, sufficient to render
ible in cold water, in the form of an
n, and concrescible by heat. Yolk
is used as the medium for rendering
nd oils diffusible in water. An oil
is procured by expression from the
f eggs, previously roasted to deprive
rous part of its fluidity. A slight
euma is given to the oil by this
ent, which might probably be avoid-
applying no greater heat than on
ight be found sufficient to coagulate
um.

products afforded by the several parts
, subjected to destructive distillation,
rly the same as are obtained by that
from other animal matters.

Reaumur found that eggs might be
ved during months or years, by being
d with mutton suet, or any other fat
nce. And Mr. Parmentier has ob-
, that the eggs of hens which have
communication with a cock keep
better than those that are fecun-
he adds too, that they are not infe-
size or flavour, and that the hens lay
s many; so that they who keep fowls
sake of the eggs alone, should have
nly, without any cocks. He recom-
the common hen as most productive,
e black legged as superior to the
.—*Annales de Chimie.—Bullet. des*
s.

CAMPANE. Neumann distilled thirty-
nces of the root, and obtained three
s and a half of oil, part of which
the head of the still, and part passed
into the receiver, along with the
made use of. He did not obtain a
e of this nature from any other vege-
It resembles camphor in some re-
but not in all. Water does not
affect it. Alcohol totally dissolves it. When laid on burning coals, it exhales without leaving any residue. Held over a gentle fire in a ladle, it flows like wax or tallow, and when cold, appears softer and more unctuous than at first. The younger Geoffroy observes, that this matter resides in the exterior parts of the root near the bark.

Alcohol distilled from the root carries nothing over, and water leaves more behind it than it takes up. One ounce of the dry root afforded six drachms and a half of extract with water; but the same quantity gave only two drachms and a half with spirit.

ELECTRUM. Amber. See the article.

ELEMENTS. A term used by the earlier chemists, nearly in the same sense as the moderns use the terms first principle. The chief, and indeed very essential difference between them is, that the ancients considered their elements as bodies possessing absolute simplicity, and capable of forming all other bodies by their mutual combination; whereas the first principles of the moderns are considered as simple merely in respect to the present state of the art of analysing bodies. That is to say, the ancients almost totally overlooked the imperfection of the art in their general deductions; but the moderns pretend to keep it in view.

The experiments made in the infancy of chemistry had for their object the phenomenon of combustion, referred by them to a substance called fire; the extrication of elastic fluid, considered to be of the same nature as the immense mass which composes the atmosphere; water, neither compoundable nor destructible by any experiments then known or understood; and substances not volatile in the strongest heat of furnaces, confounded by them, with a few exceptions, under the general term of earth. In this way they obtained four elements or first principles, fire, air, water, and earth.

Subsequent experiments and inquiries have multiplied the number of elements, and have alternately shown the inutility of any exclusive general arrangement of bodies, as absolutely simple, because not yet analysed. See PRINCIPLES, also ATTRACTION.

ELIQUATION. An operation, by means of which a more fusible substance is separated from another which is less fusible. It consists in the application of a degree of heat sufficient to fuse the former, but not the latter. It may be effected either by using a perforated crucible, or in the large way, by a furnace constructed to answer the same purpose. In order that a separation may follow by this method, it is necessary, that the combination between the two substances should be by no means intimate. Thus sulphur may be separated from its earthy admixtures by the gentle heat necessary to fuse it; but it cannot, in the same manner, be separated from its metallic combinations. So likewise lead may be separated by eliquation from copper; but tin cannot.

Elutriation. This word is used by chemists to denote the process of washing, as practised by metallurgists and others; and indeed this last and more familiar term is most frequently used. Thus the metallic ores are cleared of earthy admixtures by elutriation, that is to say, washing with water, which carries off the lighter earthy parts, while the heavier metallic parts subside to the bottom.

Emerald. A transparent precious stone, of a green colour, nearly of the same hardness as the garnet, or agate; but inferior to the topaz and ruby. Its specific gravity is 2·775. In its rough, or native state, it consists of six-sided prisms, commonly truncated at both ends. Engestrom says, that they become of an opake white in a strong fire, without the least mark of fusion: but Wallerius asserts, that this stone, when heated to a white heat, becomes of a deep blue colour, and phosphorescent, and recovers its green colour when cold. With oxigen gas, however, it fuses into an opake globule, resembling what is called a dead pearl. Friction produces electricity in the emerald. Some emeralds, of the dark green sort, resemble the tourmalin in the property of attracting small bodies, by an electricity produced by heating and cooling.

When crystallized cockle, or shirl, is found of a green colour, transparent, and free from cracks or flaws, it is commonly called emerald by the jewellers, though it is generally of a deeper colour than the true emerald, and also wants their lustre; and hence it is, that the cockle spar from Egypt is called the mother of emeralds. However, it is probable that this cockle was, in ancient times, fashionable in Egypt, under the name of emerald, though at present it is not so much valued as the emerald of this (siliceous) kind.

The true emerald is not acted upon by soda in the dry way, but it yields to borax and microcosmic salt, with which, according to Quist and Wallerius, it affords a colourless glass.

According to Vauquelin, 100 parts of this stone contain 64 of silex, 15 of alumine, 14 of glucine, 1·6 of lime, and 4·25 of oxide of chrome.

Emery. The best sort is of a dark gray colour, but becomes brown, and in a great measure magnetical, by calcination. Other sorts are of a reddish rusty white or yellowish colour. This mineral scarcely yields to any substance in hardness, excepting the diamond. It is brought to us in large quantities from the Archipelago, particularly the Isle of Naxos, and is much used for grinding and polishing. It seems to resemble corundum very much in its hardness, as well as in the foreign matters that accompany it. Mr. Tennant has analysed different specimens of emery, one of which gave ·80 alumine, ·03 silex, ·04 iron, and ·03 insoluble matter: a second, ·65 alumine, ·032 silex, ·08 iron, ·18 insoluble residuum: a third, ·50 alumine, ·08 silex, ·32 iron, ·04 residuum.—*Phil. Trans.*

Empyreuma. This term is applied to denote the peculiar smell produced by a considerable heat upon vegetable or animal substances, in closed vessels, or when burned under circumstances which prevent the access of air to a considerable part of the mass, and consequently occasion an imperfect combustion, or destructive distillation of the parts so covered up by the rest of the mass.

Mr. Macquer observes, that empyreuma is the peculiar smell of burned oils, and that no other but oily substances can produce it. He even proposes this indication as a test of the presence of oil, in bodies which contain too small a quantity of that fluid to admit of any other way of exhibiting it.

Emulsion. An imperfect combination of oil and water, by the intervention of some other substance capable of combining with both these substances. The substances are either saline or mucilaginous. Thus the volatile alkali with certain management forms the emulsive liquors called volatile liniment, and eau de luce. Gum arabic, or sugar, triturated with oils, renders them miscible with water, as do likewise white of egg and other animal mucilages. The vegetable juices obtained by compression from various seeds and other parts of vegetables are of an emulsive nature. But it does not seem probable, that they exist in the vegetable under the emulsive form, but rather that the several distinct vessels respectively contain oil, water, mucilage, or sugar, the confused mixture of which produces the emulsion. On the same principle it seems to be, that the gum resins afford emulsions when triturated with water.

Sir Isaac Newton has shown by experiment, that all bodies are transparent, the particles of which do not exceed a certain magnitude, which he has deduced by computation in his Optics. When opacity is the result of a combination of two transparent bodies, it affords a considerable proof, that their union is little more than mechanical. It is well known how slowly small particles either sink, or rise to the surface of any fluid in which they may be suspended. Atwood, in his Treatise on the rectilinear and rotatory Motion of Bodies, and other writers, have shown the methods of ascertaining these velocities, when the densities of the particles and of the fluid, together with the magnitude of the former, are known. Whence it is not to be wondered, that a slight tendency to chemical combination, assisted by minute mechanical division, should occasion the respective parts of emulsive liquors to remain for a

ne without separation. It is found,
er, that in process of time they do
e.

MELLING. The art of enamelling
als is treated at full length by Mr.
art in the Annales de Chimie, vol. 9.

on Glass, with the notes of Merret
nckel, affords a variety of good re-
for making enamels, though much
mains to be done in this art. The
ndeed retarded by the considerable
ge the enameller derives from a
ry of any colour uncommonly bril-
lear, or hard. On this account the
aturally endeavours to keep his pro-
ecret, as the source of private gain.
incipal ingredients of enamel colours
wever, well known.

re are two kinds of enamel, the opake
e transparent. Transparent enamels
ally rendered opake by adding putty,
white calx of tin, to them. The basis
namels is therefore a perfectly trans-
and fusible glass. The oxide of tin
this of a beautiful white, the per-
of which is greater when a small
y of manganese is likewise added. If
de of tin be not sufficient to destroy
sparency of the mixture, it produces
pake glass, resembling the opal.

ow enamel is formed by the addition
de of lead, or antimony. Kunckel
e affirms, that a beautiful yellow may
ained from silver.

enamel is afforded by the oxide of
nd also by that of iron. The former
most beautiful, and stands the fire
ell, which the latter does not.

le of copper affords a green; man-
, a violet; cobalt, a blue; and iron, a
ne black. A mixture of these dif-
enamels produces a great variety of
ediate colours, according to their
and proportion. In this branch of
the coloured enamels are sometimes
with each other, and sometimes the
are mixed before they are added to
reous bases.

enameller, who is provided with a
good colours, is very far from being
uation for practising the art, unless
killed in the methods of applying
and the nature of the grounds upon
they are to be laid. Many of the
are too fusible to be enamelled, and
all of them are corroded by the
of the fused glass. For this reason,
f the metals are used but gold, silver,
pper. Platina has indeed been used;
its effects and habitudes with enamels
ttle can be said, for want of a suffi-
umber of experiments.

purest gold of 24 carats is calculated
duce the best effect with enamel. 1.
e it entirely preserves the metallic bril-
without undergoing any oxidation in
e. 2. Being less fusible, it will admit
ore refractory, and consequently a
harder and more beautiful enamel. It is not usual, however, to enamel upon finer gold than 22 carats; and the operation would be very defective, if a coarser kind than that of 18 carats were used. For in this case more alkali must be added to the enamel, to render it more fusible, and this addition would at the same time render it softer and less brilliant.

Rejecting all these exceptions, the author gives the following description, by way of example, of fixing a transparent blue enamel upon gold of 22 carats.

The artist begins his operation by breaking the enamel into small pieces in a steel mortar, and afterward pulverising it in a mortar of agate. He is careful to add water in this part of his process, which prevents the splinters of glass from flying about. There are no means of explaining the point at which the trituration ought to be given up, as this can be learned only by experience. Some enamels require to be very finely triturated; but others may be used in the form of a coarse powder. As soon as he apprehends that his enamel is sufficiently pounded, he washes it by agitation in very clear water, and pouring off the fluid as it becomes turbid. This operation, which is made for the purpose of carrying off dust and every other impurity from the enamel, is continued until the water comes off as clear as it was poured on.

The workman puts his enamel, thus prepared, in a white china or earthen saucer, with water poured on it to the depth of about one tenth of an inch. He afterward takes up this enamel with an iron spatula, as equally as possible. As the enamel here spoken of is transparent, it is usual to ornament the surface of the gold with rose work, or other kinds of works, calculated to produce a good effect through the enamel.

The thickness of this first layer depends entirely upon its colour: delicate colours, in general, require that it should have no great thickness.

The moist enamel, being thus placed, is dried by applying a very clean half-worn linen cloth to it, which must be very carefully done, to avoid removing the enamel by any action of wiping.

In this state the piece is ready for the fire. If it be enamelled on both sides, it is placed upon a tile, or iron plate, hollowed out in such a manner, that the uncovered edges of the piece alone are in contact with the support. But if it be enamelled on one side only, it is simply laid upon the plate, or on a tile. Two things, however, require to be attended to. 1. If the work be very small, or not capable of being enamelled on its opposite side, the iron plate must be perfectly flat, in order that the work may not bend when softened by heat. 2. If the work be of considerable size, it is always counter-enamelled if possible; that is to say, an enamel is applied on the back surface, in order to counteract the effect which the other coating of glass might produce on the soft metal, when it came to contract by cooling.

The enameller's furnace is square and built of bricks, bedded in an earth proper for the purpose. It may be considered as consisting of two parts, the lower part, which receives a muffle, resting on the floor of the furnace, and open on both sides.

The upper part of the furnace consists of a fire-place, rather larger and longer than the dimensions of the muffle. This fire-place contains the charcoal, which must surround the muffle on all sides, excepting at the bottom. The charcoal is put in at a door above the muffle, which is closed when the fire is lighted. A chimney proceeds from the summit of the furnace with a moderate aperture, which may be closed at the pleasure of the artist, by applying a cast iron plate to it. This furnace differs from that of the assayer in the circumstance, that it is supplied with air through the muffle itself: for, if the draught were beneath the muffle, the heat would be too strong, and could not be stopped when requisite.

As soon as the fire is lighted, and the muffle has obtained the requisite degree of ignition, the charcoal is disposed toward the lower part of the muffle in such a manner, as that it shall not fall upon the work, which is then conveyed into the muffle with the greatest care upon the plate of iron or earthen-ware, which is taken up by long spring pincers. The work is placed as near as possible at the farther extremity of the muffle; and as soon as the artist perceives a commencement of fusion, he turns it round with great delicacy, in order that the fusion may be very uniform. And as soon as he perceives that the fusion has completely taken place, he instantly removes it out of the furnace: for the fusion of gold happens so very near that of the enamel, that a neglect of a few seconds might be attended with considerable loss.

When the work is cooled, a second coat of enamel is applied in the same manner as the first, if necessary. This, and the same cautious management of the fire, are to be repeated for every additional coat of enamel the nature of the work may demand.

As soon as the number of coatings are sufficient, it becomes necessary to give an even surface to the enamel, which, though polished by the fire, is nevertheless irregular. This is done with an English fine-grained file and water. As the file wears smooth, sand is used. Much precaution and address are required in this part of the work, not only because it is easy to make the enamel separate in splinters from the metal, but likewise because the colour would not be uniform if it were to be ground thinner at one part than at another.

The deep scratches of the file are in the next place taken out, by rubbing the surface with a piece of deal wood and fine sand and water. A polish is then given by a second ignition. This polish, however, is frequently insufficient, and not so perfectly uniform as the delicacy of the work may require.

The substance used by the enamellers, as a polishing material, is known by the name of rotten-stone; which is prepared by pounding, washing, decanting off the turbid water, suffering the fine suspended particles to subside from this water, and lastly levigating it upon a glass plate.

The work is then cemented to a square piece of wood with a mixture of resin and brick-dust, and by this means fixed in a vice.

The first operation of polishing is made by rubbing the work with rotten-stone upon a small straight bar of pewter. Some delicacy is here required, to avoid scratching or producing flaws in the enamel, by pressing it too hard. In this way the piece is rendered perfectly even: but the last brilliant polish is given by a piece of deal wood and the same rotten-stone.

This is the general method of applying enamels; but some colours require more precaution in the management of the fire. Opake colours require less management than the transparent. A variety of circumstances must be attended to in the management of transparent colours; every colour requires gold of a particular fineness.

When different colours are intended to be placed beside one another, they are kept separate by a small edge or prominency, which is left in the gold for that purpose, and is polished along with the enamel.

The enamelling upon silver is effected nearly in the same manner as that of gold; but the changes sustained by the colours upon the silver, by the action of fire, are much more considerable than when gold is used.

Copper is not much used by enamellers, on account of the difficulty which attends the attempt to fix beautiful colours upon it. When this metal is used, the common practice is to apply a coating of opake white enamel, and upon this other colours, which are more fusible than the white.

A good effect is produced in toys, by leaving part of the gold bare. For this purpose its surface is cut into suitable compartments by the engraver. This, however, is an expensive method, and is for this reason occasionally imitated by applying small and very thin pieces of gold upon the surface of the enamel, where they are fixed by the fire, and afterward covered by a transparent vitreous coating.

After this detail of the art of enamelling, Mr. Brogniart describes a method of taking off the enamel from any toy, without injuring its metallic part. For this pur-mixture of common salt, nitre, and n powder, is applied upon the ena- d the piece put into the furnace. n as the fusion has taken place. the sudden! thrown into water, which he enamel to fly off either totally or . The part which may remain is to oved by repeating the same opera- second time. See **Glass**; also Por- .

oat vessels of iron or copper for cu- purposes with an enamel capable of ng the metal from the action of any , and enduring any heat, or transi- m heat to cold, appears a desirable and many experiments have been n the subject by Mr. Soen Rinman; oyal Academy of Stockholm.

following compositions he found very well on copper. 1. The white nsparent fluor spar and sulphat of equal quantities, powdered, mixed, cined in a white heat; then powder- e into a thin paste with water, and a little warm to the vessel also l. When dried and heated gradually ertain point, a very strong heat, than is commonly obtained in an g furnace, is to be applied as quickly ble. 2. Sixty parts of lime, 100 of ar, 60 of gypsum, 20 of quartz, and manganese, were calcined, ground, plied in a similar manner. 3. Four f fluor spar, four of gypsum, and one rge, melted into a straw-coloured round, and applied in the same way, d a still stronger heat. 4. Five parts r spar, 5 of gypsum, 2 of minium, 2 glass, ½ a part of borax, the same of f tin, and $\frac{1}{15}$ of a part of oxide of melted together, made an enamel; when ground and applied as the fused with a less degree of heat. Ir. Rinman imagines would have ted upon in length of time by sul- acid. The oxide of cobalt was ed by saturating a solution of cobalt fortis with common salt, and eva- g to dryness.

ese would not do for iron, he tried lowing. 1. Minium 9 parts, flint pure potash 2, nitre 2, borax 1, round together, put into a covered which they only half filled, and to a glass. This poured out on a of marble, quenched in water, ed, and made into a thin paste, was both sides of an iron vessel. After been dried and heated gradually, sel was put under a muffle well in an assaying furnace, and in half te the enamel melted. The vessel nen withdrawn, was found enamelled autiful black colour, which appear- e owing to a thin layer of oxided en through the transparent glaze. same with one hundredth part of f cobalt, prepared as above, covered the vessel more perfectly with a blue enamel. 3. The same ground with potters white lead, which consists of 4 parts lead and 1 tin, produced a very smooth gray enamel, more firm and hard than the preceding. A small quantity of red oxide of iron gave it a fine dark red colour. 4. Flint glass 12 parts, minium 18, potash 4, nitre 4, borax 2, oxide of tin 3, oxide of cobalt $\frac{1}{8}$ of a part, gave a smooth pearl-coloured enamel, not brittle or subject to crack, and capable of enduring sudden changes of heat and cold, as well as the action of oils, alkalis, and weak acids; but it cannot resist the stronger vegetable acids, and still less the mineral.

These enamels can be applied only on hammered iron, cast iron being too thick to be heated with sufficient quickness. It may be unnecessary to add, none of them will bear hard blows.

Ens Martis. A name anciently given to the oxide of iron which arises in sublimation with twice its quantity of sal ammoniac. Medical practice does not at present place this preparation in a higher rank of estimation than other oxides of iron.

Ens Veneris. The ens martis is in many dispensatories called by this name; others direct a sublimation to be made with sal ammoniac, and the calx of cupreous vitriol, a process which it is well known affords no flowers, or at least a quantity proportioned merely to the iron with which the vitriol of copper may be contaminated. It appears, therefore, that there is properly no ens veneris.

Entrochi. A genus of extraneous fossils, usually of about an inch in length, and made up of a number of round joints, which, when separate and loose, are called trochitæ: they are composed of the same kind of plated spar with the fossil shells of the echini, which is usually of a blueish gray colour; and are very bright where fresh broken: they are all striated from the centre to the circumference, and have a cavity in the middle. They seem to be the petrified arms of that singular species of the sea star-fish, called Stella arborescens.

Epidermis. If the human skin be macerated in hot water, it separates into two parts, the *cutis*, or true skin, and the *epidermis*, or scarf skin. The continued action of warm water at length dissolves the cutis, but does not affect the epidermis, neither does alcohol. Caustic alkali, however, dissolves it; and so does lime, but more slowly. Hence it appears to be analogous to the kind of varnish that covers silk. It has no affinity with tannin, so that tan would penetrate the flesh side of skin only, if the epidermis were not previously removed by the limewater employed to take off the hair. —*Chaptal.—An. de Chim.*

Epsom Salt. Sulphat of magnesia.

Essay. See Assay.

Essences. Several of the volatile or essential oils are called essences by the perfumers.

Ether. A very volatile fluid, produced by the distillation of alcohol with an acid. The sulphuric ether is upon the whole best known, though there are various ethers made by means of other acids. As some advantages may be gained by treating of the whole under one article, I shall accordingly pursue that method.

Various passages in the writings of the earlier chemists sufficiently evince, that the sulphuric ether was among their secrets; but it was scarcely attended to before the year 1730, when a certain quantity was presented to the Royal Society by Dr. Frobenius, and certain experiments were made of its most obvious qualities.

When strong sulphuric acid is poured upon an equal weight of alcohol, the fluids unite with a hissing noise and the production of heat, at the same time that a fragrant vegetable smell is perceived, resembling that of apples. It is much better and safer, however, to add the acid by small portions at a time, at such intervals as that no perceptible heat may be produced. The mixture may be made in a glass retort, and the distillation performed by regulated heat on a sand-bath, a large tubulated receiver being previously well adapted and kept cool by immersion in water, or the frequent application of wet cloths. A bent glass tube luted to the tubulure of the receiver, and having its extremity immersed in a little water or mercury, will allow the gasses to escape, and confine the condensible vapour. The first product is a fragrant spirit of wine, which is followed by the ether, as soon as the fluid in the retort begins to boil. At this period the upper part of the receiver is covered with large distinct streams of the fluid, which run down its sides. After the ether has passed over, sulphurous acid arises, which is known by its white fumes and peculiar smell. At this period the receiver must be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire must at the same time be moderated, because the residue in the retort is disposed to swell. A light yellow oil, called sweet oil of wine, comes over after the ether, and is succeeded by black and foul sulphuric acid. The residue varies in its properties according to the management of the heat. If the fire be much increased toward the end of the process, the sulphurous acid that comes over will be mixed with vinegar.

The ether comes over mixed with alcohol and some sulphurous acid. It was usual to add some distilled water to this product, which occasioned the ether to rise to the top. Rectification is absolutely necessary, if the ether have a sulphurous smell; and this is indeed the better method in all cases, because the water added in the old method always absorbs about one tenth part of its weight of ether, which cannot be recovered without having recourse to distillation; and also, because the ether is found to absorb a quantity of the water. Previous to the rectification a small quantity of black oxide of manganese should be added, shaking the mixture occasionally during 24 hours. Proust prefers clean slaked lime, as recommended by Woulf: observing that the bottle must not be above three parts filled, and that it must be moved about in cold water for some minutes before the cork is taken out.

The inexperienced chemist must be reminded, that the extreme inflammability of alcohol, and still more of ether; the danger of explosion which attends the sudden mixture and agitation of concentrated acids and alcohol; and the suffocating effect of the elastic fluids, which might fill the apartment if inadvertently disengaged; are all circumstances which require cautious management.

Sulphuric ether is one of the lightest and most volatile of all non-elastic fluids. Its dissipation into the air by evaporation is so sudden as to produce extreme cold. It is highly inflammable, burns with a more luminous flame than alcohol, which is of a deep blue, and emits more smoke. At 46° below 0 of Fahr. it becomes solid.

The action of this fluid upon saline substances has been little attended to. It does not appear to act upon lime or fixed alkalis. Caustic volatile alkali combines with it in all proportions. Sulphuric acid combines with it, and extricates heat; and from this compound the sweet oil of wine may be obtained by distillation. Nitric acid causes an effervescence, and renders it more oily. It dissolves essential oils and resins, and camphor very plentifully. By long digestion it dissolves $\frac{1}{12}$ of sulphur in the light, and $\frac{1}{17}$ in the dark. This preparation Mr. Favre recommends as an excellent test of lead in wine, which it throws down in a black precipitate. He has also administered it on sugar as a medicine, as well as in different vehicles. Mixed with the muriatic solution of gold it retains a portion of the metal in solution for some time.

Nitric acid has so strong a disposition to combine with alcohol, that a considerable danger of explosion attends the mixture of these fluids. Both these circumstances have given rise to a number of processes for forming nitric ether. It has been made by mixing the two fluids in a retort, connected with very capacious receivers; a method in which it is probable, that no ordinary degree of precaution would be sufficient to secure the operator from the danger of the vessel's being blown in pieces by the elastic fluid that is so suddenly extricated. It may also be obtained without distillation, from a mixture of nitric acid and alcohol. For this purpose, six ounces of highly rectified spirit of wine are put into a strong bottle, capable

ining one pound of water, and im-
up to the neck in a vessel of very
ter, into which it will be advan-
to put three or four pounds of ice,
small. Upon the spirit, in this si-
and kept continually agitated, four
of nitric acid, of the specific gravity
re to be poured, in four or five suc-
portions, or even more gradually.
as the mixture is completed, the
ust be closed with a good cork, se-
ith leather and packthread, or wire;
whole must be left in a place where
remain undisturbed, no other at-
being necessary, than that of re-
the water from time to time, as it
come heated. In the course of two
hours the transparency of the fluid
troubled by an infinity of drops of
hich are disengaged from every
its volume. This ether gradually
the surface, and at the end of
four hours it may be separated from
of the liquor by means of a funnel.
ing the phial, it is necessary first to
he cork with a pointed instrument,
that a quantity of elastic fluid may
which might otherwise suddenly
he cork, and carry part of the fluid
ith it. The quantity of ether ob-
this way will be about four ounces.
ur is of a light orange, and part is
d to escape with effervescence,
er the bottle which contains it is
ed. This seems to arise from a
of uncombined acid contained in
d. It must be rectified in order to
pure; and in this process it loses
lf its weight.

anger attending the making of nitric
less when the acid is diluted. The
of Dr. Dehne, as described by
, though he uses concentrated acid,
to be very safe. This chemist put
nds of pure alcohol into a tubulated
o which a large receiver was luted,
ed to this half an ounce of fuming
acid every four hours, drop by drop.
ounces of the acid having been in-
d in this manner into the retort, and
ounce more being added, the mix-
gan to throw up small bubbles,
without producing any heat, and
ours elapsed before all was quiet
By this means about an ounce of
me over into the receiver, which,
arther addition of nitrous acid, re-
n increase. After this two drachms
cid only were added morning and
On the eighth day, after the first
, a greenish ether was seen to cover
or in the retort, to the depth of
lf an inch; but the addition of ni-
id was still continued, till on the
day one pound and five ounces of
cid had been introduced into the
. The mixture then began to be
with a brisker motion, when the ether was taken off, and weighed one pound and one ounce. Upon the residuum he then poured, drop by drop, as before, two drachms of nitrous acid morning and evening, till the acid fell to the bottom in the form of perfectly green globules. Dr. Dehne, in consequence of much experience, affirms, that these bubbles are a sign, that no more ether will be separated by any subsequent addition of nitrous acid; but that the mixture is saturated with nitrous acid, and will yield no farther produce, unless alcohol be added. The quantity of ether separated the second time amounted to eight ounces and three drachms. So that the whole produce of ether was one pound, nine ounces, and three drachms, afforded by adding one pound, ten ounces, and three drachms of nitrous acid to two pounds of alcohol. The residuum weighed one pound twelve ounces, and five ounces were lost, which were probably ether. The operation succeeds best in cold weather; and it has frequently been observed, that alcohol, distilled from oily bodies, yields more ether than when pure. This nitric ether, like the foregoing, is commonly still acid, and may be treated with a solution of alkali, and subsequent rectification.

We shall barely mention the other less direct processes for forming nitric ether: 1. A mixture of two parts sulphuric acid and four alcohol, added to four parts dry nitre, affords by distillation a dulcified nitrous acid, mixed with ether, of which two parts may be had by rectification. 2. If nearly one part of diluted nitric acid be carefully poured upon two parts of dense nitrous acid; and upon this there be poured, with the same caution, three parts of strong alcohol; and this compound fluid be left to stand in a phial loosely corked, the acid and spirit will gradually act upon each other, and ether will in a day or two be formed at the top. The whole being put into a retort, affords two parts and more of very pure ether, by distillation. 3. If nitric acid be disengaged in the usual way from nitre by the addition of sulphuric acid, and the acid which comes over be received into alcohol, this last will become in part converted into ether, which may be separated by rectifying. The method is said to be attended with some danger. 4. Brugnatelli introduces into a retort one ounce of sugar, and pours over it two ounces of highly concentrated alcohol. A capacious receiver being adapted to the retort, surrounded with a wet cloth, and the junctures secured by slips of paper only, he pours through the tubulure three ounces of concentrated nitric acid. A violent action takes place, the sugar is dissolved, and ether passes over into the receiver, nearly equal in quantity to the alcohol employed. 5. In the preparation of fulminating mercury a portion of nitric ether is formed, as observed by Mr. Burkitt: and it appears, that this was known to a contemporary of Cheselden, though he seems ignorant of the fulminating powder, probably because his attention was wholly occupied by the light volatile fluid he obtained.

In certain proportions of the materials, and by due management of the process for making nitric ether, the nitric acid wholly disappears, and the residue is found to contain no nitric acid, but some vinegar and the oxalic acid.

Rectified nitric ether burns with a flame rather more luminous than that afforded by the sulphuric ether, at the same time that it gives out rather more smoke, and leaves a black trace behind: in other respects it very much resembles the sulphuric ether.

The methods of making muriatic ether consist in applying the muriatic acid in the oxigenated state to alcohol; for, in the common state of the acid, their mutual action is little or none. In Mr. Westrumb's method, it is procured from four ounces of common salt, two of powdered manganese, two of sulphuric acid, and six of alcohol, by means of distillation. The liquor, being distilled to dryness, is poured back upon the residuum, and distilled afresh. In this distillation, nearly the half which comes over is dulcified muriatic acid, and most of the other half muriatic ether, which may be separated from the rest by the addition of water. It may likewise be procured by passing the oxigenated muriatic gas into alcohol to saturation, and then distilling: or, according to Klaproth, very safely and effectually by distilling equal parts of alcohol and oxymuriat of tin: or, according to Van Mons, by distilling four parts of alcohol with one of oxymuriat of potash at a boiling heat.

Muriatic ether is very transparent and volatile, and burns with a smoke and suffocating smell.

Gehlen produced fluoric ether by adding to 10 ounces of alcohol in a retort 15 ounces of fluat of lime, previously ignited and pulverised, and ten ounces of sulphuric acid at 1·86, and distilling to dryness. During the distillation a large quantity of gas was evolved, which burnt with a beautiful blue flame, and diffused a smell resembling that of phosphuretted hidrogen. During the combustion of the gas, vapours of fluoric acid were precipitated. The product was redistilled till half had passed over. This was immiscible with water, but had an acid taste. On adding a solution of potash, a considerable quantity of silex was instantly separated, and the whole converted to a gelatinous mass. This being redistilled, yielded pure fluoric ether, much resembling the sulphuric of the specific gravity of ·72. It burned with a blue flame, and its taste was bitter, like that of almonds.

To procure acetic ether, according to Westendorff, equal parts of the strongest acetic acid and alcohol are to be mixed together, and suffered to stand for some days in a well-stopped glass vessel, until the mixture has acquired a peculiarly agreeable smell. The liquor is then to be poured into a retort with a receiver accurately luted on, and nearly the half is to be drawn off by a gentle heat. One sixteenth part of fixed alkali, dissolved in four times its weight of water, is to be added to the distilled product, and the fluid gently agitated with a circular motion, which will cause the ether to rise and float at the surface like oil, whence it may be taken off. Its quantity commonly amounts to half that of the alcohol employed. Half the original quantity of alcohol may be again added to the acetous residue once or twice more, by which means the ethereal product will be still more augmented.

Various methods are given of producing acetic ether by the decomposition of an acetous neutral salt, by the addition of a mineral acid. Thus, if an ounce of alkali saturated with vinegar be dissolved in three ounces of alcohol, and a little more of any mineral acid be added than is requisite to saturate the alkali, and the mass be then distilled, acetous ether will be obtained. Or if eight ounces of acetit of lead be gently dried to deprive it of its water of crystallization, which amounts to rather more than one fourth of its weight; and in this state be put into a glass retort, and a mixture of five ounces of sulphuric acid, and eight ounces of alcohol, be poured on it, and the whole be exposed to distillation by a very gentle heat; the first ounce that passes over will consist of dulcified acetic acid, the next ounce will be almost all ether, and the whole quantity of ether produced will be near four ounces.

Acetic ether is not nearly so volatile as the nitric or sulphuric. It burns with a blue flame like alcohol. According to Sedillot it is of excellent service as an external application in rheumatism, sciatica, and gout, half an ounce being rubbed-in every twelve hours; and internally, given in a dose of about half a drachm, is a speedier sedative than opium, and gentler in its effects.

The acid obtained by distillation from wood likewise affords an ether remarkable in its quantity, which considerably exceeds that of the alcohol made use of. Ether has been obtained too with the oxalic, sebacic, and formic acids; and with the phosphoric and benzoic, indirectly.—*Journ. de Phys.—An. de Chim.—Gehlen's Journ.—Van Mons Journ.—Crell.—Wiegleb.—Fourcroy.*

Ethiops (Martial). Iron in the form of a very subtle powder, and in the first stage of oxidation, was introduced into medicine under this name by the younger Lemery, and is thus made: Very clean iron filings are to be put into a glass vessel, and covered with water to the depth of two or three inches. In this situation they are to be frequently agitated, until a considerable portion has acquired the form of a black er, easily suspended in the water. By tation of the turbid water, and subse- repose, the black powder may be ob- separate, which is afterward to be by heat in a glass retort, and ground pon porphyry.

e ethiops appears to be produced by oncurrent action of the air and water: e latter acts very little upon iron. It ormerly supposed to possess peculiar ntages as a medicine; but there is no n to think, that the degree of calcina- in which only it differs from the other s of iron, is of much consequence to edical exhibition of this metal.

e martial ethiops is in a state so nearly aching that of the pure metal, that it the magnet, and was used by Dr. it, to make artificial loadstones, by ing it up with linseed oil.

HIOPS (MINERAL). The black sul- t of mercury.

APORATION. A chemical operation y performed by applying heat to any ound substance, in order to dispel the le parts. It differs from distillation object, which chiefly consists in pre- g the more fixed matters, while the le substances are dissipated and lost. the vessels are accordingly different, oration being commonly made in open w vessels, and distillation in an ap- us nearly closed from the external air. e degree of heat must be duly regu- in evaporation. When the fixed and volatile matters do not greatly differ ir tendency to fly off, the heat must be carefully adjusted: but in other cases less necessary.

evaporation consists in the assumption e elastic form, its rapidity will be in ortion to the degree of heat and the ution of the pressure of the atmo- e. A current of air is likewise of service s process; partly from its absorbing apours, by combining with them as rise, and partly from the convenience ding the speedy removal of these va- s when of a noxious or corrosive na-

DIOMETER. An instrument for as- ning the purity of air, or rather the ity of oxigen contained in any given of elastic fluid. Dr. Priestley's dis- y of the great readiness with which is gas combines with oxigen, and is pitated in the form of nitric acid, see (NITRIC), was the basis upon which nstructed the first instrument of this

method was very simple: a glass l, containing an ounce by measure, was with the air to be examined, which ransferred from it to a jar of an inch half diameter inverted in water; an measure of fresh nitrous gas was l to it; and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was added, till all the oxigen appeared to be absorbed. The residual gas was then transferred into a glass tube two feet long, and one third of an inch wide, graduated to tenths and hundredths of an ounce measure: and thus the quantity of oxigen absorbed was measured by the diminution that had taken place.

Objections have been made to this mode, as slight variations of circumstances in the process are attended with material differences in the results. Thus a greater diminution takes place when atmospheric air is admitted to the nitrous put first into the tube, than when the opposite order is adopted: greater likewise if the tube be agitated the instant the airs come into contact, than if they be allowed to stand together a few seconds before shaking it. When the airs are admitted to each other without agitation, the diameter of the tube influences the result greatly. Thus Mr. Berger of Geneva found the absorption in a given quantity of atmospheric air with an equal bulk of nitrous gas, after standing twenty four hours, was in tubes of the diameter of

lines	absorption
43	1·17
22	1·05
18·5	1
5	0·70
3·5	0·68

After standing six days the absorption in the last tube was increased ·01; in the rest there was no difference.

The purity of the nitrous gas has been considered too as of consequence; and Mr. Von Humboldt, who still prefers this test, proposes that the gas should be examined, before it is used, by agitating a given quantity with a solution of sulphat of iron. The residuum, diminished by ·02 or ·03, to allow for the air escaping from the solution, is to be considered as the proportion of nitrogen in the gas examined. After the airs have been mixed, Mr. Von Humboldt analyses the residuum, by absorbing the nitrous gas, that may have been left for want of oxigen to convert it into nitric acid, by a solution of sulphat of iron; and, deducting the nitrogen in the test, as found by the process above, the remainder is the nitrogen of the air examined. When, however, the valuation is made in the shortest way, by adding nitrous gas sufficient to absorb all the oxigen at once or twice, and thus finding the quantity of oxigen by the quantity of nitrous acid formed, the presence of a little nitrogen will produce no sensible errour: nitrous oxide, indeed, would be absorbed by agitation with the water, and thus give rise to mistake;

but if the nitrous gas be prepared by means of mercury or copper, no nitrous oxide will be evolved.

Mr. Dalton too prefers nitrous gas, but making the mixture in a narrow tube, using no agitation, and transferring it into another tube as soon as the diminution appears to be over.

Mr. Davy employs the nitrous gas in a different manner. He passes it into a saturated solution of green muriat or sulphat of iron, which becomes opake and almost black when fully impregnated with the gas. The air to be tried is contained in a small graduated tube, largest at the open end, which is introduced into the solution, and then gently inclined toward the horizon, to accelerate the action, which will be complete in a few minutes, so as to have absorbed all the oxigen. He observes, that the measure must be taken as soon as this is done, otherwise the bulk of the air will be increased by a slow decomposition of the nitric acid formed.

Volta had recourse to the accession of hidrogen gas. For this purpose two measures of hidrogen are introduced into a graduated tube with three of the air to be examined, and fired by the electric spark. The diminution of bulk, observed after the vessel had returned to its original temperature, divided by three, gives the quantity of oxigen consumed.

Phosphorus and sulphuret of potash have likewise been employed in eudiometry.

A piece of phosphorus may be introduced by means of a glass rod into a tube containing the air to be examined standing over water, and suffered to remain, till it has absorbed its oxigen; which however is a slow process. Or a glass tube may be filled with mercury and inverted, and a piece of phosphorus, dried with blotting paper, introduced, which will of course rise to the top. It is there to be melted, by bringing a red-hot iron near the glass, and the air to be admitted by little at a time. At each addition the phosphorus inflames; and when the whole has been admitted, the red-hot iron may be applied again, to ensure the absorption of all the oxigen. In either of these modes $\frac{1}{40}$ of the residuum is to be deducted, for the expansion of the nitrogen by means of a little phosphorus which it affords.

Professor Hope of Edinburgh employs a very convenient eudiometer, when sulphuret of potash or any liquid is used. It consists of two bottles: one to hold the solution of sulphuret of potash, or other eudiometric liquor, about two inches in diameter, and three inches high, with a neck at the top as usual, and another to be closed with a stopple in the side near the bottom: the other rather less in diameter, about eight inches and a half long, with a neck ground to fit into that of the former. This, being filled with the air to be examined, and its mouth covered with a flat piece of glass, is to be introduced under water, and there inserted into the mouth of the other bottle. Taking them out of the water, and inclining them on one side, they are to be well shaken; occasionally loosening the stopper in a plate filled with water, so as to admit this fluid to occupy the vacuum occasioned by the absorption. Bottles of much smaller size than here mentioned, which is calculated for public exhibition, may generally be employed: and perhaps a graduated tube, ground to fit into the neck of a small phial, without projecting within it, may be preferable on many occasions, loosening it a little under water from time to time, as the absorption goes on.—*Priestley on Air.—Phil. Trans.—Journ. of Roy. Instit.—Manch. Mem.—Journ. de Phys.—An. de Chim.—Nich. Journal.*

Euphorbium. A gummy resin exsuding from a large oriental shrub, Euphorbia officin. Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; some of which upon being broken are found to contain little thorns, small twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity: the tears in general are of a pale yellow colour externally, somewhat white withinside: they easily break betwixt the fingers. Lightly applied to the tongue, they affect it with a very sharp biting taste; and, upon being held for some time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troublesome to pulverize, the finer part of the powder, which flies off, affecting the head in a violent manner. The acrimony is so great, as to render it absolutely unfit for any internal use. It is much employed in the veterinary art as an epispastic.

Excrements. Some have extended this term to all the various secretions from the blood, however important their functions, and included under it the hair and nails, horns and hoofs: but it properly signifies only what is discharged from the body as useless by natural passages, without the excitement of disease, as the urine and fæces. However important the knowledge of the component parts of fecal matter may be to facilitate our acquaintance with the animal system, it may easily be imagined that the pursuits of the majority of chemists would be directed to departments of the science which promised effects of a less unpleasant nature. A set of experiments was made on this subject by Homberg at the beginning of the last century. This philosopher, in consequence of alchemistical information, instituted a set of operations upon the fecal matter of men fed entirely upon the bread of Gonesse and Champaigne wine. He

, that, when recent, it afforded by
ation to dryness an aqueous, clear, in-
iquor, of a disagreeable odour, which
ned no volatile alkali; but, by con-
g to distil the residue by a graduat-
e, he obtained fluid and concrete vola-
kali, a fetid oil, and a coaly residue;
nces which this imperfect method of
sis exhibits with every kind of animal
nce.

e human fecal matter, by lixiviation in
, filtration, and subsequent evapora-
afforded an oily salt resembling nitre,
was fused on ignited coals, and took
vhen heated to a certain degree in
vessels. The same fecal matter, after
undergone a complete putrefaction
rty days in the gentle heat of a water
afterward afforded by distillation a
less oil without smell, which was the
sought after; but it did not fix mer-
s he had been led to expect.

erfect as this examination is, it is ren-
still less generally applicable by the
ar manner of the aliments, from which
atter originated. For it cannot be
ed, but that, as the excrements are
sidue of the food taken, they will
ccording to the nature of that food,
ndeed sufficiently evinced from their
obvious qualities.

ler observes, that the human fæces
n a small quantity of acid, and those
ninating animals more. Brugnatelli
ons an acid in those of birds of prey.
eces of ruminating animals effervesce
itric acid; and still more those of the
en, and pigeon. In some countries
lung is not unfrequently used instead
.

ANSION. All bodies expand by heat;
e differences are exceedingly great be-
some bodies and others. Whether
fference may depend upon, or be
cted with, any of the other known
rties of the several bodies, cannot be
ed from any experiments yet made.
substances hitherto examined, it is
, that the vegetable fibre varies its
sions lengthwise the least by change
perature; for which reason a straight-
d rod of deal wood is found to be
preferable to any other simple sub-
in the construction of pendulums
ocks. This same object, namely, the
uction of pendulums, together with
circumstances relative to geometrical
surements, have rendered it of some
tance, to ascertain the proportional
sions of metals, and some other bodies,
nge of temperature. There are two
f doing this. The first, practised by
henbroek, Ellicott, and many others,
s in the application of a train of
or levers, which magnify the motion
e increased velocity of the extreme
f the train. The other contrivance,
nsden, consists in placing two microscopes above the body, the dimensions of which are required to be ascertained; and as these instruments are fixed to a bar of cast iron constantly kept at the freezing temperature by surrounding it with melting ice, their distance does not vary from this cause. The last method, practised by General Roy, is much preferable to any other hitherto carried into effect; and it is much to be regretted, that the substances examined by the general were so few in number. He found, that the expansions of the following substances, in each foot of length, by a change of temperature of 180 degrees of Fahrenheit's thermometer, that is to say, from the freezing to the boiling points of water, were as under.

Standard brass scale, length 42·187. It expanded per foot 0·0222646 of an inch.

English plate brass rod 5 feet long, difficult from its thinness to be kept free from warping, expanded per foot 0·0227136 inch.

English plate brass in form of a trough, perfectly strong, expanded per foot 0·0227386 inch.

Steel rod 5 feet long expanded per foot 0·0137368 inch.

Cast iron prism 5 feet long expanded per foot 0·0133126 inch.

Glass tube 5 feet long expanded per foot 0·0093138 inch.

Solid glass rod 40½ inches long expanded per foot 0·0096944 inch.

The brass scale was supposed to be Hamburgh brass.

The makers of astronomical regulators availed themselves of the difference of expansion of brass and steel to make pendulums, the centres of oscillation of which remain at an invariable distance from their respective centres of suspension. Portable time-pieces are likewise made to ascertain the longitude at sea with considerable precision, by forming the rim or circular part of the balance of brass and steel soldered together, the ring of brass being outermost. The effect of two such pieces of metal being soldered together is, that they change their figure by change of temperature. For it may easily be understood, that when a rod of brass is firmly soldered to a rod of steel, and the temperature of both is raised, the greater expansion of the brass will cause that side of the compound bar to be longer than the opposite side which is steel. And this cannot take place without bending of the bar, which accordingly takes place, the brass side becoming convex. A diminution of temperature restores the original figure, and a still greater degree of diminution must of course bend it the contrary way.

The construction of time-pieces is very remotely related to the pursuits of the chemist; but there is no department of science which cannot indicate useful truths to the cultivators of other branches: this ingenious application of the differences of expansion in metals is here mentioned as a hint to the chemist, who may easily apply it in the construction of a thermometer for measuring the degrees of heat by the actual ignition of two metals rivetted, or otherwise fastened together.

Expression, or Pressure. The juices of vegetables, and the fluid parts of other soft substances, are obtained by putting them into a cloth or bag, and exposing it to the action of the press.

Extract. When decoction is carried to such a point as to afford a substance either solid or of the consistence of paste, this residual product is called an extract. When chemists speak of extract, they most commonly mean the product of aqueous decoction; but the earlier chemists frequently speak of spirituous extract.

Extracts thus prepared are mixtures of several of the materials of vegetables, whence they differ greatly according to the plants from which they are obtained; but modern chemists distinguish by the name of extract, or *extractive matter*, a peculiar substance, supposed to be one of the immediate materials of vegetables, and the same in all, when separated from any foreign admixture, except as the proportion of its constituent principles may vary. Fourcroy considers it as a kind of oxide with a triple radical, composed of carbon, hidrogen, and nitrogen, which has a tendency to absorb more oxigen than it contains, and differs from the colouring matter only in the proportion of its principles.

Eye. The humours of the eye had never been examined with any degree of accuracy till lately by Mr. Chenevix. Most of his experiments were made with the eyes of sheep, as fresh as they could be procured.

The aqueous humour is a clear, transparent liquid, with little smell or taste, and of the temperature of 60°, its specific gravity is 1·009. It consists of water, albumen, gelatine, and muriat of soda.

The crystalline contains a much larger proportion of water, and no muriat. Its specific gravity is 1·1.

The vitreous humour, when pressed through a rag to free it from its capsules, differed in nothing from the aqueous, either in its specific gravity or chemical nature.

Fourcroy mentions a phosphat as contained in these humours, but Mr. Chenevix could discover none.

The humours of the human eye gave the same products, but the specific gravity of the crystalline was only 1·079, and that of the aqueous and vitreous humours 1·0053.

The eyes of oxen differed only in the specific gravity of the parts, that of the crystalline being 1·0765, and that of the other humours 1·0088.

The specific gravity of the crystalline is not equal throughout, its density increasing from the surface to the centre.—*Phil. Trans.* 1803.

F.

Farina. See Bread.

Fat. The fat of animals is a substance of the same nature as those oils which are called fat oils in the vegetable kingdom. Its consistence is various in different animals, and in different parts of the same animal. The fat of the human species and of quadrupeds is consistent, and of a white or yellowish colour; the fat of the internal parts being usually firmer than that which is placed among the muscles. It possesses all the characters of vegetable fat oils, though the crude fat of animals appears to contain a considerable quantity of mucilage or jelly peculiar to that kingdom, which may for the most part be washed off by agitation in a large quantity of hot water.

Neumann treated the fat of the goose, the hog, the sheep, and the ox, in a glass retort, by a fire gradually raised. He obtained phlegm, an empyreumatic and brownish oil, and a brilliant coal. This analysis led him no further than to the conclusion, that there is little difference between fats. But modern experiments have shown, that they contain an acid of a peculiar nature, for an account of which see Acid (Sebacic).

Feathers. The feathers of birds much resemble horn in their nature. In the fire they melt, become brown, emit smoke with a strong smell of ammonia and empyreumatic oil, swell, inflame, and leave a light coal. Distilled in a retort they yield a fetid water, a dense and nearly concrete oil, carbonat, prussiat, and acetat of ammonia, with carburetted and sulphuretted hidrogen gas. Boiling water softens the horny matter, and at length reduces it to a jelly: the acids and alkalis soften and dissolve it likewise: and many colouring substances adhere to it, but more particularly to the plumes, whence the art of dyeing them is carried to great perfection.

Fecula. See Bread.

Fecula. The green fecula, or matter expressed from fresh vegetables, particularly the more succulent, was examined with attention by Rouelle the younger, who found it to contain gluten; and since more minutely by prof. Proust. According to him, it is concrescible at a lower temperature than albumen; and becomes elastic and horny when dry. It is precipitable by alcohol and acids. The fecula likewise contains a green resin, which is bleached and hardened by the oxigenated muriatic acid.

, either boiled or raw, be kept un-
ter in a summer heat, in less than
four it exhales a fetid smell, which
ally increases. Hence the offensive
ons from steeping hemp or flax.
quor that remains above the rotten
it the end of a year contains sulphu-
hidrogen, carbonat of ammonia, and
dissolved by means of this principle.
boiling does not destroy its noisome
though the water distilled from it is
e fetid.—*Journ. de Phys.*

term fecula is also used to denote
ylaceous substance of vegetables, or

t Spar. A hard stone of the silice-
s, called likewise Scintillating Spar,
Spar, and Rhombic Quartz. It is
y opake, white, red, yellow, brown,
violet, or iridescent; sometimes cry-
l in rhombic, cubic, or parallelopi-
orms, and often irregular. Its tex-
hough close, is lamellated, and it
ike spar. Its specific gravity is from
2·600; its hardness sufficient to give
h steel, though it is less than that of

an assures us, that it is more fusible
t addition than the fluors, and forms
sh glass, which does not act on the
es. Borax and microcosmic salt dis-
totally in the dry way without effer-
ce, but it does not easily combine
xed alkalis. The crystallized sort de-
tes in the fire.

ever constitutes veins or strata, but is
found in loose masses at most two
long, or mixed with sand or clay, or
ied in other stones, as granites.

hundred parts of the white contain
7 of silex, 14 of alumine, 11 of ba-
nd 8 of magnesia.

Kirwan says, that this is undoubtedly
untse made use of by the Saxons in
orcelain manufactories.

Labrador stone is a beautiful species
tone, exhibiting a variety of colours
ng to the position of the eye of the
r, and the direction of the light
alls upon it.

uelin, in his analysis of the green
ar, or amazon stone, obtained from
·6283, alumine ·17, lime ·03, oxide
·01, potash ·16.

ient. See Fermentation.

ientation. This word was for-
sed in a very undefined and general
o denote every change undergone
ganized substances, of which the
as not apparent; such as chemists
to call by the name of spontaneous

entation has been distinguished into
ages, or more properly species: the
or spirituous, the acid or acetous, and
rid or putrefactive; which are so
rom the principal products afforded
during each of them respectively. Some add to these the saccharine, which takes place before the vinous; and the panary and colouring, which precede the putrefactive. It is ascertained almost beyond a doubt, that the vinous fermentation takes place only in such bodies as contain saccharine juices. In this the most remarkable product is that volatile, light, colourless, inflammable fluid, which mixes with water in all proportions, and is called ardent spirit, or alcohol. The acetous fermentation is distinguished by the product known by the name of vinegar, which is the least destructible of the mere vegetable acids. It does not appear, however, that fermentation is absolutely necessary for the production of this acid, which may be had by treating various organized bodies with nitric acid. In the putrid fermentation bodies appear to be reduced into very simple principles. Volatile alkali is the product, which has been remarked as the chief in this process, and is doubtless produced by the combination of hidrogen and nitrogen, which fly off in this process. It may also be had in a variety of direct chemical processes. See Ammonia.

The acetous like the vinous fermentation is confined to vegetable substances; but the putrefactive process is most eminently perceived in animal bodies. These either putrefy immediately without any other previous change, or, if the putrefaction be preceded by either of the other stages, their duration and intensity are insensible. It is considered as an established fact, that the three stages of fermentation always follow each other in the same order in such bodies as are susceptible of them all; the vinous coming first, which is followed by the acetous, and this by the putrefactive.

These spontaneous effects are greatly retarded by extreme cold, or by sudden desiccation, or by preservation of the bodies in vessels so well closed as to prevent the escape or absorption of elastic fluid. The first two of these necessarily retard the chemical processes, by depriving the parts of the requisite fluidity; and it may without difficulty be understood, that the changes of combination cannot by any means be completely made, while the communication with the open air, the great receptacle and solvent of volatile matter, and one of the chief agents in the great operations of nature, is cut off.

The three conditions for the due accomplishment of fermentation will therefore be, fluidity, or moisture; moderate heat, or a due temperature; and the access of air. It will of course be modified also by the component parts of the body itself.

As the vinous fermentation has never been found to take place where sugar was not present, it appears the most simple to consider what happens when mere sugar and water in due proportions are exposed to fermentation. If a considerable quantity of water, holding in solution about one third of its weight of sugar, be exposed to the air, at the temperature of about 70° of Fahrenheit's thermometer, after the addition of a small quantity of yeast, it soon undergoes a remarkable change. In the course of a few hours the fluid becomes turbid and frothy; bubbles of carbonic acid are disengaged, which rise and break at the surface. This disengagement becomes more and more abundant; mucilage is separated; part of which subsides to the bottom, and part, expanded into froth by the elastic fluid, forms yeast. During the course of several days these effects gradually come to their height, and diminish again; after which they proceed very slowly, but are long before they entirely cease. The fermented liquor has no longer the sweet taste it had before, but becomes brisk and lively, with a pungent spirituous flavour. Its specific gravity is likewise considerably less than before; and when exposed to distillation, it affords a light inflammable spirit miscible with water in all proportions. The quantity of alcohol which any fermented liquor will produce, is thought to follow some proportion of the change its specific gravity undergoes in fermentation; but the truth of this has not been clearly ascertained. Wine, cider, and beer, are well-known liquors of this kind.

Some vegetable juices, as those of most ripe fruits, ferment without yeast; and Seguin asserts, that all such contain a large portion of albumen; and that albumen added to saccharine matter will occasion it to ferment as well as yeast. Hence he infers, that albumen is the true ferment.

Thenard too asserts, that the ferment contained in yeast is of an animal nature, and that it is an immediate principle of vegetables.

The subject of what passes in the vinous fermentation was carefully investigated by Lavoisier. For this purpose it was necessary, accurately to determine the constituent elements of the fermentable substances; and accordingly he did not make use of the compound juices of fruits, the rigorous analysis of which is perhaps impossible, but made choice of sugar, which is easily analysed. This substance he states to be a true vegetable oxide, with a double base, composed of hidrogen and carbon, brought to the state of an oxide by means of a certain proportion of oxigen; and these three elements are combined in such a way, that a very slight force is sufficient to destroy the equilibrium of their connection. By a long train of experiments, made in various ways, and often repeated, he ascertained, that the proportions in which these ingredients exist in sugar are, nearly eight parts of hidrogen, sixty-four parts of oxigen, and twenty-eight parts of carbon, all by weight, forming one hundred parts of sugar.

Sugar must be mixed with about four times its weight of water, to render it susceptible of fermentation; and even then the equilibrium of its elements would remain undisturbed, without the assistance of some substance to give a commencement to the fermentation. Lavoisier's translator, however, remarks here, that this is not strictly true; for, especially in warm weather, all sirups are apt to run into fermentation, unless very rich of the sugar, and carefully preserved. At the same time this spontaneous fermentation is not so regular as when assisted by yeast, and is apt to become in part acetous before completing the vinous process.

The commencement of the fermentation is accomplished by means of a little yeast from beer; and when the fermentation is once excited, it continues of itself until completed. Lavoisier usually employed ten pounds of yeast, in the state of paste, for each hundred pounds of sugar, with as much water as is four times the weight of the sugar. The following is the result of his experiments, exactly as they were obtained, preserving even the fractions produced by calculation.

TABLE I. *Materials of Fermentation.*

		lbs.
Water		400
Sugar		100
Yeast in paste, 10 lbs. composed of	Water	7·2391493
	Dry yeast	2·7608507
	Total	510 lbs.

ABLE II. *Constituent Elements of the Materials of Fermentation.*

407·2391493 lbs of water, composed of	Hidrogen -	61·0858724
	Oxigen -	346·1532769
100 lbs. of sugar, composed of	Hidrogen -	8
	Oxigen -	64
	Carbon -	28
2·7608507 lbs. of dry yeast, composed of	Hidrogen -	0·2900716
	Oxigen -	1·6437457
	Carbon -	0·7876519
	Nitrogen -	0·0393815
	Total weight	510 lbs.

TABLE III. *Recapitulation of these Elements.*

		lbs.	lbs.
	of the water - - -	340	411·7970226
	of the water in the yeast -	6·1532769	
	of the sugar - - -	64	
	of the dry yeast - -	1·6437457	
gen	of the water - - -	60	69·3759440
	of the water in the yeast -	1·0858724	
	of the sugar - - -	8	
	of the dry yeast - - -	0·2900716	
n	of the sugar - - -	28	28·7876519
	of the yeast - - -	0·7876519	
en of the yeast - - - - - -			0·0393815
		In all	510 lbs.

g thus accurately determined the nd quantity of the constituent ele- the materials submitted to ferment- e have next to examine the products from this process. For this purpose r placed the above 510 lbs. of fer- e liquor in a proper apparatus, by f which he could accurately deter- quantity and quality of gas disen- uring the fermentation, and could gh every one of the products sepa- at any period of the process he roper.

ur or two after the substances are gether, especially if they be kept perature of from 66° to 73° of Fahr. marks of fermentation commence: r turns thick and frothy; little glo- air are disengaged, which rise and the surface; the quantity of these globules quickly increases, and there is a rapid and abundant production of very pure carbonic acid, accompanied with a scum, which is the yeast separating from the mixture. After some days, less or more according to the degree of heat, the intestine motion and disengagement of gas diminish; but these do not cease entirely, nor is the fermentation completed for a considerable time. During the process 35·3458116 lbs. of dry carbonic acid are disengaged, which carry along with them 13·9140625 lbs. of water. There remains in the vessel 460·7401259 lbs. of vinous liquor, slightly acidulous. This is at first muddy, but clears of itself, and deposits a portion of yeast, When we separately analyse all these substances, which is effected by very troublesome processes, we have the results as given in the following tables:

TABLE IV. *Products of Fermentation.*

8116 lbs. of carbonic acid, composed of	Oxigen - - - - -	25·4490017
	Carbon - - - - - -	9·8968099
0816 lbs of water, composed of	Oxigen - - - -	317·6314019
	Hidrogen - - -	61·3466797
6059 lbs. of dry alcohol, composed of	Oxigen, combined with hidrogen -	31·3897570
	Hidrogen, combined with oxigen -	5·5393880
	Hidrogen, combined with carbon -	4·0390625
	Carbon, combined with hidrogen -	16·7333984
0000 lbs. of dry acetous acid, composed of	Hidrogen - - -	0·1562500
	Oxigen - - - -	1·7187500
	Carbon - - - -	0·6250000
0755 lbs. of residuum of sugar, composed of	Hidrogen - - - -	0·3275825
	Oxigen - - - -	2·6201172
	Carbon - - - -	1·1463758
4254 lbs. of dry yeast, composed of	Hidrogen - - -	0·1450738
	Oxigen - - - -	0·8218317
	Carbon - - - -	0·3938802
	Nitrogen - - -	0·0196397
		510 lbs.

TABLE V. *Recapitulation of the Products.*

409·5308595 lbs. of oxigen contained in the	Water	347·6314019
	Carbonic acid	25·4490017
	Alcohol	31·3897570
	Acetous acid	1·7187500
	Residuum of sugar	2·6201172
	Yeast	0·8218317
28·7954643 lbs. of carbon contained in the	Carbonic acid	9·8968099
	Alcohol	16·7333984
	Acetous acid	0·6250000
	Residuum of sugar	1·1463758
	Yeast	0·3938802
71·5540365 lbs. of hidrogen contained in the	Water	61·3466797
	Water of the alcohol	5·5393880
	Combined with the carbon of the alcohol	4·0390625
	Acetous acid	0·1562500
	Residuum of sugar	0·3275825
	Yeast	0·1450738
0·0196397 lbs. of nitrogen in the yeast		0·0196397
510 lbs.		510 lbs.

In the calculation of these results, Lavoisier has been exact even to minuteness; not that it is possible in experiments of this nature actually to carry our accuracy so far; but as the experiments were made only with a few pounds of sugar, and as, for the sake of comparison, he reduced the results of the real experiments to the quintal, or imaginary hundred pounds, he thought it necessary to leave the fractional parts precisely as produced by calculation.

When we consider the results presented by these tables with attention, it seems easy to ascertain what occurs during fermentation. In the first place, out of the 100 lbs. of sugar employed, 4·0940755 lbs. remain, without having suffered decomposition: so that in reality we have only operated upon 95·9059245 lbs. of sugar; that is to say, upon 61·37979168 lbs. of oxigen, 7·67247396 lbs. of hidrogen, and 26·85365886 lbs. of carbon. By comparing these quantities, we find that they are fully sufficient for forming the whole of the alcohol, carbonic acid, and acetous acid, produced by the fermentation. It is not, therefore, necessary to suppose, that any water has been decomposed during the experiment, unless it is pretended, that the oxigen and hidrogen exist in the sugar already combined in that form. On the contrary, it has already been made evident, that hidrogen, oxigen, and carbon, the three constituent elements of vegetable substances, remain in a state of equilibrium, or mutual union with each other, which subsists so long as this union remains undisturbed by increased temperature, or by means of some new compound attraction; and that then only these elements combine, two and two together, to form water and carbonic acid.

The effects of the vinous fermentation upon sugar are thus reduced to the mere separation of its elements into two portions: one part is oxigenated at the expense of the other, so as to form carbonic acid, while the other part, being disoxigenated in favour of the former, is converted into the combustible substance called alcohol; therefore, if it were possible to reunite alcohol and carbonic acid together, we ought to form sugar. It is evident, that the carbon and hidrogen in the alcohol do not exist in the state of oil, but that they are combined with a portion of oxigen, which renders them miscible with water; wherefore these three substances, oxigen, hidrogen, and carbon, exist here likewise in a species of equilibrium or reciprocal combination; and in fact, when they are made to pass through a red-hot tube of glass, or porcelain, this union or equilibrium is destroyed; these elements become recombined two and two, and water and carbonic acid are formed.

Lavoisier, in his first Memoirs on the Formation of Water, had advanced, that it was decomposed in a great number of chemical experiments, and particularly during the vinous fermentation. He then supposed, that water existed ready formed in sugar; but subsequent experiments convinced him, that sugar only contains the elements proper for composing it.

He concludes his remarks upon vinous fermentation by observing, that it furnishes us with the means of analysing sugar, and every vegetable fermentable matter. We may consider the substances submitted to fermentation, and the products resulting from that operation, as forming an algebraic equation; and by successively supposing each of the elements in this equation unknown, we can calculate their values in succession, and thus verify our experiments by calculation, and our calculations by experiments, reciprocally. He adds, that he has often successfully employed this method for correcting the first results of his experiments, and directing him in the proper road for repeating them to advantage.

When it is required to preserve fermented

n the state produced by the first
fermentation, it is usual to put
o casks before the vinous process is
ely ended; and in these closed ves-
ange very slowly continues to be
r many months, and perhaps for
ars.

the fermentative process be suffered
eed in open vessels, more especially
emperature be raised to 90 degrees,
ous fermentation comes on. In this
en of the atmosphere is absorbed;
more speedily in proportion as the
of the liquor are often changed by
from one vessel to another. The
ethod consists in exposing the fer-
liquor to the air in open casks, the
e of which is covered with a tile to
the entrance of the rain. By the
on of oxigen which takes place, the
able spirit becomes converted into
If the liquid be then exposed to
on, pure vinegar comes over instead
t spirit.

the spontaneous decomposition is
to proceed beyond the acetous pro-
e vinegar becomes viscid and foul;
itted with an offensive smell; vola-
li flies off; an earthy sediment is
d; and the remaining liquid, if any,
water. This is the putrefactive

regard to the panary fermentation,
l known, that flour mixed with wa-
a little yeast into a thin paste, or
and exposed to a temperature of 65°
swells, becomes spongy by the ex-
n of elastic fluid, and undergoes some
in its taste and smell. Some have
d, that the amylaceous matter tend-
grow sour, the saccharine vinous,
gluten putrid, at the same time,
y counteract each other, and thus
the peculiar fermentation of dough.
r this be, the process is suffered to
but a very little way, before a stop
it, by kneading and baking. If it
ed to go too far, marks of acidity
and the mass would ultimately be-
trid, but there is very little sign of
ous fermentation. Flour and water
yeast undergo a species of acid fer-
on; and a piece of this sour dough,
ay be kept some time enveloped in
ty of flour, is used as a ferment for
antities by the name of leaven, where
not to be procured.

fermentation by which certain co-
matters are separated from vege-
s in the preparation of woad and
s carried much further, approaching
efactive stage.

rn discoveries have greatly eluci-
e phenomena of fermentation; but
ill remains to be accurately deter-
concerning the processes, the pro-
nd their proportions. It is not
scertained, what the yeast or ferment performs in this operation. It seems probable, that the fermentative process in considerable masses would be carried on progressively from the surface downwards; and would, perhaps, be completed in one part before it had perfectly commenced in another, if the yeast, which is already in a state of fermentation, did not cause the process to begin in every part at once. See Bread, Putrefaction, Tartar, Alcohol, Wine, Acid (Acetous), Vegetable Kingdom.

Ferrilite. The name given by Kirwan to Rowley rag.

Filtration. An operation, by means of which the greater part of a fluid is mechanically separated from such consistent particles as may be merely mixed with it. It does not differ from straining.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Spunge is still more effectual. A strip of linen rag wetted and hung over the side of a vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for the most part, use the paper called cap paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists, who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection where the powders are such as will admit of edulcoration and drying in the open air.

Some fluids, as turbid water, may be purified by filtering through sand. A large earthen funnel, or stone bottle with the bottom beaten out, may have its neck loosely stopped with small stones, over which smaller may be placed, supporting layers of gravel increasing in fineness, and lastly covered to the depth of a few inches with fine sand, all thoroughly cleansed by washing. This apparatus is superior to a filtering stone, as it will cleanse water in large quantities, and may readily be renewed when the passage is obstructed, by taking out and washing the upper stratum of sand.

A filter for corrosive liquors may be constructed on the same principles of broken and pounded glass.

Fire. The word heat has been used with so much precision by Doctors Black, Irvine, Crawford, and others, that the word fire seems to have been rendered of little use, except to denote a mass of matter in a state of combustion, which is, indeed, its vulgar acceptation. The term has, however, been used by many eminent writers, to denote what these great philosophers call the matter of heat, now generally termed Caloric, which see.

Fish. It appears from the experiments of Neumann, that fish afford more volatile alkali by destructive distillation than the flesh of land animals does. Lobsters and other shell fish have been thought to contain a disengaged alkali; but this may with justice be doubted. With regard to their nutritious properties, the shell-fish rank next after land animals with dark coloured flesh, eels and other fish without scales perhaps next to these, and other river fish below land animals with white flesh.

Fixity. The property by which bodies resist the action of heat, so as not to rise in vapour. It is the opposite to volatility. The fixity of bodies appears to be merely relative, and depends on the temperature at which they assume the elastic state or form. Such bodies as assume this state at a low temperature will easily rise; whereas those which cannot be so dilated but at an extreme heat will remain fixed in all ordinary situations. From the analogy of a variety of facts, it does not seem probable that any substances are absolutely fixed.

Fixed bodies are, for the most part, denser than those which are more volatile. The planets nearest the sun are also found to be denser than those which are more remote, and are certainly formed of more fixed materials, as far as our experiments of heat on the solids and fluids of this globe can assure us.

Flame. Newton and others have considered flame as an ignited vapour, or red-hot smoke. This, in a certain sense, may be true, but, no doubt, contains an inaccurate comparison. Simple ignition never exceeds in intensity of light the body by contact of which it was produced. But it appears to be well ascertained, that flame always consists of volatile inflammable matter in the act of combustion and combination with the oxigen of the atmosphere. Many metallic substances are volatilized by heat, and burn with a flame by the contact of the air in this rare state. Sulphur, phosphorus, and some other bases of acids exhibit the same phenomenon. But the flames of organized substances are in general produced by the extrication and accension of hidrogen gas with more or less of charcoal. When the circumstances are not favourable to the perfect combustion of these products, a portion of the coal passes through the luminous current unburned, and forms smoke. Soot is the condensed matter of smoke.

As the artificial light of lamps and candles is afforded by the flame they exhibit, it seems a matter of considerable importance to society, to ascertain how the most luminous flame may be produced with the least consumption of combustible matter. There does not appear to be any danger of error in concluding, that the light emitted will be greatest when the matter is completely consumed in the shortest time. It is therefore necessary, that a stream of volatilized combustible matter of a proper figure, at a very elevated temperature, should pass into the atmosphere with a certain determinate velocity. If the figure of this stream should not be duly proportioned; that is to say, if it be too thick, its internal parts will not be completely burned for want of contact with the air. If its temperature be below that of ignition, it will not burn when it comes into the open air. And there is a certain velocity at which the quantity of atmospherical air which comes in contact with the vapour will be neither too great nor too small; for too much air will diminish the temperature of the stream of combustible matter so much as very considerably to impede the desired effect, and too little will render the combustion languid.

We have an example of a flame too large in the mouths of the chimneys of furnaces, where the luminous part is merely superficial, or of the thickness of about an inch or two, according to circumstances, and the internal part, though hot, will not set fire to paper passed into it through an iron tube; the same defect of air preventing the combustion of the paper, as prevented the interior fluid itself from burning. And in the lamp of Argand we see the advantage of an internal current of air, which renders the combustion perfect by the application of air on both sides of a thin flame. So likewise a small flame is whiter and more luminous than a larger; and a short snuff of a candle giving out less combustible matter in proportion to the circumambient air, the quantity of light becomes increased to eight or ten times what a long snuff would have afforded.

Flint. A semitransparent hard stone, of the siliceous order, of a grayish, black, or yellowish colour, well known for its general utility in giving fire with the steel. It is commonly found in nodules, in beds of chalk or sand, and frequently exhibits indications of its having been in a soft state. Some specimens are hollow, and internally lined with siliceous crystals. By long exposure on the surface of the ground, they gradually become white on their upper surface first, and afterward all over. This white-

a process of time, penetrates into the
ace of the flint, forming a crust some-
ne twentieth of an inch thick, which
e scraped with a knife. It has been
hat this is a conversion of flint into
eous earth; but I know of no proof
fact; and as this white matter does
pear to be affected by nitric acid, I
lined to think, that the flint is merely
red by the weather in a manner some-
nalogous to the effect of ignition and
hing in water, which renders it white
able.

gleb found the common flint to con-
parts in the 100 silex, 18 alumine,
ime. It is used in making glass and
.

olution of siliceous earth, made by
lints with a large proportion of fixed
and dissolving the mass in water, is
iquor of flints.

R. The lower part of a mine is
he floor, and the upper the roof.

R. The powder of the gramineous
Its use as food is well known. See

ERS. A general appellation used by
r chemists to denote all such bodies
received a pulverulent form by sub-
n.

ERS OF VEGETABLES. Dr. Lewis,
otes on Neumann's Chemistry, gives
ry account of many experiments
ith a view to ascertain how far the
of vegetable flowers might prove of
he dyer. He found very few capa-
eing applied to valuable purposes.
f the blue flowers gave out their co-
water, but none that he tried gave a
nge to alcohol. No preparation
itself with blue flowers, but the
ke afforded by adding lime water to
eous infusion. The red flowers
general, their colour to water, but
perishable; and his other experi-
ith these were not more productive
ntage than those upon the blue.
flowers, whether pale or deep,
a colour in general durable. Water
hol both extracted it. Neither acids
lis were found to change its species,
they varied the shade; the acids
g it paler, and the alkalis deeper.
wers afforded a green tincture with
but whether of value or not the
es not say.

ITY. The state of bodies when
ts are very readily movable in all
s with respect to each other. Many
d curious properties arise out of
fication of matter, which form the
he mechanical science called hy-
, and are of considerable import-
hemistry. But the attention of the
s chiefly directed to the state of
s it may affect the component parts
.

body may be converted into a fluid by heat. The less the temperature at which this is effected, the more fusible the body is said to be.

All fluids, not excepting the fixed metals, appear, from various facts, to be disposed to assume the elastic form, and this the more readily the higher the temperature. When a fluid is heated to such a degree as that its elasticity is equal to the pressure of the air, its interior parts rise up with ebullition.

The capacity of a dense fluid for caloric is greater than that of the same body when solid, but less than when in the elastic state. If this were not the case, the assumption of the fluid and elastic state would be scarcely at all progressive, but effected in most cases instantly as to sense. See CALORIC.

The state of dense fluidity appears to be more favourable to chemical combination than either the solid or elastic state. In the solid state, the cohesive attraction prevents the parts from obeying their chemical tendencies; and in the elastic state, the repulsion between the parts has in a great measure the same effects. Hence it has been considered, though too hastily, as a chemical axiom, that *corpora non agunt nisi fluida*.

FLUOR. This word has been used to distinguish such bodies as are for the most part fluid in the temperature of the atmosphere. Thus, for example, the fluor acids, the fluor volatile alkali, are terms sometimes used; but in general the writers on chemistry have not adopted this word.

FLUOR SPAR. The native fluat of lime.

FLUX. A general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, limestone or fusible spar are used as fluxes; but in small assays, the method of the great operations is not always followed, though it would be very frequently of advantage to do so. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalis, which render the earthy mixtures fusible, by converting them into glass; or else glass itself in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartarous acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the tartarous acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be reduced, and effects this purpose, by combining with the oxigen of the oxide.

There is danger of loss in the treatment of sulphureous ores with alkaline fluxes: for, though much or the greater part of the sulphur may be dissipated by roasting, yet that which remains will form a sulphuret with the alkali, which is a very powerful solvent of metallic bodies. The advantage of Mr. Morveau's reducing flux seems to depend on its containing no uncombined alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it.

Forge Furnace. The forge furnace consists of a hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose. It is useful for applying a considerable heat with great expedition, and is accordingly very much used by blacksmiths and other artisans. The philosophical chemist will find it very useful for fusions, reductions, and most other experiments, that require a strong heat, especially if the vessels be very small. Black lead pots, or small furnaces of every desired form, may be placed as occasions require upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

Mr. Wedgwood found the heat of a common smith's forge (I suppose without any addition to the fire-place) to be less than that required for the fusion of cast iron, and considerably below that of his small air furnace.

A principal objection to this and every other furnace with bellows is the labour of working them.

Frankincense. See Olibanum.

Freezing Mixtures. See Tab. 2. art. Caloric.

French Berries. The fruit of the *Rhamnus infectorius*, called by the French *graines d'Avignon*. They give a pretty good yellow colour, but void of permanency. When used for dyeing the cloth as prepared in the same manner as for weld. Their colour is soluble both in water and extract. They contain a small portion of gallic acid, but neither gum nor tannin. Their decoction reduces gold, and precipitates the metallic salts.—*Berthollet*.—*Proust*.

Friesland Green. An ammoniaco-muriat of copper, the same with Brunswic green. See Copper.

Fritt. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt. The calcination deprives it of any accidental combustible matter it might have contained, and disposes it to fusion in the melting-pot with less effervescence than would else have taken place.

Fruits of Vegetables. In Dr. Lewis's examination of the colouring matters of vegetable fruits, he found, that the red juices of fruits did not afford a permanent dye by any treatment he used. The dark dull stain of the black cherry proved considerably durable. Sap Green is prepared from the berries of buckthorn, and Annotto is obtained from the pellicles of the seeds of an American tree. See the words.

Fuliginous. Vapours which possess the property of smoke; namely, opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark-coloured powder.

Fullers Earth. See Earth (Fullers).

Fulminating and Fulmination. In a variety of chemical combinations, it happens, that one or more of the principles assume the elastic state with such rapacity, that the stroke against the displaced air produces a loud noise. This is called fulmination, or much more commonly detonation.

Fulminating gold, and fulminating powder, are the most common substances of this kind, except gunpowder. For the latter of these see the article Gunpowder. The fulminating powder is made by triturating in a warm mortar three parts by weight of nitre, two of carbonat of potash, and one of flowers of sulphur. Its effects, when fused in a ladle, and then set on fire, are very great. The whole of the melted fluid explodes with an intolerable noise; and the ladle is commonly disfigured, as if it had received a strong blow downwards. A drachm of the powder makes a report as loud as a cannon; but the noise of a few grains, or single pinch taken between the finger and thumb, is very unpleasant in a room. It has very little effect, unless first melted. A mixture of sulphuret of potash with twice its weight of nitre produces the same explosion, though in less time: whence it appears, that the alkali and sulphur of the former composition form a sulphuret; and that the explosion, in all probability, arises from the sudden extrication of sulphuretted hidrogen from the sulphuret, and

gas from the nitre, which burn the
they are formed.
solution of gold be precipitated by
ia, the product will be fulminating
Less than a grain of this, held over
ne of a candle, explodes with a very
and loud noise. This precipitate,
ted by filtration, and washed, must
d without heat, as it is liable to ex-
with no great increase of tempera-
and it must not be put into a bottle
with a glass stopple, as the friction
would expose the operator to the
langer.
ninating silver may be made by pre-
ing a solution of nitrat of silver by
ter, drying the precipitate by expo-
the air for two or three days, and
g on it liquid ammonia. When it is
onverted into a black powder, the
must be poured off, and the powder
dry in the air. It detonates with the
t heat, or even with the slightest
, so that it must not be removed
ne vessel in which it is made. If a
f water fall upon it, the percussion
use it to explode. It was discovered
thollet.
gnatelli made a fulminating silver by
ring a hundred grains of nitrat of
putting the powder into a beer glass,
ouring on it first an ounce of alcohol,
as much concentrated nitrous acid.
ixture grows hot, boils, and an ether
bly formed, that changes into gas.
grees the liquor becomes milky and
, and is filled with small white clouds.
all the gray powder has taken this
and the liquor has acquired a con-
y, distilled water must be added im-
tely to suspend the ebullition, and
t the matter from being redissolved,
ecoming a mere solution of silver.
hite precipitate is then to be collected
filter, and dried. The force of this
r greatly exceeds that of fulminating
ry. It detonates in a tremendous
r, on being scarcely touched with a
ube the extremity of which has been
l in concentrated sulphuric acid. A
grain, placed on a lighted coal,
a deafening report. The same thing
ns, if it be placed on a bit of paper on
ctric pile, and a spark drawn from it.
ninating mercury was discovered by
loward. A hundred grains are to be
ed with heat in an ounce and half by
re of nitric acid. The solution, when
s to be poured on two ounce measures
ohol, and heat applied till an effer-
ce is excited. As soon as the preci-
is thrown down, it must be collected
lter, that the acid may not react on
ashed, and dried by a very gentle heat.
onates with a very little heat or
n.
mixture of the hyperoxigenated muriat
tash and arsenic explodes with great violence and rapidity. A small brass cannon was split by it from top to bottom, and spread out as flat as a card. Two trains on a table, one of this mixture, and one of gunpowder, were laid in contact with each other at one end, so as to be fired at the same instant. The mixture disappeared like a flash of lightning, while the gunpowder, from the comparison, seems to burn very slowly. This mixture detonates very strongly by the stroke of a hammer, and inflames on the contact of sulphuric acid.

Three parts of this powder and one of sulphur, triturated in a metal mortar, caused numerous successive detonations, like the cracks of a whip, the reports of a pistol, or the fire of musketry, according to the rapidity and force of the pressure employed. A few centigrammes, struck with a hammer on an anvil, exploded with a noise like that of a musket, and torrents of purple light appeared round it. Thrown into concentrated sulphuric acid, it takes fire, and burns with a white flame, but without noise.

Six parts of the muriat, one of sulphur, and one of charcoal, detonate by the same means, but more strongly, and with a redder flame.

Equal parts of the muriat and antimony fulminate by the stroke, and produce only reddish sparks with the sulphuric acid.

A small proportion of zinc with the muriat fulminates by the stroke with a white flame, but is not affected by sulphuric acid.

Sulphuret of iron triturated with the muriat inflames rapidly without noise. Struck on the anvil it detonates strongly with a red flame.

The sulphurets of mercury with the muriat detonate by the stroke, but do not take fire with sulphuric acid.

Sugar, gum, or charcoal mixed with the muriat, and fixed or volatile oils, alcohol, or ether, made into a paste with it, detonate very strongly by the stroke, but not by trituration. Some of them take fire, but slowly and by degrees, in the sulphuric acid.

All these mixtures, that detonate by the stroke, explode much more loudly if previously wrapped up in double paper.—*Journ. de Phys.*—*Van Mons's Journ.*—*Phil. Trans.*—*Ann. de Chim.*

Fuming Liquor. The fuming liquors of Boyle and Libavius have been long known, and Cadet has lately added a third to the number. To prepare that of Boyle, which is a hidroguretted sulphuret of ammonia, three parts of lime fallen to powder in the air, one of muriat of ammonia, and one of flowers of sulphur, are to be mixed in a mortar, and distilled with a gentle heat. The yellow liquor, that first comes over, emits fetid fumes. It is followed by a deeper coloured fluid, that is not fuming.

The fuming liquor of Libavius is made by amalgamating tin with half its weight of mercury, triturating this amalgam with an equal weight of corrosive muriat of mercury, and distilling by a gentle heat. A colourless fluid at first passes over: after this a thick vapour is thrown out at one single jet with a sort of explosion, which condenses into a transparent liquor, that emits copious, white, heavy, acrid fumes on exposure to the air. In a closely stopped bottle no fumes from it are perceptible; but needle-shaped crystals form against the top of the bottle, so as frequently to close the aperture.

Cadet's fuming liquor is prepared by distilling equal parts of acetit of potash and arsenious acid, and receiving the product into glass bodies, kept cool by a mixture of ice and salt. The liquor produced emits a very dense, heavy, fetid, noxious vapour, and inflames spontaneously in the open air.

Furnace. See Laboratory.

Fusibility. That property by which bodies assume the fluid state. Such bodies as require a low heat for this purpose, are said to be more fusible than others which require a higher temperature to produce the same effect. Bodies vary greatly in their fusibility. No experiments have yet been made to indicate the cause of these differences. The hardness, softness, brittleness, flexibility, malleability, transparency, opacity, and, in a word, all the other obvious qualities, may, for any thing we know, be alike in two bodies, which will nevertheless differ greatly in the temperature of their fusions.—See Caloric, *Tab.* 5.

Some chemists have asserted, that fusion is simply a solution in caloric: but this opinion includes too many yet undecided questions to be hastily adopted. See Fluidity.

Fusion. The act of fusing. Also the state of a fused body.

Fustet. The wood of the *rhus cotinus*, or Venus's sumach, yields a fine orange colour, but not at all durable. It is used by the French dyers, but we believe not much in this country, with other colouring substances, particularly cochineal, to modify or heighten their effect, and in this way is more permanent. Like the French berries, its colour is soluble both in water and alcohol. Its decoction contains a small portion of gallic acid, but no gum; reduces gold; and precipitates the metallic salts.—*Berthollet.—Proust.*

Fustic, or Yellow Wood. This wood, the *morus tinctoria*, is a native of the West Indies. It affords much yellow colouring matter, which is very permanent.

A strong decoction of this wood is of a deep reddish yellow; which becomes orange on dilution. Acids render it turbid, throw down a small quantity of a greenish yellow precipitate, and leave the liquor of a pale yellow. Alkalis redissolve the precipitate, and give the liquor a deep reddish colour. Alum forms a small quantity of a yellow precipitate, and leaves the liquor transparent, but of a paler colour. Alum and tartar together produce a similar effect, but more slowly, and leave the liquor still paler. Muriat of soda heightens the colour without rendering it turbid. Sulphat of iron forms a precipitate, which grows gradually brown, and leaves the liquor brown and turbid. Sulphat of copper throws down a copious precipitate of a brownish yellow colour, and leaves the liquor slightly greenish. The precipitate with sulphat of zinc is of a greenish brown; the supernatant liquor of a reddish yellow.

The yellow given by fustic without any mordant is dull, and brownish, but stands well. The mordants employed with weld act on it in a similar manner, and by their means the colour is rendered more bright and fixed. The difference between them is, that the yellow of fustic inclines more to orange than that of weld; and, as it abounds more in colouring matter, a less quantity will suffice.

The colouring matter of fustic is soluble both in water and alcohol. The decoction contains a portion of tannin; reduces gold; and decomposes muriat of tin and the red sulphat, by means of which it dyes silk of a grayish yellow.—*Berthollet.—Proust.*

G.

GADOLINITE. By this name is distinguished the stone from Ytterby, in Sweden, in which Gadolin discovered the earth he called Yttria.

The Gadolinite is of a black colour, and its powder blackish gray. Its fracture is completely vitreous. Its specific gravity according to Hauy is 497·40. It strikes fire with steel, and is imperfectly crystallized like some kinds of garnets. It sensibly affects the magnetic needle. Exposed to the blowpipe it splits with a crackling noise into small fragments, which fly to a considerable distance in bright red sparks. What remains of the stone is of a grayish white, and does not fuse completely. It fuses with borax, and gives it a yellow colour inclining to violet. A hundred parts exposed to heat in a platina crucible assume an ochry red colour, and are reduced to 32; so that, deducting the oxigen absorbed by the iron it contains, the stone loses about 11 per cent.

It effervesces slightly with the powerful acids, and by the assistance of heat they reduce it to a thick jelly of a grayish or yellowish colour.

ccording to Vauquelin, 100 parts give ttria 35, silex 25·5, oxide of iron 25, e of manganese 2, lime 2. These leave s of 10·5, which was the smallest he in his different analyses.

ccording to Klaproth, of yttria 59·75, 21·25, black oxide of iron 17·50, alu- 0·50, water 0 50.—*An. de Chim.*—*Klap-* *Analysis*.

ALANGAL. The greater galangal is an Indian knotty root, with several cir- on the surface, of a reddish brown ur on the outside, and a yellowish white in, which greatly resembles ginger in nell, taste, and chemical composition; as ginger is the more grateful of the the galangal is scarcely ever used. It root of the *kæmpferia galanga*.

ie smaller galangal, which is knotty, marked with circular striæ like the , commonly about the size of the finger, and of a brown colour both nally and internally, is in smell stronger nore agreeable than the large, and in more pungent and hot, like pepper. is the root of the *maranta galanga*. It ins but a small proportion of oil: six- ounces afforded scarcely two scruples; gh, probably, if considerable quantities distilled at once, and the distilled water e operation employed instead of fresh r in the next, the produce upon the d would be greater. The oil is less able in smell than the galangal itself, wants its pungency, which of conse- ce remains in the extract. Very little e oil arises with alcohol: the spirit led even from a large quantity of the has scarcely any taste or smell. With d to the extracts, the water is rather pungent than the spirituous; but the r has nothing of the peculiar flavour galangal, the greater part of which ained in the latter. Sixteen ounces d with water six ounces, and after- with spirit four drachms and two les: spirit applied at first extracted an e and a half from sixteen, and water cted afterward five ounces.—*Neumann.*

LBANUM exudes from an umbelliferous , with leaves like those of anise, grow- the East Indies, but most plentifully ia and Arabia, called by Tournefort, elinum Africanum, galbaniferum, cens, anisi folio: the *bubon galbanum* his juice comes over in masses, com- of white, yellowish, brownish yel- and brown tears, unctuous to the , softening betwixt the fingers, of a sh, somewhat acrid, disagreeable taste, very strong smell, generally full of stalks, leaves, seeds, and other foreign rs.

banum contains more of a resinous gummy matter: one pound yields lcohol upward of nine ounces and a f resinous extract; but the gummy t obtained by water from the same quantity amounts only to about three ounces. The resin is hard, brittle, insipid, and inodorous: the gummy extract has somewhat of a nauseous relish, but could not be distinguished to be a preparation of galbanum. The whole smell, flavour and specific taste of this juice, reside in an essential oil, which arises in distillation both with water and spirit, and gives a strong impregnation to both: from a pound of galbanum are obtained, by distillation with water, six drachms of actual oil, besides what is retained by the water. In this respect galbanum agrees with asafœtida, and differs from ammoniacum.

The volatility of the active parts of this juice renders the common method of purifying it by solution, colature, and evaporation, very injurious to it. The smell of the galbanum is diffused, during the evaporation, over the whole house; and the inspissated matter, whatever menstruum was employed, is found to have lost the distinguishing qualities of the original juice. To prevent as much as possible this inconvenience, the solution should be made in a distilling vessel, and, after filtration, inspissated in the same, so long at least as the liquor which distils has any smell or taste; after which, the galbanum may be reduced to a due consistence by further evaporation in an open vessel, and the oil which arises in the distillation mixed with it. Galbanum may likewise be purified sufficiently for inferior purposes, as plasters, by exposing it in winter to a strong frost till it grows hard, and then pulverizing and sifting it. The woody, strawy, stony, and other foreign matters will be retained in the sieve.

Galbanum, distilled by a strong fire without addition, yields, like other resinous bodies, a large portion of empyreumatic oil, amounting to upward of eight ounces upon sixteen: it is remarkable of the oil of galbanum, that great part of it appears of a blue colour, sometimes of a deep bright blue, sometimes of only a violet blue. The matter on which the blueness depends appears to be either very volatile or very changeable: it soon escapes or changes in the air, leaving, instead of the blue, a purple colour.

GALENA, OR THE BLACK ORE OF LEAD. This, which is the commonest of all lead ores, and is frequently distinguished by the name of potter's lead ore, is of a dark bluish black colour, with a certain degree of metallic lustre. Its weight is about seven or eight times that of water; its figure usually symmetrical, being either cubical, or a variety of that figure; its texture lamellar, and its hardness variable. The component parts of galena are from fifteen to twenty-five sulphur, from sixty to eighty-five lead, and a variable quantity of silver, scarcely ever exceeding two parts in the hundred. Mineralogists assert, that the small grained galena contains the largest portion of silver; but it is not worth the extraction, if it do not contain one pound in three thousand weight. Quartz is accidentally mixed with galena; and it sometimes contains a very small portion of iron. The reduction of galena may be made by pulverization, torrefaction, and fusion, with three times its weight of black flux. The lead is obtained in a metallic button at the bottom of the crucible; and its weight, compared with that of the ore, shows its comparative richness.

The humid analysis of this ore is made by boiling the powder in diluted nitric acid, which takes up the metallic part, and leaves the sulphur, the stony matrix, and oxide of iron, undissolved. Digestion in muriatic acid will separate the iron from the residue; and caustic fixed alkali will dissolve the sulphur. The residuum, weighed before and after the application of the solvents, will show the proportion of each.

The nitric solution will contain the lead and silver: this solution may be precipitated by soda, and the precipitate washed in cold water, dried, and weighed. After weighing, it must again be digested in caustic volatile alkali, which will dissolve and take up only the oxide of silver: the residuum, being again dried and weighed, gives the proportion of the oxide of lead, of which 132 grains are equivalent to 100 in lead in its metallic state; and the difference between the weight of the precipitate, before and after the application of the volatile alkali, gives the quantity of the oxide of silver, of which 129 grains are equivalent to 100 of silver in its metallic form. See Lead.

Galena (Pseudo), an ore of zinc, known in the English mine countries by the name of black jack, or mock lead: its principal ingredients are about half its weight zinc, one third sulphur, with iron, lead, siliceous earth, water, and a small portion of arsenic.

Gall of Animals. This humor is separated in a large viscus of the lower belly, called the liver; it is afterward deposited in a bladder, or reservoir, called the gall-bladder, from which it is conveyed into the duodenum by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil; of a very bitter taste; a green colour inclining to yellow; and froths by agitation, like the solution of soap.

If it be distilled on the water bath, it affords a phlegm, which is neither acid nor alkaline, but putrefies. This phlegm, according to the observation of Fourcroy, often emits a smell resembling that of musk: bile itself has the same property, according to the general observation of butchers. When the bile has given out all the water it is capable of affording upon the water-bath, the residue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and soluble in water. By distillation in a retort, it affords ammonia, an empyreumatic oil, concrete alkali, and hidrogen gas. The coal is easily incinerated. It contains iron, muriat, phosphat, and sulphat of soda, phosphat of lime, and pure soda.

All the acids decompose bile, and disengage an oily substance, which rises to the top, and albumen.

Thenard found likewise in the bile an acrid saccharine substance, somewhat similar to certain kinds of liquorice juice. This substance is soluble in water and in alcohol, and slightly deliquescent. It is not precipitable by the common acetit of lead, but it is by the saturated acetit; and the precipitate is dissolved by the acetit of soda. It will not ferment with yeast; yields no ammonia by distillation; and is not affected by infusion of galls. Four parts of this substance combine with three of the oily matter of bile, if they be dissolved together in alcohol, evaporated, and the residuum be washed with water.

From 800 parts of ox gall Thenard obtained, water 700; oily matter 43; the peculiar substance described above 41; animal matter 4; soda 4; muriat of soda 3·2; sulphat of soda 0·8; phosphat of soda 2; phosphat of lime 1·2; oxide of iron 0·5.

The acids which act upon bile in the first passages decompose it. The greenish yellow colour of the excrements of infants at the breast, arises from a similar decomposition; and it is the resinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of these remedies, when the evacuations are putrid, and the degeneration of the bile is septic. The lymph is then coagulated, and the excrements become harder. This shews the reason why the excrements of infants are so frequently clotted.

When the bile remains a long time in the first passages, as, for example, in chronical disorders, it assumes a black colour, becomes thick, acquires the consistence of an unguent, and forms a lining of several lines in thickness in the intestinal canal, according to the observation of Mr. de Fourcroy. When smeared on paper, and dried, it becomes green; diluted with water, it forms a tincture of a yellow green colour, from which a large quantity of black scales is precipitated: with alcohol it likewise forms a black tincture, and deposits that luminated brilliant salt discovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the atra bilis of the ancients, is nothing but the bile rendered thick; and in this case the effect of acids, and the danger of irritating substances, may be easily accounted for. This thickening of the bile clogs the viscera of the lower belly, and produces obstructions.

Many disorders are referable to the predominant character of the bile. On this subject, the interesting Memoirs of Mr. de Fourcroy may be consulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

The use of the bile in the animal œconomy consists, no doubt, in dividing those substances which have undergone a first digestion in the stomach, and in giving efficacy and force to the motions of the intestines. When its flux is interrupted, it abounds in the blood, and the whole body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary, externally applied: internally taken, it is a good stomachic, and one of the best deobstruents the art of medicine possesses. This kind of remedies deserves the preference, as being more analogous to the constitution; and bile is a proper medicine, when the digestion languishes, or the viscera of the lower belly are clogged.

Bile, like other soaps, removes spots of oil, or other greasy matter, from substances to which they are adherent.

Gall-stones. Calculous concretions are not unfrequently formed in the gall bladder, and sometimes occasion great pain in their passage through the ducts into the duodenum, before they are evacuated. Of these stones there are four different kinds.

1. The first has a white colour; and when broken, presents crystalline plates or striæ, brilliant and white like mica, and having a soft greasy feel. Sometimes its colour is yellow or greenish; and it has constantly a nucleus of inspissated bile. Its specific gravity is inferior to that of water: Gren found the specific gravity of one 0·803. When exposed to a heat considerably greater than that of boiling water, this crystallized calculus softens and melts, and crystallizes again when the temperature is lowered. It is altogether insoluble in water; but hot alcohol dissolves it with facility. Alcohol, of the temperature of 167°, dissolves $\frac{1}{20}$ of its weight of this substance; but alcohol, at the temperature of 60°, scarcely dissolves any of it. As the alcohol cools, the matter is deposited in brilliant plates resembling talc or boracic acid. It is soluble in oil of turpentine. When melted it has the appearance of oil, and exhales the smell of melted wax: when suddenly heated it evaporates altogether in a thick smoke. It is soluble in pure alkalis, and the solution has all the properties of a soap. Nitric acid also dissolves it; but it is precipitated unaltered by water.

This matter, which is evidently the same with the crystals Cadet obtained from bile, and which he considered as analogous to sugar of milk, has a strong resemblance to spermaceti. Like that substance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars. Since it is contained in bile, it is not difficult to see how it may crystallize in the gall-bladder if it happen to be more abundant than usual; and the consequence must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver.

2. The second species of biliary calculus is of a round or polygonal shape, often of a gray colour externally, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part there are many of this species of calculus in the gall-bladder together: indeed it is frequently filled with them. The calculi belonging to this species are often light and friable, and of a brownish red colour. The gall-stones of oxen used by painters belong to this species.

3. The third species of calculi are most numerous of all. Their colour is often deep brown or green; and when broken, a number of crystals of the substance resembling spermaceti are observable mixed with inspissated bile. The calculi belonging to these three species are soluble in alkalis, in soap ley, in alcohol, and in oils.

4. Concerning the fourth species of gall-stone very little is known with accuracy. Dr. Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine; some of which do not flame, but become red, and consume to ashes like charcoal. Haller quotes several examples of similar calculi. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention.

Soaps have been proposed as solvents for these calculi. The academy of Dijon has published the success of a mixture of essence of turpentine and ether. Fresh vegetables, which are such sovereign remedies in destroying these concretions, owe their virtue, perhaps, to the circumstance, that they develop an acid in the stomach, as we have observed in the treating of the gastric juice. —*An. de Chim.*—*Saunders on the Liver.*

Galls. These are the protuberances produced by the puncture of an insect on plants and trees of different kinds. Some of them are hard, and termed nut galls; others are soft and spongy, and called berry galls, or apple galls. The best are the nut galls of the oak, and those brought from Aleppo are preferred. These are not smooth on the surface, but tubercular, small, and heavy; and should have a blueish or blackish tinge.

Galls contain a great portion of soluble matter. Sixteen drachms by long boiling afforded Neumann fourteen of extract, and from the remainder only four grains could be extracted by alcohol. The same quantity gave twelve drachms two scruples of spirituous extract, and the residuum yielded four scruples more to water.

Deyeux investigated the properties of galls with considerable care; and more lately Mr. Davy has examined the same subject. The strongest infusion Mr. Davy could obtain at 56° F. by repeated affusion of distilled water on the best Aleppo galls broken into small pieces was of the specific gravity of 1·068. Four hundred grains of this infusion, evaporated at a heat below 200°, left 53 of solid matter, which consisted of about 0·9 tannin, and 0·1 gallic acid, united to a portion of extractive matter. One hundred grains of the solid matter left by incineration nearly 4½, which were chiefly calcareous matter, mixed with a small portion of fixed alkali.

From 500 grains of Aleppo galls Mr. Davy obtained by infusion as above 185 grains of solid matter, which on analysis appeared to consist of tannin 130; mucilage, and matter rendered insoluble by evaporation, 12; gallic acid, with a little extractive matter, 31; remainder, calcareous earth and saline matter, 12.

The fluid obtained by a last lixiviation of galls is pale green, and Mr. Davy conceives is chiefly a weak solution of gallat of lime; as acids turn it red, and alkalis restore its green colour, which is a property of all the soluble compounds of gallic acid and alkaline earths; and the ashes of galls, deprived of their soluble matter, afford a very considerable quantity of calcareous earth.—*Phil. Trans.*

The use of galls in dyeing is very extensive, and they are one of the principal ingredients in making ink. Powdered galls made into an ointment with hog's lard are a very efficacious application in piles. They are sometimes given internally as an astringent; and in the intermittents where the bark has failed. The tubercles, or knots, on the roots of young oaks, are said to possess the same properties as the nut galls, and to be produced in a similar manner.

For their acid see Acid (Gallic).

Galley. An oblong reverberatory furnace, in which a row of retorts is placed beside each other, with their necks protruding through lateral openings.

Gamboge is a concrete vegetable juice, the produce of two trees, both called by the Indians caracapulli (gambogia gutta Lin.), and is partly of a gummy and partly of a resinous nature. It is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes: and is of a dense, compact and firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia; and thence it has obtained its name of cambadium, cambogium, gambogium.

It is a very rough and strong purge: it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted.

This gum resin is soluble both in water and in alcohol. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as dragon's blood sometimes is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterward to be heated to make the colour penetrate.

It is chiefly used as a pigment in water colours, but does not stand.

Gangue. The stones which fill the cavities that form the veins of metals are called the gangue or matrix of the ore; the rocks that lie over the veins are called the roof; those that lie under them the floor, and by some the hading: the matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus; even the rocks themselves are finer grained as they approach the vein.

There is no matrix peculiarly appropriated to any metal; it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous.

Garnet, a stone, which, when transparent and of a fine colour, is reckoned among gems. Its colour is blueish or yellowish red; its transparency often obscure, unless it be held to a strong light. The natural form of its crystals is various, and seldom regular. Its texture is granular. The specific gravity of the garnet, according to various authors, is from 3·6 to 4·4. Its hardness is nearly the same as that of the emerald, being less hard than the topaz, and more so than rock crystal.

A strong calcining heat does not deprive it of its colour. A very considerable heat is required to fuse it without addition, when it takes the form of a black slag, obedient to the magnet. Mineral alkali does not attack it so powerfully as borax or microcosmic salt.

According to the analysis of Achard, the garnet contains 48·3 of silex, 30 of alumine, 11·6 of lime, and 10 of iron. The opaque garnets scarcely give fire with steel, and afford about 20 per cent. of iron. Bergman informs us, that they contain tin, and even lead, though very rarely.

The garnet is a very common stone, frequently embodied in the masses of compound rocks. The Syrian garnet, which is of a fine red, inclining to purple, and very clear, though less brilliant than the oriental amethyst, is the most esteemed.

Gas. This term was first applied by Van Helmont, to denote the permanently elastic exhalations afforded in chemical processes. Dr. Priestley, whose extensive and successful researches into this department of natu-

ilosophy in the space of a few years
uced a revolution in the science of che-
y, used the word air as the generic
for permanently elastic fluids. Other
ical writers of gerat reputation have
ght fit to revive Van Helmont's term,
onfine the word air to the atmospheric
As this has been found convenient,
event confusion of ideas, it is now ge-
ly adopted; and we shall proceed to
an account here of these elastic fluids.

s (AMMONIACAL). This elastic fluid
first discovered by Dr. Priestley by
ng liquid ammonia, which is a solu-
of it in water, and receiving the gas
mercury. It readily occurred to him,
ver, that it might be procured more
ly by procuring it from the materials
which the liquid ammonia was obtain-
r muriat of ammonia and quicklime;
his led to the best and most œconomi-
ode of manufacturing liquid ammo-
considerable portion of which had
e been wasted, for want of water to
b it.

ppears from Mr. Davy's experiments,
100 grains of water will absorb 34 of
oniacal gas, or 475 times their bulk.
ol absorbs several times its bulk,
gh much less than water.

mmoniacal gas has a very pungent smell.
s animals; and extinguishes flame; but
lame is first enlarged by the addition
nother of a pale yellow colour, which
times descends from the top of the
It is lighter than atmospheric air. On
lution in water, like other gasses, it
out caloric; but when admitted to
liquefies it speedily and generates cold.
electric spark taken in ammoniacal
as a red colour, and after a succession
scharges the gas will be found dilated
rice its former bulk, and no longer so-
in water. It is in fact decomposed
hidrogen and nitrogen, in the propor-
of 80 of the former to 20 of the latter
weight. See AMMONIA.—*Priestley.*—
ollet.—Davy.

s (AZOTIC). See GAS (NITROGEN).

s (CARBONIC ACID.) This is the first
e elastic fluids that appears to have
distinguished from common air,
gh its nature was not properly under-
till it was investigated by Dr. Black.
eadly properties, as it is met with in
erranean cavities, particularly the ce-
ted Grotto del Cano near Naples, oc-
ned it to be distinguished by the name
piritus lethalis. Van Helmont first gave
ame of *gas*, from a German word equi-
t to our spirit, to this vapour pro-
d from burning charcoal. He like-
called it spiritus sylvestris, and when
ng from fermented liquors spiritus vi-
s. From its existing in the inelastic
in water it was called fixed air, a name
h Black and others long retained;
y termed it mephitic air; from its great abundance in nature combined with lime in the form of chalk it has been named the cretaceous and the calcareous acid, subsequent to the discovery of its acid nature. But carbonic acid has superseded all those, since it appears to have been ascertained, that its radical is carbon. Of this, or rather of charcoal, according to the experiments of Lavoisier, it contains 28 parts by weight to 72 of oxigen. Guyton Morveau considers it as composed of 17·88 pure carbon, and 82·12 oxigen.

The basis of this gas has never been obtained separate in any other form; though it exists in the solid state in the various species of carbonats; and in the fluid in various waters. Water will absorb nearly its own bulk by agitation, and thrice its bulk by the assistance of compression, in the common temperature of the atmosphere; but it is easily expelled by heat. Heat likewise expels it from its solid combinations, as is done in making lime; but this is not so ready a way of obtaining it, as by means of another acid; for, as its affinity for the different bases is very weak, it is separated from them by any of the other acids, except the prussic; and this expels it from the metallic oxides.

Carbonic acid gas exceeds every other in specific gravity, except the sulphurous. Hence the vapour in the Grotto del Cano rises but a little above the surface; and the choak damp of miners, which is this gas, lies on the ground. Thus, too, when it is emitted from a fermenting liquor, it first fills the empty portion of the vat, displacing the lighter atmospheric air; and then flows over the sides, almost as water would do. For the same reason, if a bottle filled with it be inverted over the flame of a candle at some distance, it will descend, and extinguish it. According to the experiments of Mr. Cavendish, one part of this mixed with nine of atmospheric air renders it incapable of supporting combustion.

From the powerful attraction of carbon for oxigen, the base of this gas is not easily decomposed; but Mr. Tennant effected it by introducing phosphorus into a coated glass tube, closed at one end, and over this powdered marble. A very small aperture only being left in the other end of the tube, and a red heat applied for some minutes, phosphat of lime and charcoal were found in the tube. Dr. Pearson did the same with phosphorus and carbonat of soda.

The carbonic acid gas is likewise decomposed in part by hidrogen gas, assisted by electricity. In a glass tube eight lines in diameter De Saussure exposed a column of 4 inches in height of carbonic acid gas, and 8 inches of hidrogen gas, over mercury, to the action of the electric fluid circulating between iron conductors, for 12 hours. The gasses were at first condensed very rapidly, but by degrees more and more slowly, till in this period they were reduced to four inches. Of this, one inch was absorbed by potash, being carbonic acid gas; and the other three were nearly pure carbonic oxide, the hidrogen having formed water with the oxigen abstracted from the carbonic acid. The mercury and the conductors were but very little oxided. De Saussure had previously found, that carbonic acid and hidrogen gasses standing together over mercury for the space of a twelvemonth had decreased in volume.

Dr. Priestley had found, that carbonic acid gas, exposed to the action of the electric spark, was a little increased in bulk, and so far altered in its properties, that it was no longer entirely absorbable by lime-water, or alkalis. He likewise found the surface of the mercury oxided, as well as the iron conductors. Monge made the same experiment, and ascribed the effect to the decomposition of water contained in the gas. It appears, however, that it is owing to the absorption of a part of the oxigen by the metal, and the consequent conversion of a portion of the gas into carbonic oxide. —*Priestley.—Black.—Fourcroy.—Annal. de Chim.—Phil. Trans.—Journ. des Mines.*

Gas (Carbonic Oxide). This gas, which has been mentioned in the preceding article, was first made known by Mr. Cruickshank. Dr. Priestley had observed, that, when scales of iron mixed with charcoal, or with carbonat of barytes, were exposed to a strong heat, large quantities of a combustible gas were extricated, which he supposed to be heavy inflammable air, or carburetted hidrogen. He considered this as a strong argument against the modern theory of the formation of water; as, from the dryness of the ingredients, which were previously exposed to a red heat, and mixed and experimented upon immediately, and the quantity evolved, it could not be accounted for upon the supposition of the decomposition of water. This objection was successfully combated by Mr. Cruickshank showing that the air did not contain hidrogen, but was an oxide of carbon. It is equally procured from the oxides of other metals and charcoal; but in proportion to the facility with which these give up their oxigen, the carbon is more or less saturated with it; so that the product is a mixture of carbonic acid gas, and carbonic oxide, the proportion of the former decreasing as the process is continued.

The carbonic oxide gas, freed from carbonic acid by washing with limewater, is very little lighter than atmospheric air. It does not explode, when fired in atmospheric air, but burns with a blue lambent flame: with oxigen gas it detonates. It is noxious to animals. Water absorbs about a fifth only of its bulk. It is not absorbed by the pure alkalis, and does not precipitate limewater. If it be mixed with hidrogen gas, and passed through an ignited glass tube, its oxigen unites with the hidrogen to form water, and charcoal is deposited. De Saussure jun. however ascribes this appearance of carbonaceous matter lining the tube to the action of the hidrogen on the lead in the glass, as he produced it by hidrogen alone with a glass tube; and could not by hidrogen and carbonic oxide in a tube of porcelain.

The purest oxide of carbon is obtained by passing the carbonic acid gas through red-hot charcoal, which may be done very conveniently in the apparatus of Barruel, see Pl. III., fig. 2.; an apparatus well adapted to many processes of a similar kind.—*Nich. Journ. 4to.—Journ. de l'Ecole Polytech.—Journ. de Phys.—An. de Chim.*

Gas (Fluoric Acid). See Acid (Fluoric).

Gas (Hidrogen). As an aëriform fluid capable of taking fire, is set free in many chemical processes, it could not avoid being noticed, and from this property was commonly distinguished by the name of inflammable air; though very little more than this was known of it, till Mr. Cavendish examined it more minutely. Indeed all the inflammable compounds of hidrogen gas were confounded under this name. It was not till some time after, however, that this gentleman and Mr. Watt, unknown to each other, were led to form the opinion, that its union with oxigen constituted water, from the quantity of water deposited when it was burned in close vessels. Though this opinion was strongly contested at first, it at length prevailed, and hence this gas received its present name of hidrogen.

Hidrogen gas is generally obtained from the reverse of this process, the decomposition of water. Iron moistened with water becomes oxided, by decomposing the water; but this process is very slow. If the vapour of water be passed through a tube containing iron wire kept at a red heat, the decomposition will go on with much more celerity. But the readiest method is to employ an acid, as the sulphuric diluted with five or six times its weight of water, poured on iron filings or turnings, or on zinc in small pieces. Zinc affords it the purest, as that from iron is apt to be contaminated with carbon. Muriatic acid diluted with twice or thrice its weight of water may be employed, but it is less œconomical.

Hidrogen gas is the lightest of all ponderable substances, particularly if received over quicksilver, and freed from any humidity it may contain by exposure to any substance that attracts water strongly. When perfectly dry it is free from smell, but when it contains moisture it is slightly fetid. Though highly inflammable, it extinguishes burning bodies, if completely enveloped in it without the contact of oxigen. It is incapable of supporting life, but does not appear to possess any directly noxious quality, as it may be breathed for several respirations, or even near a minute. Fired in combination with oxigen it explodes very loudly: but if kindled as it escapes from the extremity of a capillary tube into the atmosphere, it burns calmly with a white flame, the colour of which however may be varied by different substances dissolved in the gas. It is thus the philosophical fireworks without smoke or smell are formed. If a tube of glass, metal, or any elastic material, be held over a jet of inflamed hidrogen gas, musical tones will be produced, varying in depth and strength according to the length, diameter, and material of the tube. A glass jar has a similar effect, but it must not be too wide, or so narrow as to extinguish the flame. Dr. Higgins first discovered this property.

A very high temperature is generally considered as necessary to produce the combination of hidrogen and oxigen. Biot compressed the two gasses together in the syringe of an airgun; they took fire, exploded violently, and burst the syringe: but here the temperature was sufficiently increased by the pressure. A gentleman of Orkney, however, introduced nearly equal quantities of the two gasses into a glass jar over mercury, which stood in a room without fire and with little light from the beginning of January to the end of May, when he found, that of 12 cubic inches 3½ had disappeared. The residuum was still a mixture of the two gasses.

Hidrogen gas did not appear to Dr. Priestley to be at all changed by having a growing plant confined in it for some months. Von Humboldt, however, observed some plants of the order cryptogamia growing in a mine, and consequently secluded from light, of as green a colour as they would have had growing in the open air; and hence he inferred, that the hidrogen gas there evolved had supplied the place of light.

Hidrogen combined with nitrogen forms ammonia.

The chief use of hidrogen gas is for the purpose of filling air ballons.—*Phil. Trans.*—*Journ. de Phys.*—*Nich. Journ.*—*An. de Chim.*

Gas (Hidrogen Arseniated). Scheele, dissolving tin in arsenic acid, observed the extrication of an inflammable gas, holding arsenic in solution. Proust afterward obtained it by digesting arsenious acid and zinc in diluted sulphuric acid. It may be procured likewise by treating arsenious acid, or arsenic, and iron filings, or arsenic and tin filings, with muriatic acid: but still better by treating four parts of granulated zinc, and one of arsenic, with sulphuric acid diluted with twice its weight of water.

This gas is insoluble in water; does not render limewater turbid; mixed with atmospheric air no diminution of bulk ensues, but the mixture when fixed detonates loudly, and deposits metallic arsenic; it has an alliaceous smell; it extinguishes burning bodies, and is fatal to animals; it is decomposed by oxigenated muriatic acid gas. If a lighted taper be immersed in a phial of this gas, it is instantly extinguished; but the gas burns at the mouth of the phial with a lambent white flame, which diffuses white fumes of arsenious acid. If it be inflamed in a phial with a small orifice, the flame gradually descends to the bottom of the phial, which becomes coated with crystallized metallic arsenic. Two parts of this gas with one of oxigen will explode loudly, and the products are water and arsenious acid: soap bubbles made with a mixture of these gasses explode with a blueish white flame. Equal parts of the gasses explode with a much more vivid flame, but less noise. A stream of this gas burned in a large receiver filled with oxigen emits a blue flame of uncommon splendour. According to Tromsdorff's calculation, a cubic inch of the gas contains about a quarter of a grain of arsenic. Its specific gravity is rather more than half that of atmospheric air.—*Mem. of the Acad. of Berlin.*

Gas (Hidrogen Carburetted). Previous to the year 1664 the rev. Dr. James Clayton, observing that gas issuing from fissures near a coalpit at Wigan took fire on the contact of a lighted candle, distilled some coal; and found, that first phlegm came over, then a black oil, and lastly an inflammable spirit. This he collected in bladders, and amused his friends by pricking a hole in them, and setting fire to the gas as it issued out. This is the first artificial production we know of a gas that sometimes occasions fatal explosions in coalmines, where it is termed *fire damp*.

There are several varieties of this gas, the hidrogen holding different proportions of carbon in solution, according to the process by which it is obtained.

The gas of stagnant water, which may be procured by stirring the mud at the bottom with a stick, and collecting the gas, as it rises in bubbles, in an inverted bottle, is this compound. The vapour of water passed through a tube containing ignited charcoal consists of this gas and carbonic acid, which may be separated by agitating the mixture with lime diffused in water. The vapour of ether, or of alcohol, passed through a red-hot tube of porcelain coated with clay, affords the same products. If three parts of concentrated sulphuric acid, and one of alcohol, be distilled in a glass retort with a gentle heat, a carburetted hidrogen comes over. This is distinguished by the name of olefiant gas, from its property of forming an oil on coming into contact with oxigenated muriatic acid gas. If five measures be mixed with six of the oxigenated muriatic gas, as rapid a diminution takes place as when nitrous and oxigen gasses are added to each other, and a thin film of oil forms on the surface of the water.

Mr. Henry examined these and some other varieties as well as pure hidrogen, with a particular view to the light they were capable of affording, and the following are his tabulated results.

Gas	Oxigen gas required to saturate 100 measures	Measures of carbonic acid produced
Pure hidrogen - - -	50 to 54	0
Gas from moist charcoal - -	60	35
—— —— oak - - -	54	33
—— —— dried peat - - -	68	43
—— —— coal - - -	170	100
—— —— lamp oil - - -	190	124
—— —— stagnant water - -	200	100
—— —— wax - - -	220	137
Pure olefiant gas - - -	284	179

The light evolved appeared to be in proportion to the oxigen consumed, so that the first four in the list yielded very little; but the last much exceeded all the rest. Its detonation with oxigen gas too is more violent than that of any other inflammable gas, ·03 of a cubic inch, with ·17 of oxigen gas, being sufficient to burst a strong glass tube.

About the year 1792 Mr. Murdoch made various experiments on the gas from coal, peat, and other substances, as a substitute for lamps and candles, both as fixed and as moveable lights; and in 1798 he applied it to the purpose of lighting the extensive manufactory at Soho. Light was procured by the same means several years ago at the ovens in Shropshire for preparing coak and tar on lord Dundonald's plan. And six or seven years ago a projector at Paris lighted-up his house and gardens, and proposed to light the streets of the city, in a similar way.

The varieties above enumerated differ in specific gravity, the olefiant gas being the heaviest, and that from charcoal the lightest. They differ likewise in the quantity absorbed by water, which takes up $\frac{1}{8}$ its bulk of olefiant gas, $\frac{1}{27}$ of that from stagnant pools, and still less of the others.

It was observed by Dr. Austin, that carburetted hidrogen gas may be dilated permanently to more than twice its bulk by passing the electric spark through it, and in this state it consumes more oxigen in combustion. As some nitrogen was always found after the combustion, he concluded, that he had thus decomposed carbon into hidrogen and nitrogen. Mr. Henry, who repeated the experiment, ascertained, that the expansion could not be carried beyond a certain point; that it was very trifling, if the gas were previously freed from water as much as possible; and that the admission of a drop or two of water enabled the expansion to take place as usual. Hence he inferred, that the increase was owing to an evolution of hidrogen by the decomposition of water retained in the gas: but as this would liberate a proportional quantity of oxigen, to combine with a part of the carbon, it does not appear to account for the additional portion of oxigen required to burn the expanded gas. *Phil. Trans.*—*Nich. Journ.*—*Henry.*

GAS (HIDROGEN PHOSPHURETTED). This may be procured by boiling in a retort a little phosphorus with a solution of pure potash. The phosphorus should be first melted under water in the retort, which is to be emptied when the phosphorus has congealed, and then filled with the alkaline solution. Of this a sufficient portion is to be displaced by hidrogen gas. Or one part of phosphorus, cut into very small pieces, and two of finely granulated zinc, may be put into ten parts of water, and six parts of concentrated sulphuric acid added: the gas is disengaged in small bubbles, which cover the whole surface of the fluid, and take fire on reaching the air, so as to form by their succession a well of fire.

If two parts of phosphuret of lime, broken into pieces the size of a pea, and one part of hyperoximuriat of potash, be put into an ale glass, or a Florence flask; the vessel be filled with water; and six or eight parts of concentrated sulphuric acid be poured in through a long-necked funnel reaching to the bottom; as soon as decomposition commences, flashes of fire will dart from the surface, and the bottom of the vessel will be illumined with a beautiful green light.

When phosphuretted hidrogen gas is suffered to escape into the air, as it issues from the retort, it takes fire, and a dense white smoke rises in the form of a horizontal ring, enlarging its diameter as it ascends. It detonates when mixed suddenly with oxigen, oxigenized muriatic acid, or nitrous oxide gas. By standing it loses its property of spontaneous accension, the phosphorus being deposited on the inner surface of the vessel containing it.

Phosphuretted hidrogen gas may be dissolved in about four times its bulk of distilled water, at 44° F.; and imparts to it a bitter taste, and strong unpleasant smell. This solution speedily converts the oxides of lead and mercury, and nitrat of silver into phosphurets of those metals. Nitrats of lead, mercury, and arsenic, and sulphats of copper and iron, are acted upon by it more or less slowly; but some of the phosphurets then formed are changed by standing some time into phosphats.

The ignis fatuus, or jack with a lantern, is supposed to be produced by this gas, arising from the putrefaction of animal substances in swampy places.—*Nich. Journ.*—*Ann. de Chim.*—*Henry.*

Gas (Hidrogen, sulphuretted). This gas, formerly termed *hepatic air*, may be obtained by adding dilute muriatic acid to a solution of sulphuret of potash, or of soda, which evolves it with violent effervescence; or by pouring diluted sulphuric or muriatic acid on sulphuret of iron. Sulphur and iron mixed together with a little water likewise afford it by distillation.

Sulphuretted hidrogen is particularly characterized by its offensive smell, resembling that of rotten eggs. Like the other compounds of hidrogen, it detonates if mixed with oxigen or atmospheric air, and then fired, and burns silently if inflamed as it comes into contact with them from a small aperture. If three parts of it be mingled with two of nitrous gas, the mixture burns with a yellowish green flame. Prof. Lichtenberg pouring ¼ of an ounce of nitrous acid at once into an 18 ounce bottle of sulphuretted hidrogen gas, a hissing noise took place, much red vapour was disengaged, and on his corking the bottle the mixture exploded with a loud report and a blue flame. Mr. Accum observes, that he could never succeed in this experiment with the gas procured by means of an earthy or alkaline sulphuret.

This gas is decomposed by oxymuriatic acid gas, by sulphurous acid gas, or by being kept mixed with atmospheric air, and its sulphur is precipitated. If passed through ignited charcoal it is converted into carburetted hidrogen gas. It precipitates all metallic solutions, except those of iron, nickel, cobalt, manganese, titanium, and molybdæna. It tarnishes silver, mercury, and other polished metals, and immediately blackens white paint.

This gas is absorbed by water, which at 55° takes up ·86 of its bulk, and at 85° only ·78. The solution exposed to the air becomes covered with a pellicle of sulphur; and deposits sulphur even in well corked bottles. A few drops of nitric or nitrous acid likewise precipitate the sulphur.

It is remarkable, that sulphuretted hidrogen, which contains no oxigen, consisting, according to Thenard, of 29 hidrogen and 71 sulphur, should possess the properties of an acid, reddening litmus paper, and uniting with the alkalis and all the earths, except alumine and zircon. These compounds are soluble, and most of them are susceptible of crystallization. They are at first colourless; but by exposure to the air become green, or greenish yellow, and deposit sulphur. At length, however, the solution again becomes colourless, and the base is found ultimately converted into a sulphat. Acids disengage their sulphuretted hidrogen gas. Vauquelin, having lixiviated a considerable quantity of soda manufactured in France, found after some weeks a white, transparent salt, crystallized in tetrahedral prisms, terminated by quadrangular or octangular pyramids. Its taste was acrid and intolerably bitter, and it had a slight hepatic smell. It did not precipitate any of the earthy salts, except those of alumine, zircon, and yttria. Some of the German chemists have classed it as an acid by the name of the *hydrothian*.

The waters called sulphureous, or hepatic, as those of Harrowgate, are solutions of this gas. They are recommended as alteratives in cutaneous affections; against worms; in gout and jaundice; and as deobstruents: but they are said to have been very injurious in dropsy.—*Gehlen's Journ. Nich. Journ.—Ann. de Chim.—Henry.*

Gas (Muriatic Acid). Muriatic acid exists in a separate state only in the form of gas, but its attraction for water is so strong, that it can be received and confined only over mercury. According to Kirwan, water absorbs rather more than 420 times its bulk, and is augmented by it about one third: in Dr. Thomson's experiments it took up 515 times its bulk at 60° F. It liquefies ice very rapidly, and the temperature is lowered. It has a pungent smell; is fatal to animals; and extinguishes flame, first imparting to it a greenish tinge. Its bulk is increased by a succession of electric shocks, which Mr. Henry has shown to arise from the decomposition of water, of which he infers from his experiments 60 grains hold 1·4 in solution. On its coming into contact with atmospheric air a white cloud is produced. Brisson gives its specific gravity, atmospheric air being 1000, at 1430, Henry at 1730, Kirwan at 1929. For its other properties, see Acid (Muriatic).

Gas (Muriatic Acid, Oxigenized). This gas, which is a compound of the preceding with oxigen, presents another anomaly in the theory of acidification. It was observed, that sulphuretted hidrogen resembled an acid in many of its properties, though it contained no oxigen; and we here find the radical of an acid, which with a certain proportion of oxigen ranks among the most powerful, so much weakened in its properties, as even to be denied by some a place among the acids.

This gas is not invisible, as it has a greenish yellow colour. It has a pungent, suffocating smell, and is very injurious to the lungs. It extinguishes burning bodies. A temperature of 40° F. reduces it to a liquid form. Mr. Northmore condensed nearly two pints in a receiver of the capacity of 2¼ inches, in which state it was a yellow fluid, so extremely volatile as to evaporate the instant the screw of the receiver was opened. A pint of this gas being injected upon half a pint of oxigen, the result was a thicker substance, that did not evaporate so soon, and left a yellowish mass behind. Nitrogen in the same proportion gave a still thicker substance, and of a deeper yellow. In both these experiments much of the grease of the machine was carried down. Into a receiver of 3 inches capacity a pint of carbonic acid gas was pumped, and then rather more than a pint of oxigenized muriatic acid gas: the result was of a sap green colour, but still elastic. Two pints of the gas with a pint of hidrogen was of a light yellow green, without any fluid, and highly destructive of colour.

This gas acts powerfully on various combustible bodies. If four parts of it and three of hidrogen be put into a bottle closely stopped, inverted with its mouth under water, and the stopple be taken out in this situation after they have thus stood twenty-four hours, nearly the whole of the gas will have disappeared, and the remainder will be absorbed by the water. The hidrogen may be combined at once with the oxigen of this gas by the electric spark, which causes them to detonate. Phosphorus takes fire spontaneously in oxigenized muriatic acid gas; so do perfectly dry powdered charcoal of beech wood, and almost all the metals in fine filings or very thin leaves. About a cubic inch of the gas is sufficient for a grain of metal; the bottom of the vessel should have a little sand on it, to prevent it from cracking; and the temperature should not be less than 70°. If a drachm of good ether be thrown into a three pint vessel filled with this gas, and the mouth covered with a piece of paper, a circulating white vapour will arise in a few seconds, which will soon be followed by an explosion with flame.

For the rest of its properties see Acid (Muriatic, oxigenized).—*Nich. Journ.*—*Henry.*

Gas (Nitric Acid). See Acid (Nitric).

Gas (Nitric oxide), or Nitrous Gas. We owe our first knowledge of this elastic fluid to Dr. Priesley, who called it nitrous air. It may be formed by passing ammoniacal gas through the black oxide of manganese heated red hot in an earthen tube; but it is most easily obtained by abstracting a portion of its oxigen from nitric acid. For this purpose fine copper wire, or copper filings, may be put into a retort with an equal weight of nitric acid diluted with four or five parts of water, and moderate heat applied; or diluted only with an equal quantity of water, and no heat employed. After the atmospheric air is expelled from the retort, the gas that comes over may be received in the pneumatic apparatus. Other metals might be employed for the same purpose, but mercury and copper appear to afford it in the greatest purity; and the latter is perhaps preferable, because the process goes on more regularly with it.

This gas is colourless, and somewhat heavier than atmospheric air. It is extremely deleterious, killing even insects very quickly, and destroying plants. Water deprived of air absorbs about $\frac{1}{9}$ of its bulk of this gas, without acquiring any taste from it; and a boiling heat expels it again unchanged. If the water contain air, the gas is partly decomposed, and the absorption, though in reality greater, is apparently less, from the nitrogen evolved. Water impregnated with earthy salts does not absorb so much. A solution of green sulphat or green muriat of iron however absorbs it rapidly, and becomes dark brown, and almost opake. When this is effected over mercury, the gas may be expelled unchanged by a moderate heat, or by placing the solution in a vacuum, though perhaps not the whole of it. Solutions of nitrat of iron, the sulphats of tin and of zinc, and muriat of zinc, likewise absorb it.

Nitrous gas has no acid properties. It does not redden vegetable colours, but impairs them. It extinguishes the flame of a candle, or burning sulphur, and the phosphoric light of animal substances: but lighted charcoal continues to burn in it; lighted phosphorus burns in it with great splendour, though if not previously kindled it may be melted or sublimed in it without taking fire; and Homberg's pyrophorus kindles in it spontaneously. Its most important property is its affinity for oxigen gas, on account of which it was employed by Dr. Priestley, as it still is by many, to ascertain the quantity contained in atmospheric air: See Eudiometer. When mixed with oxigen gas red fumes arise, heat is evolved, and the two gasses, if in due proportion and both pure, disappear, being converted into nitric acid.

This gas is soluble in nitric acid, and alters its properties in some measure, without however converting it into an acid in a distinct state of oxigenation as some had supposed.—*Davy.*—*Murray.*

Gas (Nitrous oxide). This is the *gaseous oxide of nitrogen* or of *azote* of some; a compound of nitrogen with a still less proportion of oxigen than the preceding gas. It is not to be obtained certainly with any purity, but by the decomposition of nitrat of ammonia. For this purpose nitric acid diluted with five or six parts of water may be saturated with carbonat of ammonia, and the solution be evaporated by a very gentle heat, adding occasionally a little of the carbonat, to supply what is carried off. The nitrat crystallizes in a fibrous mass, unless the evaporation has been carried so far as to leave it dry and compact. The latter at a heat between 275° and 300° sublimes without being decomposed: at 320° it becomes fluid, and is partly decomposed, partly sublimed: between 340° and 480° it is decomposed rapidly. The nitrous is not decomposed below 400°; but a heat above 450° decomposes it: at 600° a luminous appearance is produced in the retort, and nitric oxide, nitrous oxide, and nitrogen, mixed in variable proportions, are evolved: at 700° or 800° an explosion takes place. It is best to perform the operation over an Argand's lamp, as the heat may thus be brought to the requisite degree ily, and kept from going too far. It l be received over water, and suffered nd an hour in contact with it, to free m any nitrat of ammonia that may been sublimed, as well as from any acid nded in it. Dr. Pfaff recommends g very pure sand with the nitrat, to nt the hazard of explosion; and ob- s, that it is particularly requisite it d not be contaminated with muriatic One pound of the compact nitrat s 4·25 cubic feet of gas, and a pound e fibrous nearly five cubic feet.

his gas is heavier than the preceding, a faint smell, and is sweetish to the when respired. It dissolves in about e its bulk of water, to which it imparts ste, and from which heat expels it un- ged. Alcohol absorbs more of it than r; both the essential and fixed oils ab- still more; and heat expels it unaltered them all. It is not altered in its pro- es, or diminished in bulk, by mixture oxigen nitrogen, or hidrogen gas. the latter it detonates loudly, on the ication of a lighted candle, or the elec- spark. A candle burns in it with a ant flame and crackling noise, and the c inner flame is surrounded by a blue before it is extinguished. Phosphorus iously kindled burns in it with increas- plendour; but may be melted, or sub- d in it, or touched with a red hot wire, out taking fire: on the contact of a e at a white heat, however, it burns violence, or rather detonates. Sulphur ning with a blue flame is extinguished by but if immersed in it when in a state of ve inflammation burns vividly with a -coloured flame. Red hot charcoal s in it brilliantly: and iron wire s in it nearly as in oxigen gas, but not ong.

itrous oxide does not combine directly the alkalis. If, however, sulphit of sh, intimately mixed with a consider- e quantity of pure potash, be exposed r mercury to nitric oxide, the sulphur- acid attracts oxigen from the latter, so the sulphit is converted into a sulphat; at the same time the nitrous oxide, thus duced, combines in its nascent state with free potash. By solution, evaporation, crystallization, at a low temperature, sulphat of potash, which crystallizes first, be separated.

he nitroxid of potash, as Mr. Davy calls consists by his estimation of three parts li and one oxide. Its taste is caustic, h a peculiar pungency. It changes ve- able blues to green. Powdered charcoal gled with it, and fired, burnt with ht scintillations. Projected into zinc in on a slight inflammation was produced. phuric, nitric, or muriatic acid expelled n it nitrous oxide with a little carbonic d. Even the carbonic acid dislodges the ous oxide from its combination.

Nitroxid of soda may be formed by similar means.

The most singular property of this gas is its action on the animal system. Dr. Priestley had found, that it was fatal to animals confined in it. Mr. Davy first ventured to respire it, which he did to considerable extent. When breathed alone for a minute or two, and some have gone as far as four or five minutes, it generally produces a pleasant thrilling, particularly in the chest and extremities, frequently with an inclination to laugh, and sometimes an irresistible propensity to gesticulation and muscular exertion. The mind meanwhile is often totally abstracted from all surrounding objects. Sometimes its effects are not entirely dissipated for some hours; and it is remarkable, that, however strong they may have been, no sense of debility or languor is induced after they have subsided. On a few individuals, however, its effects have been unpleasant and depressing; in some it has produced convulsions and other nervous symptoms; and on some it has had no sensible effect. Indeed not only different persons, but the same individual, will be variously affected by it, perhaps, at different times. Similar effects have been produced on those who have tried it abroad.

In debility arising from residence in a hot climate and intense application to business, this gas has proved a complete remedy. It has given voluntary power over palsied parts while inhaled, and the subsequent application of other remedies has effected a cure. Dr. Pfaff has suggested its use in melancholia: but in some cases of this disease it has done no good, and in one harm. —*Davy.—Murray.—Henry.—Nich. Journal.—Ann. de Chim.*

Gas (Nitrogen, or azotic). Under the article air it has been observed, that about three fourths of our atmosphere consist of gas unfit to maintain combustion, or support life. This gas was obtained separate by various processes, in which the other part of atmospheric air, the oxigen, was abstracted from it by entering into combination with some substance for which it had considerable affinity. In all these processes, however, the old theory ascribed the change effected to the evolution of phlogiston from the substance by which the oxigen was in fact absorbed; and hence it was termed by Dr. Priestley *phlogisticated air*, a name for some time commonly adopted. When the existence of phlogiston was shown to be very questionable, this term, involving the assertion of that hypothesis, was rejected by many, who proposed that of *azotic gas*, as not liable to the same objection. But this term, implying its unfitness for sustaining life; a quality by no means distinctive, as it is common to the greater number of the gasses, and possessed by several in a much stronger degree; though it long maintained its ground, is now giving way to the more appropriate appellation of *nitrogen gas*. Chaptal proposed this name, from its constituting with oxigen nitric acid, a fact first ascertained by Mr. Cavendish.

Wiegleb, Goettling, and Crell, indeed, have maintained, that nitrogen gas is compounded of water and caloric. They founded the assertion on an experiment first made by Priestley, in which, when the vapour of water was passed through ignited earthen tubes, nitrogen was produced. Dr. Priestley himself, however, soon discovered, that the nitrogen came from the surrounding atmosphere, to which earthen tubes thus heated are permeable. Girtanner modified this hypothesis by asserting, that nitrogen is compounded of hidrogen and oxigen with less oxigen than forms water: but Berthollet and la Grange have shown, that his experiments were erroneous.

Nitrogen gas is a little lighter than atmospheric air. It is incapable of supporting life, or combustion, yet a small portion is absorbed in respiration. It is not inflammable: though it unites with oxigen in different proportions, forming nitrous oxide when the oxigen is only ·37, nitric oxide when it is ·56, and nitric acid when ·705. It is one of the most general elements of animal substances. With hidrogen it forms ammonia; and Fourcroy suggested, that it might possibly be the alkaligenating principle, though he confesses there are no facts in support of this conjecture: the name of *alkaligen*, therefore, which has been proposed for it, is certainly inadmissible. It dissolves small portions of phosphorus, sulphur, and carbon. According to Mr. Gimbernat, the waters at Aix la Chapelle contain sulphuretted nitrogen.

Gas (Olefiant). See Gas (Hidrogen, carburetted).

Gas (Oxigen). This gas was obtained by Dr. Priestley in 1774 from red oxide of mercury exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or of a portion of it, in the calcination of metals, expelled it from the red oxide of mercury heated in a retort. Priestley, agreeably to his theory, called it *dephlogisticated air*; Scheele, from its peculiar property, *fire air*, a name before given it by Mayow, or *empyreal air*; Lavoisier, air eminently pure, and afterward eminently respirable, which Condorcet altered to *vital air*; a term to which perhaps there is no objection, but its intractability when wanted in compound names. Bergman's term, pure air, as well as Lavoisier's eminently pure, is not distinctive. When the French chemists commenced their complete system of reform of the chemical nomenclature, finding the bases of this gas present in every compound that possessed acid properties, and considering it as the acidifying principle, they gave it the name of *oxigen*, which it still retains, notwithstanding some anomalies with regard to this quality have since been observed. See Gas (Hidrogen, sulphuretted, and Muriatic Acid, oxigenized).

Oxigen gas forms about a fourth of our atmosphere, and its base is very abundant in nature. Water contains ·85 of it: and it exists in most vegetable and animal products, acids, salts, and oxides.

This gas may be obtained from nitrat of potash, exposed to a red heat in a coated glass or earthen retort, or in a gun barrel; from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly toward the end of the process, to a mixture of nitrogen. It may be expelled, as already observed, from the red oxide of mercury, or that of lead; and still better from the black oxide of manganese, heated red hot in a gun barrel, or exposed to a gentler heat in a retort with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the hyperoxymuriat of potash is preferable to any other substance, rejecting the portions that first come over as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, gave out oxigen gas; so do leaves laid on water in similar situations, the green matter that forms in water, and some other substances.

Oxigen gas has neither smell nor taste. It is a little heavier than atmospheric air. Under great pressure water may be made to take up about half its bulk. It is essential to the support of life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies, though a fresh animal of the same kind can still sustain life for a certain time in the residuary air.

Combustion is powerfully supported by oxigen gas. Any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxigen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. Mr. Accum says, a thick piece of iron or steel, as a file, if made very sharp at the point where it is first kindled, will burn in this gas. If the wire, coiled up in a spiral like a corkscrew, as it usually is in this experiment, be moved with a jerk the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant, or, if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell glass, set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it so as not to be separable without detaching the glaze, though it has passed through perhaps two inches of water.

Mr. Varley has made numerous experiments on the combustion of gems, on the suggestion of Mr. Francillon, who furnished them, on ignited charcoal before the blowpipe supplied with a stream of oxigen gas. A rose diamond, weighing $\frac{15}{64}$ths of a carat, was reduced in one minute 50 seconds to $\frac{4}{64}$ths. It had lost its transparency, figure, and polish; but no appearance of soot on its surface had been observed. The remaining fragment continued to draw colour as before.

Another, weighing $\frac{17}{64}$ths, was reduced in 1′ 53″ to $\frac{15}{64}$ths; at which time, falling from the charcoal, it was seen to emit a flame of a blueish pearl colour as it passed through the air. The remaining fragment had lost its figure and polish, and was studded all over with matter of a somewhat metallic brilliancy, appearing to the magnifier like plumbago.

An amethyst, weighing $\frac{17}{16}$ths of a carat, in 40″ broke into several pieces. Some of these at the expiration of 1′ 55″ were taken from the charcoal and weighed, and being exposed to the blowpipe again for 1′ 15″ were fused into one mass, which broke to pieces on cooling. The colour was gone. Another, weighing half a carat, was fused in 5′ into a globule full of bubbles and cracks, like glass thrown hot into water. A portion on one side resembled white enamel; the rest was colourless and transparent as glass.

A sapphire, weighing $\frac{11}{64}$ths of a carat, in 2′ 53″ had its angles rounded off, and lost its transparency, but nothing of its weight. It was a semitransparent whitish mass, with some traces of its original colour; partly covered and interspersed with brown scoriæ very like bronze. Seven sapphires, weighing together $\frac{48}{64}$ths of a carat, in 9′ 55″ were agglutinated together. The remainder of the stones appeared through the semitransparent whitish coat to retain somewhat of their colour. The mass was as hard, and took as good a polish, as the original stones; nor had they lost any weight.

Oriental topazes lost their colour, and became nearly opake, and of a dirtyish white colour. One lost nearly a tenth of its weight. Some pieces, that were agglutinated together in 4′ 26″, and melted into a globule in 4′ 30″ more, appeared a little heavier than before. A Brazilian topaz was perfectly fused in 3′ 26″, lost $\frac{1}{32}$ths of its weight, and was rendered white and opake.

Oriental rubies were sometimes agglutinated together, and in one instance fused into a mass. They were exposed from 6′ to 9′. What was completely fused remained of a dirty white; the stones, or parts, not fused, recovered their colour on cooling. They lost nothing in weight or hardness. A spinel ruby in 2′ 3″ assumed the appearance of a rough garnet.

A jargon, weighing $\frac{14}{64}$ths, in 2′ assumed the appearance of white enamel, without loss of weight.

Vermilions were fused in 2′ or 2′ 30″ into polished opake globules, almost black, like very dark bottle glass.

A garnet in 1′ 40″ broke into two pieces, both of which became fused. One piece was nearly black, like the vermilions; the other of a dark lead, or brown colour, and chatoyant.

An emerald in 2′ was fused into an opake white globule.

A chrysolite was fused in 2′ into a rough, opake, greenish black globule.

A jacynth was fused in 1′ 14″ into a globule resembling dark bottle glass.

An opal in 44″ was melted into a polished globule of a greenish white, almost transparent, but full of bubbles.

Crystal in 1′ 44″ melted into a transparent globule, but full of cracks and bubbles. Two pieces melted together in 5′ 19″, but on cooling flew to pieces, and partly to powder, resembling a pure white salt.

Sixteen carats of crude platina in grains were perfectly fused in a few seconds, and the globules were perfectly pure and malleable; the iron being completely oxided, and scaling from the surface when struck. In consequence of this result, the experiment of fusing platina with a blast of oxigen gas in the large way was tried, but without success: as the heat is too great to allow the process to be continued long enough to oxidate and separate all the iron. Possibly a mixture of oxigen gas and atmospheric air might answer better.

An attempt to measure the heat excited was made, but Wedgwood's pyrometer pieces were completely fused by the blast in a few seconds.

As oxigen gas appears to be a very powerful stimulus to the animal œconomy, it has been applied medicinally; and is said to have been of great service in many cases of debility, palsy, nervous affection, scrofula, rickets, and even hydrocephalus. In some cases we have witnessed its good effects, and we have heard of astonishing instances of its powers.—*Phil. Trans.*—*Journ. de Phys.*—*Annales de Chimie.*—*Nich. Journal.*—*Philos. Mag.*—*Priestley.*—*Murray.*—*Beddoes.*

GAS (SULPHUROUS ACID). When sulphur is burnt slowly a gas arises, of a suffocating pungent smell, consisting of sulphur combined with oxigen in less proportion than is requisite to form sulphuric acid. This was known to the earlier modern chemists, and Stahl examined some of its combinations. Priestley showed it was permanently elastic; Berthollet pointed out its difference from the sulphuric acid, and Fourcroy and Vauquelin completed its examination.

In the mode above mentioned it is very difficult so to regulate the combustion, as to obtain it free from sulphuric acid, which is formed when the sulphur burns with a certain degree of rapidity: so that it is commonly made by abstracting oxigen from sulphuric acid, by some other inflammable substance. The metals answer the purpose, but such as do not decompose water should be employed, otherwise more or less hidrogen will be evolved. Tin or quicksilver answers best; one part of which may be put into a retort with two of concentrated sulphuric acid, and heat applied. It should be received over mercury, as water absorbs it, taking up 33 times its bulk.

This gas is above twice as heavy as atmospheric air: it kills animals very speedily, and extinguishes burning bodies. From this latter property it has been recommended, when a chimney is on fire, to throw a spoonful or two of flowers of sulphur into the grate. It whitens and gives lustre to silk, and is useful in bleaching woollens. Fresh prepared muriat of tin decomposes it, sulphur being deposited, and the muriat oxigenized. Mr. Northmore has condensed it by pressure: and Monge did the same, with the addition of artificial cold. According to Dr. Thomson, it consists of sulphur 68 parts, oxigen 32. For its other properties and compounds, see Acid (Sulphurous).—*Annales de Chimie.*—*Nich. Journ.*—*Murray.*

TABLE *showing the absolute Weights and Specific Gravities of Gasses, and the Quantity of each absorbed by Water.*

Temperature 60° Fahr., Barometer 29·8.

Kind of gas.	Weight of 100 cubic inches in grains.	Specific gravity.			Number of cubic inches absorbed by 100 inches of water.	
		Water the standard at 1000.	Air the standard.	Authority.		
Nitric acid - -	76·	3·	2425	D.		
Sulphurous -	70·215	2·75	2240	K.	3300·	T.
Vapour of ether -	62·1*	-	2250	Dal.		
Muriatic acid -	59·8	-	1929	K.		
Vapour of alcohol	51·5†	-	2100	Dal.		
Nitrous oxide -	50·1	1·985	1615	-	86·	H.
Carbonic acid -	46·5	1·84	1500	K.	108·	H.
Ditto, ditto -	45·5	1·802	1470	D.		
Muriatic acid -	44·7	1·765	1430	B.	51500·	T.
Sulphuretted hidrogen	48·17	-	1231	Th.		
Nitric oxide -	37·	1·465	1193	K.	5·	H.
Nitric oxide -	34·3	1·36	1105	D.		
Oxigen gas - -	34·74	1·39	1127	D.		
Sulphuretted hidrogen	34·286	1·36	1142	K.	108·	H.
Oxigen gas - -	34·	1·35	1103	K.	3·7	H.
Atmospheric air -	31·	1·2279	1000	S. K.		
Azotic gas - -	30·535	1·21	985	K.	1·53	H.
Azotic gas - -	30·45	1·20	980	D.		
Carbonic oxide -	30·	1·185	967	Cr.	2·01	H.
Olefiant gas - -	28·18	-	905	Dei.	12·5	Dal.
Hidrocarburet from stagnant water	20·66	-	666	Dal.	1·40	H.
Ditto from coal -	20·2	-	650	Dal.		
Ditto from ether	20·	-	645	Cr.		
Ammonia - -	18·16	0·715	585	K.		
Ditto - -	18·	0·713	580	D.	47500·	D.
Arsenicated hidrogen gas - -	-	0·6499	529	Tr.		
Hidrocarburet from alcohol -	16·	-	516	Cr.		
Ditto, from water over ignited charcoal	14·5	-	463	Cr.		
Hidrogen gas -	2·613	0·1031	84	K.	1·61	H.
Phosphuretted hidrogen	-	-	-		2·14	H.

B. Brisson; Cr. Cruickshank; D. Davy; Dal. Dalton; Dei. Deiman; H. Henry; K. Kirwan; S. Shuckburgh; T. Thomson; Th. Thenard; Tr. Tromsdorff.

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* Of temperature 100° Fahrenheit, and force = 30 inches of mercury.

† Of temperature 190° Fahrenheit, and force = 30 inches of mercury.

Gastric Juice. That humour, which is known by the name of the gastric juice, is separated by glands placed between the membranes which line the stomach; and from these it is emitted into the stomach itself.

In order to obtain the gastric juice in a state of purity, the animals intended to furnish it are kept fasting for two days, after which the stomach is extracted. In this manner Spallanzani obtained thirty-seven ounces of this juice out of the first and second stomach of a sheep. The same naturalist caused animals to swallow thin tubes of metal, pierced with several holes, into which he had put small sponges, very clean and dry. He caused crows to swallow eight at a time, which were vomited up at the end of three hours and a half. The juice which he obtained was yellow, transparent, salt, bitter, and leaving very little sediment, when the bird was fasting. The gastric juice may likewise be procured by the vomiting which is excited by irritation during fasting. Scopoli has observed, that the most fluid part is only thrown up by irritation; and that the thicker part does not quit the stomach, but by the assistance of an emetic. Mr. Gosse, who had long accustomed himself to swallow the air, which answered the purpose of an emetic with him, availed himself of this habit to make some experiments with the gastric juice. He suspends his respiration, receives air into his mouth, and pushes it towards the pharinx with his tongue. This air, rarefied in his stomach, produces a convulsive motion, which clears it of its contents. Spallanzani has observed, that eagles spontaneously emit a considerable quantity of gastric juice, when fasting in the morning.

We are indebted to Reaumur, and the abbé Spallanzani, for very interesting experiments respecting the virtue and effects of the gastric juice in digestion They caused animals to swallow tubes of metal, perforated in various places, and filled with aliments, to examine their effects. The philosopher of Pavia used purses of thread, and bags of linen and woollen. He himself swallowed small purses filled with flesh boiled or raw, with bread masticated, and also in its original state, &c.; and likewise small cylinders of wood, five lines in length, and three in diameter, pierced with holes, and covered with cloth.

Mr. Gosse, availing himself of the facility with which he was able to vomit by means of the air, has taken all kinds of food, and examined the changes they had undergone, by returning them after intervals more or less remote from the time of deglutition.

From these various experiments it follows:

1. That the gastric juice reduces the aliments into a uniform magma, even out of the body, and in vitro; and that it acts in the same manner on the stomach after death: which proves that its effect is chemical, and almost independent of vitality. 2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration. 3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals with a muscular stomach, such as ducks, geese, pigeons, &c. Some of these animals, bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs. Spallanzani has ascertained, that flesh, included in spheres sufficiently strong to resist the muscular action, was completely digested. 4. That gastric juice acts by its solvent power, and not as a ferment; because the ordinary and natural digestion is attended with no disengagement of air, or inflation, or heat, or, in a word, with any other of the phænomena of fermentation.

Scopoli observes very well, that nothing positive or certain can be asserted respecting the nature of the gastric juice. It is sometimes acid, and sometimes insipid. Brugnatelli has found in the gastric juice of carnivorous birds, and some others, a disengaged acid, a resin and animal substance, united with a small quantity of common salt. The gastric juice of ruminating animals contains ammonia, an extractive animal substance, and common salt. In our time the phosphoric salts have been found disengaged in the gastric juice.

It appears from the observations of Spallanzani and Gosse, that the nature of the gastric juice varies according to that of the aliments. This juice is constantly acid when the diet is vegetable. Spallanzani affirms, contrary to Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice; and he affirms the same of serpents, frogs, fishes, &c.

In order to show clearly, that there is a great difference between the gastric juices of various animals, it is sufficient to observe, that the gastric juice of the kite, the falcon, &c., does not dissolve bread, though it digests flesh meat; and that the gastric juice of the turkey, the duck, &c., has no action upon flesh, but converts the hardest grain into a pulp.

Jurine, Toggia, and Carminati, have made the most successful applications of the gastric juice in the treatment of wounds.

Geanthrax. See Peat.

Gelatine, Gelly, or Jelly, an animal substance, soluble in water, but not in alcohol, capable of assuming a well-known elastic or tremulous consistence by cooling when the water is not too abundant, and liquefiable again by increasing its temperature. This last property remarkably distinguishes it from albumen, which becomes consistent by heat. It is precipitated in an insoluble form by tannin, and it is this action of tannin on gelatine that is the foundation of the art of tanning leather.

Jellies are very common in our kitchens; they may be extracted from all the parts of animals, by boiling them in water. Hot water dissolves a large quantity of this substance. Acids likewise dissolve them, as do likewise more particularly the alkalis. Jelly which has been extracted without long decoction, possesses most of the characters of vegetable mucilage; but it is seldom obtained without a mixture of albumen.

Jellies in a pure state have scarcely any smell or remarkable taste. By distillation they afford an insipid and inodorous phlegm, which easily putrefies. A stronger heat causes them to swell up, become black, and emit a fœtid odour, accompanied with white acrid fumes. An impure volatile alkali, together with empyreumatic oil, then passes over, leaving a spongy coal, not easily burned, and containing common salt and phosphat of lime.

The jelly of various animal substances is prepared for the use of sea-faring persons, under the name of portable soup. The whole art of performing this operation consists in boiling the meat, and taking the scum off, as usual, until the soup possesses the requisite flavour. It is then suffered to cool, in order that the fat may be separated. In the next place, it is mixed with five or six whites of eggs, and slightly boiled. This operation serves to clarify the liquid, by the removal of opake particles, which unite with the white of egg at the time it becomes solid by the heat, and are consequently removed along with it. The liquor is then to be strained through flannel, and evaporated on the water bath to the consistence of a very thick paste; after which it is spread rather thin upon a smooth stone, then cut into cakes, and, lastly, dried in a stove until it becomes brittle. These cakes may be kept four or five years, if defended from moisture. When intended to be used, nothing more is required to be done than to dissolve a sufficient quantity in boiling water, which by that means becomes converted into soup. See Glue.

Gems. This word is used to denote such stones as are considered by mankind as precious. These are the diamond, the ruby, the sapphire, the topaz, the chrysolite, the beryl, the emerald, the hyacinth, the amethyst, the garnet, the tourmalin, the opal; and to these may be added, rock crystal, the finer flints or pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-stone, the onyx, the carnelian, the sardonyx, agates, and the Labrador-stone; for which, consult the several articles respectively.

Geodes. A kind of ætites, the hollow of which, instead of a nodule, contains only loose earth, and is commonly lined with crystals.

Gilding. The art of covering the surfaces of bodies with gold. Manufacturers use the term improperly to denote silvering as well as gilding, and likewise the various methods of producing a golden colour without actually using gold.

The real application of gold as a covering may be performed, either by a metallic mixture after the manner of a pigment; or by friction, upon the same principle as black lead and coloured chalks are used; or by the chemical precipitation of gold from mercury, or some other fit solvent; or, lastly, by glueing or fastening extremely thin leaves of gold to the surface intended to be gilded.

The gold prepared for painting is called shell-gold or gold-powder, and may be obtained by amalgamating one part of gold with eight of quicksilver, and afterward evaporating the latter, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration. For this purpose, gold-leaf must be ground with honey or strong gum-water for a long time; and when the powder is sufficiently fine, the honey or gum may be washed off with water.

For cold gilding by friction, a fine linen rag is steeped in a saturated solution of gold, till it has entirely imbibed the liquor; this rag is then dried over a fire, and afterward burned to tinder. Now, when any thing is to be gilded, it must be previously well burnished; a piece of cork is then to be dipped, first into a solution of salt in water, and afterward into the black powder; and the piece, after it is burnished, rubbed with it.

The chemical application of gold to the surface of metals is usually called water-gilding, a term probably at first confined to such processes as demand the use of a solution of gold in aqua regia. The solution of gold may be evaporated till it is of an oily consistence, suffered to crystallize, and the crystals dissolved in water be employed instead of the acid solution. If the solution of gold in aqua regia be copiously diluted with alcohol, a piece of clean iron will be gilded by being steeped therein. Or add to the solution about three times its quantity of sulphuric ether, which will soon take up the nitro-muriat of gold, leaving the acid colourless at the bottom of the vessel, which must then be drawn off. Steel dipped into the ethereal solution for a moment, and instantly washed in clean water, will be completely and beautifully covered with gold. The surface of the steel must be well polished, and wiped very clean.

For the method called Grecian gilding, equal parts of sal ammoniac and corrosive mate are dissolved in nitric acid, and a ion of gold is made in this menstruum; this the solution is somewhat concen- d, and applied to the surface of silver, h becomes quite black; but, on being sed to a red heat, it assumes the ap- ance of gilding.

he method of gilding silver, brass, or er, by an amalgam, is as follows: Eight s of mercury, and one of gold, are in- orated together by heating them in a ible. As soon as the gold is perfectly lved, the mixture is poured into cold r, and is then ready for use.

fore the amalgam can be laid upon the ce of the metal, this last is brushed with dilute aqua fortis, in which it is vantage that some mercury may have dissolved. Some artists then wash the l in fair water, and scour it a little with and, previous to the application of the ; but others apply it to the metal while vet with the aqua fortis. But in either he amalgam must be laid on as uni- ly as possible, and spread very evenly a brass-wire brush, wetted from time ne with fair water. The piece is then pon a grate, over a charcoal fire, or in ll oven or furnace adapted to this pur- The heat drives off the mercury, and s the gold behind. Its defects are then and may be remedied by successive ications of more amalgam, and addi- l application of heat. The expert ar- however, make these additional appli- ns while the piece remains in the fur- though the practice is said to be highly us on account of the mercurial fumes. this it is rubbed with gilders' wax, may consist of four ounces of bees one ounce of verdigris, and one ounce phat of copper: then expose it to a eat, which burns off the wax; and the work is cleared with the scratch , and burnished, if necessary, with a ool. The use of the wax seems to merely in covering defects, by the on of a quantity of red oxide of cop- vhich is left behind after the burning.

gilding of iron by mere heat is per- d by cleaning and polishing its sur- nd then heating it till it has acquired colour. When this has been done, t layer of gold leaf is put on, slightly hed down, and exposed to a gentle t is usual to give three such layers, r at the most, each consisting of a leaf for common works, or two for rdinary ones. The heating is re- at each layer, and last of all the s burnished.

gilding of buttons is done in the fol- way: When the buttons, which are er, are made, they are dipped into itric acid to clean them, and then ed with a hard black stone. They n put into a nitric solution of mer- nd stirred about with a brush, till they are quite white. An amalgam of gold and mercury is then put into an earthen vessel with a small quantity of dilute nitric acid, and in this mixture the buttons are stirred, till the gold attaches to their surface. They are then heated over the fire, till the mercury begins to run, when they are thrown into a large cap made of coarse wool and goat's hair, and in this they are stirred about with a brush. The mercury is then volatilized by heating over the fire in a pan, to the loss of the article, and injury of the workmen's health; though the greater part might be recovered, with less injury to the operators. By act of parliament a gross of buttons, of an inch diameter, are required to have five grains of gold on them; but many are deficient even of this small quantity.

The gilt trinkets that are now common in the shops, are said to be made of copper coated with brass in the following manner: An amalgam of one part zinc and twelve mercury is put into muriatic acid with some argal. In this the copper, previously cleaned with nitric acid is boiled. If a little gold be added to the amalgam, the effect is improved; but this is not always done. Copper thus coated may be drawn out to the fineness of a hair.

Painting with gold upon porcelain or glass is done with the powder of gold, which remains behind after distilling the aqua regia from a solution of that metal. It is laid on with borax and gum-water, burned in, and polished. The gilding of glass is commonly effected by covering the part with a solution of borax, and applying gold leaf upon it, which is afterward fixed by burning.

The gilders of wood, and other compositions designed to supply the place of carved work, make use of two methods: the one called oil-gilding, or gilding in oil, because the gold is made to adhere by means of an oily composition; the other is sometimes called water-gilding, though seldom, but more frequently burnished gold, on account of the burnish it is capable of, which is one of the principal advantages it possesses over the other method.

Gilding in oil is performed by means of a paint sold under the name of gold size. It consists of drying oil (that is to say, linseed oil boiled upon litharge), and mixed with yellow ochre. It is said to improve in its quality by keeping. This is laid upon the work; and when it has become so dry as to adhere to the fingers without soiling them, the gold leaf is laid on, and pressed down with cotton. This method of gilding is proper for work intended to be exposed to the weather.

The method of gilding in burnished gold consists in covering the work with parchment size and whiting, thinly laid on at five or six different times. This is covered with a yellow size made of Armenian bole, a little wax, and some parchment size; but in this, as in most other compositions used in the arts, there are variations which depend on the skill or the caprice of the artists. When the size is dry, the gold is applied upon the surface previously wetted with clear water. A certain number of hours after this application, but previous to the perfect hardening of the composition, the gold may be very highly burnished with a tool of agate made for this purpose. This gilding is fit only for work within doors; for it readily comes off upon being wetted.

The edges of the leaves of books are gilded by applying a composition of one part Armenian bole, and one quarter of a part of sugarcandy, ground together with white of eggs. This is burnished while the book remains in the press, and the gold is laid on by means of a little water.

Leather is gilded either with leaf-brass or silver, but most commonly by the latter, in which case a gold coloured varnish is laid over the metal. Tin-foil may be used instead of silver-leaf for this less perfect gilding, upon such works as do not possess flexibility.

Ginger, is the produce both of the East and the West Indies. Two sorts of this root are brought to us, one internally white, the other brown: whether they are the roots of different species of the ginger plant, or of one species taken up at different ages, or in different seasons, is not certainly known. This pungent aromatic is of common use as a spice, and is observed not to heat the constitution near so much as might be expected from its strong biting taste. Its pungency resides not in its volatile but in its fixed parts: the essential oil contains the smell and distinguishing flavour of the ginger, but all the pungency is left behind in the still.

From sixteen ounces of the common brown ginger may be obtained a drachm or a little more of oil. The same quantity yielded, with alcohol, an ounce and two scruples of resinous extract, containing all the hot biting matter of the root: from the residuum, water extracted a strong mucilage, which had little or no taste, was difficultly reduced to dryness, and weighed, when exsiccated, five drachms and a half. Sixteen ounces, treated first with water, gave four ounces of extract, considerably pungent, a portion of the resinous matter being taken up by the water along with the gummy: from the residuum, alcohol extracted five scruples four grains of a very pungent resin. The indissoluble earthy matter amounts to near three fourths of the root, viz. eleven ounces six drachms and sixteen grains. Alcohol elevates in distillation some of the more subtile parts of the oil, so as to taste a little of the ginger, though not considerably.

The white ginger contains more soluble matter than the brown. From sixteen ounces of this sort were gained five ounces five drachms and a scruple of watery, and afterwards three drachms twelve grains of spirituous extract. Spirit applied at first, extracted one ounce and three drachms wanting a few grains; and water applied afterward, took up four ounces and a half: so that the indissoluble part does not amount quite to ten ounces on sixteen. The quantity of essential oil is nearly the same as in the brown sort.—*Neumann.*

Ginseng. Panax quinquefolium, Lin. A small root brought from North America, and sometimes from China; an inch or two in length, taper, finely striated, of a whitish or yellowish colour. It has a very sweet taste, accompanied with a slight bitterishness and warmth.

The Chinese are said to have a very extraordinary opinion of the virtues of this root, and to look upon it as a universal restorative in all decays, from age, intemperance or disease. The great value there set upon it has prevented its being exported thence into other countries, and its discovery in North America is but of late date; so that among us it has hitherto been very rarely made use of, although, from what can be judged of it from the taste, it seems to deserve some regard, especially as it is now procurable in plenty.

The American ginseng appears opake and white when broken; and though it produces a good price in the Chinese market, yet it is vastly less valuable than the ginseng of Chinese growth, which is nearly as transparent as horn. This property seems to have been produced by art, perhaps by long continued and gentle boiling in water.

Girasole, a name given by the Italians to the opal, which is of the flint kind, and remarkable for the mutability of its colours, according to the various directions of the light which falls on it, and the position of the eye of the observer.

Gizzard. The gizzards of poultry with white flesh have long been considered in France as medicinal. They have been recommended in obstructions of the urinary passages, complaints of the bladder, and nephritic pains; but particularly as a febrifuge. The gizzards are to be opened, cleaned from their contents, slightly washed, and strung up in the sun, or in a chimney, to dry; or between sheets of paper exposed to a gentle heat. They are then to be powdered, sifted, and kept in a bottle closely corked. The dose for adults is a drachm. This is given in intermittents, about half an hour before the fit is expected, in half a glass, or a glass, of good old white wine.

According to Bouillon Lagrange the dried gizzard contained a little acid phosphat of lime, with still less sulphat, muriat, and carbonat of potash, and carbonat of lime, and a small portion of iron. Its principal substance he considers as oxigenated

ine, with a small quantity of extractive
er.—*Ann. de Chim.*

ACIES MARIÆ. A name given to the
transparent gypsum, or sulphat of
It is seldom used.

LASS. The vitriform state is that of an
nbustible body, which has been fused
red heat. All substances, therefore,
ufficient fixity to suffer ignition, and
cient fusibility to be rendered fluid by
greatest temperatures we are capable of
ucing, may be converted into glass.
metals, though fixed enough to sustain
on, and fusible under that tempera-
are not converted into glass, until they
passed through the process of oxida-
or combustion.

is probable, that all substances which
ot rise into the atmosphere by heat,
mbine with it in combustion, are in
own nature vitrifiable, that is to say,
e; and that the differences between
s in this respect are merely relative to
ower of producing heat. We shall not
ver insist more fully upon this extend-
ew of the subject, but shall proceed to
der glass as a body more or less trans-
t, very hard, brittle, fusible in a
g heat, artificially prepared by fire,
ic by friction, and scarcely, if at all,
ed by the action of air, water, alcohol,
r the major part of saline substances.

hen, or by whom, the art of making
was first found out, is uncertain: some
have it invented before the flood; but
out any proof. Neri traces the anti-
of this art as far back as the time of
but Dr. Merret will have it as ancient
her pottery, or the making of bricks;
se, that a kiln of bricks can scarce be
, or a batch of pottery be made, but
of the bricks and the ware will be at
uperficially turned to glass; so that it
have been known at the building of
, and as long before as the making of
was used. It must have been known
quently among the Egyptians, when
raelites were employed by them in
g bricks. Of this kind, no doubt, was
ossil glass mentioned by Ferrant.
at. to be found under ground where
fires had been. The Egyptians in-
boast, that this art was taught them
great Hermes. Aristophanes, Ari-
Alexander Aphrodisæus, Lucretius,
hn the divine, put us out of all doubt
ass was used in their days.

st of the glasses made for direct use
of an earthy substance called the
and a saline or metallic substance
the flux. The basis is usually sili-
earth, the salt an alkali, and the metal
But various admixtures of earth and
c oxides are used in the actual prac-
the art. None of the acids, except
hosphoric, are sufficiently fixed to
and the heat required to form the
us combination with an earth; and this salt has not yet been afforded cheap enough to be used, except in assays by the blowpipe. The fluxes in glass-making are useful, not only because more fusible than the earthy matter, to which they communicate the same property, but likewise as solvents which combine with it in the dry way, and in some instances produce a compound possessing greater fusibility than belonged to any of the ingredients. See EARTH, under art. LIME.

Mr. Loysel, who was well acquainted with all the processes of the art adopted in France, and at the same time a man of science, has published a very full and able work on the subject. He observes:

Vitrification such as takes place in the large way demands two principal conditions: 1. A furnace constructed of substances capable of resisting the action of a violent and long-continued fire, and vessels capable of containing the vitrifiable matter in fusion without becoming fused themselves. 2. Substances which have the property of forming by means of fire a solid glass, suitable to the object of the manufactory.

Of the Furnaces and Crucibles.

The matter employed for the construction of the furnaces and crucibles must be of such a nature, as to take and preserve the forms required for the operations of the glass-house. Clay possesses this property in the highest degree; for which reason, though grit-stone is used in some glass-houses, and a mixture of quartz and silex with clay, for the construction of furnaces, it has nevertheless been almost generally adopted for the construction of furnaces, and exclusively for that of the vessels.

Pure clay cannot be fused by any degree of heat yet known, unless what is excited by oxigen gas; but the mixture of other earths, and particularly calcareous earth, causes it to enter into fusion, though itself alone is infusible.

The property of resisting the most extreme heat is more or less altered in clay, by the admixtures it may contain. Sand, quartz, and mica do not prevent a clay from being proper for the use of the glass-house, provided they do not too greatly diminish its ductility: but the same observation does not apply to bituminous matters, calcareous earth, gypsum, pyrites, or the metallic oxides; for these substances render it more or less fusible.

The whitest clay is generally said to be the most refractory; but whiteness is a very equivocal character, because it may consist with a large addition of calcareous earth. Now this earth is hurtful, not only because it renders the clay fusible, but because it forms pores in the crucibles by the swelling it occasions, when its carbonic acid is disengaged by the heat. A twentieth part of calcareous earth simply renders the compound less dense than clay alone, when exposed to the fire of the glass-house; but a tenth part renders it sensibly porous.

The choice of a clay in a glass manufactory is of so much the greater consequence, as a failure in this article is attended with a loss of all the expenses in fabrication.

The clay to be preferred for this use ought to possess the following qualities: 1. It must be so refractory, as not to vitrify, or even perceptibly change its figure, by the heat of the furnace. 2. It must be ductile enough to receive and retain the requisite forms.

With regard to the refractory quality Mr. Loysel proposes three proofs. In the first, after having reduced the clay into small particles, and separated such foreign matters as can be distinguished, the application of a mineral acid will show whether it effervesce It it do, there is reason to reject it; but it may be easily seen, that this proof is uncertain.

The second proof consists in working the clay into a paste with water. Of this paste, several prismatic rods and some very thin crucibles of five or six inches in diameter, and the same height, are to be made. These, after being gently dried, are to be exposed five or six days in the furnace of the glass-house. The rods must be suspended by their extremities on two supports. When these are taken out, they must be put into the annealing furnace, and cooled by insensible degrees. If the rods have not bended, if the crucibles have preserved their figure, and if no cavities be perceived upon breaking them, the clay may be judged to be good.

The third proof, which he prefers to the others, consists in judging the refractory quality of the clay by the action of an alkali upon it. For this purpose, it is mixed with different doses of fixed alkali, in crucibles of the same earth, or any other of known goodness, and a comparison is made of the proportion necessary to effect a complete vitrification with that which produces the same effect in a refractory sand exposed to the same degree of fire. Mr. Loysel has found, that if eight ounces of alkali be required to vitrify one pound of the sand of Aumont near Senlis, and ten ounces of the same alkali to produce the same effect, in a like degree of fire, upon a pound of baked clay, this clay may be employed in the construction of furnaces, and crucibles not intended to undergo a more violent heat than that of the proof, provided its firmness and tenacity be likewise sufficient.

The essay of clays, with regard to their tenacity, forms the second object. The solidity of works constructed with clay depends on the force of the cohesion of its parts. This force, when the work has been dried by degrees to a temperature of 25 or 30 degrees of Reaumur, which correspond with the 88th and 107th degrees of Fahrenheit, is so much the greater in proportion to the ductility of clay when in the state of paste; so that both these qualities may be confounded with the tenacity of the clay. But this tenacity is extremely variable. Sand diminishes it more than any other foreign admixture.

All the parts of the furnace of fusion do not require the same tenacity. The thicker parts require many cavities for the dissipation of the moisture; but the crucibles demand a compact and tenacious clay, to resist the fluxes, and oppose the pressure of the glass they are to contain. It is of importance therefore to determine the degree of tenacity suitable to each object. Of the different methods tried by Mr. Loysel, the following succeeded the best:

He forms with the clay intended to be tried, small four-sided rods, which he leaves to dry at the temperature of 25 degrees of Reaumur. He then fashions them, and reduces one of their extremities to a dimension of six lines in each of its four sides. He inserts this extremity into a cubical cavity, and at the distance of eighteen lines he places the knife edge of a balance, into the basin of which he pours sand, until a fracture takes place in that part which is only six lines thick; and from the weight of the balance, the sand, and the broken pieces, he estimates the tenacity of the clay. To avoid accidental irregularities, he repeats the experiment with several of these rods. Hence, he finds, that his constructions are solid, when the tenacity of the clay, prepared for the walls and the arched roof of the furnace of fusion of eight feet diameter, is such, as to resist about twenty-four ounces applied as here described; and for crucibles of three feet in diameter, and three inches and a half thick in the lower part, when it resists fifty-six ounces. But the degrees of tenacity, which may be usefully applied, have limits of considerable extent, and may likewise be changed according to the dimensions of the articles. Thus the resistance of a crucible may be increased by adding to its thickness.

When it is known by experience what are the thickness and tenacity of clay, suitable for vessels of a certain dimension, it is easy to determine by computation for other dimensions. Mr. Loysel has given a table for this—the thickness of the lower part of the pots, where the pressure is greatest, whence the thickness diminishes to the rim. At this part, though the pressure vanishes, it is nevertheless necessary, that a certain thickness should be given, that it may dry with regularity, and resist such occasional slight blows as the vessel is likely to receive.

For the most part it is not usual to employ native clay, because it retains moisture very obstinately, is apt to crack, and adheres strongly to the moulds. To remedy this inconvenience, its tenacity is diminished, and its porosity increased, by a mixture

of sand or of baked clay, which is
d into powder, and improperly called
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tion of such glassy matter as may ad-
o them, are used for this purpose;
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s used for several other parts of the
e, and more especially for the pots.

s manufacturers differ in their opi-
is to the degree of fineness proper to
en to the cement; but it is easily seen,
f the cement be more grossly powder-
paste will be less homogeneous, more
ed to contract irregularly, and to ac-
vacuities into which the fluxes will
ate themselves. It is requisite, there-
that the cement be reduced to a fine
r, for which purpose it must be pass-
ough very close sieves of silk.

e tenacity of a mixture of clay and a
quantity of cement be determined, it
e easy to ascertain that of another
re; for the tenacity of the first mixture
e to that of the second, in the same
rtion as the quantity of clay: and the
rtional tenacities of mixtures, deter-
l at a certain degree of heat, continue
preserved very nearly at every other
e of heat, provided the tenacity of the
ade use of in both mixtures were ori-
y equal.

contraction which clay undergoes
fire is subject to great variation in
nt kinds, and deserves particular
on. Such clays as contract very
retain water with more force, and
s easily dried; they support the al-
ons of heat and cold more difficultly;
e filled with cracks and clefts, through
the fusible matters penetrate, and ap-
n the outside in vitrified exudations.
st inconvenience is more particularly
eared in those glass-works where the
main uncovered, as is the case where
and not pit-coal, is the fuel. For then
ss which drops from the roof mixes
e vitrified matter, and produces tears
ins.

ent and sand diminish the contrac-
clay in proportion to their quantity;
the same time they diminish its tena-
nd by rendering it more porous cause
e more easily vitrified by the fluxes.
aster of the glass work must deter-
what mixture is most suitable to his
aking, by combining these different
rties. If he use covered vessels, he
nploy a much greater proportion of
r cement in the roof of his furnace.

There are some who prefer sand to cement; but a distinction must be made as to the degree of fusibility in the clay made use of; for if the cement have more fusibility than the sand, as will happen with clays of middling quality, the sand should then undoubtedly be preferred; but with a good clay, the cement is certainly best.

Concerning the Construction of the Furnaces for Fusion.

There are three methods of constructing the furnace of fusion in a glass-house. 1. By using soft bricks. 2. By using bricks dried at the ordinary temperature of the atmosphere. And 3. By using bricks baked in the usual heat of a brick-kiln.

The soft bricks are made as follows: The clay is first dried, and the foreign matters which can be discerned are taken out, for which purpose the pieces must be broken, and examined within. If the clay contain much pyrites, the earth is mixed with water, in such a quantity, that the mass may be passed through the common sieve of the mealman. The larger pyrites remain behind, and those which come through subside to the bottom with the coarser sand. The mixture is then left to rest, the earth gradually subsides, and the water is from time to time drawn off, by cocks at different heights in the side of the vessel, until the mixture is sufficiently thick to be worked up with the sand or cement. This operation lasts between two and three months; at the end of which time, the matter, rejecting the inferior or lower part, is mixed with the sand or cement into a proper paste. If the clay do not contain pyrites, it is ground without water in a mill under a millstone of grit, then sifted and mixed with the sand or cement. Water is then added to convert the whole into a paste; or otherwise the clay purified by the first process of examination is soaked with water for four-and-twenty hours, and mixed with sand or cement.

In whatever manner the paste may have been prepared, it must be of such a consistence, that a ball of lead weighing four ounces may bury itself the depth of its diameter, when let fall out of the hand from a height not less than twenty-four inches, nor more than forty-five.

In this state the bricks would be too soft for the construction of a furnace, and would contract too much in drying. It is necessary therefore, that they be left to dry upon planks of wood. The firmer they are, the better for use, provided they do not break under the mallet of the workman, who strikes them with all his force to unite the different courses together, and to give them the figure required in the different parts of the arch-work. In this state a ball of lead of four ounces will require not less than a height of twenty-five feet, nor more than thirty-five, to bury itself half its diameter in the clay; but a consideration of importance is, that all the bricks ought to be sensibly of the same consistence, in order that the contraction of the different parts of the furnace may be as equal as possible.

This method of construction is the best which is known in the glass works. It is attended with the fewest cracks, and endures the longest. It is particularly advantageous in the manufactories of fine glass, and those wherein the vessels are uncovered. Nevertheless it is used only in great establishments. The reason is, that this construction requires more care, time, and expense than any other. It requires likewise a building, in which there are no other furnaces at work, in order that the drying may not be too hasty.

The construction with bricks dried in the air, or baked in the ordinary method, has nothing peculiar in it. This method of building ought to be reserved for glass-works where the pots are covered, or for common glass. And even in these, the first method would be found the most advantageous, if the necessary capital be not wanted.

Concerning the Fabrication of the Vessels or Crucibles.

The paste or mixture of clay and cement is prepared in the same manner as for the bricks already described, with this difference only, that it must be more consistent. A ball of lead of four ounces weight ought not to fall from a less height than sixty-five inches, nor a greater than eighty-three, to bury itself beneath the surface.

There are two methods of making pots for the glass-house. In the first, a mould of wood is made use of, lined within with a strong and well stretched cloth, and rolls of the paste are applied successively one above the other. In the second method a potter conducts his work without a mould, and joins the rolls of clay together by pressing them strongly between his hands. This second method is considered as better and more exact than the first.

The drying of the pots must be effected in the shade, in a place defended from currents of air, in a temperature between 55° and 65° of Fahrenheit. The drying must be slow, in order that the contraction may be regular. It is likewise requisite to defend them from frost and dampness. For this purpose, when the pots begin to dry, they are put into a close place, where the heat is gradually raised to 90° or 100°. They are then conveyed into the annealing furnace, where they are gradually heated to ignition; after which they are put into the melting furnace, heated less than its usual rate. The fire is successively raised to its greatest degree of heat. In large works, this diminution of the heat lasts three or four hours; but this time is not sufficient to effect a complete drying, for pots of large dimensions. These are usually left empty during the first working of the other pots.

Concerning the Heat of the Furnaces of a Glass-house.

The heat is greater the larger the quantity of air consumed. The entrance of the furnace ought to be therefore entirely free for the access of air; and the vapours of the furnace, which consist in a great measure of air unfit to maintain combustion, ought to be carried off as much as possible. Hence it follows, that the method employed in glass-works where pit-coal is the fuel, and in a few others where wood is used, deserves approbation. It consists in establishing a current of air through one or more arched passages, commonly under ground, one of the extremities abutting at the furnace, and the other being placed without the building which contains the furnace, and is commonly called the hall. By this means, several furnaces of fusion may be placed in succession in the same hall, without the combustion of the one being injurious to that of the other, as usually happens in less judicious arrangements. That disposition which approaches nearest to this is when the doors of the hall are opposite the furnaces; but the most injudicious is that which is commonly employed in glass-works where wood is burned. In this, the doors of the hall are on one side. The time required for the fusion and depuration may vary by the difference between the first and the last disposition from 18 to 34 hours.

The air ought to be heated before it arrives at the fire, that its temperature may be less remote from that wherein the combustion is effected. It ought therefore to pass through the ash-hole. Ordinarily in furnaces wherein wood is burned, the current is directed against a small dome above the ash-hole. It ought to be directed immediately into the furnace.

The interior part of the furnace cannot acquire its greatest degree of heat, but in proportion as that which is produced in the fire is deprived of the liberty of escaping during its disengagement. It is even necessary, that it should be distributed as equally as possible through the whole interior capacity of the furnace. Now this effect depends on the magnitude and position of the issues of the flame, and the interior figure of the furnace.

It is easy to ascertain by experience in each particular case the proportion which ought to exist between the entrance of the air, and the escape of the flame, by making the apertures of that escape at first larger than necessary, and then diminishing them with movable bricks disposed for this purpose, until the furnace appears to be in the greatest state of ignition.

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furnaces, in France, is a square or
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e the work commences. Mr. Loysel
fore proposes, that the figure of the
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e vault or dome of the furnace is the
to which artists pay the greatest atten-
Its figure is not the same in all glass-
s; but in a considerable number its
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coal and wood are equally capable of
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The flame may be more or less
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he colour of the glass be a matter of
nsequence, pit-coal may be used for
e operations, provided that the me-
oxide do not enter into the compo-
; but if an equally quick fusion be required, with similar doses of fluxing-matter in covered as in uncovered pots, a greater heat must be applied, on account of the resistance opposed to the transmission of the heat by the cover.

Resinous woods afford more smoke than poplars, ash, &c.; and these more than birch, oak, sycamore, and beech. The last three are the best for heating the melting furnaces; as well for the purity of the flame, as the intensity of the heat.

In order to obtain the greatest quantity of flame, and the least of smoke, the same quantity of fuel must be constantly kept on the fire. It must therefore be added in small quantities, and at frequent intervals.

It has already been mentioned that Mr. Loysel, in order to determine the tenacity of different mixtures of clay and cement, and of clay and sand, made use of rods of clay, each face of which was six lines broad; that these rods were dried in the same degree of heat, and afterwards broken by weights suspended at the distance of eighteen lines from the plane of fracture. He also made experiments, to ascertain the proportions of tenacity acquired with the different degrees of heat to which the clay was exposed. With this view he prepared a great number of rods with the same clay, and in each experiment he baked at least four or five in the same degree of heat, to exclude those of which the results might be too discordant, on account of inequality or the variable porosity of the materials.

In this manner he made six experiments from 70° F. to 558°; after which having constructed a curve, the ordinates of which represent the degrees of temperature, and the abscissæ the weights necessary to break the rods, he found that his curve did not sensibly differ from the parabola; and from the equation of this curve he determines a law between the degrees of temperature and the weights necessary for the fracture.

The degrees of heat which he found immediately by the thermometer, or by the preceding rule, are as follows:

The heat of the apartments in which the unbaked pots are kept ought not to be less than 88°, and sometimes rises as high as 122°; that of the annealing furnace ought not to be higher than this, when the unbaked pots are introduced: it is gradually increased during eight days. At this period the proof of the rods indicated between 900 and 1000 degrees. The lowest heat of a great melting furnace proved to be about 8000 degrees. The most usual heat is about ten or eleven thousand degrees, and ought not to exceed fourteen or fifteen thousand degrees, because at this last temperature, pots of two feet diameter within, and three inches and a half thick, made of good clay, are broken by the pressure of twenty-five inches in depth of glass.

It may be observed that Mr. Loysel has

availed himself of a different property from that used by Wedgwood. See PYROMETER. The first has chosen the tenacity, and the second the contraction of clay, to determine the degree of heat. The second method, as the academicians observe, requires less apparatus; to which we may add, that it appears to depend less on arbitrary dimensions, and indicates minuter differences in less time. But these reporters justly question whether the one or the other method be adequate to prolong the graduation of our thermometers. The heat, at which it was possible for Mr. Loysel to make his comparative experiments, extended no farther than from 17 degrees to 234 of Reaumur; a space much too contracted to establish a progression to the extent of 14000 degrees. As to the agreement of these two methods, Wedgwood remarks, that there are three heats in the glass furnaces; a strong heat for vitrification, a low heat for settling, and a greater called the working heat. This last was found in plate glass to be 57° of his thermometer, which we may suppose to correspond with considerable latitude to the ordinary heat of Mr. Loysel just mentioned. Now Mr. Loysel's ordinary heat, reduced to the scale of Fahrenheit, is 23407°, and the working heat of Wedgwood, according to the same scale, is 8480°; a difference apparently too great to be admitted without the supposition of error in the parabolic curve of the former, the short intermediate scale of the latter, or, which is still more probable, a change in the measuring property of the clay at the higher temperatures. It must not however be overlooked, that the heats used in the glass furnaces, and elsewhere, for the same nominal purposes, were found by Wedgwood to differ extremely, though not so much as the preceding numbers do from each other.

Of the Choice of Vitrifiable Earth.

The whitest sand is the most frequently mixed with other earthy substances. To clear it of these, it is washed with agitation in clean water. The earthy parts, which are lighter than the sand, remain suspended in the water, which is decanted off, and fresh parcels added, till it comes off clear. If it contain combustible matters capable of colouring the glass, it is ignited for the purpose of burning them off. This is the method of purifying the sand for fine glass.

Of the Metallic Oxides considered as Fluxes.

Of all the metallic oxides considered as fluxes of siliceous earth, those of lead are the most used; not only because they are capable of vitrifying a larger dose of this earth, but because they are less costly, and may be employed in considerable proportions without injuring the whiteness of the glass. Minium is preferred to any other oxide of lead. If it be used with the vitrifiable earth of pulverized flints, or the white sand of Aumont near Senlis, five pounds of minium cannot completely vitrify more than two pounds of this earth in the ordinary fire of the glass-house. The glass which results is of an orange yellow, and full of veins; and specifically near five times as heavy as water. If the dose of earth be smaller, the vitrification is more speedy, and the glass is more coloured and heavy. The greater proportion of oxide of lead which enters into a composition, the less brittle the glass proves by the alternations of heat and cold. The more on the other hand the vitrifiable earth predominates, the glass will be more white, transparent, light, subject to break by sudden change of temperature, and difficult to soften by heat. The proportions of oxide of lead and sand must therefore be varied according to the object desired.

Concerning Arsenic.

The use of arsenic is avoided in glasses which contain oxide of lead, because this material favours its sublimation. The most effectual, as well as the most common method, is to mix nitre along with the vitrifiable materials. A large dose of arsenic gives a milky appearance to glass, and may even render it entirely opake. As glass is sometimes capable of being attacked by acids, it is proper to avoid arsenic in all vessels intended to contain liquors for drinking.

Arsenic mixed with coaly matter and exposed to the fire becomes violently inflamed and flies off. Advantage has been taken of this property: when it is perceived during the fusion, that the glass is coloured yellow for want of calcination, and that the mass is not sufficiently fluid, some manufacturers are in the habit of throwing pieces of arsenic into the pot. The arsenic takes away some of the colour from the glass, and by its inflammation and volatilization gives to the mass an internal movement, which facilitates its settling, and partly clears it of bubbles. But it is evident, that it is useful only as a remedy for preceding negligence. Mr. Loysel is of opinion, that arsenic may and ought to be banished from the glass-house.

Concerning Saline Fluxes.

The potash and soda employed as saline fluxes vary considerably by the quantity of earth and neutral salt they contain. For common glasses the mere ashes are frequently used. In all cases trial is made in the small way of the best proportions of the sand and the alkali.

The neutral salts which are mixed with the alkali are not only hurtful because they diminish the proportion of this last, but principally because they are incapable of combining with vitrifiable earth, and when mixed through the whole mass of the glass, they form a foreign opake matter. In this state the most active and long-continued heat would be scarcely sufficient to dissipate these salts. The most effectual remedy hitherto discovered consists in diminishing the heat of the furnace when the time of complete fusion is past. The neutral salts, being specifically lighter, rise to the surface, where they are taken off, and form what is called sandiver, salt of glass, or glass-gall; but this operation is attended with a loss of time, which is of prejudice, and some of the salt may remain in the manufacture. It is usually seen in the form of white flowers resembling flakes of snow. These kinds of glass are brittle, especially when part of the salt of glass is at the surface. It would therefore be a valuable operation, to deprive the alkalis of the neutral salts, with which they are mixed. Mr. Loysel avails himself, for the purification of potash, of its property of being much more abundantly soluble in water than the neutral salts it may contain. One hundred pounds of the saturated solution of potash contain forty-eight or fifty pounds of alkali; and this solution makes forty-eight or fifty degrees on the areometer of Baumé. If the evaporation be carried on till the solution is concentrated to the fortieth degree, the greater part of the foreign salts separates, and what remains cannot injure the glass. This method adds very little to the expense, because the best manufacturers are in the practice of dissolving their potash, to separate its impurities

During the fusion the carbonic acid is disengaged from the alkali, and produces an effervescence, which renders it necessary to increase the number of fusions; adding but small quantities of the mixture at a time, in order that the elastic fluid may be at liberty to escape. By this means the time of fusion is prolonged. The inconveniences of this effervescence are avoided by adding, as Mr. Loysel proposes, an equal weight of lime to the alkali, in the solution made for the last-mentioned purpose. This pure alkali is very deliquescent, but it may without any inconvenience be employed in the glass-works immediately after its desiccation.

Pure alkali dissolves a quantity of vitrifiable earth, which is more considerable the greater the intensity of the heat: so that the point of saturation depends on this circumstance. Whence it happens, that the glass made at different furnaces is more or less alkaline, and consequently more or less subject to decomposition. If the proportion be such, that the alkali in the glass is less than one fourth of its weight, the glass will be very solid: but if the heat made use of be so feeble, that the point of saturation cannot be obtained but by the proportion of equal parts of these two ingredients, the glass, though clear and transparent, will be of so loose a composition, as to be attacked and dissolved by mere water.

Concerning Lime.

Calcareous earth renders the glass into which it enters less subject to attract moisture, and less brittle by changes of heat and cold. Its whiteness is not perceptibly altered; but in order to avoid the effervescence produced by the disengagement of carbonic acid, the common practice is to use lime. This practice is still more advantageous, because the combustible matters of the lime stone are burned by calcination; and the water, which is one of its component parts, is dissipated. This water, together with the carbonic acid, if volatilized in the furnace of fusion, would facilitate the escape of part of the alkali.

Vegetable earth, such as is obtained by lixiviation of the ashes of vegetables, is used only for the most ordinary glass, because it alters their clear white colour. As it is fusible alone, which lime is not, it might be employed in large doses, without fear of impeding the vitrification of the sand and alkali, if there were not cause to fear the destruction of the pots, which it very speedily corrodes. This property makes it necessary to limit its proportion to one pound for every two pounds of sand, and a sufficient quantity of alkali.

The lime demands for its vitrification a greater quantity of alkali than sand does; yet the doses of sand and alkali being determined for the vitrification, a good glass may be obtained by adding a certain quantity of lime. Whence it happens, that with the same quantity of flux a larger quantity of glass is afforded, without considering the good qualities the lime communicates. Lime cannot, however, be used but with great moderation, because the glass of which it is a part vitrifies the clay of the pots, of which the preservation is an important object. From this consideration no more than ten or fifteen pounds of lime are added to one hundred pounds of alkali, and two hundred or two hundred and twenty pounds of vitrifiable earth.

There is an easy remedy against the action of the glass containing calcareous earth upon the pots. It consists in adding to the composition of the glass a sufficient quantity of clay to effect a saturation This is accordingly done in the manufacture of bottles. But as the clay used in the glass-houses always produces a green glass, it cannot be admitted in the composition of white glass.

A very remarkable effect of calcareous earth, and also of the vegetable earth, in vitrification, is the decomposition of the sulphuric salts with bases of fixed alkali, whatever may be the manner of their favouring the disengagement of the acid. Calcareous earth may be vitrified in the proportion of one part of the earth to three or four of salt, according to the degree of the fire. This property renders the use of lime and the vegetable earth very advantageous in the manufactories of common glasses, wherein the soda of kelp is used, which contains a considerable proportion of sulphat of soda.

Concerning the Substances proper to purify the Glass.

The substances most advantageously employed in the purification of glass are the oxide of arsenic, nitre, and the oxide of manganese. The first has been already mentioned.

Nitre serves as a flux by virtue of its alkaline part, and may supply the place of alkali according to the proportion it contains; but its high price prevents its being employed for this purpose. It is with a view to destroy the coaly matters contained in the mixture that it is added, and accordingly it is never used but when the materials have not been sufficiently calcined.

It is likewise with the same view that the oxide of manganese is used. We are indebted to Scheele for a knowledge of the manner in which this oxide operates. Naturally it gives a violet red colour to glass; but when deprived of part of its oxigen by the combustion of coaly matter, it loses its colour, and leaves the glass white. Hence a notion may be formed of its effects when added to glass in different proportions. If the dose be too small, it does not destroy entirely the yellow colour produced by the coal of the ingredients not sufficiently calcined; if it be too large, it communicates its own peculiar tinge.

The oxide of manganese is capable of destroying such colours only as are produced by coaly matter; but not those which arise from metallic substances, such as iron, lead, and cobalt. In these cases it produces a mixed colour from the combination of its own tinge and that of the metal already in the glass.

If it be proposed to communicate to glass the colour of the oxide of manganese, the materials must be well calcined; and arsenic must not be used, as it would attract the oxigen of the oxide. Nitre will restore the colour if destroyed. It effects this by affording oxigen.

In some cases, when it is desirable to give a slight green tinge to glass, instead of the yellow colour produced by a metallic oxide, a small quantity of the oxide of cobalt is added which gives a blue colour, and this by mixture with the yellow produces a green.

The oxide of manganese forms a glass specifically heavier than common glass; whence it arises, that the glass at the bottom of the pots in many glass-works is violet. It is undoubted, that when this happens the dose of manganese is too great. The usual method of remedying this inconvenience is to stir up the glass with an iron bar, after previously raising the fire to render it more fluid. It is thought, that the manganese is in part dissipated by that means; but it is merely distributed through the mass. A more effectual remedy is to add some combustible substance to the glass to destroy its colour; such as arsenic, charcoal, sulphur, &c.

Concerning the Calcination of the Vitrifiable Matters.

The calcination is an important preparation of the materials intended to be vitrified. Its chief effects are the dissipation of volatile substances, which ought not to enter as constituent parts of the glass, and the combustion of coaly matters, which without this operation never fail to colour the glass.

Two conditions are requisite to a perfect calcination: 1. The materials must present a large surface to the air; and 2. the heat to which they are exposed ought not to be attended with the smoke of the fuel. The first condition demands that the heat should not be so violent as to produce fusion. And moreover the heat should be gradually raised, to drive off the volatile matters, without raising along with them any part of those which are more fixed.

The sand made use of is commonly more or less white in its natural state; but it becomes still more so by calcination, and the glass is improved in consequence. The fire may be urged to the strongest degree when sand is calcined by itself; but a moderate heat is commonly used, unless when the very finest glass is intended to be made. In general the sand is subjected to no other calcination than that of the mixture of alkali, lime, &c., called the frit.

The calcination of the alkali is of the first importance. By this means the elastic fluid is driven off, which would disturb the fusion. Part of the evaporation of the salt, which takes place before it acts as a solvent to the sand, is thus prevented. And more particularly the coaly matters are burned, which it always retains notwithstanding any other previous depuration.

In the purification of alkalis all such vessels are to be avoided as might communicate colouring particles to them; such as boilers of iron. Those of lead are preferable; because, if any portions of the metal should be detached, no sensible inconvenience will arise as to the whiteness of the glass.

The heat must be more particularly attended to in the purification of the alkali, that it may be so moderate, as not to produce that liquefaction which is called the aqueous fusion, and arises from the water it contains. For this purpose the salt must be frequently turned, and not calcined in too great a quantity at a time.

calcined fixed alkali may be pre- in its concrete form in apartments ed from moisture. The same pre- is not required for the lime and sand. r the mixture of these three sub- , the mixture may be subjected to ation in the pots of the furnace of ; or it may be subjected to another tion called the operation of the frit. mixture of vitrifiable matters be not ted to this operation, the other ingre- are likewise added at this period, er they be nitre, arsenic, or oxide of nese, for purifying the glass, or such c oxides as are intended to produce . But if the mixture be fritted, no naterials are now added but the oxides are intended to possess the last state lation.

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en a mixture of very dry concrete al- nd sand is made, and immediately ted to a heat sufficient for its vitri- on, the alkali speedily enters into ; the sand, being more heavy than luid alkali, falls to the bottom of the , and the supernatant alkali is in part rated before the whole of the sand dissolved. In this case the glass will n unvitrified sand, notwithstanding a ent or even superabundant proportion ali may have been used. This incon- ce is but too common in those works the operation of the frit is not used; is avoided by that commencement of which the sand, lime, and alkali e in this operation, and which holds ogether till the vitrification is com- .

accurate mixture of the vitrifiable s can alone produce the clearest glass, is the properest to receive the several s afforded by the metallic oxides. The therefore an operation of advantage loured glasses, as it prevents the pro- n of false or irregular tinges.

ifiable matters newly fritted destroy rrode the crucibles less than such as ot been so treated: 1. because they empt from humidity: and 2. because ali is no longer in a disengaged state. en it is proposed to augment the den- a glass by means of a metallic oxide s, such as those of lead, the glass pro- will be more uniform in its texture, ore equally the combination has effected through the whole of the Now the commencement of combi- , which is established between all the parts of the frit, prevents the oxide of lead from falling down as readily as it would otherwise do.

The operation of fritting is performed in one or more furnaces adjacent to the furnace of fusion which communicate with it, and to which the name of *arches à fritte* is given by the French; or otherwise it is done in separate furnaces. The former method is preferable, because the flame does not arrive at the frit until all the parts of the fuel have had time to be consumed; because they can more easily be kept at a steady and suitable heat without an additional expense of fuel, and because the vitrifiable matters may be immediately transferred in their white heat to the furnace of fusion. Hence the vitrification is more speedy, and the crucibles less injured, than if the materials were put in cold.

Concerning the Fusion of the Vitrifiable Matters.

It is necessary to diminish the heat of the furnace at the time of working the glass, in order that it may assume consistence enough to be wrought; but as the ingredients required to be added from time to time occasion a refrigeration, the furnace is again heated before they are introduced. The time of reheating differs in different works: but it is ordinarily one or two hours for furnaces of six or seven feet in diameter.

The cold produced by this circumstance being in proportion to the quantity added, it is clearly requisite not to add too much at a time; because too much cooling might even break the vessels. The pots are therefore filled at two, three, or four different intervals; and this is called making two, three, or four fusions, or fonts.

The second font must not succeed the first until the preceding vitrification is completed. Two methods are used to ascertain this. The first consists in observing the end of the effervescence, and the dissipation of the alkali superabundant to the vitrification; which may be known by the tranquillity of the font. The second consists in taking proof of the glass, after the cessation of the fumes arising from the evaporation of the alkali. If it be found, that the bubbles are dissipated, the second font may be made: and the same observation applies to the succeeding fonts.

The time employed in the vitrification is distinguished by the name of the time of fonding, and that employed in the dissipation of the bubbles, the settling or refining. The glass is said to be fine, or well refined, when it contains no more bubbles. If the second font were to be made before the glass of the first were well refined, the subsequent cooling would prevent the dissipation of the bubbles, at least during the whole time requisite to produce the original fluidity, and the subsequent refining would prove long and tedious. While the pots are thus supplied, the vents of the flame must necessarily be kept open, which cools the furnace also. For these reasons, it is proper to avoid either too few or too many fonts.

As soon as the glass is fine, the heat of the furnace is diminished by adding less fuel, or none at all, according to the nature of the work, whether of blown or of cast glass. By the diminution of heat, the glass becomes thicker or less fluid, and is fit for working. During the whole time of working the consistence must be the same: and for this reason, in the operation of blowing, of which the working may continue from five hours to twenty or more, according to the nature of the articles, the furnace must be kept at the same degree. But this need not be as intense as for the fonding and refining.

This last remark does not quite agree with the account given by Mr. Wedgwood of the fonding, settling, and working heats, see **Pyrometer**. But I suppose the working heat to be, as Mr. Loysel informs us, lower than the others for blown glass; and that Mr. Wedgwood's increased heat for working may be used only in the manufacture of *cast* plate glass.

There are two methods in practice of conducting the fonding, refining, and working of glass. In the first, each operation is made at the same time in all the pots; in the second, the fonding and refining are effected in one half of the pots, while the glass is worked in the others. It is easy to imagine, that the glass-works where this last practice prevails cannot have so intense a fire as the others. To supply this defect, a greater quantity of flux is used in the vitrification; and the glass, containing less earth, is tender, and subject to be decomposed. Exception must however be made with regard to those glass-works in which no other materials are used but old glass, or very fusible matters, such as lavas, basaltes, &c.

Of the Annealing of Glass.

Glasses of any considerable thickness, as for example two or three lines, if suffered to cool in the open air immediately after being formed, suffer an unequal contraction from their surface on account of the inequality of their thickness. These glasses frequently break of themselves by change of temperature. They fly or break with some noise, when an attempt is made to cut them with the diamond, or to grind them on the wheel or other tool. The annealing is a remedy for this defect. It consists in passing the glass, slowly and by insensible degrees, from the state of ignition it possesses in the furnace of fusion to the temperature of the atmosphere. For this purpose, as soon as the work is finished, and has assumed consistence enough to retain its form, it is conveyed, while still at a red heat, into a furnace which has nearly the same heat as itself. There the cooling is effected in one of the two following ways: The annealing furnace, or leer, is filled with the manufactured articles, and kept at the same heat during the whole time of working, after which it is suffered to cool slowly together with its contents: or otherwise, one or several pieces newly made are gradually passed along the annealing furnace by occasionally removing them from one end, which is hottest, to the other, where it is so low that the pieces may thence be safely transferred into the open air.

The slowness of annealing varies according to the brittleness of the kind of glass, and the thickness of the work. Thus, a glass made with flint and alkali alone is more difficult to anneal, than if it contained a metallic oxide or lime; and the first kind will always be more subject to break by alternations of heat and cold. The vessels to be annealed must be cool enough not to adhere to the support on which they are placed; for the inequality of contraction between them and the support might occasion them to break. The same accident arrives to pieces made of glasses of different dispositions to contract. The contraction of the piece to be annealed is effected more easily, the less friction it has to overcome: for which reason, when large plates of glass are to be annealed, the surface is placed on movable bodies, such as grains of sand.

Concerning the principal Defects observable in Works made of Glass.

The most considerable defects, as enumerated by Mr. Loysel, are striæ or veins, threads, tears, cords, bubbles, and knots.

The striæ or veins arise from the heterogeneous composition of the glass. It seldom happens, that glasses of any considerable magnitude are exempt from them, and the reason is not difficult to explain.

Glass produced by the solution of siliceous earth by fixed alkali, at the ordinary heat of the glass-house, possesses a specific gravity of 2·3 or 2·4, water being assumed as usual at one. Glass made with alkali and the clay commonly used weighs about 2·5. That of alkali and chalk, 2·7 or 2·8. The oxide of manganese vitrified alone weighs 3·2 or 3·3. Glasses produced by other metallic oxides are still more ponderous: that of lead, for example, weighs about 7·2 or 7·3. When the partial combinations of the ingredients of the glass are not well mixed together, but form strata of different density in the pots, they produce undulated veins in the work, similar to those observed when two liquids of very different densities are first mixed, such as water and alcohol.

As the glass in the operations of blowing is taken up nearly from the same part of the pot, and as in the casting of glass the pot is suddenly reversed and its whole contents mixed together, it is found, that blown glass is much more uniform than that which has been cast.

The name of threads is particularly given to those veins which are produced by the vitrification of clay. They are greener than those produced by calcareous earth. These threads render the glass very brittle, when they are abundant, or when any of them are of considerable size, because the contraction and dilatation of this kind of glass, from change of temperature, are very different from those of the glass of sand and flint.

Tears are the greatest defect which can be found in glass. They are the drops of glass afforded by the vitrification of the furnace of fusion. Articles in which these are found are brittle. Most of them break by the alternations of temperature, and that the more surely, the nearer the tear is to the surface. Such articles are generally thrown aside in the glass-house.

Cords are asperities on the surface of certain articles of blown glass. They are produced whenever the heat of the furnace becomes so low, that the threads of glass which fall from the pipe into the crucible cannot resume the proper degree of fluidity. When this appearance presents itself, the work is given up, till the heat of the furnace is again brought to the requisite degree.

The small bubbles abundantly diffused through certain glasses show, that the refining is imperfect. They arise from the disengagement of elastic fluid during the vitrification. This imperfection shows, either that the quantity of flux has been too small, or the fire too weak. In the first case, the glass may be used to hold liquids without fear of being attacked; in the second, the glass is tender and easily acted on by acids, if the flux were of an alkaline nature, because its proportion is too great.

Bubbles may also be produced in glass, during the working, by certain foreign matters, which are fixed, and emit aërial fluids by the heat.

Knots are of three kinds. They are either formed by grains of sand enveloped in the glass, or by the salt of glass which is found in pieces, or white flocks, or lastly by pieces detached from the crucible or the sides of the furnace.

The fused glass has the property of sticking to an iron rod or tube, by which means it is taken out, either to ascertain its state of perfection, or to blow it into such utensils as may be wanted.

The quantity to be used at once is regulated by a process somewhat resembling that of the tallow-chandlers; that is to say, the part first dipped out is suffered to cool a little, and serves as a receptacle for more glass to be taken up at a second dip, and so forth, until the quantity is sufficient. The lump of glass may be softened at pleasure, by holding it before the mouth of the furnace. The workman renders it hollow, and of a spherical form, by blowing through the tube. This sphere may be converted into a cone, a cylinder, or any other solid, the transverse section of which is a circle, by rolling it on a flat plate of iron. It may be stretched in length by swinging the tube in the air, or giving it a vibratory motion like that of a pendulum. The workmen show great dexterity in heating the glass in the various stages of the manipulation. They do this in such parts as they are desirous of extending; and on other occasions they cool certain parts of their work, by fanning the air against it. The glass, in the ignited state it possesses after it comes out of the pots, is very tough and flexible, may be cut with shears, bended with pincers, pressed into moulds, and wrought in a variety of methods dependent on these properties, of which the artists very dexterously avail themselves.

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referable to the property of crystallization, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water, it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial, which is a small vessel of thick glass suddenly cooled by exposure to the air. Such a vessel possesses the property of flying in pieces, when the smallest piece of flint or angular pebble is let fall into it, though a leaden bullet may be dropped into it from some height without injury. Many explanations have been offered, to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat. The immediate cause, however, appears to be derived from the fact, that the dimensions of bodies suddenly cooled remain larger, than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater than that of the same steel gradually cooled It is more than probable, that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopment of the interior part, which is less slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions, and likewise to remain in contact by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at, that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once, of so brittle a material, should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled are numerous and interesting to the philosopher, yet they constitute a serious evil with respect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace above the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure free from the defects of glass which has been too hastily cooled.

It is difficult to speak with any precision concerning the materials, proportion, and management necessary to make the different kinds of glass, such as the green glass for bottles, the greenish or blueish glass for windows, the white glass for mirrors, the white flint glass for bottles, and the crystal glass used for the finer wares, called cut glass, not to mention the dense white glass made expressly for optical uses. All these are made of better quality at some manufactories than at others; and it is probable, that this superiority of produce is thus confined by the natural disposition for secrecy, which prevails among men, whose pecuniary success in a great measure depends on their monopolizing the effects of their own skill. Far be it from me to pretend to consider this proceeding as immoral. On the contrary, I very much doubt, whether any species of property can be defended under a title in any respect so strong as that which a man must hold in his own superiority of intellect and exertion. I mean simply to observe in this place, that, from the causes here mentioned, it is impossible to give a minute account of the art. The green glass is made from impure materials; the basis consisting of a ferruginous stone or sand, and the alkali being such as can be the most cheaply purchased. The colour chiefly depends on the iron; and the glass is harder, more durable, and less destructible by acids remaining in it for a long time, the less the quantity of alkali, and consequently the greater the heat. Pit coal is used as fuel in the English glass-houses. It produces a more intense heat than wood. Chaptal, in his Elements of Chemistry, mentions the successful establishment of a manufactory of opaque bottles of excessive strength and lightness, composed chiefly of basaltes; but he relates that the establishment failed, chiefly on account of the quality of the basaltes, which did not constantly prove the same, but, becoming in the latter stages of the undertaking more calcareous, produced an article of a perishable nature.

All the white glasses owe their clearness to the purity of the materials. The finest siliceous sand is fused with purified alkali. The oxides of lead act as a powerful flux, and are much used in compositions of this nature. They give density, softness, and a disposition to take a brilliant polish.

Optical writers teach us, that the refracting telescope consists of a convex lens, called the object lens, in the focus of which the image of a remote object is formed; and that this image is seen magnified and distinct by a microscope applied to it, which forms the apparatus at the other end of the telescope. It may easily be imagined, that, if the focal image be indistinct, or if there be a number of focal images occupying different parts of the field of view of the telescope, the effect will be less perfect, and the magnifying power must be less, in order that the confusion may be at all tolerable. Whenever a ray of white or compounded light is refracted out of its course, by passing into another simple medium of different density from that through which it originally passed, it is found to be separated into its component parts, which produce the sensations of various colours. This separation is made by virtue of the different properties possessed by the several rays of light, by which some are more refracted in like circumstances than others. Thus the blue is more refracted than the green and yellow, and these are more refracted than the red rays. Whence it follows, that a pencil of white light, which passed in parallel rays to a wedge or prism of glass, will come out of the prism on the other side, not only refracted in the whole, but differently refracted as to its parts; the red being less turned out of its course than any of the other rays, and the violet being the most deflected of any. And this difference of direction will be greater, the greater the mean refraction. The edges of a convex lens may be considered as wedges of the same nature, with regard to the light, as the prism here mentioned. Such a lens, refracting the red rays less than any other, will form a red image at a certain focal distance. The yellow rays, being somewhat more refracted, will afford a yellow image, at a distance less remote from the lens: and, for similar reasons, there will be formed, at still nearer distances, images of green, blue, and violet, with all

ntermediate shades of colour. The
focal image will consist of all these
s irregularly combined. It has been
ered, that the quantity of dispersion
ater in some kinds of glass than in
s, while the mean refraction or focal
n remains the same. Two prisms of
different kinds of glass, producing the
mean refraction toward contrary
on a ray of light, would not therefore
ct the colorific dispersion, though the
ould proceed onward nearly in its ori-
direction. It would be necessary, in
that this dispersion produced by the
lass should be accurately corrected by
her, that the mean refraction should
atest in that which possessed the least
in dispersing the rays of light; and,
s case, the colourless emergent ray
not proceed in its first direction. To
this doctrine to telescopes—Suppose
ex lens formed of such glass as afford-
y little colorific dispersion of the rays,
concave lens of such glass as afforded
of this effect: it will follow, that,
these two lenses possess such a figure,
the concave shall destroy the pris-
colours produced by the convex, the
of mean refraction must be in the
and consequently, that the compound
will act like a convex lens, and pro-
real colourless focal image.

e problem of constructing telescopes
shall be truly achromatic, depends,
have before observed, chiefly on the
tion to which the glasses can be
ht. The general facts respecting
for this use are, that lead, and pro-
other metallic oxides, increase the
ive power more than alkalis, and
ast more than earthy fluxes; and that
lition of alkali to glasses containing
rves greatly to diminish the mean
ion, without much affecting the di-
e power occasioned by the metal.
it might seem easy to compose such
s the theorems of the optician de-
but the practice is by no means so
Regular refraction demands, that
dium should possess a uniform den-
roughout, or, in other words, that
ts of the glass should be well com-
ogether. This however is seldom the
pecially in the dense metallic glass.
und, that the great fusibility of the
lead causes it to flow, and occupy
rstices between the particles of the
fore these are melted. So that some
right and apparently homogeneous
exhibit an infinity of small focal
of a candle, when examined by a
er, which are produced by rounded
s of sand remaining in every part of
stance. Another fault, still more
n, consists in veins of a different
from the rest, partly arising from
ct fusion, and partly from the density of the glass in the pots being greater, the lower its position.

Various have been the attempts to remedy these defects, more especially since the Board of Longitude has offered a considerable premium for this object. We do not, however, possess any ample detail of these unsuccessful experiments. It is generally understood, that it is in vain to endeavour to make this glass in small furnaces, because the heat in these is continually varying, and is either too low for the requisite fluidity, or so high as to extricate bubbles of elastic matter; whereas a steady heat is required for the purpose. Macquer and others have attempted to correct the evil by repeated fusions and pulverization of the glass, and by exposing it to long continued fires, but without success. It is said, that one of the practices in our glass-houses consists in lading the melted matter from one pot to another in the furnace. But this, on account of the heavy duty of excise, and the impolitic manner in which it is levied, cannot be done to any great extent in this country. If the glass be suffered to cool in the pots after a good fusion, its parts take a symmetrical arrangement, of the nature of crystallization, by which the light is acted upon in a manner independent of its figure, which is thought to be a great impediment to its optical use. Mr. Kier, who has had much experience in this branch of chemistry, is disposed to recommend the trial of component parts different from any which have yet been admitted into the common glasses.

Without presuming to speculate in a department of science, wherein my experience is much confined, I shall point out a few facts, which may be of use to the philosophical operator, and leave the manufacturer to his own trials. It is generally affirmed, that Mr. Dollond made his original experiments, and constructed those excellent three-foot glasses (which at present bear so high a price, and are not to be made) with one single pot of glass made at the glass-house near Wellclose Square, and that none of the same quality has since been made. But the proprietor of that glass-house has assured me, that the original receipts and practice are still followed in the making of optical glass: that the principal opticians always complain of the bad quality of the glass, but never fail to take the whole quantity he makes at their request; and that when they renew their orders, they always desire it may be exactly the same as the last. From these circumstances I think it probable, 1. That, though one pot of glass may differ from another, yet there may be as good glass obtained for optical uses now as formerly, if an optician skilled in the theory and practice, like the late Mr. Dollond, were to undertake the task of adapting the curvatures, and selecting the best lenses.

2. That Mr. Dolload's purpose as a tradesman being now answered, by the establishment of an extensive business, he has not the same motives for exertion upon powerful telescopes as actuated his father. 3. That the profits of this trade are greater, and more certain, when many hundreds of cheap perspectives are made by common workmen, than when a few extraordinary telescopes are made by the most excellent artists, superintended by the master himself; and, consequently, it is not the interest of an established house to extend the latter branch. 4. That it is not the interest of a glass manufacturer, who can gain a large and regular income by making common utensils, to employ his time in costly experiments upon optical glass, which, if brought to perfection, would afford but a moderate demand, probably no greater than he now experiences: and, therefore, that the improvement of achromatic telescopes is rather to be expected from a man of science, who may be a practical chemist, than from mere tradesmen.

I suspect the opinion to be ill founded, that those kinds of glasses are unfit for optical uses, which are veiny or clouded, or otherwise unpromising On the contrary, there are reasons to think, that the defects of glass arise from irregularities too minute and numerous to be discerned or discovered in any way, but by the actual proof of constructing a telescope. There are good glasses, which abound with the larger veins; and I possess two achromatic lenses, each of thirty inches focus, the obvious qualities of which, and excellence as object glasses, differ very much, and in opposite respects. They are each composed of a convex of crown glass, applied to a concave of flint. The one was constructed for the tube of an astronomical quadrant. It produces no colour, has no aberration from figure, and, when the eye is placed in its focus so as to receive the pencil of light from a fixed star, the whole aperture is uniformly covered with light. The other glass, though perfectly similar, was made for a pocket perspective. It produces scarcely any colour, has considerable aberration from figure, and when the eye placed in its focus receives the light of a fixed star, the whole aperture is covered with light of an irregular, curdled, or cloudy appearance. I have no doubt but the former glass was applied to the superior, and the latter to the inferior use, from their obvious qualities: but when they are examined by the true test of optical excellence, the application of a large magnifying power, the former proves dark and indistinct, while the latter exhibits the object bright and well defined, and is on the whole an excellent lens.

Mr. Reaumur was the first who made any direct experiments upon the conversion of glass into porcelain, which takes place by the evaporation or absorption of its alkali, during the continuance of a degree of heat less than is sufficient to melt it. Saline glasses are the best for this purpose; and the less salt they contain, the more readily they are converted. Instances of this effect may be observed among the rubbish of brick-kilns, where pieces of green bottles are not unfrequently subjected by accident to the requisite heat; but the direct process is as follows: A vessel of green glass is to be filled up to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessels must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted, and put into a potter's kiln, where it must remain during the whole time that the pottery is baking; after which, the glass vessel will be found transformed into a milk-white porcelain. The glass, on fracture, appears fibrous, as if it were composed merely of silken threads laid by the side of each other: it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel, though not so briskly as real porcelain. Lewis observed, that the above-mentioned materials have not exclusively this effect upon glass; but that powdered charcoal, soot, tobacco-pipe clay, and bone-ashes, produce the same change. It is remarkable, that the surrounding sand becomes in some measure agglutinated by this process, which, if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it pulverulent.

The ancient stained glass has been much admired, and beautiful paintings on this substance have been produced of late years. The colours are of the nature of those used in enamelling, and the glass should have no lead in its composition. Mr. Brongniart has made many experiments on this subject. The purple of Cassius, mixed with six parts of a flux composed of borax and glass made with silex and lead, produces a very beautiful violet, but liable to turn blue. Red oxide of iron, prepared by means of the nitric acid and subsequent exposure to fire, and mixed with a flux of borax, sand, and a small portion of minium, produces a fine red. Muriat of silver, oxide of zinc, white clay, and the yellow oxide of iron, mixed together without any flux, produce a yellow, light or deep according to the quantity laid on, and equal in beauty to that of the ancients. A powder remains on the surface after baking, which may easily be cleaned off. Blue is produced by oxide of cobalt, with a flux of silex, potash, and lead. To produce a green, blue must be put on one side of the glass, and yellow on the other: or a blue may be mixed with yellow oxide

on. Black is made by a mixture of
with the oxides of manganese and

e bending of the glass, and alteration
e colours, in baking, are particularly
e avoided, and require much care.
um has been recommended for their
ort, but this frequently renders the
white, and cracked in all directions,
ably from the action of the hot sul-
c acid on the alkali in the glass. Mr.
gniart placed his plates of glass, some
em much larger than any ever before
ed, on very smooth plates of earth or
lain unglazed, which he found to an-
extremely well.

auber's Salt. Sulphat of soda.

azing. See Pottery.

mmer. A name occasionally applied
aceous earths.

e. An inspissated jelly made from
arings of hides and other offals, by
g them in water, straining through a
r basket, suffering the impurities to
e, and then boiling it a second time.
rticles should first be digested in lime-
to cleanse them from grease and
hen steeped in water, stirring them
om time to time; and lastly laid in a
to have the water pressed out, before
re put into the boiler. Some recom-
that the water should be kept as
as possible to a boiling heat, without
ing it to enter into ebullition. In this
t is poured into flat frames or moulds,
cut into square pieces when congealed,
fterward dried in a coarse net. It is
improve by age; and that glue is
ed the best, which swells consider-
without dissolving by three or four
nfusion in cold water, and recovers
mer dimensions and properties by

ds or parings of vellum, parchment,
ite leather, make a clear and almost
less glue.

ween two and three years ago, a Mr.
of Hull took out a patent for making
om the tail, fins, and other parts of
ale.

rs. Parmentier and Pelletier made
udicious experiments upon glue made
ones by Mr. Grenet, of which an
t is inserted in the 13th volume of
nales de Chimie, p. 192. Six pounds
ings of bone from the button-mould
were put into a copper boiler with
-four pints of water, and in that state
soak for two days without heat. At
riod the vessel was placed on a fire,
ter the expiration of one hour the
as in a state of ebullition, which was
ed for nine hours. The materials
en left to subside for a night. The
atant fluid, or glue, was by this means
ed clear. It was drawn off with a
. The quantity was fourteen pints,
o pints more were obtained by pressure from the dregs. This clear fluid was afterward concentrated by farther evaporation, then suffered to cool for half an hour, and poured into wooden moulds. In the course of the day it had acquired the consistence of a firm jelly, which was cut into cakes, and dried upon a net. Fourteen days were requisite for this purpose, in the shade, the weather being rainy and damp. The quantity of glue was fifteen ounces and four drachms, with the addition of four drachms more obtained by pressure from the dregs. The dried residue weighed four pounds three ounces, and the loss was thirteen ounces. The glue was therefore one sixth of the weight of the bones.

Ivory raspings, treated in the same manner, afforded upward of one fifth part of their weight of glue.

The dark colour of glue was found to arise from the action of the heat in the last evaporation. These intelligent chemists, adverting to the fact, that isinglass is rendered clear and white by fumigation with sulphur; but at the same time reflecting, that glue, not being composed of thin fibres, was incapable of undergoing this process, as to its interior part, determined to try the solution of sulphurous acid. They prepared a pale jelly by a short ebullition of raspings of bones in the smallest possible quantity of water. To this they added a little water charged with sulphurous acid, and mixed the fluids well together. The experiment succeeded. They proposed as a preliminary operation, to bleach the raspings by the same means, where a pale-coloured glue is required.

These commissaries found, that the glue manufactured by Mr. Grenet was equal in quality to the best made in England, or elsewhere. They could not make glue from horn.

Gluten (Vegetable). If wheat flour be made into a paste, and washed in a large quantity of water, it is separated into three distinct substances; a mucilaginous saccharine matter, which is readily dissolved in the liquor, and may be separated from it by evaporation; starch, which is suspended in the fluid, and subsides to the bottom by repose; and gluten, which remains in the hand, and is tenacious, very ductile, somewhat elastic, and of a brown gray colour. The first of these substances does not essentially differ from other saccharine mucilages. The second, namely the starch, forms a gluey fluid by boiling in water, though it is scarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitric acid, are nearly the same as those of gum and of sugar. It appears to be as much more remote from the saline state than gum, as gum is more remote from that state than sugar.

The vegetable gluten, though it existed before the washing, in the pulverulent form, and has acquired its tenacity and adhesive qualities from the water it has imbibed, is nevertheless totally insoluble in this fluid. It has scarcely any taste. When dry, it is semitransparent, and resembles glue in its colour and appearance. If it be drawn out thin, when first obtained, it may be dried by exposure to the air; but if it be exposed to warmth and moisture while wet, it putrefies like an animal substance. The dried gluten applied to the flame of a candle, crackles, swells, and burns, exactly like a feather or piece of horn. It affords the same products by destructive distillation as animal matters do: is not soluble in alcohol, oils, or ether; and is acted upon by acids and alkalis, when heated. According to Rouelle, it is the same with the caseous substance of milk. See Cheese.

Tessier has made several experiments on the gluten obtainable from different sorts of wheat. He took a pound of the flour of each species, made it into a thick paste, and continued handling it a long time under a slender stream of water, or rather water falling drop by drop on it, till all the starch was washed away from the gluten; which he first weighed, and afterward dried on the cover of a saucepan full of water, kept boiling on the fire. Two sorts of wheat, one a very early kind of bearded wheat, with smooth, red ears, divergent barbs, and grains of the common colour or yellow; the other with white, smooth, beardless ears, and white grains, originally from Philadelphia, afforded each five ounces of gluten. A wheat with red, smooth, bearded, clustered (*grouppés*) ears, a variety of the *bled de miracles*, and another with white, straight bearded, elongated ears, and hard long grains, the *triticum polonicum* L., Polish wheat; afforded, one two ounces, the other two ounces and half. From a wheat with violet coloured, bearded, hairy ears, and hard grains spotted on the germ, originally from Nice and the Canary Islands, Mr. Tessier obtained only four drachms. The other sorts he tried, gave from four ounces to four ounces five drachms.

In general the flour from hard corn afforded less than that from soft. That from the hard was more friable after drying. It loses considerably by drying, so that in this state the greatest product scarcely exceeded two ounces. The diminution of weight was in the inverse ratio of the quantity obtained. By long keeping too it loses weight, so that in four years the different specimens had lost from $\frac{2}{3}$ to $\frac{7}{8}$ of their weight.

Mr. Tessier made some experiments also to try the effect of manure on the production of gluten. He divided a piece of ground, apparently of a uniform soil, into nine plots, each containing two perches, twenty-two feet square, French measure. On one he folded a flock of a hundred and forty sheep and goats about two hours. One he manured with two sacks (*sachées*) of rotten horsedung: one with the same of rotten cowdung: one with sixty-four quarts of urine: one with thirty-six quarts of bullock's blood: one with two sacks of vegetable refuse reduced to mould: one with three bushels of pigeon's dung: and one with the same quantity of dried night soil. The ninth was left without manure. On all these he sowed the same spring wheat, with white, smooth, beardless ears. The patch manured with pigeon's dung yielded the most corn: those with dried soil and urine the next: then those with bullock's blood and horsedung. Those with vegetable refuse and cowdung did not succeed so well; and that without manure produced little more than double the quantity of seed, while some yielded six times as much as was sown. With respect to the gluten, the wheat from the patch manured with urine gave six ounces from a pound of flour; that from the patch with night soil only four ounces; and each of the others five.

From the flour of barley, rye, or oats, no gluten can be extracted as from that of wheat, probably because they contain too small a quantity.

Cadet informs us, that gluten, after it has undergone the acetous fermentation, is soluble in alcohol. That when dissolved in alcohol, and reduced to the consistence of a sirup, it forms a good varnish. That pigments, particularly of the vegetable kind, mixed with at least an equal quantity of this solution, may be applied on wood, glass, or any other substance; to which they adhere strongly, drying quickly without any offensive smell; and that this painting may be washed without injury, if not rubbed too roughly. Acetous acid will furnish a varnish with gluten, but not equal in quality. Gluten with lime makes a very strong and tenacious luting.—*Journ. de l'Institut.—An. de Chim.*

Gneis. The Saxon name of a rock, consisting of mica, felt spar, and quartz, of a slaty, continuous, or fibrous texture, and not granular, as in granite.

Gold is a yellow metal, of much greater specific gravity than any other body in nature, except platina. It is soft, very tough, ductile, and malleable; unalterable and fixed, whether exposed to the atmosphere, or to the strongest heat of furnaces. The most powerful burning mirrors are said to have volatilized it; and it has been driven up in fumes, in the metallic state, by flame urged upon it by a stream of oxigen gas. The electric shock converts it into a purple oxide, as may be seen by transmitting that commotion through gold leaf between two plates of glass; or by causing the explosive spark of three or more square feet of coated glass to fall upon a gilded surface. A strong heat is required to melt it, which does not happen till after ignition. Its colour, when melted, is of a blueish green; and the same colour is exhibited by light transmitted through gold leaf.

The limits of the ductility and malleability of gold are not known, and its tenacity exceeds that of any other metal. A gold wire of one tenth of an inch diameter, requires 500lb. weight to break it.

The method of extending gold used by the gold-beaters, consists in hammering a number of thin-rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold-leaf, it is found, that one grain is made to cover 56$\frac{3}{4}$ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows, that the leaf itself is $\frac{1}{282000}$ part of an inch thick. This, however, is not the limit of the malleability of gold; for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the irregularities of the newest skins, and not over them; and in using the old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains. The wire which is used by the lace-makers is drawn from an ingot of silver, previously gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold used, it is found, by computation, that the covering of gold is only $\frac{1}{12}$ part of the thickness of gold-leaf, though it still is so perfect as to exhibit no cracks when viewed by a microscope.

No acid acts readily upon gold but aqua regia and the oxigenized muriatic acid. The sulphuric acid, distilled from manganese, has some action upon it; as have likewise the pale nitric acid, and the phosphoric acid when boiling. Chromic acid added to the muriatic enables it to dissolve gold.

The small degree of concentration of which the oxigenized muriatic acid is susceptible, and the imperfect action of the latter acids, render aqua regia the most convenient solvent for this metal.

When gold is immersed in aqua regia, an effervescence takes place with the escape of air, which has not been examined; the solution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine crystals of a topaz colour are obtained. The gold is precipitated from its solvent by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalis exhibit the same appearance; but an excess of alkali redissolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali appears to be a true oxide, and is soluble in the sulphuric, nitric, and muriatic acids; from which, however, it separates by standing, or by evaporation of the acids. Gallic acid precipitates gold of a reddish colour, very soluble in the nitric acid, to which it communicates a fine blue colour.

Ammonia precipitates the solution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, possesses the property of detonating with a very considerable noise, when gently heated. It is known by the name of fulminating gold. The presence of ammonia is necessary to give the fulminating property to the precipitate of gold; and it will be produced by precipitating it with fixed alkali from an aqua regia previously made by adding sal ammoniac to nitric acid; or by precipitating the gold from pure aqua regia, by means of sal ammonia, instead of the ammonia alone. The fulminating gold weighs one fourth more than the gold made use of. A considerable degree of precaution is necessary in preparing this substance. It ought not to be dried but in the open air, at a distance from a fire, because a very gentle heat may cause it to explode. Several fatal accidents have arisen from its explosion, in consequence of the friction of ground stoppers in bottles containing this substance, of which a small portion remained in the neck.

Fulminating gold, when exposed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into an oxide at the same time that ammoniacal gas was disengaged. From this dangerous experiment it is ascertained, that fulminating gold consists of oxide of gold combined with ammonia. The same eminent philosopher caused fulminating gold to explode in copper vessels. Nitrogen gas was disengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the ammonia was decomposed; that the nitrogen, suddenly assuming the elastic state, caused the explosion, while the oxigen of the oxide united with the hidrogen of the alkali, and formed the water.

This satisfactory theory was still farther confirmed by the decomposition of fulminating gold,. which takes place in consequence of the action of the concentrated sulphuric acid, of melted sulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its ammonia.

Sulphurets precipitate gold from its solvent, the alkali uniting with the acid, and the gold falling down combined with the sulphur; of which, however, it may be deprived by moderate heat.

Most metallic substances precipitate gold from aqua regia: lead, iron, and silver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state; bismuth, zinc, and mercury, likewise precipitate it. A plate of tin, immersed in a solution of gold, affords a purple powder, called the purple powder of Cassius, which is used to paint in enamel. There are various methods of managing this process. That described by Macquer consists in dissolving tin by very small portions at a time, without heat, in an aqua regia composed of two parts of nitric and one of muriatic acid, previously weakened with water equal in weight to both the acids. The first small portion of tin must be suffered to be entirely dissolved before a second is added. This addition must be continued till the acid has acquired a yellow colour, and scarcely acts at all upon the tin last added.

On the other hand, the purest gold must be dissolved in an aqua regia composed of three parts of nitric, and one of muriatic acid. This solution may be made, as expeditiously as the operator chooses, by the assistance of the heat of a sand bath.

The solution of tin must then be largely diluted, as for example, with one hundred parts of distilled water; and a small quantity of this may then be assayed, by separating it in two parts, and diluting one of the parts still farther. Upon trial of both, by letting fall a drop of the solution of gold into each, it will be seen which affords the most beautiful purple precipitate. The whole of the solution of tin must accordingly be altered, if necessary, by adding more water. Pour into this solution, in a large glass or earthen vessel, nearly half as much of the solution of gold as it contains of solution of tin, stirring the mixture with a glass stick. In a short time the liquor will become of a beautiful red colour, which will gradually disappear on the subsidence of the precipitate. By adding a small quantity of the solution of tin, it will be seen whether the whole of the gold is precipitated. The clear liquor must then be decanted, and the precipitate washed. It consists of metallic gold and oxide of tin at a maximum in combination, and is the only known substance which has the property of communicating a purple colour to glass. This purple powder is perfectly soluble in ammonia. Nitric acid boiled on it brightens it to a tint approaching that of cinnabar.

The difficulties attending the preparation of this article appear to depend on the state of the tin. If the solution of this metal be made with heat and rapidity, it becomes too much oxided to adhere to the acid, or to precipitate the gold; and the combination of the two metals, which falls down, varies in colour according as this term is approached. These are the chief circumstances; but there is no doubt, that a complete examination of the process would indicate others worthy of notice.

Ether, naphtha, and essential oils, take gold from its solvent, and form liquors which have been called potable gold. The gold which is precipitated by evaporation of these fluids, or by the addition of sulphat of iron to the solution of gold, is of the utmost purity.

In the dry way, gold resists the action of neutral salts, more especially nitre, which deflagrates with the imperfect metals. Nitre, however, does not afford an expeditious way of purifying gold, because this metal in some measure protects and covers the alloys from its action. It is remarked, that borax, used as a flux with gold, renders it paler; and that this alteration of colour disappears by the addition of nitre or common salt. As the acid of borax forms a compound with gold, which falls to the bottom when this acid is added to the metal in solution, it is probable, that the paleness produced by borax may arise from the combination of a small portion of its acid with the gold, which might be driven off by a continuance of the heat, and united by stronger affinity with the alkali of the nitre, or of the common salt, in proportion as their acids are dissipated by heat.

Earths and alkalis do not act on gold in the dry way. Sulphur, which combines with most metals, has no effect on this. A process, called dry parting, is grounded on this property; and is more especially used in separating silver from gold, when the quantity of the latter metal is too small to answer the expense of dissolving the larger mass of silver in nitric acid. For this purpose, the mixed metal is fused, and flowers of sulphur thrown on its surface. These combine with the silver in the form of a black scoria, while the gold remains at the bottom in its metallic state. The operation of dry parting does not leave the gold in a state of purity; because the last portions of silver are defended from the action of the sulphur. But when the quantity of silver is thus diminished, the operation of parting with aqua fortis, or nitric acid, may be advantageously used.

Sulphuret of potash dissolves gold in the dry way. Equal parts of sulphur and potash are hastily fused with one fourth of a part of gold-leaf. This combination is soluble in water, with which it forms a yellowish green solution. By the addition of an acid, the gold is thrown down in combination with the sulphur, of which it may be deprived by heat.

Most metals unite with gold by fusion. With silver it forms a compound, which is paler in proportion to the quantity of silver added. It is remarkable, that a certain proportion, for example a fifth part, renders it greenish. From this circumstance, as well as from that of a considerable proportion of these metals separating from each other by fusion, in consequence of their different specific gravities, when their proportions do not greatly differ, it should seem, that their union is little more than a mere mixture without combination; for, as gold-leaf transmits the green rays of light, it will easily follow, that particles of silver, enveloped in particles of gold, will reflect a green instead of a white light.

A strong heat is necessary to combine platina with gold: it greatly alters the co-

f the gold, if its weight exceed the
eventh part of the mass. Mr. Fran-
however informs us, that six parts of
nd one of malleable platina, produce
l of a beautiful colour, great mallea-
susceptible of a fine polish, and more
rable than gold itself. It does not
affect the ductility. The Spanish
ry has prohibited the exportation of
from America, lest it should be used
lterating gold; but this does not ap-
o be a danger which need be feared,
emistry has long been in possession
eral simple and expeditious methods
ecting this fraud, which besides is
t to the sight when the quantity of
ment is considerable. It may be
oned likewise, whether the value of
would not soon equal that of gold,
roperties and uses were better known
ety. Gold made standard by platina,
ammered, is tolerably elastic.

rcury is strongly disposed to unite
old, in all proportions with which it
an amalgam: this, like other amal-
is softer the larger the proportion of
ry. It softens and liquefies by heat,
ystallizes by cooling.

d unites with gold, and considerably
rs its ductility, ¼ of a grain to an
rendering it completely brittle. Cop-
enders gold less ductile, harder, more
e, and of a deeper colour. This is the
addition in coin, and other articles
in society. Tin renders it brittle in
ortion to its quantity; but it is a com-
error of chemical writers to say, that
lightest addition is sufficient for this pur-
When alloyed with tin however it will
ear a red heat. With iron it forms a
mixture, which obeys the magnet. This
is very hard, and is said to be much
ior to steel for the fabrication of
g instruments. Bismuth renders gold
e and brittle; as do likewise nickel,
anese, arsenic, and antimony. Zinc
uces the same effect; and, when equal
eight to the gold, a metal of a fine
is produced, which is said to be well
ted to form the mirrors of reflecting
opes, on account of the fine polish it
ceptible of, and its not being subject
rnish. The alloys of gold with mo-
ena are not known. It could not be
d with tungsten, on account of the in-
ility of this last substance. Mr. Hat-
gives the following order of different
ls arranged as they diminish the duc-
of gold: Bismuth, lead, antimony,
ic, zinc, cobalt, manganese, nickel, tin,
platina, copper, silver. The first
e were nearly equal in effect; and the
na was not quite pure.

r the purposes of coin Mr. Hatchett
iders an alloy of equal parts of silver
copper as to be preferred, and copper
e as preferable to silver alone.

Gold is found mostly in the metallic state, though generally alloyed with silver, copper, iron, or all three. It is found either in separate lumps, or visible grains, among the sands of rivers in many parts of Europe and elsewhere. The quantity is for the most part insufficient to pay the cost of separating it; but it is thought to be more universally diffused in sands and earths than any other metal, except iron. The greatest quantity of gold is imported into Europe from South America. Some is brought from the East Indian islands and China, and some from the coast of Africa. The principal gold mines in Europe are those of Hungary. Some sands afford gold by simple washing; the heavy metallic particles subsiding soonest: but when it is bedded in earths or stones, these substances are pounded, and boiled with one tenth of their weight of mercury together with water. The mercury, after a certain time, absorbs the gold, and may be separated by pressure through leathern bags, and subsequent distillation. Or otherwise, if the sand be heated red-hot, and quenched in water several times, for the purpose of cracking and dividing it, and the whole be then melted into glass, with twice its weight of the oxide of lead called litharge, and charcoal powder be then added, the lead will be revived in the metallic state, and will carry the gold along with it. By exposure to a proper degree of heat, with access of air, the lead may again be converted into litharge, and the gold will be left pure. This last operation is, in fact, a method of assaying sands which contain gold, rather than of obtaining it from them in the large way.

Gold is also found in certain martial pyrites in Sweden and elsewhere; from which it may be extracted by torrefaction or burning of the sulphur, and subsequent digestion in aqua regia.

To obtain gold in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation.

After gold has passed the cupel, it may still contain either of the other perfect metals, platina or silver. The former is seldom suspected; the latter is separated by the operations called quartation and parting. For all these operations see **Assay**.

The quantity of alloy is never considered as part of the value of metals which contain either gold or silver. In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real or merely proportional, like the assayer's weights; and the pure gold is called fine. Thus, if gold be said to be twenty-three-carats fine, it is to be understood that, in a mass weighing twenty-four carats, the quantity of pure gold amounts to twenty-three carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality or fineness by the touch. This is a method of comparing the colour and other properties of a minute portion of the metal, with those of certain small bars whose composition is known. These bars are called touch-needles; and they are rubbed upon the black basaltes, which, for that reason, is called the touchstone. Black flint, or pottery, will serve the same purpose. Sets of golden needles may consist of pure gold; pure gold 23½ carats with half a carat silver; 23 carats gold with one carat silver; 22½ carats gold with 1½ carat silver, and so forth, till the silver amounts to four carats, after which, the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition, consisting either of equal parts silver and copper, or such proportions as the occasions of business require.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information, which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touchstone by the metal under examination with that produced by his needle, but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aqua fortis, which will affect them very differently, if they be not similar compositions; or the stone itself may be made red-hot by the fire or by the blowpipe, if thin black pottery be used, in which case the phenomena of oxidation will differ according to the nature and quantity of the alloy.

Gold ores may be assayed in the moist way by pounding them very fine, weighing a determinate portion, and attempting their solution in nitric acid, which will dissolve the matrix if it consist of calcareous earth; or if it be sulphat of lime the powder may be digested in aqua regia as long as any metallic substance is taken up; after which the gold may be precipitated by an addition of sulphat of iron, which will cause it to fall down in the metallic state.

The principal use of gold is, as the medium of exchange in coin, for which it has been chosen to occupy the first place, on account of its scarcity, its great weight, and its not being subject to tarnish. The gold coins of Great Britain contain eleven parts of gold, and one of copper.

Gold is likewise used in gilding. See GILDING.

The other uses of gold, in laces, &c. are sufficiently known.

GOULARD'S EXTRACT. A saturated solution of acetat of lead. See LEAD.

GRANITE, a compound rock, consisting of quartz, feltspar, and mica, and occasionally hornblende, steatites, garnet, or basaltes. It is seen among the paving stones of London, consisting of quartz of a white colour, a reddish feltspar, and black or violet shoerl. The parts of granite are so well adapted to each other, that Mr. de Saussure concludes it to have been the product of confused crystallization.

The granite is called moorstone in English. The proportion and size of its component parts are extremely variable, as well as their colour. The quartz, feltspar, and mica, constitute the hardest sort of granite, the most anciently known. That into which the shoerl enters is more subject to decomposition. The granite never has any particular texture or regular form, but consists of enormous shapeless masses, of great hardness.

In the finer granites, the quartz is transparent; in others, generally white or gray, violet or brown. The feltspar, white, yellow, red, green, or black, is generally the most copious ingredient. The mica is also gray, brown, yellow, green, red, violet, or black, and is commonly least copious. The shoerl is generally black, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the spar or shoerl. The red granites consist commonly of white quartz, red feltspar, and gray mica. The gray, of white quartz, gray or violet feltspar, and black mica. The black commonly contain shoerl instead of feltspar; and the green commonly contain green quartz.

The globular granite of Casica is composed of crystals of hornblende, feltspar, quartz, and mica; in which are immersed spheroids, an inch and a half or two inches in diameter, composed of concentric alternate coats of quartz and hornblende.

If granite be exposed to flame urged by a blowpipe, its different concretions separate from each other. In a crucible, Mr. Gerhard found the feltspar of a piece of granite melted into a transparent glass; under it the mica lay in the form of a black slag, and the quartz remained unaltered. But when all three were powdered and mixed, it melted somewhat better; yet still the quartz may be distinguished by the help of a lens. This well explains why small white grains are frequently found in lavas. The experiments of Messrs. d'Arcet and Saussure perfectly coincide on this subject.

The mixture of mica prevents the silex or quartz from cracking or splitting: and

e its infusibility and advantageous .use
rnaces.

he granitone, mentioned by Ferber, in
Letters from Italy, is a stone composed
eltspar and mica. A substance of this
, which moulders by being long ex-
d to the air, is found in Findland: it
id to contain sometimes saltpetre, and
etimes common salt. It is there called
kivi.

RANULATION. The method of dividing
llic substances into grains or small
icles, in order to facilitate their combi-
n with other substances, and some-
s for the purpose of readily subdividing
by weight.

the entire metals cannot be pulverised,
use not sufficiently brittle, and as the
anical subdivision of their parts is at-
d with considerable labour and diffi-
, recourse is generally had to fusion;
he subdivision is made at the instant of
elation. This is done either by pouring
nelted metal into water, or by agitating
a box until the moment of congelation,
hich instant the whole becomes con-
d into a powder. These different pro-
s are preferable the one to the other,
ding to the nature of the metallic sub-
e. Thus gold, silver, copper, or iron,
ot be granulated by agitation; not only
use the great heat required for their
n would be productive of inconve-
ce, but likewise because they possess a
t degree of tenacity, when heated al-
to melting. Lead, tin, and brass, on
contrary, are very brittle when heated,
are therefore best granulated in this

rious contrivances are used to prevent
er, and insure success, in the several
factories that require granulation.
er is granulated for making brass, by
ng it through a perforated ladle into
ered vessel of water with a moveable
bottom. A compound metal, consist-
hiefly of lead, is poured into water
gh a perforated vessel of another
for making small shot, in which the
t above the surface of the fluid is said
uire particular adjustment. But in a
anufactory of this kind, we understand
he height is very great, being upward
hundred feet.

AVITY, a term used by physical
s to denote the cause, by which all
move toward each other, unless pre-
l by some other force or obstacle. Its
on the motions of the celestial bodies
plained by astronomical writers. The
familiar effect, and that which con-
y obtrudes itself on our notice, is the
t of bodies, or their tendency toward
ntre of the earth. Though the phe-
a arising from the weight of bodies
he basis of a separate science, called
nics, yet they are of great consequence to the chemist. It has not been ascertained, or rendered probable, that gravity is a secondary property of matter; that is to say, that it flows from any of the other known original properties. Sir Isaac Newton, however, was of opinion, that our reasonings on the subject might be simplified, by supposing it to depend on a prodigiously elastic and rare fluid, by him called ether, and assumed to possess an increasing degree of condensation, in parts of space more and more remote from the various masses of matter. According to this doctrine, a falling body moves, because it is pressed toward the rarer parts of this extended fluid. We shall leave this theory to its merits, as being neither very perspicuous, nor much related to our subject. Bergman and others have considered the chemical and cohesive attractions to be one and the same with the attraction of gravity; but modified in its laws, by variations in the masses, densities, and distances of the particles of bodies. Many difficulties appear at first sight to offer themselves against this supposition. But in truth it cannot be examined at first sight; and requires to be submitted to the rigour of mathematical investigation. I do not know that any attempt of this nature has been made. See ATTRACTION.

GRAVITY (SPECIFIC). Boyle is among the first of our philosophers, who suggested the advantage, that chemistry and mineralogy might derive from an attention to the specific gravities of bodies. Much advantage may indeed be derived from this property in the general determination of the classes of minerals, and the purity of some metallic bodies; and it is very probable, that an attention to the specific gravities, capacities for heat, fusibilities, volatilities, laws of crystallization, elasticity, hardness, tenacity, malleability, and some other obvious specific properties of bodies, may produce a more intimate acquaintance with the mutual actions of their particles, than any we have hitherto acquired.

Annexed to this article is a table of specific gravities. In compiling this, I had Brisson's table at the end of Lavoisier's Traité Elémentaire de Chimie, and Muschenbroek's large table in his Cours de Physique, before me. Some few specific gravities are from other authors, or from experiment. It appeared useless to carry it to more than four places of figures, as the temperatures were not noted; and the various specimens of the same substance often differ in the third figure. These assertions may be thought to require proof: for which reason I shall observe, that, by experiment, I find that the fifth figure changes in water at every three degrees of Fahrenheit's thermometer; that lead, tin, and probably all other metals, though cast out of the same fusion, will vary in their specific gravities in the third figure, from circumstances not yet determined, but most likely from the cooling, as is seen in the hardening of steel; that salts, and other artificial preparations, retain more or less of the solvent they were separated from, according to the temperature at which the crystallization was effected; and that all parts of organized substances not only differ according to the place of their production, their age, and other circumstances, but likewise from their dryness, moisture, and manner of preservation.

The specific gravity of solids is determined by weighing them first in air, and then in water. The loss of weight, arising from the action of the water, is equal to that of a mass of the fluid possessing the same dimensions as the solid itself. Whence it is easy to construct a general table of specific gravities, by reducing the proportion of the absolute weight to the loss sustained by immersion, into terms of which that expressing water shall be unity. If the solid be so light as to float upon water, it is convenient to attach to it a heavier body sufficient to cause it to sink, but the weight of which in water must be added in computing the loss. The specific gravity of fluids is ascertained by weighing a known body immersed in them. For the loss by immersion will accurately show the weight of the same bulk of the fluid; and, consequently, the proportion of these several quantities to the loss the same solid sustained in water, being reduced as in the other case to the common standard of unity, will exhibit the specific gravity. Other methods are likewise used in experiments with fluids. Thus equal bulks of different fluids may be weighed by filling a small bottle with a ground stopper with each respectively, and from their several weights the weight of the bottle and stopper must be deducted. Or otherwise, the instrument called the hydrometer may be used. See HYDROMETER. This possesses the advantage of portability, speed, and a degree of accuracy not easily obtained by the use of ordinary balances.

A TABLE

Shewing the Specific Gravity of Metals and other bodies to Rain Water, and the Weight of a Cubic Inch of each in Parts of a Pound Averdupoise.

Bodies.	Sp. Gravity.	W. lb. Averd.	Bodies.	Sp. Gravity.	W. lb. Averd.
Pure gold cast	19258	0·71036	Zinc	7191	0·26009
——— hammered	19362	0·70030	Antimony	6702	0.24240
Standard gold cast	17486	0.63250	Manganese	6850	0·24776
——— hammered	17589	0·63618	Wolfran	17600	0·63657
Pure silver cast	10474	0·37790	Diamond	3251	0·11759
——— hammered	10511	0·38017	Ruby	4283	0·15491
Standard silver in coin	10391	0·37580	—— Spinell	3760	0·13600
Crude platina in grains	15602	0·56431	Topaz, oriental	4011	0·14507
Platina purified and fused	19500	0·70530	——— Brazillian	3536	0·11718
——— hammered	20377	0·73557	——— Saxon	3564	0·12891
——— drawn into wire	21042	0·76107	Sapphire, oriental	3994	0·14446
——— laminated	22069	0·79821	Emerald	2775	0·10037
Mercury	13568	0·49074	Adamantine sapar	4180	0·15118
Lead fused	11352	0·40965	Rock crystal from Madagascar	2653	0·09596
Copper fused	7788	0·28168	Quartz	2654	0·09599
——— drawn into wire	8878	0·32111	Agate	2590	0·09368
Brass cast	8396	9·30367	Onyx	2376	0·09537
—— in wire	8544	0·30903	Muscovy talc	2792	0·10098
Iron cast	7207	0·26067	Common slate	2672	0·09664
—— bar	7788	0.28168	Calcareous spar	2715	0·09820
Steel, soft, and not hammered	7810	0·28356	Alabaster	2730	0·09874
—— hardened	7816	0·28270	White marble	2716	0·09823
Tin, English, fused	7291	0·26371	Limestones, from	1386	0·05113
—— hammered	7299	0·26400	——— to	2390	0·08644
Malacca tin fused	7296	0·26382	Ponderous spar	4474	0·16182
——— hammered	7306	0·26486	Fluor spar	3180	0·11502
Bismuth	9823	0·35529	Pumice-stone	914	0·03306
Nickel	8660	0·31323	Green glass	2620	0·09476
Arsenic, the metal	5763	0·20844	English crown glass	2520	0·09115
Cobalt	7812	0·28255	White flint glass, English	3290	0·11900

A TABLE

wing the Specific Gravity of Metals and other Bodies to Rain Water, and the Weight of a Cubic Inch of each, in Parts of a Pound Averdupoise.

(Continued).

Bodies.	Sp. Gravity.	W. lb. Averd.	Bodies.	Sp. Gravity.	W. lb. Averd.
ner piece -	3216	0·11632	Acetous - -	866	[illegible]
e flint glass for romatic uses	3437	0·12431	Concentrated sulph. acid	2125	[illegible]
e glass, French -	2892	0·10460	——— nitric acid	1580	[illegible]
of S. Gobin -	2488	0·090[illegible]	——— muriatic acid	1194	[illegible]
tone - -	1990	0·07198	Fluor acid - -	1500	[illegible]
phorus - -	1714	0·06199	Oil of olives - -	915	0·03309
w amber -	1078	0·3899	— of sweet almonds -	917	0·03316
led water -	1000	0·03617	Linseed oil - -	940	0·03400
vater - -	1026	0·03711	Naphtha - -	708	0·02561
non spirit of wine	837	0·03027	Gum elastic - -	393	0·03375
t of wine, the pu- t that can be had mere distillation	820	0·2960	Camphor - -	989	0·03577
			Yellow wax - -	965	0·03490
			White ditto - -	969	0·03505
			Spermaceti - -	943	0·03411
uric ether -	739	0·02673	Tallow - -	942	0·03407
ous - -	909	0·03288	Heart of oak - -	1170	0·04232
ne - -	730	0·02640	Cork - -	240	0·01868

or the specific gravities of different ds of elastic fluids, see the table at the of the article Gas.

Great Work. A process for converting ransmuting metallic substances into gold. emistry possesses no facts tending to w, that any of the metals are convertible o each other; neither do we know of y, which evince the absurdity of suppo- g such a conversion to be possible. The hemists were doubtless misled, either by desire of profit, or by the effect of a delusive phenomena, or specious gene- reasonings, adapted to the infant state chemistry. These hopes, these facts, and se reasonings, have not yet entirely lost eir force with the ignorant. But the ongest terms are insufficient to describe deplore the situation of those, who may ect their exertions to a pursuit so much culated to agitate and distress the mind, d possessing so little probability of success, the great work of the alchemists.

Gritt-stone. A stone consisting of nd agglutinated together. Its properties fer according to the fineness or coarseness its grain, and the firmness of its texture. me kinds are pounded, to convert them ain into sand; others are used for build- g, others for grinding edge tools, and hers for filtering water.

Growan. A Cornish mine term used to note a compound stone, consisting of hite clay mixed with mica, quartz, and of particular texture.

Guaiacum. A resinous substance exud- g from incisions in a tree, the wood of hich is known by the name of *lignum vitæ*. xternally it is of a green hue, tinged with d; but when powdered is gray. This owder changes to a green when acted upon by air and light. The powder has a pleasant balsamic smell and not much taste, though when swallowed it excites a burning sensation in the throat. When heated it melts, and diffuses a pungent aromatic smell. Its specific gravity is 1·2289. Exposed to distillation, 100 grains afforded acidulated water 5·5; thick brown oil, becoming turbid on cooling, 24·5; thin empyreumatic oil, 30; coal, 30·5; mixed gasses, consisting chiefly of carbonic acid and carburetted hidrogen, 9. The coal yielded 3 grains of lime.

From the action of different solvents, Mr. Brandé observes, it differs from resins in affording a portion of vegetable extract; by being converted into a more perfect resin by the addition of oxigen, which may be imparted to it by nitric acid not used in too large proportion; by yielding oxalic acid; and by the quantity of charcoal and lime obtained from it.

One hundred grains of guaiacum give out about nine to water, and about ninety-five to alcohol. Ether does not dissolve so much as alcohol. It is soluble in alkalis, and their carbonats. Two ounces of a saturated solution of caustic potash took up 65 grains; the same quantity of liquid ammonia 25 grains.

Formerly guaiacum was much commended in siphilis and other complaints; at present it is used chiefly in rheumatism, dissolved in liquid ammonia.—*Phil. Trans.*

Guano. A substance found on many of the small islands in the South Sea, which are the resort of numerous flocks of birds, particularly of the ardea and phœnicopteros genus. It is dug from beds 50 or 60 feet thick, and used as a valuable manure in Peru, chiefly for Indian corn. It is of a dirty yellow colour, nearly insipid to the taste, but has a powerful smell partaking of castor and valerian. According to the analysis of Fourcroy and Vauquelin, about one fourth of it is uric acid partly saturated with ammonia and lime. It contains likewise oxalic acid, partly saturated with ammonia and potash; phosphoric acid combined with the same bases and with lime; small quantities of sulphat and muriat of potash and ammonia; a small portion of fat matter; and sand, partly quartzose, partly ferruginous.—*An. de Chim.*

GUHR. A loose calcareous earth found in the clefts or cavities of rocks, mostly of a white colour, but sometimes red or yellow, from a mixture of clay or ochre.

GUM. The mucilage of vegetables. It is usually transparent, more or less brittle when dry, though difficultly pulverable; of an insipid, or slightly saccharine taste; soluble in, or capable of combining with water in all proportions, to which it gives a gluey adhesive consistence in proportion as its quantity is greater. It is separable, or coagulates by the action of weak acids; insoluble in alcohol, or in oil; and capable of the acid fermentation, when diluted with water. The destructive action of fire causes it to emit much carbonic acid, and converts it into coal without exhibiting any flame. Distillation affords water, acid, a small quantity of oil, a small quantity of ammonia, and much coal.

These are the leading properties of gums, rightly so called; but the inaccurate custom of former times applied the term gum to all concrete vegetable juices, so that in common we hear of gum copal, gum sahdarach, and other gums, which are either pure resins, or mixtures of resins with the vegetable mucilage.

The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry-tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elsewhere. This forms a clear transparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic: the pieces are larger and clearer; and it seems to communicate a higher degree of the adhesive quality to water. It is much used by calico-printers and others. The first sort of gums are frequently sold by this name, but may be known by their darker colour.—4. Gum Adragant or Tragacanth. It is obtained from a small plant of the same name growing in Syria, and other eastern parts. It comes to us in small white contorted pieces resembling worms. It is usually dearer than other gums, and forms a thicker jelly with water.

Mr. Willis has found, that the root of the common blue bell, hyacinthus non scriptus, dried and powdered, affords a mucilage possessing all the qualities of that from gum arabic. The roots of the vernal squill, white lily, and orchis, equally yield mucilage. Lord Dundonald has extracted a mucilage also from lichens. See LICHEN.

Gums treated with nitric acid afford the acid of sugar.

GUM (ELASTIC). See CAOUTCHOUC.

GUM RESIN. Vegetable juices consisting of a mixture of gum and resin, or essential oil. These parts do not appear to be in a state of combination, for no menstruum completely dissolves the whole. If water be applied, by the assistance of trituration, the gummy matter is completely dissolved; and the resin, being suspended in a state of minute division, exhibits the emulsive form. Alcohol in like manner takes up the resinous matter; and the gum, for similar reasons, gives opacity to the fluid.

Macquer observes, that, since the gum resins consist of principles not truly combined with each other, the compound must be opake; and he therefore lays it down as a rule, that all transparent vegetable concretes are either pure gums, or pure resins.

The principal gum resins are frankincense, scammony, assafœtida, aloes, gum ammoniac, and gamboge.

GUNPOWDER. This well-known powder is composed of seventy-five parts, by weight, of nitre, sixteen of charcoal, and nine of sulphur, intimately blended together by long pounding in wooden mortars, with a small quantity of water. This proportion of the materials is the most effectual. But the variations of strength in different samples of gunpowder are generally occasioned by the more or less intimate division and mixture of the parts. The reason of this may be easily deduced from the consideration, that nitre does not detonate until in contact with inflammable matter; whence the whole detonation will be more speedy, the more numerous the surfaces of contact. The same cause demands, that the ingredients should be very pure, because the mixture of foreign matter not only diminishes the quantity of effective ingredients which it represents, but likewise prevents the contacts by its interposition.

The nitre of the third boiling is usually chosen for making gunpowder, and the charcoal of light woods is preferred to that of those which are heavier, most probably because this last, being harder, is less pulverable. An improvement in the method of making the charcoal has lately been adopted, which consists in putting the wood, cut into pieces about nine inches long, into an iron cylinder laid horizontally, closed at one end, and furnished with small pipes at the other, that the pyroligneous acid and carburetted hidrogen may escape, and thus exposed to the heat of a fire made underneath. It is said, this charcoal improves the strength of gunpowder so much, that only two thirds of the old charge of gunpowder for ordnance are now used in our navy. The requisite pounding of the materials is performed in the large way by a

in which wooden mortars are dis-
in rows, and in each of which a pestle
ved by the arbor of a water-wheel:
ecessary to moisten the mixture from
o time with water, which serves to
nt its being dissipated in the pulveru-
orm, and likewise obviates the danger
plosion from the heat occasioned by
lows. Twelve hours pounding is in
al required to complete the mixture;
hen this is done, the gunpowder is in
ade, and only requires to be dried to
r it fit for use.

ferent modes of trying gunpowder
been adopted. A ready one is, to lay
three small heaps on separate pieces
ting paper, and fire one with a red
ire. If the flame ascend quickly, with
l report, leaving the paper free from
specks, and not burnt into holes;
the same time the other heaps be
ed by the sparks, the powder is well
and the ingredients are good.

re are experiments which seem to
that gunpowder is stronger in the fine
able form, than when granulated.
ppears to be true with regard to gun-
er originally made, or pounded till it
es that form; but it may be doubted,
er it have any foundation in general,
eed that the greater strength depends
upon this form. The granulation of
owder is performed by placing the
while in the form of a stiff paste, in a
sieve, covering it with a board, and
ing the whole: by this means it is cut
mall grains or parts, which, when of
isite dryness, may be rendered smooth
ssy by rolling them in a cylindrical
or cask. Gunpowder in this form
fire more speedily than if it be after-
reduced to powder, as may be easily
nted for from the circumstance, that
flammation is more speedily propagated through the interstices of the grains. But the process of granulation does itself, in all probability, weaken the gunpowder, in the same manner as it is weakened by suffering it to become damp; for, in this last case, the nitre, which is the only soluble ingredient, suffers a partial solution in the water, and a separation in crystals of greater or less magnitude; and accordingly the surfaces of contact are rendered less numerous.

The detonation of gunpowder has been always an interesting problem in chemistry. Numerous theories have been offered, to account for this striking fact. But it is now very well settled, that the nitric acid is decomposed by the heat of ignition; that its oxigen combines with the charcoal, and forms carbonic acid, while the nitrogen, or other component part, with steam from the water of crystallization, becomes disengaged in the elastic form. Berthollet found, that the elastic product, afforded by the detonation of gunpowder, consisted of two parts nitrogen gas, and one carbonic acid gas. The sudden extrication and expansion of these airs are the cause of the effects of gunpowder.

The muriat afforded by combining the oxigenized muriatic acid and potash, affords gunpowder of much greater strength than the common nitre, but too dangerous for use. For the method of making this salt, see ACID (MURIATIC, OXIGENIZED).

GYPSEOUS EARTH, OR GYPSUM. A combination of lime with sulphuric acid. As this salt requires about five hundred times its weight of water to dissolve it, the earlier chemists reckon it among the earths. But as its component parts and properties are now well known, gypsum is at present considered as a salt by chemists. See ACID (SULPHURIC).

H.

R. Mr. Vauquelin boiled hairs in wa-
for several days without being able
olve them; yet the water contained a
uantity of animal matter. He effected
olution, however, without any alte-
in Papin's digester, by regulating
gree of heat. In this operation, if the
carried beyond a certain point, the
ill be wholly or partly decomposed;
own by the ammonia, carbonic acid,
npyreumatic fetid oil, which is found
solution, to which the oil imparts a
ellow colour. He likewise dissolved
water, containing merely 4 per cent.
stic potash.

n numerous experiments Mr. Vau-
infers, that black hair is formed of
ifferent substances, namely:
an animal matter, which constitutes the greater part; 2. A white concrete oil in small quantity; 3. Another oil of a grayish green colour, more abundant than the former; 4. Iron, the state of which in the hair is uncertain; 5. A few particles of oxide of manganese; 6. Phosphat of lime; 7. Carbonat of lime, in very small quantity; 8. Silex, in a conspicuous quantity; 9. Lastly, a considerably quantity of sulphur.

The same experiments show, that red hair differs from black only in containing a red oil instead of a blackish green oil: and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphat of magnesia, which is not found in them.

From this knowledge of the nature of the constituent principles of hair, Mr. Vauquelin thinks we may account for the various colours that distinguish it. According to him, the black colour will be owing to a black and as it were bituminous oil, and perhaps likewise to a combination of sulphur with iron. Carroty and flaxen hair will be occasioned by the presence of a red or yellow oil, which when deepest, and mixed with a small quantity of brown oil, produces the dark red hair. Lastly, white hair is owing to the absence of the black oil and sulphuretted iron. He believes, that in the carroty and flaxen, as well as in the white, there is always an excess of sulphur; since, on the application of white metallic oxides to them, such as those of mercury, lead, bismuth, &c., they grow black very speedily. The manner in which this substance acts on metallic bodies leads him to suspect, that it is combined with hidrogen.

Mr. Vauquelin attempts next to explain the whiteness produced suddenly in the hair of persons struck with profound grief or great terror. We must suppose, he says, that in these critical moments, when nature undergoes a revolution, and the natural functions are in consequence suspended or changed, some agent is developed in the animal œconomy, which, passing into the hair, decomposes the colouring matter. But what agent can produce this effect? The acids alone appear capable of it; at least this is certain, black hair immersed some time in them, particularly in the oxigenized muriatic, whitens very evidently.

The rapid production of an acid in the animal œconomy does not appear to him impossible, considering that a fit of anger in men, as well as in inferior animals, is sufficient to change the nature of certain of their fluids, and render them venomous; and seeing that the galvanic fluid frequently occasions the formation of an acid or an alkali, according to circumstances, both in animal and vegetable substances. As to the whiteness produced gradually by age, he ascribes this to a deficient secretion of colouring matter.

In hair, exclusive of the animal matter that forms its basis, and which is the same in all, there is a colouring matter, that may be separated from it, and the hue of which varies according to the kind of hair of which it constitutes the distinction. To this fatty substance Mr. Vauquelin attributes the suppleness, elasticity, and unalterability, which exist in hair: to this substance too is owing no doubt the property it has of burning so rapidly, and that of forming soap abundantly with alkalis.

After having treated of the colouring matters of hair, he endeavours to characterize the animal matter, that forms its substance, and this appears to him to be mucus.

This humour, which is secreted in the nostrils, mouth, œsophagus, trachea, stomach, bladder, and all the cavities of the body in general, imparts to water a considerable viscosity, and the property of frothing greatly on agitation. In certain species of coryza it may be drawn out into threads like the substance of silk, or the web of the spider; retains its transparency and flexibility after desiccation; and Mr. Vauquelin has no doubt, that it would perfectly resemble hair, if it contained a little oil.

The epidermis, nails, horns, wool, and hair of beasts in general, are formed of the same animal mucus, and equally include in their composition a certain quantity of oil, which imparts to them the suppleness and elasticity they are known to possess.

Mr. Vauquelin has begun an examination of the humour of the *plica polonica*, with which he was furnished by Mr. Alibert, physician to St. Lewis's Hospital; and from what he has done, he is led to believe, that it is of the same nature as the substance of the hair, but secreted in greater quantity than the formation of the hair requires.—*An. de Chim.*

HARDNESS may be defined as that property of bodies by which they resist indentation. It differs from tenacity, which is the opposite quality to frangibility, whereas hardness is the opposite quality to softness, or the disposition which the parts of a solid body possess of easily yielding without fracture. Chemists and others usually ascertain the comparative hardness of bodies by rubbing the one against the other; any angular prominence of a harder body being capable of scratching or making a mark upon the surface of a softer. This is not a bad method, though it may be rendered uncertain by the greater or less brittleness of the respective bodies. Thus hardened steel will scratch glass, and will in return be scratched by glass; the brittleness of the glass causing it to yield under the steel, which is more tenacious, though softer. On this principle likewise it is, that the keenest edge tools, and those best calculated to cut hard bodies, are not hardened to the highest temper the steel is capable of, but to such a degree only as to retain much tenacity with a moderate hardness.

The mechanical philosophers, at the beginning of the present century, accounted for the hardness of bodies, by supposing their particles to be of such a form as to apply to each other with large surfaces of contact. This doctrine seems in some measure to be true, when applied to the crystals of bodies on their assumption of the solid form. Sugar-candy, or the more slowly formed crystals of sugar, are harder (or perhaps less brittle) than loaf sugar, in which the same small crystals are more confusedly applied to each other: calcareous spar is harder than chalk, &c. But how far this doctrine may apply to the hardness arising from the hasty crystallization of steel and other bodies by immersion in water, remains to be settled by future researches.

. Kirwan, in his Mineralogy, has ex-d the hardness of the different species ones, as ascertained by Mr. Quist, by npression made on each other. In the ving table the stones, which stand first, ole to scratch or cut the succeeding, not vice versa; and such stones, the ness of which does not exceed 11, may ratched by steel. The first column es the hardness, and the second the fic gravity.

Diamond from Ormos	20	
Pink diamond	19	3·4
lueish diamond	19	3·3
Yellowish diamond	19	3·3
Cubic diamond	18	3·2
Ruby	17	4·2
Pale ruby from Brazil	16	3·5
Spinell	13	3·4
Deep blue sapphire	16	3·8
Ditto paler	17	3·8
Topaz	15	4·2
Whitish ditto	14	3·5
Bohemian	11	2·8
Emerald	12	2·8
Garnet	12	4·4
Agate	12	2·6
Onyx	12	2·4
ardonyx	12	2·6
Amethyst	11	2·7
Crystal	11	2·6
Carnelian	11	2·7
Green jasper	11	2·7
Reddish yellow ditto	9	2·7
Shoerl	10	
Tourmaline	10	
Quartz	10	2·7
Opal	10	2·6
Chrysolite	10	3·7
Zeolite	8	2·1
Fluor	7	
Calcareous spar	6	
Gypsum	5	
Chalk	3	

AT. The sensations expressed in com-anguage by the words heat and cold-re of too simple a nature to require or nit of definition. These words, how-are not always used to denote the same ; but are indiscriminately applied to the sensation itself, and to that causes it. Thus, we say, that we lves are hot or cold; and that the fire which heats or cools us, is likewise cold, though the sensations we expe- are certainly very different things that which enables bodies to excite

It may also be remarked, that, in nbiguous manner of speaking, there is er cause of uncertainty, that arises the use of a variable standard of com-n. Every one knows, that the esti-n of heat or coldness differs in various ns, because each forms his judgment his own sensations; and the same body ppear hot to one person, and cold to er, or to the same person at different ; though the variation is not in the body itself, but in the state of the person in whom these sensations are excited. Hence it appears necessary, in order to avoid error in the pursuit of inquiries concerning heat, that the sense of the words made use of should be accurately defined, and that some fixed standard of comparison be made use of instead of the human body, which, though fixed enough for the common affairs of life, is certainly not enough so for the purposes of science.

The word heat, in a philosophical sense, is used to denote the cause of the power which bodies possess of exciting the sensations of heat or coldness.

The word temperature denotes the state of the body with respect to that power. So that a body which excites a more intense sensation of heat or coldness than another body is said to possess a higher or lower temperature.

It has not yet been determined in what heat itself, or the cause of temperature, consists. Two opinions have long divided the scientific world. One is, that heat consists of a peculiar motion or vibration of the parts of bodies, so that the temperature is higher, the stronger the vibration. The other is, that heat is a substance or fluid, the greater or less quantity of which produces a higher or lower temperature. The decision of this great question is highly deserving of the attention of philosophers. But it will not be necessary to consider its merits in our first steps of investigation, because the doubts respecting it will not impede our reasoning concerning such phenomena as are well known. For since effects are proportioned to their causes, we may speak of the quantities of heat in bodies, without deciding whether they be quantities of motion or quantities of matter; the relation of these quantities to each other, and not their peculiar nature, being the chief object of our research.

That heat is actually matter, however, which was an opinion held by some in very ancient times, is now pretty generally maintained; and it is as generally distinguished by the name CALORIC. To that article, therefore, we refer, for what is at present known on the subject: the facts being the same, whether we understand by it a peculiar substance, or a power of producing certain effects.

HEDERÆ (GUM). Lemery says, that this gum exsudes from incisions made in the hedera arborea, or tree ivy, whence it is collected by the peasants in Italy, Provence, and Languedoc. The account is confirmed by Pomet; but Neumann, from unsuccessful inquiries made on his own travels, is disposed to consider the account as doubtful, though he learned, that it was the produce of Sicily and the kingdom of Naples.

This gum resin, when genuine, is of a bright transparent reddish brown colour, deeper than the hyacinth, and approaching to the garnet; when reduced to powder, of a saffron yellow, and of an agreeable aromatic taste and smell. From an ounce of this, Neumann obtained five drachms and a half of resinous extract by solution in alcohol, and of the residue water took up half a drachm, and left two drachms of insoluble residue. When water was applied first to another ounce, it took up two drachms of gummy matter, and of the residue alcohol dissolved three drachms two scruples, and left two drachms and half a scruple undissolved. By distillation with alcohol, the fluid came over with a slight taste of the gum resin. Water distilled from the hederæ was considerably impregnated both with the taste and smell, and brought over a small quantity of essential oil, less hot to the taste than other oils of that class.

Heliotropium, Turnsole. See Archil.

A beautiful siliceous stone likewise, imported lately from Egypt, has been sold under the name of heliotropium. It is of a fine apple-green colour: semitransparent when its thickness does not exceed half an inch: spec. grav. 2·708: sufficiently hard to strike fire with steel, but capable of being scratched by the point of a good penknife. Its fracture is even and sharp.

By Mr. Accum's analysis 500 grains give silex 365; alumine 20·25; oxide of iron 29·25; lime 56·5; water 24.—*Nich. Journ.*

Hellebore. Two ounces of the root of white hellebore yielded with water nine drachms and one scruple of gummy extract; and the same quantity of root yielded with alcohol seven drachms of resinous extract. The powder of this root is a violent sternutatory. It is sometimes mixed in external applications for destroying cutaneous insects. Internally it operates with great violence both upward and downward, but on account of its acrimony is now never given.

From six ounces of the roots of black hellebore, six drachms and one scruple were extracted by alcohol; and from the same quantity of root, six drachms and two grains were extracted by water. Borrichius relates, that the distilled water of the entire plant possesses emetic and purgative virtues. The root is a stimulating cathartic. —*Neumann.*

Hepar. The combination of sulphur with an alkali was formerly denominated Hepar Sulphuris, or Liver of Sulphur, from its brown-red colour. Chemists have applied the term *hepar* in a general way to all combinations of alkali or earth with sulphur or with phosphorus.

Hepatic Air. See Gas (Hidrogen, Sulphuretted).

Hidrargillite. This fossil was found many years ago, in a quarry near Barnstaple, by Dr. Wavell. It is commonly in small hemispherical groups of crystals, white, sometimes with a tinge of gray, green, or yellow. Its texture is loose, but its small fragments are hard enough to scratch agate. Spec. grav. about 2·7. Some specimens are semitransparent. Its component parts, as analysed by Mr. Davy, are alumine ·70, lime ·014, water ·262. The loss ·024 Mr. Davy thinks should be added to the water. There was a very small quantity of acid in the water, which Mr. Davy afterward found to be the fluoric, in such a state of combination in the stone as not to be rendered sensible by the sulphuric acid.—*Phil. Trans.*—*Nich. Journal.*

Hidrat. This term has been employed by some to express a chemical combination of water, not in the state of moisture, with some other substance.

Hidrocarburet. See Gas (Hidrogen, Carburetted).

Hidrogen. The base of the air formerly called inflammable, which, united with oxigen, composes water. See Gas (Hidrogen).

Hidrogenation. A term implying the act of combining hidrogen with any other substance. It has lately been maintained by some, that metals are susceptible of hidrogenation, as well as of oxigenation, and in different degrees. This is deduced from facts observed in metals exposed to the action of the galvanic pile. The doctrine of Ritter on this subject is, that positive galvanism, and positive electricity, disengage oxigen from water; and negative electricity, or negative galvanism, disengages from it hidrogen. And the negative pole of the galvanic pile disposes metals to combine with the hidrogen of water, as the positive pole does with its oxigen. Silver hidrogenated at a maximum is converted into a gas. If a little vessel of iron or platina filled with mercury be placed in contact with the negative pole, and the surface touched with the positive conductor, a point or circle of a powder very different from the black oxide of mercury is produced.

Hidroguretted Sulphuret. Supersulphuretted hidrogen combined with a base. See Sulphur.

Homberg's Phosphorus. The combination of lime and muriatic acid, which remains after distilling the volatile alkali from sal ammoniac, has usually an overproportion of lime. If it be urged by a violent heat it fuses; and when cold it has the property of emitting a phosphoric light, when struck with any hard body. It is called Homberg's phosphorus, from the name of the first observer of the fact.

Honey. Honey is contained in a peculiar organ of plants, called the nectary, which is commonly attached to some of the parts of fructification. It serves as food for most insects which have a proboscis. It appears to consist of sugar, mucilage, and water. The sugar sometimes separates in crystals. Alcohol too separates crystals from it, particularly from that which has a

ulous appearance; but these, according
Proust, are less sweet than common
r.

oney is supposed to have undergone no
ation in the body of the bee, as it re-
the odour, and not unfrequently the
ities, of the plants it was gathered from;
at it is sometimes deleterious, in the less
vated parts of North America, where
onous shrubs abound. Dioscorides and
y mention the same fact.

hirty-six ounces of honey, diluted with
quarts of warm water, and fermented
a little yeast, yielded on distillation a
of watery spirit, which by rectification
reduced to eight ounces.

oofs of Animals. The hoofs of ani-
are composed of a substance nearly of
ame nature as Horn; which see. They
ot applied to any use, but to afford
onia and animal coal, in the prepara-
of the prussiat of potash, and in the
hardening of iron.

ops. It is universally taken for granted,
hops render beer less liable to change
become sour. Neumann affirms the
thing, and that they sensibly increase
pirituosity. It is well known, that the
atic bitter of the hop is an agreeable
probably a wholesome addition to beer:
the rest remains yet to be proved by
eriment.

orn. Among the consistent parts of
nals, we observe a resemblance in the
eral properties of such as appear to be
sted of sensation, namely, the bones,
ns, hoofs, hair or wool, and epidermis.
e bony substances are very hard, and
ear to consist of much phosphat of lime,
ther with about one sixth of their weight
roper jelly or glue, soluble in hot water
ell as cold. Ivory, which is softer, con-
about one fourth of its weight of glue.
tshorn, which approaches as much to
nature of bone as horn in its obvious
erties, affords about one fifth, and skin
ears to afford most of all. Horn affords
with difficulty, which Fourcroy attri-
s to the gelatine in it being combined
a considerable portion of oxigen. This
tance differs from bone in its remark-
elastic flexibility, and the softness it
ires by a moderate heat.

acquer asserts, that horn may be en-
y converted into jelly, by treatment
water, in Papin's digester. What hap-
in this process requires to be examined.
mann found, that twenty-five grains of
xtract, of a brownish colour and saline
, were obtained by boiling half an
ce of cow's horn in water. When treated
e dry way, horn affords the same pro-
s nearly as other animal matters, namely,
queous alkaline liquor, concrete vola-
alkali, and a fetid oil, which, by re-
ed rectifications, becomes more and
e limpid and clear.

Tortoiseshell and whalebone appear to be nearly of the same nature as horn.

Hornblende, or Hornstone. This forms the tenth species of the argillaceous genus of Kirwan's System of Mineralogy. Its general characters, beside a partial solubility in acids, without effervescence, and a hardness never sufficient to strike fire with steel, are, 1. a specific gravity, never less than 2·66, and in many specimens as high as 3·88; 2. a strong earthy smell, when breathed upon, or wetted with hot water; 3. a toughness when pounded in a mortar, resembling that of mica, or horn, from which property it obtained its name; 4. its affording a greenish gray powder, when pulverized; 5. fusibility without addition, as it is said, though Mr. Kirwan could not fuse it with the blowpipe. It is frequently mixed with pyrites. Of this species the author reckons three varieties.

Hours (Mineralogical). The direction of veins, with respect to the meridian, is in the language of miners denoted by hours. The circle of the horizon is divided into twice twelve hours. The north and south directions are denoted by twelve, and consequently the east and west by six o'clock.

Hyacinth. A stone of an orange red, nearly as hard as rock crystal: specific gravity from 3·687 to 4·62. It refracts the rays of light double. It is fusible with oxigen gas, and loses its colour in the fire. It is now classed with the jargon of Ceylon, as a species of the genus zircon, from the earth of this name being its basis. When it is of a pure bright flame colour, jewellers distinguish it by the epithet of la belle: when it is of a fine deep red, they call it rubicelle, and class it with the rubies. The andreolite was ranked among the hyacinths by Bergman, and called cruciform white hyacinth by Romé de Lisle. The sommite too has been termed a white hyacinth. But neither of these stones contains zircon.

According to Klaproth 100 parts give zircon 70; silex 25; oxide of iron 0·5: according to Vauquelin, zircon 64·5: silex 32; oxide of iron 2. The hyacinth of Expailli gave 1·5 more of zircon, and 1 less of silex. Bergman's analysis of the hyacinth gave alumine 40; silex 25; lime 20; and oxide of iron 13.

Hydrogen, &c. See Hidrogen, &c.

Hydromel. A fermented liquor made of honey and water. It is more commonly known by the name of Mead.

Hydrometer. The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in inclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shows with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change have taken place. See GRAVITY (SPECIFIC).

But as the operation of weighing requires considerable attention and steadiness, and also a good balance, the floating instrument called the hydrometer has always been esteemed by philosophers, as well as men of business. It consists of a hollow ball, either of metal or glass, capable of floating in any known liquid: from the one side of the ball proceeds a stem, which terminates in a weight, and from the side diametrically opposite proceeds another stem, most commonly of an equal thickness throughout. The weight is so proportioned, that the instrument may float with the last mentioned stem upright. In the less accurate hydrometers this stem is graduated, and serves to show the density of the fluid, by the depth to which it sinks; as the heavier fluids will buoy up the instrument more than such as are lighter. In this way, however, it is clear, that the stem must be comparatively thick, in order to possess any extensive range. For the weight of vitriolic ether is not equal to three fourths of the same bulk of water; and therefore such an hydrometer, intended to exhibit the comparative densities of these fluids, must have its stem equal in bulk to more than one fourth of the whole instrument. If this bulk be given chiefly in thickness, the smaller differences of density will not be perceptible, and it cannot, with any convenience, be given in length.

To remedy this imperfection, various contrivances have been proposed for the most part grounded on the consideration, that a change in the ballast, or weight employed to sink the ball, would so far change the instrument, that the same short range of graduations on a slender stem, which were employed to exhibit the densities of ardent spirit, might be employed in experiments upon water. Some have adjusted weights to be screwed upon the lower stem; and others, with more neatness and accuracy, have adjusted them to be slipped upon the extremity of the upper stem. But the method of Fahrenheit appears to be on all accounts the simplest and most accurate.

The hydrometer of Fahrenheit consists of a hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known; this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly the specific gravities for the common form of the tables will be had by the proportion:

As the whole weight of the hydrometer and its load, when adjusted in distilled water,
Is to the number 1,000, &c.
So is the whole weight when adjusted in any other fluid
To the number expressing its specific gravity.

In order to show the degree of accuracy an instrument of this kind is capable of, it may in the first place be observed, that the greatest impediment to its sensibility arises from the attraction or repulsion between the surface of the fluid and that of the stem. If the instrument be carefully wiped with a soft clean linen cloth, the metallic surface will be equally disposed to attract or repel the fluid. So that if it possess a tendency to descend, there will be a cavity surrounding the stem; or if, on the contrary, its tendency be to rise, the fluid will stand round the stem in a small protuberance. The operator must assist this tendency, by applying the pincers, with which he takes up his weights, to the rim of the dish. It is very easy to know when the surface of the fluid is truly flat, by observing the reflected image of the window, or any other fit object seen near the stem in the fluid. In this way the adjustment of the weights in the dish may, without difficulty, be brought to the fiftieth part of a grain. If, therefore, the instrument displace 1000 grains of water, the result will be very true to four places of figures, or even to five. This will be as exact as most scales are capable of affording.

Some writers have spoken of the adjustment of an hydrometer of this kind, so that it shall at some certain temperature displace 1000 grains of water, as if this were a great difficulty. It is true, indeed, that the performance of a piece of workmanship of this nature would require both skill and judgment on the part of the artist: but it is by no means necessary. Nothing more is required on the part of the workman, than that the hydrometer shall be light enough to float in ether, and capable of sustaining at least one third of its own weight in the dish, without oversetting in a denser fluid. This last requisite is obtained by giving a due length to the stem beneath, to which the counterpoise is attached. With such an instrument, whatever may be its weight, or uantity of water it displaces, the che- may proceed to make his experiments, deduce his specific gravities by the pro- ion before laid down. Or to save oc- nal computation, he may once for all e a table of the specific gravities, cor- onding to every number of the load in lish, from one grain up to the whole ber of grains, so that by looking for oad in one column, he may always find pecific gravity in the column opposite. l this method very ready and conveni- n practice: but, if it be preferred, the hts may be adjusted to the hydrometer, to show the specific gravity, without utation or reference. For this purpose ydrometer must be properly counter- d in distilled water, at the assumed ard temperature; suppose 60°, and the e weight of the instrument and its load l 1·000, &c. Then the weight of the ment and its load must be separately mined in grains and parts, or other hts, by a good pair of scales. And as vhole weight of the instrument and its is proportioned to the weight of the ment alone; so will be the number , &c. to a fourth term expressing the ht of the instrument in such parts as the whole 1·000, &c. Make an actual f decimal weights (see Balance, § 16, of which 1·000, &c., shall be equal to hydrometer and its load. And it is , that, whatever may be the load in weights, if it be added to the number ting the weight of the instrument, the will denote the specific gravity of the , wherein the instrument floats with load.

following the above easy method it be found, that every hydrometer, esoever made, must give the same re- The subject is indeed in itself suffi- y simple, and would require scarcely liscussion, if it had not happened, that philosophers, for want of requisite tion, have made their experiments with ometers graduated on the stem by no n rule by which operators at a di- e from each other might compare their iments. The hydrometers, or *pese- rs* of Baumé, though in reality com- le with each other, are subject in part e defect, that their results, having no endent numerical measure, require nation to those who do not know the ments. Thus, for example, when a ist acquaints us, that a fluid indicated grees of the *pese-liqueur* of Baumé, we t usefully apply this result, unless we some rule to deduce the correspondent ic gravity: whereas we should not been in any respect at a loss, if the r had mentioned the specific gravity As a considerable number of French ophers refer to this instrument, it will use to explain its principles.

. Baumé appears to have directed his ion chiefly to the acquisition of a means of making hydrometers with a graduated stem, which should correspond in their results, notwithstanding any differences in their balls or stems. There is little doubt but he was led into the method he adopted, by reflecting on that by which thermometers are usually graduated (see Thermometer). As thermometers are graduated, independent of each other, by commencing with an interval between two stationary points of temperature, so Mr. Baumé adopted two determinate densities for the sake of marking an interval on the stem of his hydrometer. These densities were those of pure water, and of water containing $\frac{15}{85}$ parts of its weight of pure dry common salt in solution. The temperature was 10 degrees of Reaumur above freezing, or 54·5° of Fahrenheit. His instrument for salts was so balanced, as nearly to sink in pure water. When it was plunged in this saline solution, the stem arose in part above the surface. The elevated portion was assumed to be 15 degrees, and he divided the rest of the stem with a pair of compasses into similar degrees.

It is unnecessary to inquire in this place, whether this interval be constant, or how far it may be varied by any difference in the purity, and more especially the degree of dryness, of the salt. Neither will it be requisite to inquire how far the principle of measuring specific gravities by degrees representing equal increments, or decrements, in the bulks of fluids, of equal weight but different specific gravities, may be of value, or the contrary. It does not seem probable, that Baumé's instrument will ever become of general use; for which reason nothing further need be ascertained, than the specific gravities corresponding with its degrees, in order that such experiments as have this element among their data may be easily understood by chemical readers.

Mr. Baumé, in his Elemens de Pharmacie, has given a table of the degrees of his hydrometer for spirits, indicated by different mixtures of alcohol and pure water, where, he says, the spirit made use of gave 37 degrees at the freezing point of water; and in a column of the table he states the bulk of this spirit, compared with that of an equal weight of water, as $35\frac{5}{8}$ to 30. The last proportion answers to a specific gravity of 0·842, very nearly. A mixture of two parts, by weight, of this spirit, with thirty of pure water, gave twelve degrees of the hydrometer at the freezing point. This mixture, therefore, contained $6\frac{1}{2}$ parts of Blagden's standard to 100 water; and, by Gilpin's excellent tables, its specific gravity must have been 0·9915. By the same tables, these specific gravities of 0·842 and 0·9915 would, at 10° Reaumur, or 55° Fahr., have fallen to 0·832 and 0·9905. Here then are two specific gravities of spirit corresponding with the degrees 12 and 37, whence the following table is constructed.

Baumé's Hydrometer for Spirits.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
10	1·000	17	·949	23	·909	29	·874	35	·842
11	·990	18	·942	24	·903	30	·868	36	·837
12	·985	19	·935	25	·897	31	·862	37	·832
13	·977	20	·928	26	·892	32	·857	38	·827
14	·970	21	·922	27	·886	33	·852	39	·822
15	·963	22	·915	28	·880	34	·847	40	·817
16	·955								

With regard to the hydrometer for salts, the learned author of the first part of the Encyclopédie, Guyton-de-Morveau, who by no means considers this an accurate instrument, affirms, that the sixty-sixth degree corresponds nearly with a specific gravity of 1·848; and as this number lies near the extreme of the scale, I shall use it to deduce the rest.

Baumé's Hydrometer for Salts.

Temperature 55° Fahrenheit, or 10° Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
0	1·000	15	1·114	30	1·261	45	1·455	60	1·717
3	1·020	18	1·140	33	1·295	48	1·500	63	1·779
6	1·040	21	1·170	36	1·333	51	1·547	66	1·848
9	1·064	24	1·200	39	1·373	54	1·594	69	1·920
12	1·089	27	1·230	42	1·414	57	1·659	72	2·000

It may not be amiss to add, however, that in the Philosophical Magazine, Mr. Bingley, the assay-master of the mint, has given the following numbers as the specific gravity of nitric acid found to answer to the degrees of an areometer of Baumé by actual trial; temperature about 60° Fahr. But his appears to have been a different instrument, as it was graduated only from 0 to 50°.

Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.	Deg.	Sp. Grav.
18	1·150	29	1·250	34	1·300	38	1·350	42	1·400
20	1·167	30	1·267	35	1·312	39	1·358	43	1·416
26	1·216	31	1·275	36	1·333	40	1·367	45	1·435
28	1·233	32	1·283	37	1·342	41	1·383		

There are a variety of hydrometers used for determining the strength of ardent spirit. See ALCOHOL.

HYDROPHANES. This stone, which is also called oculus mundi, and lapis mutabilis, was formerly of great value. Its distinguishing characteristic is that of becoming transparent by immersion in water. Bergman has written a distinct treatise upon it.

The hydrophanes is either of a whitish brown, yellowish green, milky gray, or yellow colour, and opake. Some specimens give fire with steel. Its specific gravity is about 2·048, and it is easily cut and polished. Without addition, it is infusible; but the flame of the blowpipe changes it into a brown brittle substance. Neither acids nor alkalis have any action upon it in the humid way. Wiegleb and baron Racknitz say it is so soft in the mine, as to receive impressions from hard bodies.

Three of these stones are to be seen in the British Museum in London. The largest is about the size of a cherry-stone, but of an oval form. It is opake, and in colour resembling the common yellow pea. It may be scratched, though not without difficulty, with a knife, but it seems to leave a trace upon common glass. The nitric acid does not cause any ebullition when applied to it.

When it has lain in water some hours it becomes transparent, and of a yellow amber colour. This change begins soon after the immersion, and at one end, in the form of a small spot (but in a small one of the same kind the beginning is round the edges), which increases by slow degrees, till the whole stone has become uniformly clear throughout. When taken out of the water, it loses its transparency, first at one end, and then gradually over the remainder. This change happens in less time than is required to produce the transparency, as might indeed be naturally expected. For the stone cannot become transparent, until ater has soaked through its whole nce; but it becomes opake, as soon ertain thickness from the surface is ried.

ere is no doubt but this phenomenon duced in the same way as oil or water rs paper transparent. It depends on a al principle, which is well explained r Isaac Newton, in his Optics, viz., all porous bodies may be rendered arent, by filling their pores with some matter of nearly the same density. this last case the light passes through ery little impediment or deviation; as it was before subject to reflection efraction at all the surfaces of the r particles, and therefore became ab- and lost. That the hydrophanes s moisture, and emits air, which is a f much less density, is evident from ight it acquires, and the small bubbles cover its surface during the time it es transparency.

se facts evidently show that the effect rom a coarse porosity in the structure stone. It is a general circumstance, ose siliceous stones, which resemble mmon flint in breaking smoothl and y, are frequently surrounded by a ng of coarser material. Bergman these coarser parts were extruded by ntraction of the more homogeneous r, during the gradual transition from ft to the hard state. It is not easy to any notion of a mechanical action of ind; and it seems more probable, that arseness, or rather porosity, of these al crusts may have arisen from the of water, air, or other agents, which a long course of time may have car- some of the parts to a certain depth, e cracked, split, or destroyed the ity to a certain depth, as is seen upon face of broken flints, and other stones d to the weather. These crusts must rily differ in texture, density, and ss; and accordingly it cannot be ex- , that the requisites of the hydro- should be very frequently met with. roper pieces, which are generally nded with such as are useless, cannot inguished by their external appear- but such as do not adhere to the may be rejected. Immersion in water ay will determine their quality, be- uch as require a longer time to be- ransparent are of no value.

ugh it is probable, that the crusts of varieties of siliceous stones may yield drophanous stone, yet experience that it is chiefly to be sought for those of a loose texture, such as opals alcedonies. The opal gives admit- o water, but wants the opacity re- to make the experiment striking. If ndered opake by fire, which must be autiously and gradually applied, it becomes the hydrophanes. Too sudden heat causes it to fly in pieces.

Bergman found the same component parts in the opal and the hydrophanes. He reduced the stone to a very fine powder, and separated 100 grains of the most subtile particles by elutriation. He formed this into a ball, with three times as much mineral alkali, and a little water, and exposed it for an hour and half in an iron vessel to a fire gradually raised, but not to such a degree as to melt the mass. If this last event should happen, which it is difficult to prevent, the fluid becomes loaded with iron, and is so troublesome to analyse, that it is better to repeat the process as at first, but with more care. After a certain time the ball splits again into a powder, by the dissipation of part of the alkali. In this powder the siliceous earth was combined with alkali, and the other earths were rendered much more accessible to acid menstruums, from which the silex might have defended them. By digestion of the powder in muriatic acid he found, that sixteen parts of alumine were taken up, and eighty-four parts of silex remained untouched. There was not the smallest appearance of any lime. Klaproth found in Saxon hydrophanes silex 93·125, and alumine only 1·625, in the hundred parts: the remaining 5·25 he considers as volatile inflammable matter and water.

The value of the hydrophanes is estimated by its bulk, the quickness of the change, and the beauty of its colour. Of two equally penetrable, the larger must be longer in becoming transparent; but the effect may be increased by giving them a flat thin figure. The colour is derived from iron. Hot water produces the effect more speedily than cold. If frequent repetition of the experiment should render the stone less disposed to become transparent on immersion, it will most probably have arisen from calcareous deposition; in which case it may be cleared by immersion in acids. Alkalis, or acids, penetrate this stone, and render it transparent; the concentrated sulphuric acid renders it permanently so, by attracting water from the atmosphere. But the opacity may be restored by immersing it in a hot alkaline liquor. Nitric acid highly concentrated oxides the iron, and alters the colour of this stone, by that means producing various shades of yellow. Bergman thinks, that acids, by dissolving part of the alumine, may improve the quality of such stones as admit the water too slowly.

This stone probably received the name of oculus mundi, from an internal spark, or luminous spot, which changes its position according to the direction of the incident light. Bergman has made the most accurate remarks on this phenomenon, and finds, that it proceeds from the caustic curves and focal image, by refraction from the usual rounded form of the stone, and rendered visible by the semiopacity of the material through which the light passes.

Though this mutability is chiefly found in stones of the siliceous order, yet as it depends upon the mechanism or construction, rather than the component parts, it may naturally be expected to be met with in the other orders. The requisites are, that transparent particles should be so joined, or agglutinated together, as to leave innumerable minute interstices capable of admitting water. This construction is sometimes met with among the steatites. It may easily be understood how this may be rendered transparent, as more than half its weight consists of siliceous particles, frequently pellucid. But the hydrophanous steatites, being loaded with magnesia, seldom acquire the same degree of transparency as those which almost entirely consist of siliceous earth, which are likewise harder, though less beautiful and various in their colours. Dr. Bruckmann, quoted by Bergman, mentions red, white, green, and gray steatites possessed of this property. He directs, that they should be first boiled in an alkaline lixivium, and then in vinegar.

If the hydrophanes be made completely dry, and then steeped in melted wax, or spermaceti, it acquires the property of being rendered transparent by heat. Some years ago a dealer abroad sold such stones as natural curiosities by the name of *pyrophanes*.

Hypericum Perforatum. St. John's wort. Mr. Baunach says, that the tops and flowers of this plant give out a blood red colour to water and alcohol, and a fine bright crimson to vinegar. With the stronger acids it affords a yellow colouring matter. Alum with a little potash is the proper mordant for it: and a bath of water sufficiently impregnated with the juice of this plant, in which there is a due quantity of the mordant, will give a bright yellow to linen, woollen, silk, or cotton. If a larger quantity of the mordant be used, the tint will approach toward green: and the addition of solution of tin will give a rose, cherry, or crimson hue, with a fine lustre. The shade produced, and durability of the colour, depend chiefly on the heat of the bath, the time the stuff is kept in it, and the mordant employed.

If the expressed juice be dried in an oven, powdered, and rubbed with a little turpentine, it may be readily dissolved, either in essential or fat oils. With linseed oil, and a little oil of turpentine, it makes a fine red varnish.

The oil of St. John's wort, made by macerating the flowers in olive oil, was formerly used externally: and the plant itself has been recommended in hysteria.—*Ann. de Chim.*

I.

ICE. Water in the solid state. Mairan observed, that water, in freezing, has a tendency to form angles of sixty degrees, and to form stars with six rays. Romé de Lisle calculates, that the primitive form of ice is an equilateral eight-sided figure. Hassenfratz has observed, that water, when it freezes under favourable circumstances, always assumes a hexahedral prismatic form. This fact is not inconsistent with the deduction of R. de Lisle.

The specific gravity of ice being considerably less than water, it always floats at the surface, where it is most commonly formed, in consequence of the superior coldness of the atmosphere. It may nevertheless be formed at the bottom or side of any vessel, if the temperature be more effectually diminished in those parts than elsewhere, as by a freezing mixture. Ice is sometimes formed at the bottom of running waters, which Hales explains by remarking, that the superior parts of stagnant waters, as also of the earth, are colder in frosty weather than the inferior; but in running waters the uppermost parts are mixed with the lower, and all are cooled nearly alike; and as the water at the surface flows *quicker* than that below, the water at the bottom freezes soonest. There seems to be something defective in this explanation; for, as far as we know, agitation can impede freezing or crystallization in no other way, than by mixing the warmer parts of the fluid with the colder. But there is no doubt of the fact, from the concurring testimony of fishermen and other inhabitants near rivers, who are well acquainted with ground ice; beside which, Mr. Pott made an experiment in frosty weather with two similar tubs, into each of which were thrown nails, iron wire covered with flannel, hair, &c. A current of water was made to pass through one of them, and in the other was placed water with no current. Ice was formed on the nails and other substances at the bottom of the former, but none at the surface. And in the latter the surface was congealed, but there was no ice at the bottom. I am inclined to think, that the formation of ground ice depends on the springs, which issue from the earth at a more elevated temperature than the freezing point; namely, at the medium tempe-

ure of the climate. Suppose a spring to
e from the earth at the temperature of
, into a freezing atmosphere, it naturally
ows, and experience shows, that the
am must run over a certain extent of
und before it can be cooled as low as
, and become congealed. And if other
ngs flow into it from distances nearer
ir own sources, the distance of the place
ongelation from the first source may be
more augmented. When the original
am has increased to the size of a river,
effect of the additional springs will be
fined to the surface. Hales is mistaken
upposing, that the water at the surface
s quickest, for all hydrostatical writers
e the contrary. Suppose now the water
cooled as low as 32°, or lower, at a
ain part of the river. It will there begin
reeze, and the larger masses will be ac-
ulated where the crystallization is least
rbed, namely, at the edges. But the
equent accessary streams will flow on
surface of this, because warmer, and
equently lighter; and as the lower part
river runs the swiftest, it will follow
the stream, in the act of congelation,
llow on beneath the upper and warmer
am, and deposit ice upon the stones at
ottom, while none appears at the sur-
. If this explanation be true, it will be
d, 1. That wherever ground ice is
d, there will be ice at the surface, high-
p the stream; and, 2. the river has re-
ed a supply from some warmer springs
ome place intermediate between the
es where the ice is formed at the surface,
where it is formed at the bottom.

e expansive force of water, when it is
erted into ice, is greater than any
gth in the texture of bodies which has
opposed to it. Boyle and Hales made
experiment with pistol-barrels and
shells, which were bursten by the
nsion. Other philosophers have since
ted these experiments with similar re-

e freezing point of water is the 32° on
enheit's scale. See Caloric, Ther-
eter, Water.

land Spar. A substance, which has
ly engaged the attention of philoso-
s, under this name, or the name of
nd crystal. Bartholin, Huyghens,
on, Beccaria, and others of later date,
made experiments on its remarkable
erty of separating the rays of light in
a manner as to exhibit two images of
ject seen through it. It is the trans-
t specimen of common calcareous
and usually contains about 54 parts
35 carbonic acid, and the rest water.
ecific gravity is about 2·7. Priestley's
s, and the authors referred to by him,
be consulted, for an account of as
of the laws of this unusual refraction
et known. Magellan says, that Mr.
ond, professor of natural philosophy

at Milan, has observed, that glass has the same effect, whenever a number of parallel lines have been cut on its surface with a diamond, at the distance of the five hundredth or thousandth of an inch asunder; and that he (M.) had seen one of the pieces of glass, which produced this effect. Hence it should seem, as if the effect were produced either by inequalities at the surface, or fissures in the mass itself.

Ichthyocolla. Fish-glue, or *Isinglass*; which see.

Ignis Fatuus. A luminous appearance or flame, frequently seen in the night in different country places, and called in England *Jack with a lantern*, or *Will with the wisp*. It sometimes appears in the form of a flame dancing or undulating above the lower plants of the field; in other instances it has the appearance of an extensive luminous exhalation; sometimes it is seen to have a considerably rapid progressive motion; and other observations show, that it may have a stationary appearance, and definite form. Philosophers are not agreed as to its cause; but it appears probable that these meteors near the surface of the earth may not all be of the same nature. It seems with us to be mostly occasioned by the extrication of phosphorus from rotting leaves and other vegetable matters, which may be carried up in the first state of combustion by the summer heat, and rendered visible at night. Whether the hidrogen gas extricated from marshes may produce an appearance of this kind, is doubtful, unless it be phosphuretted. It is probable, that the motionless ignes fatui of Italy which are seen nightly on the same spot, are produced by the slow combustion of sulphur, emitted through clefts and apertures in the soil of that volcanic country.

Illumination. See Light.

Incineration. The combustion of vegetable or animal substances, for the purpose of obtaining their ashes or fixed residue.

Incombustible Cloth. See Asbestos.

Incrustation. When the external part of any mineral is of a different texture and appearance from the internal part, the former is called the incrustation.

Indigo. A blue colouring matter extracted from a plant called Anil, or the Indigo Plant.

In the preparation of this drug the herb is put into a vat or cistern, called the steeping trough, and there covered with water. The matter begins to ferment sooner or later, according to the warmth of the weather and the maturity of the plant; sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture is let out by cocks in the bottom into another vat placed for that purpose, so as to be commanded by the first. Mr. Quatremere says, that hidrogen gas is disengaged during this fermentation.

In the second vat, called the beating vat, the liquor is strongly and incessantly beaten with a kind of buckets fastened to poles, till the colouring matter is united into a body. Lewis, from Labat, says, that much nicety is required to hit the point, at which the colour is disposed to subside, because it is again taken up, if the beating be too long continued; and that the manufacturers accordingly make frequent observations on small quantities of the liquid taken out in a cup. But this does not agree with the assertion of Mr. le Blond, who affirms, that the effect of beating is to dissipate a quantity of carbonic acid, by which the blue fecula is suspended; that this method is insufficient to throw down the whole; but that the addition of lime water completely accomplishes it. It is said by Labat, that lime-water, or lime, is sometimes used in the beating; and he conjectures, that the hardness or flintiness of some indigo may be caused by this practice.

As soon as it is judged, from the blue colour of the liquid, that the beating is sufficient, it is left at rest for two hours; after which the clear liquor is drawn off by cocks in the side of the vat, and the blue part is discharged by another cock into a third vat, where it is suffered to settle for some time longer; then conveyed in a half fluid state into bags of cloth, to strain off more of its moisture; and lastly, exposed to the air in the shade in shallow wooden boxes, till it is thoroughly dry.

The indigo thus produced differs in its quality, not only according to that of the plant, but likewise the care taken in manufacturing it. Its colouring part appears nevertheless to be always the same, and its variations depend only on the admixture of foreign matter, and the consistence it acquires in drying.

Berthollet speaks of the indigo from Guatimala, as the best of any. It is so light as to swim on the surface of water, instead of sinking to the bottom, as all the other kinds do. Another kind is called coppery indigo, because its surface acquires a copper colour when rubbed with a hard body: there are other kinds of less purity, such as that from Carolina.

Bergman examined this drug in his usual masterly way: he found, that one ninth part of the indigo was taken up by boiling it in water. The parts dissolved were partly mucilaginous, partly astringent, and partly saponaceous. The solution of alum, and of sulphat of iron as well as of copper, precipitate the astringent portion.

Mr. Quatremere likewise separated the soluble part of indigo by means of water. He pretends, that the quantity thus taken up is more in proportion, as the indigo is of inferior quality; and affirms, that the indigo thus purified is equal to the best. Berthollet remarks upon this method of purifying, that, though doubtless advantageous, it is not perfectly effectual, because it leaves the earthy insoluble parts, which, though not detrimental to the colour, must certainly affect the proportion of colouring matter.

Powder of indigo, digested in pure alcohol, afforded a tincture, first yellow, then red, and lastly brown. By several repetitions of this process it lost one twenty-seventh part of its weight. Water being added to the alcohol, threw down a brownish resinous matter.

Ether had nearly the same action on indigo as the alcohol; but oils, whether fixed or volatile, affected it very little.

Bergman mixed one part of well pulverized indigo with eight parts of colourless sulphuric acid, of the specific gravity of 1·900, in a glass vessel slightly closed. The acid very quickly acted upon the indigo, and excited much heat. After a digestion of twenty-four hours the solution was effected; but the mixture was opake and black. By the addition of water it became more transparent, exhibiting in succession all the shades of blue, according to the quantity of water added. At least twenty pounds of water were required to render the smallest drop of the solution imperceptible in a cylindric glass of seven inches diameter.

If the sulphuric acid be first diluted in the water, it attacks only the earthy principle which is mixed with the indigo, and some of the mucilaginous parts.

The fixed alkalis saturated with carbonic acid separate a very fine blue powder from the solution of indigo, which is deposited very slowly. Bergman distinguishes this by the name of precipitated indigo. It is also obtained by pouring the solution drop by drop into alcohol, or into the saturate solutions of alum, of sulphat of soda, or of other salts containing the sulphuric acid. But the liquid always remains a little coloured.

The concentrated nitric acid attacks indigo with so much activity, as to set it on fire; but if the acid be properly diluted, it acts with less violence. The colour of the indigo becomes ferruginous, and the residue, which has the appearance of amber, amounts to no more than one third of the weight of the indigo. Fixed alkali precipitates from the acid a small quantity of oxide of iron, mixed with lime and barytes. But if too much alkali be added, part of the precipitate is redissolved, and the colour of the fluid is rendered deeper than before.

Haussman, in a very interesting dissertation, in the Journal de Physique for March 1788, has given a more connected set of observations on the changes produced

igo by the nitric acid. When the
of the indigo he had exposed to the
of this acid had appeared to be
yed, he found in the vessel a coagu-
which, after all the nitric acid had
carried off by washing, formed a
viscid mass of the appearance of
resin. It was soluble in pure alcohol,
indigo is not; and was not soluble
ter, but when the quantity was great.
more soluble in hot water than cold,
vas considerably bitter. The water
had been used in the lotions afforded
aporation small crystals, which exhi-
several of the properties of the acids
ar and of sorrel, but which were not
ely determined by the author. Brug-
says, that indigo distilled with four
of nitric acid leaves half an ounce of
the alcoholic tincture of which gives
tiful and durable yellow to linen or
and likewise to the skin.

muriatic acid by digestion, and even
upon indigo, takes up the earthy
, the iron, and a little of the extrac-
atter, which gives it a brown colour,
no respect attacks the blue colour.
indigo be precipitated from the sul-
acid, the muriatic will very readily
p a certain quantity, and acquires a
blue colour. Other acids, such as the
c, acetic, and phosphoric, have the
habitudes with indigo as the muriatic.
uric acid too much diluted to be ca-
of dissolving indigo, or nitric acid
from the same cause is too weak to
on it, takes up only the earthy and
tive parts, which are foreign to the
ing matter.

oxigenized muriatic acid has scarcely
fect upon indigo in substance; but
roys the colour of indigo in a state of
n. Berthollet applied it to the so-
in sulphuric acid. By the admixture
oxigenized muriatic acid the blue
was entirely destroyed, and the fluid
e of a yellow brown. He evaporated
this state, and obtained by gradual
tion a viscid blackish matter, which
ed to be of the same nature as that
d to Mr. Haussman by the nitric

effect of the oxigenized muriatic
considered by Berthollet, as afford-
ood method of ascertaining the pro-
nal quantities of colouring matter in
fferent kinds of indigo. For this
e he takes equal weights of each
ly powdered, puts them into se-
matrasses, with eight times their
of concentrated sulphuric acid.
are to be kept for twenty-four hours
at between 100° and 120° of Fahren-
or which purpose a dunghill, or the
d of a hothouse, may be employed.
olution is then diluted with an equal
y of water filtered, and the residue
on the filters collected, separately ground in a glass mortar, again digested with a little sulphuric acid, diluted with equal quantities of water, and each added to its corresponding liquor. And lastly, to each solution is added so much oxigenized muriatic acid as is necessary to discharge the colour, or rather to bring them all to the same shade of yellow, The goodness of each kind of indigo is proportionate to the quantity of oxigenized acid employed to destroy the colour.

Pure or caustic fixed alkali dissolves some matters foreign to the colouring matter of the indigo, but acts very little on the colouring particles. Pure volatile alkali has nearly the same effect. Precipitated indigo is speedily dissolved in the cold in the alkalis, whether fixed or volatile, if pure or caustic. The blue colour is gradually changed to a green, and at last destroyed. But mild alkalis do not alter the colour. Lime water has little action upon indigo; but it dissolves it when precipitated, and affects the colour nearly in the same manner as caustic alkalis do.

Indigo exposed to the action of fire in an open crucible, or under a muffle, smokes, swells up, ignites, and sometimes takes fire with a white flame. One hundred parts of indigo leave thirty-three or thirty-four parts of ashes. These do not afford fixed alkali when lixiviated with distilled water. Muriatic acid dissolves the greater part of the ashes with a slight effervescence. The insoluble remainder is about one eleventh part, and has the characters of siliceous earth.

From this muriatic solution prussiat of potash throws down from thirty to thirty-two grains of the blue precipitate, which represents five or six of iron in the ounce. The ashes likewise contain lime and barytes, beside the iron and silex.

Indigo detonates strongly with nitre. By destructive distillation it affords carbonic acid gas, a liquor containing a little ammonia and an oil resembling the empyreumatic oil of tobacco, and very soluble in alcohol.

Bergman concludes from his analysis, that one hundred parts of good indigo contain of mucilaginous matter separable by water 12, resinous matter soluble in alcohol 6, earthy matter taken up by the acetous acid, which does not attack the iron, here in the state of oxide, 22, oxide of iron taken up by the muriatic acid 13.

There remained forty-seven parts, which are the colouring matter, nearly in a state of purity, and afforded by distillation, carbonic acid 2, alkaline liquor 8, empyreumatic oil 9, coal 23.

The coal, when burned in the open air, afforded four parts of earth, of which nearly half was oxide of iron, and the rest silex in a very subtle powder.

From these results Bergman concludes, that indigo is a substance analogous to

Prussian blue, and the colouring matter of ink; and that its colour, like theirs, is owing to iron. Upon this deduction Berthollet remarks, with regard to Bergman's inference respecting the iron, that by an error in estimating the value of the Prussian blue, this great chemist has stated the quantity of this metal about four times too large; that the iron taken up by muriatic acid is extraneous to the pure indigo, as well as the earths, and the mucilage and resin taken up by water and alcohol. So that, on an accurate consideration of the facts, there does not appear to be more than one thirtieth part of iron in a combined state. He observes, that it is at present well known, that the products of destructive distillation, such as oil, carbonic acid, and volatile alkali, do not previously exist in bodies, but are afforded by new combinations of the principles which formed the body acted upon. And accordingly he concludes, that indigo contains a considerable quantity of hidrogen, a small quantity of nitrogen, a very small portion of iron, and particularly a larger quantity of coal than is obtained from any other known vegetable substance. It does not appear, whether the siliceous earth be merely an admixture, or whether it enter into the combination of the colouring matter.

From the great quantity of coal and hidrogen he accounts for the combustibility of this substance, its detonation with nitre, and the effects of the nitric and muriatic acids upon it. The fixity of its colour is also, in conformity to other observations of Berthollet, deduced from the quantity of coal, which is but slowly consumed by the action of oxigen from the atmosphere. From a mature consideration of the process of the manufactory, this intelligent author deduces, that the indigo exists in the plant in a resinous state; that the kind of putrefaction it undergoes is of the nature of combustion, during which, part of its hidrogen is burned, and part flies off; and that the utility of the process of beating is grounded on the facility it affords for the absorption of oxigen. If the beating be continued too long, the indigo is rendered black, and becomes what is called burnt indigo.

The solubility of indigo in alkalis appears to be produced by the abstraction of part of the oxigen it had absorbed. This appears to be well established from the experiment of Bergman, wherein equal weights of sulphat of iron and indigo, and double the weight of lime, are mixed together in water, and produce a solution of the indigo in the lime-water. But if the iron of the sulphat be previously oxided to a higher degree, by boiling it in much water for several hours, and subsequent evaporation, the solution will not be effected, because the precipitated iron is no longer disposed to absorb oxigen, as the experiments of Priestley show the common precipitate from sulphat of iron to be. Or again, if indigo be added to a solution of caustic fixed alkali, and orpiment be added (which consists of arsenic and sulphur), the indigo is soon dissolved, and takes a green colour. If the arsenic corresponding with the orpiment be only added, the bath will never be fit for the dyer; but if the quantity of sulphur it ought to contain be added, the appearances of solution will speedily be had.

Mr. Haussman proved by a direct experiment, that the solution of orpiment mixed with indigo is disposed to absorb oxigen. For having placed this solution, which is known in the dye-houses by the name of printing blue, in contact with oxigen gas, seven-eighths of the air were absorbed, and the remainder was nitrogen. The blue solution was entirely spoiled. The indigo was regenerated. Some of the alkali formed sulphat of potash with the acid; a portion of the alkali remained pure and uncombined; and the arsenic, instead of being in the metallic state as it is in the orpiment, was combined with it in the form of oxide, or probably acidified.

It follows therefore, that indigo contains oxigen in its natural state; that in this state it will not unite with lime or alkalis; but that substances capable of depriving it of part of its oxigen render it soluble in lime or alkalis; and lastly, that the natural state of the indigo is restored by the contact of oxigen which it absorbs. In this last way it is that the blue dye is effected. The piece comes out of the vat of the same colour as the solution: viz. green; but becomes blue by exposure to the air. The alkali, or lime, is carried off by the washing, and the indigo remains combined with the stuff by this means dyed.

The action of acids, even the sulphuric, upon indigo, appears to affect it in the way of combustion; by which it is so far altered, as not to adhere so strongly to wool or silk as when in its natural state. For other interesting particulars, consult the Memoir of Mr. Haussman before cited, and compare with the theories of Bergman and Berthollet.—*Lewis.—Berthollet.—Journ. de Phys.—Ann. de Chim.*

Infernal Stone. Lapis infernalis. A name frequently given to the combination of silver with the nitric acid, which is fused into little sticks to be used as a caustic.

Inflammable Air. See Gas (Hidrogen).

Inflammable Principle. See Phlogiston.

Inflammation of Oils. See Acid (Nitric).

Infusion. The process of infusion differs from maceration in the menstruum being poured hot, generally boiling, on the substance to be infused; and from digestion in the heat not being kept up by artificial means. It is by no means unfrequent, however, that we see the term in-sometimes indeed with the incon- pithet *cold* prefixed, used improper- ad of maceration. It is likewise em- by chemists, to denote a quantity of oaded with as much of the principles substance, not totally soluble, as it e up in the usual temperature of the here.

Every liquor or pigment used for or printing, is distinguished by the f ink. Common practice knows only nd red.

lack ink there are three principal 1. Indian ink, 2. printers' ink, and, ng ink.

Indian ink is used in China for writ- h a brush, and for painting upon the ible paper of Chinese manufacture. ertained as well from experiment as formation, that the cakes of this ink de of lamp black and size, or animal th the addition of perfumes or other ces not essential to its quality as an is used in Europe for designs in nd white, in which it possesses the ge of affording various depths of according to its state of dilution with The coarse lampblack of the shops ot answer the purpose; but the fine om the flame of a lamp or candle, d by holding a plate over it, mixed lean size from shreds of parchment e-leather not dyed, will make an ink to that imported.

general composition of printers' ink known, but the particulars of the s by which ink of the best quality is re kept secret by the few manufac- of this article. It is probable, that nand is not sufficient to afford induce- for men of research to make many nents on this object, and it is not un- that much may depend on minute stances in the management.

d printers' ink is a black paint, and uniform in its composition, of black colour, and possesses a singular le to adhere to paper thoroughly im- ted with moisture. It is remarkable, is composition adheres uniformly to ted sheep-skin cover of the printers'- which a common oil paint would not at it quits the wet ball to adhere to e of the dry metallic type, and this so ly as to leave a new skin bare where pe touches it; and that much the part of the ink afterward leaves the adhere to the moistened paper, but ot if the paper be dry. If the ink possess these requisites, it will not well, but will clog the face of the and give an imperfect impression.

consistence and tenacity of the oil in mposition are greatly increased, and asiness diminished, by means of fire. d oil or nut oil is made choice of for e. The nut oil is supposed to be the nd is accordingly preferred for the black ink, though the darker colour it acquires from the fire renders it less fit for the red. It is said, that the other expressed oils cannot be sufficiently freed from their unctuous quality; whence the ink made with them dries exceeding slowly, is apt to come off and smear the paper in the beating and pressing it undergoes in the hands of the bookbinder, or sinks into the substance of the paper beyond the mark of the type, and stains it yellow.

Ten or twelve gallons of the oil are set over the fire in an iron pot, capable of holding at least half as much more; for the oil swells up greatly, and its boiling over into the fire would be very dangerous. When it boils it is kept stirring with an iron ladle; and if it do not itself take fire, it is kindled with a piece of flaming paper or wood; for simple boiling, without the actual accension of the oil, does not communicate a sufficient degree of the drying quality required. The oil is suffered to burn for half an hour or more, and the flame being then extinguished by covering the vessel close, the boiling is afterward continued with a gentle heat, till the oil appears of a proper consistence; in which state it is called varnish. It is necessary to have two kinds of this varnish, a thicker and a thinner, from the greater or less boiling, to be occasionally mixed together, as different purposes may require; that which answers well in hot weather being too thick in cold, and large characters not requiring so stiff an ink as small ones.

The thickest varnish when cold may be drawn into threads like weak glue; by which criterion the workmen judge of the due boiling, small quantities being from time to time taken out and dropped upon a tile for this purpose. It is very viscid and tenacious, like the soft resinous juices, or thick turpentine. Neither water nor alcohol dissolves it; but it readily enough mingles with fresh oil, and unites with mucilages into a mass diffusible in water in an emulsive form. Boiling with caustic alkali produces a soapy compound. It is by washing with hot soaplees and a brush that the printers clean their types. The oil loses from one tenth to one eighth of its weight by the boiling into the thick varnish. This loss seems to differ in different samples of the same kind of oil. Dr. Lewis found that fish oil lost three fourths of its weight by this treatment, before it acquired the thickness produced in linseed oil.

The workmen are accustomed to add in the preparation of ten or twelve gallons of oil, as soon as the burning is over, a pound or two of dry crusts of bread, and a dozen or two of onions, by which they suppose the greasiness to be more effectually destroyed. Dr. Lewis, with much appearance of justice, doubts the advantage of such additions, and that more especially, as he prepared the varnish seemingly of a good quality by the fire alone. There are other additions of more evident effect, namely, turpentine or litharge, both which are occasionally used. The turpentine is boiled first by itself to a state nearly of resin, and the oil being taken from the fire, the hot fluid turpentine is poured in, and the boiling then continued to the proper point. This is somewhat difficult to attain, because the mixture is more disposed to grow too thick if overboiled; and is full of little hard grains, probably of resin, if not sufficiently boiled. It is affirmed, that varnish containing either turpentine or litharge, particularly the latter, is more adhesive than other varnish, and presents a great difficulty in cleaning the types, which soon become clogged. Very old oil requires neither of these additions. New oil can hardly be brought into a proper state for drying, so as not to set off, without the use of turpentine.

Lamp black is the common material to give the black colour, of which two ounces and a half are sufficient for sixteen ounces of the varnish. Vermilion is a good red. They are ground together on a stone with a muller, in the same manner as oil paints.

The ink used by copper-plate printers differs in the oil, which is not so much boiled as to acquire the adhesive quality. This would render it less disposed to enter the cavities of the engraving, and more difficult either to be spread or wiped off. The black is likewise of a different kind. Instead of lamp black, or sublimed charcoal, the Frankfort black is used, which is a residual or denser charcoal, said to be made from vine-twigs. This is softer and less gritty than the ivory or other blacks prepared among us, and no doubt contains more coal than any animal residue, as all these abound with phosphat of lime. It is said, that lamp black gives always a degree of toughness to the ink, which the Frankfort black does not; but the goodness of the colour seems to be the leading inducement for the use of the latter. A pale or brown black can be much more easily endured in a book, than in the impression of an engraving.

We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' use.

Common ink for writing is made by adding an infusion or decoction of the nut gall to sulphat of iron, dissolved in water. A very fine black precipitate is thrown down, the speedy subsidence of which is prevented by the addition of a proper quantity of gum arabic. This is usually accounted for by the superior affinity of the gallic acid, which, combining with the iron, takes it from the sulphuric, and falls down. But it appears as if this were not the simple state of the facts; for the sulphuric acid in ink is not so far disengaged as to act speedily upon fresh iron, or give other manifestations of its presence in an uncombined state. According to Deyeux, the iron in ink is partly in the state of a gallat, partly in that of a carburetted oxide.

Mr. Ribaucourt paid particular attention to the process for making black ink, and from his experiments he draws the following inferences: That logwood is a useful ingredient in ink, because its colouring matter is disposed to unite with the oxide of iron, and renders it not only of a very dark colour, but less capable of change from the action of acids, or of the air. Sulphat of copper in a certain proportion gives depth and firmness to the colour of the ink. Gum arabic, or any other pure gum, is of service, by retarding the precipitation of the feculæ; by preventing the ink from spreading or sinking into the paper; and by affording it a kind of compact varnish, or defence from the air, when dry. Sugar appears to have some bad qualities, but is of use in giving a degree of fluidity to the ink, which permits the dose of gum to be enlarged beyond what the ink would bear without it. Water is the best solvent.

Lewis had supposed, that the defects of ink arise chiefly from a want of colouring matter. But the theory, grounded on the facts discovered by Mr. Ribaucourt, requires, that none of the principles should be in excess. If there be a want of the gallic acid, part of the sulphat will not be decomposed; if, on the contrary, there be too much, the sulphat will take as much as it can decompose, and the remainder will be nearly in the state of the decoction of galls, subject to change by becoming mouldy, or to undergo an alteration after writing, which destroys its legibility much more completely than the change undergone by ink containing too small a proportion of the galls.

It is doubtful whether the principles of the galls be well extracted by maceration; and it is certain, that inks made in this way flow pale from the pen, and are not of so deep a black as those wherein strong boiling is recurred to.

From all the foregoing considerations, Mr. R. gives these directions for the composition of good ink:

Take eight ounces of Aleppo galls (in coarse powder); four ounces of logwood (in thin chips); four ounces of sulphat of iron; three ounces of gum arabic (in powder); one ounce of sulphat of copper, and one ounce of sugar candy. Boil the galls and logwood together in twelve pounds of water for one hour, or till half the liquid has evaporated. Strain the decoction through a hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone ware, well corked.

 recommend, that the sulphat of
ould be calcined to whiteness. Mr.
eaux jun., an ink manufacturer in
elds, has given the following in the
phical Magazine as the result of
xperience: Boil 4 ounces of log-
bout an hour in 6 beer quarts of
adding boiling water from time to
train while hot; and when cold add
enough to make the liquor five
Into this put one pound averd.
galls coarsely bruised; 4 oz. of sul-
iron calcined to whiteness; 3 oz. of
orown sugar; 6 oz. of gum arabic;
oz. of acetit of copper, triturated
ittle of the decoction to a paste, and
oroughly mixed with the rest. This
kept in a bottle uncorked about a
nt, shaking it twice a day, after
t may be poured from the dregs, and
up for use.

ewis uses vinegar for his menstruum;
r. Ribaucourt has sulphat of copper
his ingredients. I have found an
enience from the use of either, which,
it does not relate to the goodness of
, is sufficiently great, in their prac-
xhibition, to forbid their use. The
the vinegar acts so strongly upon
, that it very frequently requires
g; and the sulphat of copper has a
re unpleasant effect on the penknife.
om happens when a pen requires
ng, that the ink is wiped very per-
from it; and often, when the nib
to be taken off, it is done without
at all. Whenever this is the case,
immediately deposits a film of cop-
on the knife, and by superior elec-
traction of the sulphuric acid, a cor-
dent portion of the edge of the knife
lved, and is by this means rendered
ble of cutting till it has been again
n the hone.

little sugar be added to ink, a
f the writing may easily be taken off,
ng a sheet of thin unsized paper,
d with a sponge, on the written
and passing lightly over it a flat iron
oderately heated.

of other colours may be made from
ng decoction of the ingredients used
ng, mixed with a little alum and gum
For example, a strong decoction
il wood, with as much alum as it can
e, and a little gum, forms a good red
These processes consist in forming a
nd retarding its precipitation by the
See Lake.

many occasions it is of importance to
an ink indestructible by any pro-
at will not equally destroy the ma-
on which it is applied. Mr. Close
ecommended for this purpose 25
of copal in powder dissolved in 200
of oil of lavender, by the assistance
tle heat, and then mixed with 2½
of lamp black and ½ a grain of indigo; or 120 grains of oil of lavender, 17 grains of copal, and 60 grains of vermilion. A little oil of lavender, or of turpentine, may be added, if the ink be found too thick. Mr. Sheldrake suggests, that a mixture of genuine asphaltum dissolved in oil of turpentine, amber varnish, and lamp black, would be still superior.

When writing with common ink has been effaced by means of oxigenized muriatic acid, the vapour of sulphuret of ammonia, or immersion in water impregnated with this sulphuret, will render it again legible. Or if the paper that contained the writing be put into a weak solution of prussiat of potash, and when it is thoroughly wet a little sulphuric acid be added to the liquor, so as to render it slightly acidulous, the same purpose will be answered.

Mr. Haussman has given some compositions for marking pieces of cotton or linen, previous to their being bleached, which are capable of resisting every operation in the processes both of bleaching and dyeing, and consequently might be employed in marking linen for domestic purposes. One of these consists of asphaltum dissolved in about four parts of oil of turpentine, and with this is to be mixed lamp black, or black lead in fine powder, so as to make an ink of a proper consistence for printing with types. Another, the blackish sulphat left after expelling oxigen gas from oxide of manganese with a moderate heat being dissolved and filtered, the dark gray pasty oxide left on the filter is to be mixed with a very little solution of gum tragacanth, and the cloth marked with this is to be dipped in a solution of potash or soda, mild or caustic, in about ten parts of water.

Among the amusing experiments of the art of chemistry, the exhibition of sympathetic inks holds a distinguished place. With these the writing is invisible, until some reagent gives it opacity. We shall here mention a few out of the great number, that a slight acquaintance with chemistry may suggest to the student. 1. If a weak infusion of galls be used, the writing will be invisible till the paper be moistened with a weak solution of sulphat of iron. It then becomes black, because these ingredients form ink. 2. If paper be soaked in a weak infusion of galls, and dried, a pen dipped in the solution of sulphat of iron will write black on that paper, but colourless on any other paper. 3. The diluted solutions of gold, silver, or mercury, remain colourless upon the paper, till exposed to the sun's light, which gives a dark colour to the oxides, and renders them visible. 4. Most of the acids or saline solutions being diluted, and used to write with, become visible by heating before the fire, which concentrates them, and assists their action on the paper. 5. Diluted prussiat of potash affords blue letters when wetted with the solution of sulphat of iron. 6. The solution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but disappears again when suffered to cool. This has been used in fanciful drawings of trees, the green leaves of which appear when warm, and vanish again by cold. This effect has not been explained. If the heat be continued too long after the letters appear, it renders them permanent. 7. If oxide of cobalt be dissolved in acetous acid, and a little nitre added, the solution will exhibit a pale rose colour when heated, which disappears on cooling. 8. A solution of equal parts of sulphat of copper and muriat of ammonia gives a yellow colour when heated, that disappears when cold.

Sympathetic inks have been proposed as the instruments of secret correspondence. But they are of little use in this respect, because the properties change by a few days remaining on the paper; most of them have more or less of a tinge when thoroughly dry; and none of them resist the test of heating the paper till it begins to be scorched.—*Lewis's Phil. Com. of Arts.—Ann. de Chim.—Nich. Journ.—Phil. Mag.*

Insects. Various important products are obtained from insects. The chief are, 1. Cantharides. 2. Millepedes. 3. Cochineal. 4. Kermes. 5. Lac. 6. Silk. 7. Wax. For all which the several titles may be consulted.

Instruments (Chemical). See Balance, Thermometer, Laboratory.

Intermedium, or **Medium**. When two chemical principles, which are not disposed to unite, are made to enter into a triple compound, by the addition of a third, this last is frequently called the medium, or intermedium. Thus fat oils are made to unite with water by the intermedium of a pure alkali, which converts the oil into soap.

Iridium. Mr. Tennant, on examining the black powder left after dissolving platina, which from its appearance had been supposed to consist chiefly of plumbago, found it contained two distinct metals never before noticed, which he has named iridium and osmium. The former of these was observed soon after by Descostils, and by Vauquelin.

To analyse the black powder, Mr. Tennant put it into a silver crucible with a large proportion of pure dry soda, and kept it in a red heat for some time. The alkali being then dissolved in water; it had acquired a deep orange or brownish yellow colour, but much of the powder remained undissolved. This digested in muriatic acid gave a dark blue solution, which afterward became of a dusky olive green, and finally, by continuing the heat, of a deep red. The residuum being treated as before with alkali, and so on alternately, the whole appeared capable of solution. As some silex continued to be taken up by the alkali, till the whole of the metal was dissolved, it seems to have been chemically combined with it. The alkaline solution contains oxide of osmium, with a small proportion of iridium, which separates spontaneously in dark-coloured thin flakes by keeping it some weeks.

The acid solution contains likewise both the metals, but chiefly iridium. By slow evaporation it affords an imperfectly crystallized mass; which, being dried on blotting-paper, and dissolved in water, gives by evaporation distinct octaedral crystals. These crystals, dissolved in water, produce a deep red solution inclining to orange. Infusion of galls occasions no precipitate, but instantly renders the solution almost colourless. Muriat of tin, carbonat of soda, and prussiat of potash, produce nearly the same effect. Ammonia precipitates the oxide, but, possibly from being in excess, retains a part in solution, acquiring a purple colour. The fixed alkalis precipitate the greater part of the oxide, but retain a part in solution, this becoming yellow. All the metals that Mr. Tennant tried, except gold and platina, produced a dark or black precipitate from the muriatic solution, and left it colourless.

The iridium may be obtained pure, by exposing the octaedral crystals to heat, which expels the oxigen and muriatic acid. It was white, and could not be melted by any heat Mr. Tennant could employ. It did not combine with sulphur, or with arsenic. Lead unites with it easily, but is separated by cupellation, leaving the iridium on the cupel as a coarse black powder. Copper forms with it a very malleable alloy, which, after cupellation with the addition of lead, leaves a small proportion of the iridium, but much less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is tarnished merely by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion; nor is it separable either by cupellation or quartation. If the gold or silver be dissolved, the iridium is left as a black powder.

The French chemists observed, that this new metal gave a red colour to the triple salt of platina and sal ammoniac, was not altered by muriat of tin, and was precipitated of a dark brown by caustic alkali. Vauquelin added, that it was precipitated by galls, and by prussiat of potash; but Mr. Tennant ascribes this to some impurity.

Mr. Tennant gave it the name of iridium from the striking variety of colours it affords while dissolving in muriatic acid.

Wollaston has observed, that among
ins of crude platina there are some
y distinguishable from the rest but
r insolubility in nitro-muriatic acid.
re harder, however, when tried by
; not in the least malleable; and of
ecific gravity of 19·5. These ap-
to him to be an ore, consisting en-
of the two new metals.—*Phil. Trans.*

is a metal of a bluish white colour,
nsiderable hardness and elasticity;
nalleable, exceedingly tenacious and
, and of a moderate specific gravity
metallic substances. It is much
d to rust by the access of air, or the
of water, in the common tempera-
f the atmosphere. The appearance
matic colours on its polished surface
lace long before ignition; and at so
temperature, that the slightest coat-
grease is sufficient to prevent their
ance by defending it from the con-
air. It may be ignited, or at least
ed sufficiently hot to set fire to
one, by a quick succession of blows
hammer. When struck with a flint,
er hard stone, it emits decrepitating
particles, such as can be obtained
o other metal by the same means.
particles are seldom larger than the
ndredth part of an inch in diameter;
hen examined by a magnifier, are
o be hollow, brittle, and of a gray-
our, resembling the scales of burned
This metal is easily oxided by fire.
e of iron wire, immersed in a jar of
gas, being ignited at one end, will
irely consumed by the successive
stion of its parts. It requires a very
heat to fuse it; on which account it
ly be brought into the shape of tools
ensils by hammering. This high de-
infusibility would deprive it of the
aluable property of metals, namely,
ting of smaller masses into one, if it
possess another singular and advan-
property, which is found in no
netal except platina; namely, that of
g. In a white heat, iron appears as
red with a kind of varnish; and in
te, if two pieces be applied together,
ll adhere, and may be perfectly united
ing. Iron is thought to be the only
ce in nature, which has the property
oming magnetical. It is highly pro-
from the great abundance of this
that all substances which exhibit
ism do contain iron; but it must be
ed, that there remain many experi-
to be made among the earths and
s which exhibit magnetical proper-
fore this negative proposition, which
s magnetism to iron, can be admitted
ed.

n iron is exposed to the action of
ter, it acquires weight by gradual
on, and hidrogen gas escapes: this is
a very low operation. But if the steam of water be made to pass through a red-hot gun barrel or through an ignited copper or glass tube, containing iron wire, the iron becomes converted into an oxide, while hidrogen gas passes out at the other end of the barrel. The action of air, assisted by heat, converts iron into a black oxide, containing ·25 of oxigen. By the action of stronger heat this becomes a reddish brown oxide, containing ·48 of oxigen. The yellow rust, formed when iron is long exposed to damp air, is not a simple oxide, as it contains a portion of carbonic acid. According to Mr. Chenevix, there are four stages of oxidation of iron: the first, or minimum, white; the 2d green; the 3d black; the 4th, or maximum, red. Thenard admits only three, the white, green, and red.

The concentrated sulphuric acid scarcely acts on iron, unless it is boiling. When the acid is distilled to dryness from this metal, the retort is found to contain sublimed flowers of sulphur, and a white and reddish mass, partly soluble in water, which is sulphat of iron more or less decomposed: the product which comes over is sulphurous acid, fluid and aëriform. If the sulphuric acid be diluted with two or three parts of water, it dissolves iron readily, without the assistance of any other heat than is produced by the act of combination. During this solution, hidrogen gas escapes in large quantities. If heat be applied, the acid proceeds to dissolve more iron, and deposits a white saline mass, or pale sulphat of iron.

The green sulphat of iron is much more soluble in hot than cold water; and therefore crystallizes by cooling, as well as by evaporation. The crystals are efflorescent, and fall into a white powder by exposure to a dry air, the iron becoming more oxided than before. A solution of sulphat of iron, exposed to the air, imbibes its oxigen; and a portion of the iron, becoming too much oxided to adhere to the acid, falls to the bottom in the form of ochre. The solution, as well as the crystals it affords by evaporation, are thus rendered paler than before.

Sulphat of iron is not made in the direct way, because it can be obtained at less charge from the decomposition of martial pyrites. It exists in two states, one containing oxide of iron with ·27 of oxigen, which is of a pale green, not altered by gallic acid, and giving a white precipitate with prussiat of potash. The other, in which the iron is combined with ·48 of oxigen, is red, not crystallizable, and gives a black precipitate with gallic acid, and a blue with prussiat of potash. In the common sulphat these two are mixed in various proportions.

Sulphat of iron is decomposed by alkalis and by lime. Caustic fixed alkali precipi-tes the iron in deep green flocks, which are dissolved by the addition of more alkali, and form a red tincture. The mild alkali does not redissolve the precipitate it throws down, which is of a greenish white colour. Distillation separates the acid from sulphat of iron, and leaves the brown oxide of iron, called colcothar.

Vegetable astringent matters, such as nut-galls, the husks of nuts, logwood, tea, &c., which contain the gallic acid, precipitate a fine black fecula from sulphat of iron, which remains suspended for a considerable time in the fluid, by the addition of gum arabic. This fluid is well known by the name of ink. See INK.

The beautiful pigment, well known in the arts by the name of Prussian blue, is likewise a precipitate afforded by sulphat of iron.

If two parts of alum, and one of sulphat of iron, be dissolved in 8 or 10 parts of boiling water, and a solution of prussiat of potash be added as long as any effervescence and precipitation are produced, the precipitate, thoroughly washed by affusion of boiling water, will have a green colour. This is owing to yellow oxide of iron thrown down with the prussiat, which must be dissolved by adding muriatic acid. The deep blue powder, insoluble in this acid, is then to be washed and dried for use. According to prof. Proust, the iron in Prussian blue contains ·48 of oxigen, and is obtainable only from a superoxigenated sulphat; the precipitate from a pure alkaline prussiat and sulphat of iron with a minimum of oxigen being white, and containing only ·27 of oxigen. This may explain a fact observed by a French colourman, who, having mixed some Prussian blue and white lead with nut oil, and set it by for some time covered with water, found the surface only blue, and all the rest white. On pouring it out on his stone, and beginning to grind it afresh, with intention to add more Prussian blue, he found the colour gradually returning of itself. Here it might be supposed the oxide of the prussiat had parted with oxigen to the oil, or the oxide of lead, or both, thus becoming white; except that on the surface, which was supplied with oxigen from the superincumbent water; and that it recovered its colour by attracting oxigen from the air. But on this supposition it would seem, that light must contain oxigen, since the colour of this paint, spread on wood or paper, returned by exposure to light in vacuo as well as in the open air. The colour of Prussian blue is affected by the contact of iron. Mr. Gill, finding a knife with which he was mixing some Chinese blue acquire a green tinge, spread a little of it, and afterward a little Prussian blue, sufficiently diluted, on the blade of a knife, and with a camel hair pencil took off enough to form a tint on paper, and thus continued, till he had taken off in the first instance 36, and in the second 86, without adding any fresh colour. These tints differed in regular gradation from greenish blue to green, olive green, yellowish green, yellow, and so on to a buff.

Concentrated nitric acid acts very strongly upon iron filings, much nitrous gas being disengaged at the same time. The solution is of a reddish brown, and deposits the oxide of iron after a certain time; more especially if the vessel be left exposed to the air. A diluted nitric acid affords a more permanent solution of iron, of a greenish colour, or sometimes of a yellow colour. Neither of the solutions affords crystals; but both deposit the oxide of iron by boiling, at the same time that the fluid assumes a gelatinous appearance. This magma, by distillation, affords fuming nitrous acid, much nitrous gas, and some nitrogen, a red oxide being left behind.

If potash be added to the nitric solution of iron, a brown precipitate falls down; of which a small quantity is redissolved by the alkali. Carbonat of potash separates a yellowish oxide, which soon becomes of a beautiful orange red colour. If the mixture be agitated during the effervescence, the precipitate is redissolved in much greater quantity than by the pure potash; doubtless by the medium of the carbonic acid. This solution is known by the name of Stahl's martial alkaline tincture, and is of a fine red colour, which however is impaired by time. Pure ammonia separates a deep green and almost black precipitate from the nitric solution of iron. The carbonat of ammonia redissolves the iron, which it separates from the acid; and forms an alkaline tincture of a more lively colour than that of Stahl.

Diluted muriatic acid rapidly dissolves iron, at the same time that a large quantity of hidrogen is disengaged, and the mixture becomes hot. In this, as well as in the sulphuric solution of iron, the same quantity of alkali is said to be required to saturate the acid as before the solution; whence it is inferred, that the acid is not decomposed, but that the oxidation is effected by the oxigen of the water; whence also it appears to follow, that the hidrogen must be afforded from the decomposed water, and not from the metal.

The muriatic solution of iron is of a yellowish green colour, and is much more permanent than the solutions of that metal in the sulphuric or nitric acid; though, like all the other solutions of iron, it deposits its metal by exposure to the air. By evaporation it assumes the consistence of sirup; in which, needle-formed and deliquescent crystals appear. Some chemists affirm, that the acid quits the iron by distillation, though much more difficultly than either the nitric or sulphuric acid; in fact, a porn of the iron rises at first with the acid, toward the end of the operation, iron is sublimed in the state of black de.

The muriatic solution of iron is decomed by lime and by alkalis; but the preitates are more easily reduced to the callic state than those afforded by other ls. Alkaline sulphurets, sulphuretted rogen, and astringents, decompose this, vell as the other solutions of iron; and prussiat of potash throws down a very blue precipitate. If iron filings be urated with muriat of ammonia, moistng the mixture; then drying, powdering, again triturating; and lastly subliming h a heat quickly raised; yellow or nge coloured flowers will rise, consistof a mixture of muriat of ammonia h more or less muriat of iron. These, ch were called *flowers of steel*, and still re improperly *ens veneris*, were oncemuch emed; but are now little used, as they nauseous in solution, and cannot very veniently be given in any other form.

Carbonic acid, dissolved in water, comes with a considerable quantity of iron, roportion to its mass. Vinegar scarcelissolves it, unless by the assistance of air.

hosphoric acid unites with iron, but y slowly. The union is best effected by ing an alkaline phosphat to a solution one of the salts of iron, when it will down in a white precipitate. A saated phosphat of iron has been found ve in France, semitransparent, of a red wn colour, and foliated texture. A blue phosphat of iron, lamellated, fragile, of the specific gravity of 2·6, ught from the Isle of France, and anad by Laugier, Fourcroy, and Vauquegave iron 41·25, phosphoric acid 19·25, er 31·25, alumine 5, and ferruginous 1·25, in 100 parts. A similar phosphat been found in Brazil. This acid is nd combined with iron in the bog ores, being at first taken for a peculiar metal called *siderite* by Bergman.

iquid fluoric acid attacks iron with ence; the solution is not crystallizable, thickens to a jelly, which may be rened solid by continuing the heat. The may be expelled by heating it strongly, ing a fine red oxide.

orat of iron may be obtained by precitting a solution of the sulphat with tral borat of soda.

rsenic acid likewise unites with iron. s arseniat is found native in Cornwall, pretty large cubic crystals, tolerably sparent, of a dark green colour with ownish tinge; sometimes yellowish, or brown yellow, like resin. The count Bournon found likewise a cupreous arat of iron, in minute rhomboidal crystals faint sky blue colour and uncommon liancy. Specific gravity 3·4. The green and red sulphats of iron may be decomposed by arseniat of ammonia, and afford arseniat of iron in the two different states.

Chromat of iron is said to have been found abundantly in the department of Var in France, and to form a beautiful green for enamelling or colouring pastes. Its analysis by Vauquelin and Tassaert gave chromic acid 43, oxide of iron 34·7, alumine 20·3, silex 2, in 100 parts.

In the dry way, this metal does not combine with earths, unless it be previously oxided; in which case it assists their fusion, and imparts a green colour to the glass. It appears to combine with alkalis by fusion. Nitre detonates strongly with it, and becomes alkalized.

Sulphur combines very readily with iron, in the dry and even in the humid way, though neither of these substances is scarcely at all soluble in water. A mixture of iron filings and flowers of sulphur being moistened, or made into a paste, with water, becomes hot, swells, adheres together, breaks, and emits watery vapours of an hepatic smell. If the mixture be considerable in quantity, as for example, one hundred pounds, it takes fire in twenty or thirty hours, as soon as the aqueous vapours cease.

By fusion with iron sulphur produces a compound of the same nature as the pyrites, and exhibiting the same radiated structure when broken. If a bar of iron be heated to whiteness, and then touched with a roll of sulphur, the two substances combine, and drop down together in a fluid state. It is necessary that this experiment should be made in a place where there is a current of air to carry off the fumes; and the melted matter, which may be received in a vessel of water, is of the same nature as that produced by fusion in the common way, excepting that a greater quantity of sulphur is fused by the contact of the bar of iron. The experiment of combining iron and sulphur together by fusion has not been made with an attention to the volatile products, if any be extricated. As neither of these substances contains water, and both are supposed to be simple bodies, the experiment might, perhaps, afford an interesting result. According to Proust the native sulphuret, or pyrites, contains 47·36 per cent. of sulphur, the artificial sulphuret but 37·5. Mr. Hatchett however has found, that the magnetical pyrites contains the same proportion as the artificial sulphuret.

Phosphorus may be combined with iron by adding it cut into small pieces to fine iron wire heated moderately red in a crucible: or by fusing six parts of iron clippings, with six of glacial phosphoric acid, and one of charcoal powder. This phosphuret is magnetic; and Mr. Hatchett remarks, that iron, which in its soft or pure state cannot retain magnetism, is enabled to do so when hardened by carbon, sulphur, or phosphorus, unless the dose be so great as to destroy the magnetic property, as in most of the natural pyrites and plumbago.

The combination of carbon with iron is of all the most important, and under the names of Cast Iron and Steel will be considered in the latter part of the present article. We shall just observe here, that according to Mr. Mushet of the Calder Iron-works, who has investigated the subject very extensively in the large way, soft cast steel capable of welding contains $\frac{1}{120}$ of carbon, common cast steel $\frac{1}{100}$, cast steel of a harder kind $\frac{1}{90}$, steel too hard for drawing $\frac{1}{50}$, white cast iron $\frac{1}{25}$, mettled cast iron $\frac{1}{20}$, black cast iron $\frac{1}{15}$. He conceives, however, that in steel the carbon is more intimately united with the iron. When iron is saturated with carbon it becomes what is commonly called plumbago.

Iron unites with gold, silver, and platina. When heated to a white heat, and plunged in mercury, it becomes covered with a coating of that metal. Long trituration of mercurial amalgams likewise causes a coating to adhere to the ends of iron pestles; small steel springs, kept plunged beneath the surface of mercury in certain barometers, become brittle in process of time; and the direct combination of iron and mercury in the form of an amalgam may be obtained, according to Vogel, by triturating the filings with twice their weight of alum, then adding an equal weight or more of mercury, and continuing the friction, with a very small quantity of water, till the union is completed. Mr. A. Aikin unites an amalgam of zinc and mercury with iron filings, and then adds muriat of iron, when a decomposition takes place, the muriatic acid combining with the zinc, and the amalgam of iron and mercury assuming the metallic lustre by kneading, assisted with heat. Iron and tin very readily unite together, as is seen in the art of tinning iron vessels, and in the fabrication of those useful plates of iron, coated with tin, which are generally distinguished by the simple name of tin alone. The chief art of applying these coatings of tin consists in defending the metals from oxidation by the access of air. After the iron plates are scraped, or rendered very clean by scouring with an acid, they are wetted with a solution of sal ammoniac, and plunged into a vessel containing melted tin, the surface of which is covered with pitch or tallow, to preserve it from oxidation. The tin adheres to, and intimately combines with the iron to a certain depth, which renders the tinned plates less disposed to harden by hammering, than before; as well as much less disposed to alter, by the united action of air and moisture. The process for tinning iron vessels does not essentially differ from that which has already been described for copper vessels. Iron does not unite easily with bismuth, at least in the direct way. This alloy is brittle, and attractable by the magnet even with three fourths of bismuth. As nickel cannot be purified from iron without the greatest difficulty, it may be presumed that these substances would readily unite, if the extreme infusibility of both did not present an obstacle to the chemical operator. Arsenic forms a brittle substance in its combination with iron. Cobalt forms a hard mixture with iron, which is not easily broken. The inflammability and volatility of zinc present an obstacle to its combination with iron. It is not improbable, however, but that clean iron filings would unite with zinc, if that metal were kept in contact with them for a certain time, in a heat not sufficient to cause it to rise; for it has been found, that zinc may be used in the operation of coating iron in the same manner as tin. Antimony unites with iron, and forms a hard brittle combination, which yields in a slight degree to the hammer. The sulphuret of antimony is decomposed by virtue of the greater affinity of the iron to the sulphur. For this purpose, five ounces of the points of nails from the farriers may be made red hot in a crucible, one pound of pulverized ore of antimony must then be thrown into the crucible, and the heat quickly raised to fuse the whole. When the fusion is perfect, an ounce of nitre in powder may be thrown in, to facilitate the separation of the scoriæ. After the mass is cooled, the antimony is found separate at the bottom of the crucible, while the iron remains in combination with the sulphur and alkali. If the proportion of the iron be considerably greater than five ounces to the pound of ore, the antimony will be alloyed with iron. Manganese is almost always united with iron in the native state. Tungsten forms a brittle, whitish-brown, hard alloy, of a compact texture, when fused with white crude iron. The habitudes of iron with molybdena are not known.

Iron is the most diffused, and the most abundant, of metallic substances. Few mineral bodies or stones are without an admixture of this metal. Sands, clays, and the waters of rivers, springs, rain, or snow, are scarcely ever perfectly free from it. The parts of animal and vegetable substances likewise afford iron in the residues they leave after incineration. It has been found native, in large masses, in Siberia, and in the internal parts of South America. This metal however in its native state is scarce: most iron is found in the state of oxide, in ochres, bog ores, and other friable earthy substances, of a red, brown, yellow, or black colour. The hematites, or blood stones are likewise ores with oxide of iron: these are either of a red colour, or blue, yellow, or brown. An iron ore is likewise found, of a blue colour, and powdery appearance. This useful metal is so abundant, that whole mountains are composed of iron

e; whereas other metals usually run in
l veins. Beside these ores of iron, which
either nearly pure, or else mixed with
is, as in spars, jasper, boles, basaltes,
iron is mineralized with sulphur, as
e pyrites; or with arsenic. The coally
ores contain bitumen. The magnet,
adstone, is an iron ore, the constitution
hich has not yet been accurately exa-
d. Iron is also found in combination
the sulphuric acid, either dissolved in
r, or in the form of sulphat.

analyse the ores of iron in the humid
they must be reduced to a very subtle
ler, and repeatedly boiled in muriatic
If the sulphureous ores should prove
of solution, a small quantity of nitric
must be added to accelerate the ope-
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ble part of the matrix only will re-
Prussiat of potash being added to
ecanted solution, will precipitate the
n the form of Prussian blue. This
pitate, when washed and dried, will be
in weight to six times the quantity of
lic iron it contains; and from this
four parts in the hundred must be
ted, to allow for the iron which is
ined in the prussiat of potash it-
But as this alkali, and every other
ration containing the prussic acid,
not constantly afford the same quan-
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addition of the prussiat of potash.
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me alkali in other solutions. For
weight of the precipitate obtained
trial experiment is to the quantity
n which was dissolved and precipi-
so is the weight of the precipitate
ed from any other solution to the
ty of iron sought.

e iron be united to any considerable
tion of zinc or manganese, the
an blue must be calcined to red-
nd treated with strong nitric acid,
will take up the oxide of zinc.
anganese may then be dissolved by
acid with the addition of sugar;
e remaining iron being dissolved by
ic acid, and precipitated by subcar-
of soda, will afford 225 grains of
itate for every 100 grains of metallic

xamine the ores of iron in the dry
he only requisite is fusion, in contact
arcoal. For this purpose eight parts
verized glass, one of calcined borax,
lf a part of charcoal, are to be well
together. Two or three parts of
ux, being mixed with one of the
ed ore, and placed in a crucible, lined
mixture of a little clay and pounded
al, with a cover luted on, is to be
urged with the strong heat of a smith's forge for half an hour. The weight of the ore, in this experiment, should not exceed 60 grains. Other processes for determining the contents, or metallic product, of iron ores, are instituted by performing the same operations in the small, as are intended to be used in the large way.

In the large iron-works, it is usual to roast or calcine the ores of iron, previous to their fusion; as well for the purpose of expelling sulphureous or arsenical parts, as to render them more easily broken into fragments of a convenient size for melting. The mineral is melted or run down, in large furnaces, from 16 to 30 feet high; and variously shaped, either conical or elliptical, according to the opinion of the iron-master. Near the bottom of the furnace is an aperture for the insertion of the pipe of large bellows, worked by water or steam, or of other machines for producing a current of air; and there are also holes at proper parts of the edifice, to be occasionally opened, to permit the scoriæ and the metal to flow out, as the process may require. Charcoal or coke, with lighted brushwood, is first thrown in; and when the whole inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel, and commonly a portion of limestone, as a flux: the ore gradually subsides into the hottest part of the furnace, where it becomes fused; the earthy part being converted into a kind of glass; while the metallic part is reduced by the coal, and falls through the vitreous matter to the lowest place. The quantity of fuel, the additions, and the heat, must be regulated, in order to obtain iron of any desired quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts which compose the ore.

The iron which is obtained from the smelting furnaces is not pure; and may be distinguished into three states: white crude iron, which is brilliant in its fracture, and exhibits a crystallized texture, more brittle than the other kinds, not at all malleable, and so hard as perfectly to withstand the file: gray crude iron, which exhibits a granulated and dull texture when broken; this substance is not so hard and brittle as the former, and is used in the fabrication of artillery and other articles which require to be bored, turned or repaired: and black cast iron, which is till rougher in its fracture; its parts adhere together less perfectly than those of the gray crude iron: this is usually fused again with the white crude iron.

Whenever crude iron, especially the gray sort, is fused again in contact with air, it emits sparkles, loses weight, and becomes less brittle. In order to convert it into malleable iron, it is placed on a hearth, in the midst of charcoal, urged by the wind of two pair of bellows. As soon as it becomes fused, a workman continually stirs it with a long iron instrument. During the course of several hours it becomes gradually less fusible, and assumes the consistence of paste. In this state it is carried to a large hammer, the repeated blows of which drive out all the parts that still partake of the nature of crude iron so much as to retain the fluid state. By repeated heating and hammering, more of the fusible iron is forced out; and the remainder, being malleable, is formed into a bar or other form for sale. Crude iron loses upwards of one fourth of its weight in the process of refining; sometimes indeed one half.

Purified or bar iron is soft, ductile, flexible, malleable, and possesses all the qualities, which have been enumerated under this article as belonging exclusively to iron. When a bar of iron is broken, its texture appears fibrous; a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition destroys this fibrous texture, and renders the iron more uniform throughout; but hammering restores it.

If the purest malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a strong red heat (which time must be longer or shorter, according to the greater or less thickness of the bars of iron), it is found, that by this operation, which is called cementation, the iron has gained a small addition of weight, amounting to about the hundred-and-fiftieth, or the two-hundredth part; and is remarkably changed in its properties. It is much more brittle and fusible than before. Its surface is commonly blistered when it comes out of the crucible; and it requires to be forged, to bring its parts together into a firm and continuous state. This cemented iron is called steel. It may be welded like bar iron, if it have not been fused, or over-cemented; but its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardness produced is greater in proportion as the steel is hotter, and the water colder. The colours which appear on the surface of steel slowly heated are yellowish white, yellow, gold colour, purple, violet, deep blue, yellowish white; after which the ignition takes place. These signs direct the artist in tempering or reducing the hardness of steel to any determinate standard. If steel be too hard, it will not be proper for tools which are intended to have a fine edge, because it will be so brittle, that the edge will soon become notched; if it be too soft, it is evident, that the edge will bend or turn. Some artists ignite their tools, and plunge them into cold water: after which, they brighten the surface of the steel upon a stone: the tool being then laid upon charcoal, or upon the surface of melted lead, or placed in the flame of a candle, gradually acquires the desired colour; at which instant they plunge it into water. If a hard temper be desired, the piece is dipped again, and stirred about in the cold water as soon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools used in working upon metals; if dipped while blue, it will be proper for springs, and for instruments used in the cutting of soft substances, such as cork, leather, and the like; but if the last pale colour be waited for, the hardness of the steel will scarcely exceed that of iron. When soft steel is heated to any one of these colours, and then plunged into water, it does not acquire nearly so great a degree of hardness, as if previously made quite hard, and then reduced by tempering. The degree of ignition required to harden steel is different in the different kinds. The best kinds require only a low red heat. The harder the steel, the more coarse and granulated its fracture will be; and as this is not completely remedied by the subsequent tempering, it is adviseable to employ the least heat capable of affording the requisite hardness. It is a circumstance worthy of remark, that steel has a less specific gravity when hardened, than when soft; but there are no circumstances, upon which a probable connection between these two properties, namely, the increased hardness and the diminished specific gravity, can be made out.

The usual time required for the cementation of steel is from six to ten hours. If the cementation be continued too long, the steel becomes porous, brittle, of a darker fracture, more fusible, and incapable of being forged or welded. On the contrary, steel cemented with earthy infusible powders is gradually reduced to the state of forged iron again. Simple ignition produces the same effect; but is attended with oxidation of the surface. The texture of steel is rendered more uniform by fusing it before it is made into bars: this is called cast steel; and is rather more difficultly wrought than common steel, because it is more fusible, and is dispersed under the hammer if heated to a white heat.

The English steel made by cementation, and afterward fused, and sold under the name of cast-steel, in bars, plates, and other forms, possesses great reputation for its uniformity of texture, and other good qualities. I have been informed by various authorities, of which the respectability and connections are calculated to produce the most absolute confidence, that all the prime steels of England are made from Swedish iron, known in this country by the name of steel-iron, of

different marks, the first of which
tes the best quality, and the third the
; and that the whole produce of this
f iron is monopolized, under a con-
with Sweden, by two commercial
s, one in London, and the other at
ngham, the names of which were
oned to me. Hence it seems probable,
e useful art of steel-making might be
promoted by examining this material,
certaining chemically, as well as me-
ally, what may be the cause of its
ority. By chemical examination, I
the determination of its component
and by mechanical examination,
er these parts be uniformly distribut-
ough the whole mass. For one of
eatest imperfections of steel consists
unequal distribution, which produces
espondent inequality of hardness in
veral parts of such utensils as may be
of it.

conversion of iron into steel, either
sion, viz. the direct change of crude
nto steel, or by cementation of bar-
present many objects of interesting
y. From various experiments of
an it appeared, that good crude iron,
or a certain time in a state of fusion,
such additions as appeared calculated
oduce little other effect than that
ending the metal from oxidation, be-
converted into steel with loss of
t. These facts are conformable to
general theory of Vandermonde,
e, and Berthollet: for, according to
researches, it should follow that part
carbon in the crude iron was dissi-
, and the remainder proved to be
n proportion as constitutes steel. The
chemist cemented crude iron with
ago, or carbonat of iron, and found
he metal had lost no weight. Mor-
repeated the experiment with gray
iron. The loss of weight was little,
. The metal exhibited the black
by the application of nitric acid, as
usually does, but it did not harden by
on and plunging in water. Hence I
de, that it was scarcely altered: for
irons also exhibit the black spot, and
t by common management acquire
rdness of steel.

m the experiments of the three excel-
hemists last mentioned, it appears,
he gray crude iron consists princi-
of iron, with as much carbon as it can
ve in the strong heat of the smelting
ce. They have shown also, that it de-
part of this addition when cooled in
ct with an iron bar immersed in the
This separation must be general in
rdinary or gradual way of cooling,
ce the gray colour must arise from the
hite colour of the iron mixed with
ack of the carbon. And this gray
r is also in a degree perceived, when
lose-grained steel is broken. These

circumstances lead me to conclude, that hard steel may in a certain respect differ from that which is softer by the intimate combination of a larger proportion of carburet. This accounts for the whiter and more metallic aspect of hardened steel, than of such as is soft. For the former contains less of disengaged carburet. Hence also we may account for the greater hardness of steel which has been made quite hard, and then let down by tempering to a certain colour, than of steel merely heated to that colour, and plunged in water. For in the first method of hardening, a sufficient degree of heat is given to produce combination between part of the disengaged carburet and the iron, which in the latter does not take place. If the carburet be merely sufficient to saturate all the iron at a moderate degree of ignition, the hardness will be considerable; but the steel will be easily degraded to the state of iron by frequent ignition. Such steel in its hard state will be very uniform in its texture, not excessively hard in its temper, but disposed to take a very fine firm edge, which will not easily be broken or injured by violence. These are accurately the properties of the English cast steel, which is of so uniform a nature, as to be distinguished by its conchoidal or glassy fracture. When the dose of carbon in steel is greater, it will bear a greater heat without degradation, insomuch, that it may be welded like iron. Its hardness will also be capable of a higher degree; and if this degree produced by a stronger ignition be not given, the edge of the tool will never become fine and smooth; and even at this higher degree, with all the advantage of subsequent tempering, it will be less smooth than that of the cast steel, and more disposed to break. Steel of this kind is better adapted for the construction of hammers, vices, hatchets, leather-cutters' knives, and other instruments wherein the edge is either stout, or sudden blows unnecessary, or the construction demands frequent heating and welding.

By pursuing this train of reflection, it will follow, that, since crude iron differs from steel only in the superabundance of carbon, it ought to be capable of extreme hardness, if ignited to that degree, which is requisite to combine the greater part of this carbon with the iron, and then suddenly cooled. This is accordingly found to be the case. If the gray crude iron, commonly distinguished by our founders by the name of soft metal, be heated to a white heat, and then plunged into water, it becomes very hard, much whiter, denser, and more metallic in its appearance; and will bear a pretty good edge fit for gravers, for the use of turners in iron or steel. In these tools the angle of the planes which form the edge is about 45°. The hardness of this kind of iron is not considerably diminished but by ignition continued for a length of time, which is a fact also conformable to what happens in steel. For the cast steel will be softened nearly as much by annealing to the straw colour, as the harder steels are by annealing to a purple or full blue.

Some of our artists have taken advantage of this property of soft crude iron in the fabrication of axles and collars for wheelwork; for this material is easily filed and turned in its soft state, and may afterward be hardened so as to endure a much longer time of wear.

The founders who cast wheels and other articles of mechanism are occasionally embarrassed by this property. For, as the metal is poured into their moulds of moistened sand, the evaporation of the water carries off a great portion of the heat, and cools the iron so speedily, as to render it extremely hard, white, and close in its texture. This is most remarkable in such portions of the metal, as have the greatest distance to run from the git or aperture of reception. For these come in contact successively with a larger portion of the sand, and are therefore more suddenly cooled. I have seen the teeth of cog-wheels altogether in this state, while the rim and other parts of the wheel remained soft. The obvious remedy for this defect is to increase the number of gits, and to have the sand as dry as possible or convenient. In other articles this property has been applied to advantage, particularly in the steel rollers for large laminating mills, which Messrs. Vandermonde, Monge, and Berthollet have supposed to be an over-cemented steel. They are made by casting the gray crude iron in moistened sand, the contact of which gives the hard steel temper to the outside surface, for the depth of more than half an inch. I have no doubt, but that the iron-masters pay considerable attention to the quality of the iron, and perhaps to the degree of heat and moisture of the sand in this operation, in order that the hardness may be such as to yield to the turning tool; and I likewise understand, that a considerable number crack longitudinally in the cooling, a loss which in all probability arises from the difference of contraction between the hard and soft parts.

In the experiments of Rinman, a bar of cast iron being placed over the fire of a smelting furnace was almost fused. It was observed in breaking it, that the side nearest the fire had become soft iron to the depth of one sixteenth of an inch; that the rest was steel, excepting the upper part exposed to the air, which remained in the state of crude iron.

I must refer to the Encyclopédie for a considerable enumeration of experiments relative to the cementation of iron with various metals, and also to such as relate to the return of steel to the state of iron. It appears in general, as might be expected, that iron by a sufficient continued heat in closed vessels, in contact with coally matter, becomes steel; but that if such matter be not present, the effect does not take place; and even the state of steel, if possessed by the iron, that is to say, its power of hardening by moderate ignition, goes off.

A variety of facts concerning the hardening and softening of steel are collected by Guyton-Morveau, the most interesting of which I shall here subjoin. According to Reaumur, that part of the steel which was hottest at the time of immersion in the water will be the hardest; whence it has been thought a fair conclusion, that the hardness of steel is the greater, the stronger the ignition, and the more speedy the cooling. Nevertheless, the celebrated Rinman deduces a very different consequence; namely, that the steel which is naturally the hardest is that which requires the least heat, and that the best temper for each kind of steel is that produced by the lowest degree of heat suitable to that peculiar kind. Hence, various methods have been proposed to ascertain the degree of heat most advantageous to any particular sample of steel. They are all reducible to that of igniting one end of a bar to a white heat, and plunging it into water. The hardness of the several parts may then be ascertained by examination.

It appears to me, that the considerations on which the first-mentioned general rule is founded, are rather of a complicated nature. If it be true, as conjectured above, that the hardness of steel depends principally on the intimate combination of its carbon; it will follow, that the utmost hardness any steel is capable of will be produced by a degree of heat sufficient to effect this purpose, and that any superior degree will only degrade the quality of the steel; and consequently, that the general rule will apply only to heats inferior to this maximum. It may also happen, when the mass of water is not considerable, though I doubt the fact when the quantity is large, that the heating of the water, and the production of hidrogen, may so far modify the rate of cooling, as even to render it less sudden than might have happened with an inferior degree of ignition. Lavoisier has remarked, that the conversion of iron into the hard brittle oxide, when water is decomposed, may perhaps be of the same nature as the hardening of steel. There is another fact, which is of great consequence, and may perhaps afford the principal ground for Rinman's apparent exception to the general rule concerning the hardening of steel. Hardness is that property of bodies by which they resist indentation, and rather break than bend, or suffer contusion. It is the opposite to softness. Tenacity, which

ry frequently confounded with hard-
is not the property by which they re-
ndentation, but separation of their
. It is the opposite to friability or
eness. Now that steel, in common
age, is said to be the hardest, which
s most eminently the properties of
ness and tenacity. But the effect of
and sudden cooling is directly opposite
ese two respects. Soft steel is the most
ious, but the least hard. The opera-
of hardening diminishes its tenacity,
ncreases its hardness progressively to
aximum of heat the steel is formed to
There will be no difficulty then in
iving, that the best state of steel, re-
to any particular use, will be at some
e degree between the softest and
est qualities. Thus for springs, much
ity and moderate hardness are re-
d. For chissels and similar tools,
operate by a blow, a greater hard-
nay be admitted. Razors, knives, and
tools as effect the intended purpose
gradual stroke, will be still more
ble the harder they are; but even in
the tenacity must not be too much di-
hed, otherwise the edge will be liable
reak. They must all be capable of
g the edge turned or bended on one
n the operation of whetting. Files
rhaps of all tools such as require the
est hardness; but in these, it is far
being the utmost the steel is capa-
of receiving. It is found, that the
ty of steel is considerably increased
ntinued hammering to a certain point.
he whole effect of this hammering is
off by strong ignition. Good steel by
ning at a white heat may be rendered
ttle, that it will break full as easily as
of the same dimensions, and its tex-
is then found to be coarse and large
ed. As the subsequent annealing does
estore the effect of the hammering,
ring the grain of the steel to the state
ld have possessed if a lower heat had
used at first; it is evident, that the
useful hardness is produced by that
e of heat, which is just sufficient to
the purpose. And accordingly, tools
of cast steel, and intended to sustain
d edge for cutting iron and other me-
re not afterward annealed, but the
on is carefully regulated at first. An-
g ought only to be used, where con-
ble softness is required.

man affirms, that steel does not har-
when cooled in a close cylinder, or
n a vessel purged of air. Not having
rk in my possession, I find some dif-
in conceiving how the experiment
be made, so as to obviate all objec-
relative to loss of time, unless the
ng glass and receiver of an air-pump
used. Reaumur also found, that a
piece of steel introduced red-hot into a tube of glass full of mercury, which was immediately set upright so as to form an ordinary barometer with the vacuum at the top, continued as soft as if it had been cooled in the open air. Do these facts warrant the strange conclusion, that the mere pressure of the atmosphere is concerned in the hardening of steel? It seems, nevertheless, that no other effect of the air could be transmitted to the steel so instantaneously through a body of water. When we reflect on the effectual modifications which the smallest agitation, or even the presence of light, have upon the arrangement of the parts of solid bodies in crystallization, we shall have less cause for wonder if these facts should be confirmed.

Iron may be hardened to a certain degree by ignition and plunging in water, but this effect is confined to the surface; except, as it very often happens, the iron contains veins of steel. These are no small impediments to the filing and working this material. It sometimes likewise may happen, that the iron may have undergone a process of the nature of case-hardening from the fuel. I have been informed by a workman, that ignited iron, suddenly plunged into the soft leather of a shoe, becomes very hard on its surface, which must arise from an instantaneous effect of this kind.

The increase of dimensions acquired by steel in hardening is such, that in general such pieces of work as are finished soft will not fit their places when hardened. Rinman found, that bars of steel six inches long, six lines wide, and half an inch thick, were lengthened at least one line after hardening by a whitish red heat, which is about one seventieth of the linear dimensions; and supposing the dilatation to be proportional, Guyton-Morveau computes the bulks to be as 48 to 49. But the cubes of 72 lines and 73 lines are in proportion more nearly as 47 to 50. Various kinds of steel at different hardness must no doubt greatly differ in this respect. The specific gravities, as given by Brisson, p. 366, art. Gravity (Specific), afford a much less ratio. Rinman found by his experiments on two different kinds of fine cemented steel, the specific gravity of which was 7·991, that one after hardening gave only 7·553, and the other 7·708. These numbers agree sufficiently near with the experiment of the six-inch bar. Yet he once found Styrian steel augmented in density by hardening in the ratio of 7·822 to 7·782. Morveau found, with pieces of steel 28 lines long, that the increase of length by hardening was about the 350th part.

The fineness of grain in hard steel, as exhibited in its fracture, is various according to the quality of the metal, and the temper it has received. The harder the steel the coarser the grain. But in like circumstances, fine steel has the closest grain, and is ever the most uniform in its appearance. Workmen avail themselves much of this indication. In general a neat curve lined fracture, and even gray texture, denote good steel; and the appearance of threads, cracks, or brilliant specks, denotes the contrary. But the management of the forging and other circumstances of manufacturing will modify these indications; and the steel that is good for some purposes may be less suited to others.

The fluid into which ignited steel is plunged is of great consequence. All the facts seem reducible to these general conclusions. The hardness will be greater, 1. The hotter the steel is made, provided it be not decomposed: 2. The more considerably its temperature is lowered in the cooling: 3 The shorter the time of cooling: and 4. The more favourable the fire or the cooling material may be to the steel-making process. But the most useful combination of hardness and tenacity will be at a medium temperature in each kind of steel.

With regard to the first particular, little need be said, but that the decomposition of steel in heating will be prevented, and its surface somewhat improved, if it be bedded in charcoal, or the cementing compound, during the application of the heat. The second and third, namely the quantity and suddenness of cooling, require an attention to the doctrine of Caloric, as explained under that article. The cooling will be more sudden and effectual the greater the quantity of heat absorbed in the same time. There are three circumstances which favour this effect, namely, a very low temperature of the body to which the hot steel is applied; that it shall be a good conductor of heat; or that it shall assume either the fluid or elastic state, which always demand a supply of heat for their maintenance. Thus it is found, that steel is more effectually hardened in cold than in warm water, and at like temperatures more effectually in mercury than in water. It may also be remarked, that these two fluids cool the steel by different energies. The water is partly converted into vapour, which carries off the heat, and leaves the fluid much less altered in temperature than mercury, which acts by its conducting property. This last fluid, not having evaporated in the process, is found to have acquired a much more elevated temperature by the immersion. Oil is found to harden the surface of steel much more than its internal part, so that it resists the file, but is much less easily broken by the hammer. This effect arises from its imperfect conducting quality, and the elevated temperature it demands to be converted into the vaporous state; to which we may also add, that a stratum of coal is formed round the steel from the burned oil, which still more effectually prevents the transmission of the heat. A remarkable instance of this nature presented itself to my observation in hardening a small piece of steel two inches long, and a quarter of an inch diameter. At the time of ignition, the water nearest at hand had been used with soap. The steel made very little noise when plunged into the water, and remained hot for a considerable time; but when taken out was found to be scarcely at all hardened. It was covered with coally matter; which being cleared off, and the process repeated with clean water, it became perfectly hard. The heat in both cases was a low red heat, proper for cast steel, which is not intended to be afterwards annealed. I have very little doubt, but that alcohol and the essential oil of turpentine, which are good conductors of heat and very volatile, would render steel very hard, if their inflammability, and the little necessity there is for using them, were not an impediment to their application. Various artists avail themselves of different substances for the immersion of ignited steel. Some use urine, others water charged with common salt, nitre, or sal ammoniac. Tallow and oil are used for such works as are not required to be brittle, though very hard, the reason of which has just been mentioned; but tallow differs from oil in the heat which becomes latent for its fusion; and accordingly, solid tallow is an excellent material for hardening drills and other small articles. It has been found by Reaumur, that saline liquids produce rather more hardness than common water; and in particular, that aqua fortis possesses this property in an eminent degree, probably from its conducting power: the makers of files cover them with the grounds of beer and common salt, which assist their hardening, and keep the surface from scorifying. The mucilage of the beer supplies a coally matter; and the fused salt seems not only to form a varnish in the fire and defend the steel, but may also produce cold, by its sudden solution in the water at the time of immersion. Very small articles heated in a candle are found to be hardened perfectly by suddenly whirling them in the cold air; and thin bars or plates of steel, such as the magnetic needle of a compass, acquire a good degree of hardness by being ignited, then laid on a plate of cold lead, and suddenly covered with another plate. These would be unequally hardened, and bend, if plunged in water.

The *blueing* of steel appears to affect its elasticity in a manner not easily explained. This operation consists in exposing steel, the surface of which has been first brightened, to the regulated heat of a plate of metal, or a charcoal fire, or the flame of a lamp, till the surface has acquired a blue colour. Now, if this blue coal be removed by grinding, the elasticity is completely destroyed, d may be restored by blueing the steel ain. Rubbing with sand or emery-paper, azing, or burnishing, equally impairs the asticity in proportion as it destroys the ue coat. Sawmakers first harden their ates in the usual way, in which state they e brittle and warped: they then soften em by *blazing*, which consists in smearing e plate with oil or grease, and heating it l thick vapours are emitted, and burn off ith a blaze; and after this they may be mmered flat: lastly, they blue them on hot iron; which renders them stiff and astic without altering their flatness.

The Damascus swordblades have long een celebrated for their excellence, but it not known how they are made. Mr. oddart took six small bars of good alleable iron, and the same number of eer steel; laid them alternately on each her; welded them together; forged them to a stout flat plate, which was twisted irally into a cylinder, hammered flat, and gain welded; hammered this flat, doubled throughout its length, inserted in the fold slip of good steel to form the edge, and y another welding heat consolidated the hole into one mass. This being forged to proper shape, cracked in different places n being cooled in water after heating: but Ir. Stoddart conceives, that by using more ieces, repeating the twisting, and not uenching in water, the process would ucceed.

Mr. Duhamel, in the Encyclopédie, gives n ample account of the methods of making eel by the ancient way of fusion from the re, and the more modern way of cemen- ation. We have treated concisely of both lready, and in this place shall only add a ew of the facts noted by this author con- erning cementation. The English, who eservedly possess the greatest reputation n this work, have found, that every species f iron is convertible into steel by cemen- ation; but that good steel is not to be nade except from iron of the best quality, vhich possesses a certain stiffness and hard- ess as well as malleability. Swedish iron, s we have before remarked, is the best for his purpose. Mr. Duhamel tried a great umber of the irons of France, Sweden, and pain. He found the second to be the best; ut he likewise obtained excellent steel, su- erior to those of Styria and Carinthia, vhich are the best German steels, by using ertain iron made in France. But this iron vas selected without fault, and, in some in- tances, the loup or piece at the smelting urnace was fused and forged a second ime; a process which, though attended vith loss of weight and additional expense, e recommends as absolutely necessary for naking steel iron from ores of indifferent uality. The white spathose iron ores af- orded him the best iron for the purpose f cementation; and these also are the ores, vhich afford the best steel by fusion in, Styria, Carinthia, and Tyrol. He informs us, that the English use no other cement than mere charcoal, which he also finds perfectly adequate to the purpose; and moreover, that the quality of the steel is not affected by the different kinds of charcoal made use of. He remarks nevertheless, that it may be adviseable to add from one fourth to one third of wood-ashes, especially where the iron is not of so good a quality as to afford steel possessing tenacity or body, as well as hardness. These ashes, which he used with success, prevent the steel-making process from being effected as rapidly as it would otherwise be, and give the steel pliability without diminishing its hardness. It is remarked, that in the case of this management, the blisters on the surface of the steel are smaller and more numerous. He likewise tried sea-salt. Fifty pounds of salt are sufficient for a furnace of steel of twelve thousand weight. The salt is pulverised, and sprinkled on the bars of iron when put into the furnace. He found, that this ingredient likewise contributes to give body to the steel. In the arrangement of the bars in the furnace, the cement is laid one inch thick at the bottom, and half an inch thick between each layer of iron. Our author affirms, that the process would succeed equally well, if the thickness were a little more than a quarter of an inch. The thickness of the bars of iron is indifferent, but there ought not to be a great difference in this respect between bars cemented at the same time. The common thickness is a little more than half an inch. It is not adviseable, that they should be very broad in proportion to the thickness, as this figure is found to produce flaws and cracks in the direction of the length of the bar. The bars may be square, or their breadth may conveniently be somewhat more than twice their thickness. The fire for cementation must be of considerable intensity, and kept up until the conversion has perfectly taken place, which is ascertained by proof bars, so disposed as to be taken out from time to time. The cementation is finished on the sixth day; that is to say, it commonly lasts five times four-and-twenty hours. And accordingly, the workmen take one of the proofs out on the fifth day, which is forged, hardened, and examined by the fracture. If it break short, and show no indications of iron, the fire of the furnace is suffered to go out. But if it contain iron, the fire is kept up for twelve or twenty-four hours, accordingly as the quantity of fibrous iron may have proved greater or less in the first proof. A second proof bar taken out at the proper time serves to direct them in the same manner with regard to their operations. By this management, the cementation is continued somewhat beyond the time requisite for the entire conversion. For there is less inconvenience attending a slight degree of excess in the cementation, than would result from a portion of iron remaining in the steel. The charcoal after cementation is as black, and apparently in the same state, as it was before. Mr. Duhamel moistened it, and applied it to the same use a second time. It answered the purpose, but so much more slowly, that he objects to the use of it in manufactories. From this, as well as other circumstances attending the steel-making process, it seems advantageous, at least with regard to expedition, that the coals should contain volatile matter. And hence the superior advantages of animal coal, such as the coal of leather, or the hoofs and horns of animals, imperfectly burned, which are used in case-hardening, though they may be less applicable to the longer process of steel-making for various reasons.

Mr. Duhamel advises to have two tilting hammers; one of the weight of one hundred and fifty pounds, and the other half that weight; the first, for the purpose of forging large work, and the latter small bars for cutlers. He recommends another small hammer of about twelve pounds for forging bars still smaller, to make gravers, small files, and the like. The steel must not be heated beyond the degree of cherry red for forging. The tilting hammers should give at least three hundred strokes in a minute.

On this head, I must make a reflection, which perhaps may be of value to the manufacturer, though experience certainly affords the only means of determining the utility of proposed alterations in the implements or utensils. When a hammer strikes with a certain momentum, the change of figure produced by the blow will be greater, the more of velocity and the less of mass possessed by the hammer. It seems therefore, in the application of mechanic force, that in most cases the expenditure would prove more profitable, if an extreme velocity were given to a small weight, the face of the hammer remaining the same, than if a larger weight were moved proportionally slower. And so likewise, it should appear, that more work would be done by a certain number of swift blows, than by twice the number with only half the swiftness. When the usual number of strokes is three hundred in a minute, or five in a second, the velocity cannot be considerable, even when assisted by a back spring, or other contrivance. It would therefore at least be worth trying in situations where the power is limited, as in the case of a small stream of water, or steam engine, whether the weights and velocities of the hammers may not be altered with profit. An ingenious mechanic would find no difficulty in contriving a simple apparatus, by which these correspondent alterations might be made at pleasure, accordingly as the nature of the work or other circumstances might demand.

The cast steel of England is made by a process, which the manufacturers keep a secret. Mr. Duhamel gives the following account of it: A crucible about ten inches high, and seven in diameter, is filled with ends and fragments of the crude steel of the manufactories, and the filings or fragments of steel works. Magellan affirms, that they buy up broken tools at Sheffield or elsewhere for this purpose. They add a flux, the component parts of which are carefully concealed It is probable, however, that the success does not much depend upon this flux, which, from the quality of the cast steel itself, may be presumed to be of the nature of a steel cement. This crucible is placed in a wind furnace, like that of the founders, but smaller, because intended to contain one pot only. It is likewise surmounted by a cover and chimney to increase the draught of air. The furnace is entirely filled with coke or charred pit-coal. Five hours are required for the perfect fusion of the steel. It is then poured into long square, or octagonal moulds, each composed of two pieces of cast iron fitted together. The ingots when taken out of the moulds have the appearance of cast iron. It is then forged in the same manner as other steel, but with less heat and more precaution; because more liable to break.

This cast steel is almost twice as dear as other good steel. Mr. Duhamel says, that it is not proper for all kinds of work, particularly those which require much tenacity, as well as hardness to resist violent blows and strains; but it is good for razors, knives, and all toys and small work which require an exquisite polish. It does not seem, however, that the tenacity of this steel is inferior to that of the best of the other kinds, and its uniformity of texture is for many works an invaluable advantage. It is daily more and more used in England, but must necessarily be excluded from many works of considerable size, on account of the facility with which it is degraded in the fire, and the difficulty of welding it, which cannot be done in the common way. I have been informed, that the faces of anvils and broad hammers, for the use of silver-smiths and other artists, have been made of cast steel and welded to iron by a particular management, which consisted in substituting between the iron and the steel another kind of steel in the form of filings, or a thin plate. The steel plate intended for the face was made as hot as could be done with safety, and the iron being at the same time brought to the welding heat, was applied to the steel, and quickly united by hammering.

When we consider the operations by which crude iron is brought into the malleable state, then converted into steel, and afterward into a fusible metal, which is not malleable; we may perceive that steel, making is a kind of inversion of the process of refining iron, as practised in the first instance. When the oxide of iron is mixed in the smelting furnace with combustible matter and glass, it will either be completely or partially revived, according to the management of the process. Much of the coal will however be so enveloped with the vitreous matter as to remain unburned: and the reduced iron, with which it may be in contact, will be in the same situation as forged iron in the cementing pot; that is to say, it will be in contact with coal at a very elevated temperature, and defended from the air. From the great infusibility of iron, it may reasonably be concluded, that the reduced metal does not flow into the bottom of the furnace, until the charcoal has converted it into a fusible matter similar to steel, by the same action which takes place in cementation, whatever that action may be. Hence it must follow, that the various specimens of crude or cast iron will differ in their qualities, as well on account of the degree of cementation they have undergone, as the degree of reduction which has taken place among the metallic parts, which are carried down, and form the whole mass. Since the coal, in the process of cementation, communicates or adds weight to the iron; and since crude iron, as well as steel, exhibits sparkles, and is more easily burned than other iron; it may therefore be concluded, that in the process of refining, that part of the inflammable substance which had united with the metal is burned, and leaves the iron much less fusible than before. Stirring the mass multiplies the contacts of the air with the burned substances; these surfaces of contact will therefore successively afford thin coats of infusible metal. In this manner it is found, that, if a large piece of crude iron be exposed to heat in a wind furnace, the external part will be deprived of its fusibility during the time required to produce a strong heat in the whole mass; and the internal part will be melted, and run out, leaving the shell behind. Iron, which is of the consistence of paste, may therefore be considered, like any other paste, as a mixture of a fluid with a solid. It will be easily understood, that the forging will bring the parts of difficult fusion together, and extrude the less refined and fluid parts: it will also be evident, that this operation is not likely to drive out the whole of the fusible matter. When the iron has arrived at that state, wherein the quantity of fibre or tough iron is sufficient to answer the mechanical purposes to which it is intended to be applied, the artist will consider it as sufficiently refined; and the residue of fusible iron contained in the bar answers, in all probability, the valuable purpose of connecting these infusible masses together. Thus we find, that forged iron appears as if covered with a varnish, when urged to a white heat; we find that this varnish is more abundant in steel; and that iron and steel may be respectively welded together by application in this state; an effect which it would be very difficult to account for, in this most infusible of metals, if it were not for such an admixture. But cast steel, steel overcemented, and crude iron, appear to be in the state of all other metals, platina excepted. They cannot be welded, because welding implies a partial fusion; or an effect similar to the glueing or uniting of solids by the application of a fluid, which afterward becomes consistent. And as platina possesses this valuable property, it seems reasonable to infer, that it must also consist of two metallic substances of different degrees of fusibility; a supposition that appears to be confirmed by the discoveries of Dr. Wollaston and Mr. Tennant.

Crude iron, and steel of a uniform texture, consist therefore of a fusible combination of iron with the combustible substance of the coal, or something which is imparted from it; the crude iron differing from the steel simply in being overdosed with carbon, and less pure, on account of the admixture of metallic oxide, which can scarcely, perhaps, be avoided in the large process. It appears therefore, that crude iron must pass through the state of steel, before it can become forged iron; and consequently, that the fabrication of steel from this last is a circuitous process, which can only be repaid by the absence of those unreduced parts, which may exist in the crude iron. At some forges, however, where the ore, the flux, the fuel, and the management, are adapted to each other, the produce affords steel, when duly refined. At other manufactories, the crude iron is either refined, or converted into steel, by running it into thin plates, which are stratified with charcoal, and burned in a close furnace. In this way the metal is refined by degrees, without undergoing fusion; and if the heat be raised to that of cementation, the iron will not only be reduced, but converted into steel. In the forges of Carinthia the gray crude iron is also converted either into soft iron, or steel, according to the management of a somewhat similar process. The iron is fused in a large melting-pot; and a small quantity of water, being thrown upon the surface of the metal, causes a thin plate to congeal, which is taken off; and by continuing the operation, the greatest part of the fused iron becomes converted into plates. To produce steel, these plates are again fused, and kept a long time in an elevated heat; at the same time that the metal is defended from the contact of the air by a sufficient quantity of the vitreous slag. To produce soft iron, the plates are exposed to a continued roasting, while the air is constantly renewed by means of two pair of bellows. The extensive surface of the plates renders it unnecessary to use that agitation, or stirring, which is required when fused crude iron is refined. In these processes it is evident, that the same matter in the crude iron, which it obtained in the smelting furnace, is employed, and supplies the place of the charcoal used in forming steel by cementation; and, on the other hand, that this substance, which prevented the crude iron from being soft, tough, and infusible, is burned away, together with a portion of the iron itself, while the remainder is left in a much purer state.

These are facts observed at the furnaces. But the observations and inquiries of the chemist must be carried farther, in order to determine what it is that iron gains or loses at the time of its conversion into its various states. It is found, that crude iron approaches towards the soft state, not only by heating with exposure to the air, which burns the combustible addition, but likewise by fusion, without the free access of air. In this case, when the fusion has been complete, and the cooling gradual, it is found that a black substance is thrown up to its surface, which is more abundant the grayer or blacker the iron; and the same black substance is observed to coat the ladles of forged iron, which are used to take out the metal, and pour it into moulds for casting shot, and other articles. It appears therefore, that the heated iron, like other heated fluids, is capable of holding a larger quantity of matter in solution than when cold; and that a portion of this black substance separates during the cooling, whether by the gradual effect of surrounding bodies, or by the contact of the ladle, in the same manner as various salts are separated, in part, from water, by a diminution of temperature. From chemical analysis, as well as from its obvious characters, this black substance is found to be plumbago, or the materials used to make pencils, and commonly known by the name of black lead, which is nothing but a carburet of iron.

The presence of this black matter is likewise exhibited by dissolving steel, or crude iron, in acids, in which plumbago is insoluble, and therefore remains behind in the form of a powder. Hence likewise is deduced the cause of the black spot which remains upon steel, or crude iron, after its surface has been corroded by acids; for this spot consists of the plumbago, which remains after the iron has disappeared by solution.

Solution in the sulphuric or muriatic acid not only exhibits the plumbago contained in iron, but likewise possesses the advantage of showing the state of its reduction by the quantity of hidrogen gas which is disengaged: for the quantity of this gas, in like circumstances, is proportional to that of the iron which is converted into oxide. There are considerable differences between the various products of the smelting furnace in these respects; but it is found, that the white crude iron affords the least quantity of hidrogen in proportion to its bulk, and leaves a moderate portion of plumbago; the gray crude iron affords more hidrogen, and more plumbago than the white; and the softest bar iron affords most hidrogen of any, and little or no plumbago. The quantities of hidrogen gas, at a medium, by ounce measures, were 62, afforded by 100 grains of the white crude iron; 71 by the gray crude iron; and 77 by the malleable iron.

Hence it may be inferred, that, in the white crude iron, the processes of reduction and cementation are both carried to a less extent than in the gray crude iron, which is produced by means of a stronger heat, excited with a larger quantity of fuel: and that the reduction of gray crude iron is still less perfect than that of the soft bar iron; though this last, by the refining in an open vessel, is so far from being more cemented, that it scarcely contains any plumbago at all.

It must be admitted, however, that the solution in acids serves only to support these general conclusions, in conjunction with the facts observed in the dry processes; but cannot accurately show the quantities either of hidrogen or plumbago afforded by the several kinds of iron. For the plumbago, as it becomes disengaged, floats on the top of the sulphuric acid; where it gradually disappears, though insoluble in that acid. It must therefore be taken up by the hidrogen gas, and it is found that the volume of this air is diminished by the absorption. Hence there is a double source of inaccuracy from the loss of plumbago, and the contraction of the hidrogen gas.

On the whole then, since iron contains plumbago in a state of combination, of which it may be deprived by heat with access of oxigen, which converts its carbon into the carbonic acid; and since it recovers the plumbago by cementation with charcoal; there can be no question, but that this substance is originally afforded by the fuel. It appears also, that the reduction of the metallic oxide takes place first at a lower temperature; and that the combination of the carbon follows at a greater heat. Whence, in the refining of iron, the carbon is first burned, and the iron remains reduced; and in the cementation of bar iron, the metal is converted into steel, with blisters on its surface; which most probably arise from carbonic acid, formed by the oxigen of some portions of unreduced oxide uniting with the acidifiable base from the charcoal. And, lastly, as iron holds this acidifiable base, or carbon, in solution, so likewise it may not be separable from this metallic solvent, without carrying a portion with it; in the same manner as salts, which crystallize in water, always take up part of the solvent in the formation of their crystals.

It would require many volumes to enumerate the leading uses of iron. This most valuable of metals is applied to so many, and such important uses, that we cannot look round us without seeing its effects. When we contemplate the innumerable effects of human industry, and ask ourselves the simple question, Could this have been done without iron? there is not a single instance, which will not immediately show its value.

Iron is one of the principal ingredients for dyeing black. The stuff is first prepared with a bath of galls and logwood, then with a similar bath to which verdegris is added, and lastly dyed in a similar bath with the addition of sulphat of iron. If it be wished, that the colour should be particularly fine, the stuff should previously be dyed of a deep blue: otherwise a brown may be first given with the green husks of walnuts. Silk however must not be previously blued with indigo, and sumach may be substituted instead of galls. Leather, prepared by tanning with oak bark, is blackened by a solution of sulphat of iron.

Cotton has a very strong affinity for oxide of iron, so that, if it be immersed in a solution of any salt of iron, it assumes a chamois colour, more or less deep according to the strength of the solution. The action of the air on the oxide of iron deepens the colour; and if the shade were at first deep, the texture of the stuff is liable to be corroded by it. To prevent this, the cotton should be immersed in the solution cold, carefully wrung, and immediately plunged into a ley of potash mixed with a solution of alum. After having lain in this four or five hours, it is to be wrung, washed, and dried.

Mr. Brewer, to give a nankin colour, prepares his cotton yarn by boiling it five hours in a mixture of water made grass green with sheep's dung and a solution of white soap; twice more, an hour each time, with half the quantity of soap; and a fourth time in a ley of pot or pearl ashes, one pound to twenty of yarn, another hour. He then passes it through iron liquor, to every gallon of which half a pound of red chalk, or ruddle, in powder is added; the liquor being poured off clear, after it has stood four hours to settle; and immerses it in an alkaline lixivium. When of the proper colour, for which this operation may be repeated if necessary, he dries it, as after each of the former processes; and then puts it into a warm lixivium, in which it is brought to a scald. It is afterward to be soaked an hour in water made almost as sour as lemon juice with sulphuric acid, and then washed and wrung twice. Lastly, it is to be boiled slowly an hour in a solution of white soap, one pound to ten of yarn.

The ancients appear to have had the art of preparing a blue enamel from iron. Mr. Klaproth analysed a piece of antique glass of a sapphire blue colour, transparent only on the edges, two hundred grains of which gave the following products: silex 163 grains; oxide of iron 19; alumine 3; oxide of copper 1; lime 0·5. The loss was 13·5.

Iron is very liable to be oxided, or contract rust. Conté informs us, that if fat oil varnish be mixed with half, or at most four fifths of its weight of oil of turpentine, and this be applied lightly and evenly with a sponge to iron or steel, and left to dry where it is not exposed to dust, the metal will retain its lustre, without any danger of rusting. In order to prevent gunbarrels from rusting they are frequently browned. This is done by rubbing it over when finished with aqua fortis or spirit of salt diluted with water, and laying it by for a week or two till a complete coat of rust is formed. A little oil is then applied, and the surface, being rubbed dry, is polished by means of a hard brush and a little bees-wax.

The yellow spots called iron moulds, which are frequently occasioned by washing ink spots with soap, may in general be removed by lemonjuice, or the oxalic or tartarous acids; or by muriatic acid diluted with five or six parts of water, but this must be washed off in a minute or two. Inkspots may readily be removed by the same means. If the iron mould have remained so long, that the iron is very highly oxided, so as to be insoluble in the acid, a solution of an alkaline sulphuret may be applied, and, after this has been well washed off, the acid will remove the stain.—*An. de Chim.*—*Crell's Annals.*—*Bergman.*—*Magellan.*—*Des Mortiers on Decoloration of Pruss. Blue.*—*Phil. Mag.*—*Bullet. des Sciences.*—*Phil. Trans.*—*Van Mons Journ.*—*Nich. Journ.*—*Fourcroy.*—*Henry.*

Iserine. An ore of titanium, found near the source of the Iser, on the borders of Bohemia, in small, obtuse angular grains, of an iron black, inclining to brown, much resembling iron sand: and in pebbles with a rough, glimmering surface; of a conchoidal fracture; and shining internally with a semimetallic lustre.—*Irish Trans.*

Isinglass. This substance, though well known in the arts, has been greatly mistaken, not only with regard to the manner of its fabrication, but as to the effects it produces. It is almost wholly gelatine: 100 grains of good dry isinglass containing rather more than 98 of matter soluble in water.

The principal consumption of isinglass is in fining liquors of the fermented kind. It appears to do this merely by the mechanical effect of its organization, which forms a kind of strainer, or fine net-work, and carries the gross impurities before it as it subsides. Glue is unfit for this purpose, because it wants the peculiar structure. Isinglass itself, if converted into glue by boiling ment, and is infusible in the fire. Mr. Saussure seems to have extracted iron from it.

It is sometimes of a whitish milky colour, from China; but mostly of a greenish, or deep green colour, from America, or of a gray, yellowish and olive colour. The jade is vulgarly denominated lapis nephriticus, from being supposed to cure nephritic pains by external application to the loins.

The semitransparency, hardness, and specific gravity are the characters by which the lapis nephriticus may be distinguished from other stones.

Jalap is the root of a species of convolvulus, with leaves like those of ivy, but not so thick, and beautiful red flowers, which have this remarkable property, that they open in the night, and shut again on the least appearance of the sun; whence the plant is called by the French *Belle de nuit*, The beauty or fair one of the night: in rainy or cloudy days the flowers open a little, but fall off the sooner, as if daylight were injurious to them. The jalap plant is a native of the province Chalapa or Xalapa, in New Spain, whence its name is derived, and written, according to the pronunciation of different languages, *Jalapa* or *Jalapium*, *Gialappa*, *Chalapa*, *Xalapa*, *Zalopa*, &c. The roots raised in Europe have been found much weaker than the American.

Jalap is brought over in thin slices; of which the best are compact and hard, so as not to be broken by the fingers; ponderous, of a dark brown colour, of a glossy resinous appearance, or at least furnished with resinous streaks and circles; easily inflammable, of no smell, or a faint unpleasant one, and of a slightly acrid taste. The fine dust, which flies off in powdering them, provokes sneezing. Those which are thoroughly resinous are not liable to be worm-eaten, the worms preying chiefly upon the gummy or mucilaginous parts, and not touching the resin, or at least not till these are consumed: hence we may suppose the worm-eaten roots to have been originally of a bad kind, produced in moist soils or rainy seasons, &c.; and hence the worm-eaten may be employed for extracting the resin equally with any other, the resin being equal in goodness, though less in quantity.

From sixteen ounces of good jalap root, Neumann obtained, by alcohol, five ounces and four scruples of resinous extract; and afterward by water, two ounces and a half of a gummy one: on applying water at first, he gained four ounces and a half of gummy extract, together with six drachms of a resinous matter, which fell to the bottom in evaporating the decoction; the remainder yielded, with spirit, three ounces of resin: the indissoluble part amounted in the first case to eight ounces three drachms, in the latter to seven ounces six drachms. By precipitating a spirituous tincture of the root with water, he gained, from a pound, four ounces of pure resin.

The inferior sorts of jalap yield less resinous and more gummy extract; such must have been that employed by Boulduc, who obtained, from sixteen ounces, only two ounces five drachms and a scruple of resinous extract; but upwards of eight ounces and a half of a gummy one.

It has been remarked, that jalap possesses a notable degree of fermentative power; exciting this action in gross, sweet, vegetable juices, such as melasses, and at the same time impregnating them with its purgative quality. I am informed, however, that this is by no means the case, but that it is used to check the rapid progress of fermentation in the manufacture of melasses' spirits, for which purpose it is strewed over the surface of the liquor. It is a late discovery, that common resin will do as well. This effect requires explanation. Perhaps the resin may combine with part of the alcohol, at the instant of its extrication. If this be true, it seems likely that so much of the spirit may be prevented from rising in distillation, and more loss may be sustained by this practice than might have followed from the activity of the fermentation.

Japan Earth. See Catechu.

Jargon. A hard gem brought from the East Indies in the form of thin plates, which appear to be split from pebbles. They are of different colours, white, black, yellow, and brown, about as hard as the sapphire. As they have a great resemblance to the diamond, they are substituted instead of it in jewellers' work, sometimes fraudulently. It is probable that the great specific gravity of this stone, which is from 4·416 to 4·615, may be attended with an extraordinary degree of refractive power, on which the brilliancy of precious stones depends. See Diamond.

Bomare says, that the jargon is found in Brasil, but Romé de l'Isle informs us that it comes from Ceylon, and that its form consists of two tetrahedral pyramids of equal sides, separated by a short quadrangular prism. Mr. D'Arcet exposed it to a violent heat in a porcelain test. Its surface was a little vitrified, and it stuck to the vessel; the blowpipe with oxigen gas destroys its transparency, without diminishing its weight, and gives it the appearance of white enamel.

It was in this stone Mr. Klaproth discovered the new earth, called from the French name of this stone zircon, of which it contains ·69, with ·265 of silex, and ·005 of oxide of iron.

Jaspachates. See Jade.

Jasper. *Jaspis.* (The Diaspro of the Italians.)

All opaque flints are called by this name, the texture of which resembles dry clay, and which have no other known quality, whereby they may be distinguished from other flints, except that they may be more easily melted in the fire; and this quality, perhaps, may proceed from the mixture of iron. It often breaks with conchoidal surfaces; is capable of a fine polish; its colour is generally reddish, or green, or striped; but it is also found blue, gray, or whitish; its specific gravity is from 2·58 to 2·778, or more, when it contains more iron.

Jasper is infusible alone with the blowpipe; with the mineral alkali it is only partially soluble, separating itself with effervescence into small particles; but it melts with *borax* or *microcosmic salt*, without any effervescence. Wedgwood found that the action of fire increases its hardness.

According to Bergman, in his Sciagraphia, it is composed of *siliceous earth*, united to alumine very full of iron. The mineral acids have no action upon jasper in a short time, but at the end of some months it is found corroded, if immersed in them. De la Metherie's analysis of the Egyptian pebble, which is a variety of jasper, gave silex ·54, alumine ·30, oxide of iron ·16.

Mr. Daubenton mentions 15 varieties of jasper. 1. The *green*, from Bohemia, Silesia, Siberia, and the shores of the Caspian sea. This seems to be the *pavonium* of Aldrovandus. 2. The *red*, or the *diaspro rosso* of the Italians, which is neither so common, nor in such great masses, as the green. 3. The *yellow*, from Freyberg and Rochlitz; it is sometimes of a lemon colour, and looks as if composed of silky filaments. This is called the *silk jasper*. 4. *Brown*, from Dalecarlia, in Finland and Sweden. 5. The *violet*, from Siberia. 6. The *black*, from Sweden, Saxony, and Finland. This is the *paragone antico* of the Italians. 7. The *bluish gray*, which is very rare. 8. The *milky white*, of which Pliny speaks; it is found in Dalecarlia. 9. The *variegated* with *green*, *red*, and *yellow* clouds. 10. The *blood stone*, which is green with red specks, from Egypt, and was supposed to stop the blood. 11. The *veined*, with various colours. When these veins have the resemblance of letters, it is then called *jaspe grammatique* by the French. Some of this kind are found near Rochelle in France, and called *polygrammatiques* by the curious in these trifling accidental qualities. 12. That which has various coloured zones. 13. That called *fiorito* by the Italians, which has its various colours promiscuously, without any order. 14. When the jasper has a great number of colours together, it is then (very improperly) called universal. 15. Lastly, when the jasper is found to contain some portions of agate, it is then called *agatized jasper*.

Jelly. See Gelatin.

Jesuits Bark. See Cinchona.

Jet. *Gagas*, *Succinum nigrum*, Lat. *Jet*, *Jayet*, French.

The *jet*, the *lapis obsidianus*, and the *fossil wood*, penetrated by mineral inflammable matter, are often confounded together, on account of their black glossy colour. But the lapis obsidianus is a volcanic glass, and jet is a compact bitumen. Jet is much harder than asphaltum, always black, susceptible of a good polish, and glossy in its fracture, which is conchoidal; its specific gravity is about 1·104, or according to Brisson 1·259; it melts in a moderately strong heat, with a disagreeable smell; when burnt, it leaves a gray earthy ochrous residuum; it is partly soluble in alcohol. By friction it becomes slightly electric.

It is found in *England*, *Scotland*, *France*, *Italy*, *Germany*, *&c.* Wallerius, Bomare, and others assert, that it floats on water; a circumstance which, if true, must indicate a specific gravity less than 1·000.

The use of this fossil consists in the manufacture of small toys. It is also said to be an ingredient in some varnishes.

Jews Pitch. See Asphaltum.

Juices of Plants. The juices of several plants are expressed to obtain their essential salts, and for several medicinal purposes, with intention either to be used without further preparation, or to be made into sirups and extracts.

The general method of extracting these juices is, by pounding the plant in a marble mortar, and then by putting it into a press. Thus is obtained a muddy and green liquor, which generally requires to be clarified, as we shall soon observe.

The juices of all plants are not extracted with equal ease. Some plants, even when fresh, contain so little juice, that water must be added while they are pounded, otherwise scarcely any juice would be obtained by expression. Other plants, which contain a considerable quantity of juice, furnish by expression but a small quantity of it, because they contain also much mucilage; which renders the juice so viscid, that it cannot flow. Water must also be added to these plants to obtain their juice.

The juices thus obtained from vegetables by a mechanical method are not, properly speaking, one of their principles, but rather a collection of all the proximate principles of plants, which are soluble in water; such as the saponaceous extractive matter, the mucilage, the odoriferous principle, all the saline and saccharine substances; all which are dissolved in the water of the vegetation of the plants. Beside all these matters, the juice contains some part of the resinous substance, and the green colouring matter. These two latter substances, not being soluble in water, are only interposed between the parts of the other principles which are dissolved in the juice, and consequently disturb its transparency. They nevertheless adhere together in a certain degree, and so strongly in most juices, that they cannot be separated by filtration alone.

When therefore these juices are to be clarified, some previous preparations must be used, by which the filtration may be facilitated. Juices which are acid, and not very mucilaginous, are spontaneously clarified by rest and gentle heat. The juices of most antiscorbutic plants, abounding in saline volatile principles, may be disposed to filtration merely by immersion in boiling water; and as they may be contained in closed bottles while they are thus heated in a water bath, their saline volatile part, in which their medicinal qualities chiefly consist, may thus be preserved. Fermentation is also an effectual method of clarifying juices, which are susceptible of it; for all liquors, which have fermented, clarify spontaneously after fermentation. But this method is not used to clarify juices, because many of them are susceptible only of an imperfect fermentation, and because the qualities of most of them are injured by this process.

The method of clarification most generally used, and indispensably necessary for those juices which contain much mucilage, is by boiling with the white of an egg. This matter, which has the property of coagulating in boiling water, and of uniting with mucilage, does accordingly, when added to the juice of plants, unite with and coagulate their mucilage, and separates it from the juice in form of scum, together with the greater part of the resinous and earthy matters, which disturb its transparency. And as any of these resinous matters, which may remain in the liquor after this boiling with the white of eggs, are no longer retained by the mucilage, they may easily be separated by filtration. See **Filtration**.

The juices, especially before they are clarified, contain almost all the same principles as the plant itself, because, in the operation by which they are extracted, no decomposition happens, but every thing remains, as to its nature, in the same state as in the plant. The principles contained in the juice are only separated from the grosser, oily, earthy, resinous and woody parts, which compose the solid matter that remains under the press. These juices, when well prepared, have therefore exactly the same medicinal qualities as the plants from which they are obtained. They must evidently differ from each other, as to the nature and proportions of the principles with which they are impregnated, as much as the plants from which they are extracted differ from each other in these respects.

K.

KALI is a maritime plant, from the ashes of which a considerable quantity of soda is obtained by lixiviation. See **Soda**. Henckel informs us, that by boiling the plant in water, and by evaporating the decoction, he obtained a considerable quantity of sea salt.

Kannel Coal. See **Cannel Coal**.

Kaolin. The Chinese name of an earth used as one of the two ingredients of the oriental porcelain. Some of this earth was brought from China, and examined by Reaumur. He found that it was infusible, and supposed it to be a talky earth; but Macquer supposed it to contain clay, because it forms a tenacious paste with the other ingredient called petuntse, which has no tenacity. Bomare found, that it was a compound of clay, calcareous earth, mica, and small quartz crystals. He says, that he has found a similar earth upon a stratum of granite, and conjectures that it may be a decomposed granite.

As porcelain is now manufactured in various parts of Europe, some mineralogists have applied the term kaolin to the porcelain clay.

Karabe, or **Carabe**. See **Amber**.

Karat. The fineness of gold is commonly noted by karats. Pure gold being considered to be divided into twenty-four equal parts, or karats; it is then said to be twenty-four karats fine. If the quantity of pure gold in any mass be less than this, that quantity only is noted in expressing the fineness. Thus, for example, if two parts out of the twenty-four be copper or other base metal, the gold is said to be twenty-two karats fine. This is the standard of British coin. See **Assay**.

The karat is a real weight used by jewellers, divided by us into four grains: but these grains are less than the grains of troy weight; four grains troy being equal to five of these subdivisions of the karat, according to David Jefferys. See **Diamond**.

Kedria Terrestris. Barbadoes tar. See **Bitumen**.

Keffekil. The *meerschaum* of the Germans, *spuma maris*. A stone of a white or yellow colour, soapy feel, and moderate hardness, which increases in the fire. It is the substance of which the large Turkey pipes are made. It is found in Crim Tartary, in Canada, in Flanders, and elsewhere. The Tartars use it instead of soap, as do likewise the country people in the barony of Hierges, in Austrian Flanders. Wiegleb found it to consist of equal parts of magnesia and silex, whence it seems to operate as a fullers-earth. See **Earth** (**Fullers**). What Wiegleb analysed had been manufactured into a pipe. Klaproth analysed it in its crude state. A whitish variety, of the specific gravity of 1·6, afforded him from 100 parts, silex 50·5; magnesia 17·25; lime 0·5; water 25; carbonic acid 5. A gray sort gave silex 41; magnesia

25; lime 5; water and carbonic acid 39. a third he found the proportion of silex ch less, and of magnesia as much greater. could not expel the whole of the carnic acid in the humid way.

Kermes (*coccus ilicis*, Lin.) is an insect nd in many parts of Asia, and the south Europe. It was known to the ancients the name of *coccum scarlatinum*, *coccus hicus*, *coccus infectorius*, *granum tincton*. That which came from Galatia and menia was preferred; but at present it is hered chiefly in Languedoc, Spain, and tugal.

he kermes lives on a small kind of oak *rcus coccifera*, Lin.). The females grow and at length remain motionless; when are nearly the size and shape of a pea, of a reddish brown colour. On acnt of their figure, they were a long taken for the seeds of the tree on ch they live; whence they were called *s of kermes*. They also bore the name ermilion.

the living insect be bruised, it gives a red colour. Its smell is somewhat sant; its taste a little bitter, rough, pungent. When dry it imparts this smell taste to water, and also to alcohol, to which it gives a deep red colour. This ur is retained by the extracts made from e infusions.

o dye spun worsted with kermes, it is boiled half an hour in water with bran; two hours, in a fresh bath, with one of Roman alum, and one tenth of tarto which *sour water* is commonly added; which it is taken out, tied up in a bag, and carried to a cool place, re it is left some days. To obtain a full ur, as much kermes as equals three hs, or even the whole of the weight e wool, is put into a warm bath, and vool is put in at the first boiling. As is more dense than wool, either spun the fleece, it requires one fourth less e salts in the boiling, and of kermes e bath. Less proportions of kermes produce lighter and paler colours. If vant a succession of shades, we must, ual, begin with the deepest.

ellot directs a small handful of cot or e wool to be thrown into the boiler in h the kermes is, and to let it boil a ent before the wool to be dyed is put This will absorb a kind of black dregs, he wool afterwards dipped will take a r colour. Before the wool that is just is taken to the river, it may be dipped bath of water a little warm, in which ll quantity of soap has been dissolved: is way the colour will acquire more tness, though it will be rendered a rosy, that is, will have a crimson cast.

using kermes and tartar, without , and with as much solution of tin as quired for a scarlet with cochineal, e obtained a very lively cinnamon colour in a single bath. Cloth steeped in a solution of sulphat of potash took with kermes a pretty fine and permanent agate gray: in a solution of sulphat of iron and tartar a fine gray: in a solution of tartar and sulphat of copper, an orange colour: and the same with nitrat of copper. Solution of bismuth, added drop by drop to a kermes bath, produced a violet. All acids convert it to a cinnamon colour, which inclines more or less to red, according as the acids are weak, and their quantity small. Alkalis render its colour dull and rosy.

The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known.—*Berthollet.*

Formerly it was used in medicine as a cordial and mild astringent, and gave its name to a confection.

Kermes Mineral. See Antimony.

Killas. This stone is chiefly found in Cornwall; its colour is pale gray or greenish gray; its texture either lamellar or coarsely granular: the lamellar is softer and less martial than the roof schistus: its specific gravity from 2·63 to 2·666.

Kirwan found a hundred grains of the lamellar sort to contain about 60 of silex, 25 of alumine, 9 of magnesia, and 6 of iron. The greenish sort contains more iron, and gives a greenish colour to the nitric acid.

Kingdoms. Naturalists and chemists divide all natural bodies into three great classes, called kingdoms, namely, the mineral, the vegetable, and the animal kingdoms. The utility of these divisions appears to be in a great measure confined to the natural history of the various subjects examined by the chemist. The distinctive criterions of their respective principles are difficult, and perhaps impossible to be ascertained, excepting in bodies of no great simplicity; for none of the principles of organized bodies exhibit their peculiar characters when resolved by putrefaction or otherwise into their simplest parts. See Animal Kingdom, Vegetable Kingdom, Mineral Kingdom, and Analysis.

Kino. A few years ago this was introduced into our shops and medical practice by the name of a gum; but Dr. Duncan has shown that it is an extract. It was first brought from Gambia, but what we have now comes chiefly from Jamaica, and is an extract of the seaside grape, *coccoloba uvifera*: the finest however is made from different species of *eucalyptus*, particularly the *resinifera*, or brown gum tree of Botany Bay.

Vauquelin too found it was not a gum, and analysed probably the latter sort. By distillation it yielded first an aqueous fluid; then a light and nearly colourless oil, which grew heavier and darker; a small quantity of carbonic acid, and a large quantity of carburetted hidrogen. The aqueous fluid has an acrid taste, and contains ammonia. 100 parts left 42·5 of a very bulky coal, which by incineration left 3·6 of ashes, consisting chiefly of lime, silex, alumine, and oxide of iron. It is little soluble in cold water, but more in hot. Its decoction grows turbid on cooling. Alkalis precipitate it: so does gelatine, and ferruginous salts; but the precipitate with the latter is green, like those with infusions of cinchona and rhubarb. Wool and cotton boiled in a solution of kino, and then dipped in a bath of sulphat of iron, appeared of a bottle green, which was changed by washing and drying to a blackish brown, that proved very durable. Hot alcohol dissolves about three fourths of its weight; and the remainder, which has lost its bitterness and astringency, and tastes rather mucilaginous and sweet, dissolves easily in hot water, and gives it a deep red colour. This is precipitable by alcohol, but neither by glue, nor by any metallic solution. Sulphuric acid diminishes the action of water on kino.—*Edinb. Disp.*—*Ann. de Chim.*—*Nich. Journ.*

Kolmord Marble. A white calcareous stone of a scaly texture, interspersed with spots of steatites, or soap rock, either green or black.

Koumiss. A vinous preparation of Milk, which see.

Kupfer Nickel. See Nickel.

Kuteera. A gum somewhat resembling tragacanth, but not of so glutinous a nature, lately imported from Hindostan. In water it slowly softens to a pulp: but if first powdered, and then boiled a quarter of an hour, it dissolves completely, a teaspoonful giving three pints of water a thin sirupy consistence. The natives mix it with other gums to make varnishes, and use it much in some diseases of horses.—*Trans. of Soc. of Arts.*

L.

LABDANUM. A resin of a species of cistus in Candia, of a blackish colour. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black sand, and has been given as an astringent, but is chiefly used in cephalic and stomachic plasters and perfumes.

Laboratory. A place properly fitted up for the performance of chemical operations. The several laboratories intended for the preparation of articles of the materia medica, or the arts, in the large way, have their respective accommodations and contrivances, the description of which would occupy several volumes. The philosophical chemist, whose operations afford products chiefly of value for the results they exhibit, naturally endeavours, as well for the advantage of time, as expense, to perform all his operations on as small a scale as possible. It was once thought to be indispensably necessary, that a philosophical chemist should be provided with a regular laboratory, or room fitted up with furnaces and other apparatus, on a considerably extensive scale. This is no doubt of great utility and advantage; but the researches of Bergman, Morveau, and other eminent chemists, have shown, that many, if not most of the chemical operations, may be performed with the blowpipe, or by very small glass vessels, and a lamp, with greater speed, perspicuity, facility, and cheapness, than where larger quantities of the materials are used. But as the proportional quantities of products, and the indications afforded by experiment for conducting manufacturing processes, are more accurately deduced from considerable quantities, I shall in this article give the excellent sketch of a laboratory, as I find it in Macquer's Dictionary, with such additions or improvements as have since been made.

As chemistry is a science founded entirely on experiment, we cannot hope to understand it well, without making such experiments as verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those, whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, there are many qualities in the several agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses.

A chemical laboratory necessarily occasions certain expenses, but not so much as is generally believed, when the operator knows how to manage his utensils, and to employ only the proper quantity of the several substances upon which he operates; and lastly, when he chooses the least expensive methods of attaining his purposes.

Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but

CHEMICAL APPARATUS.

Plate I.

Fig. 1.

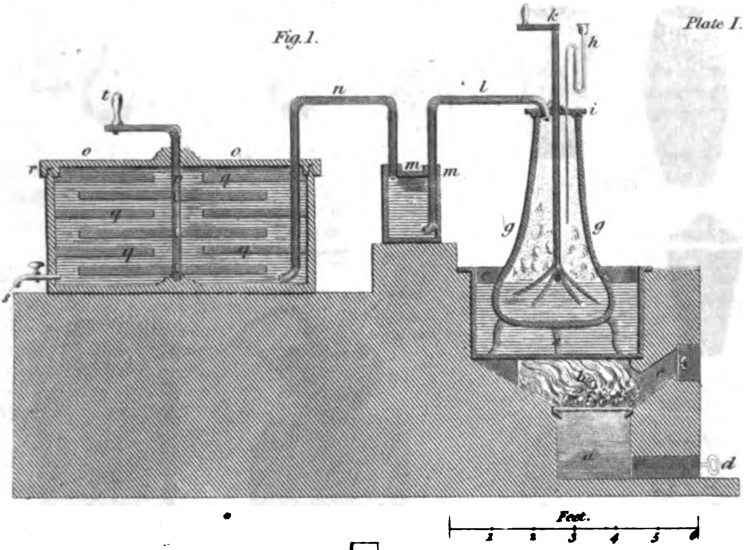
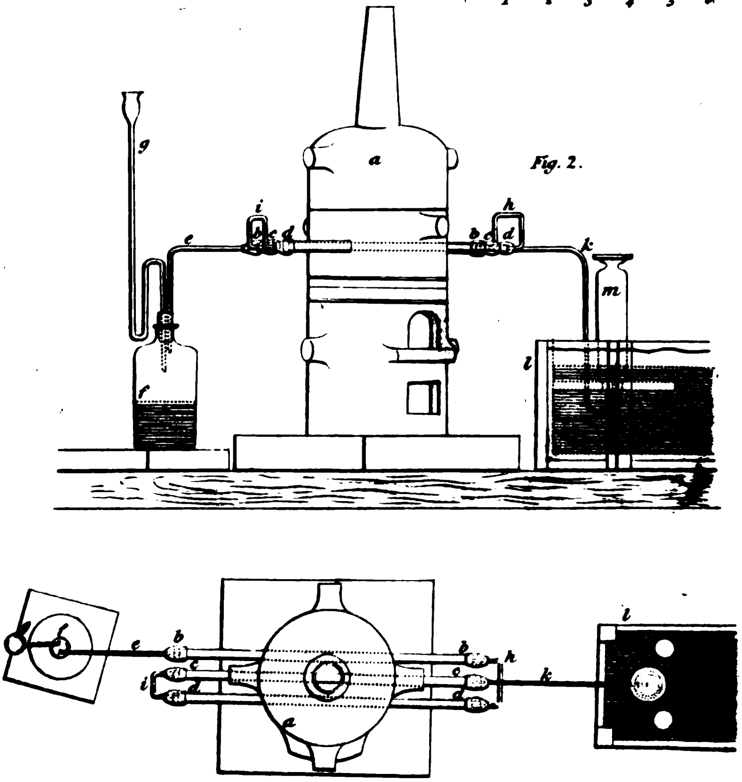


Fig. 2.

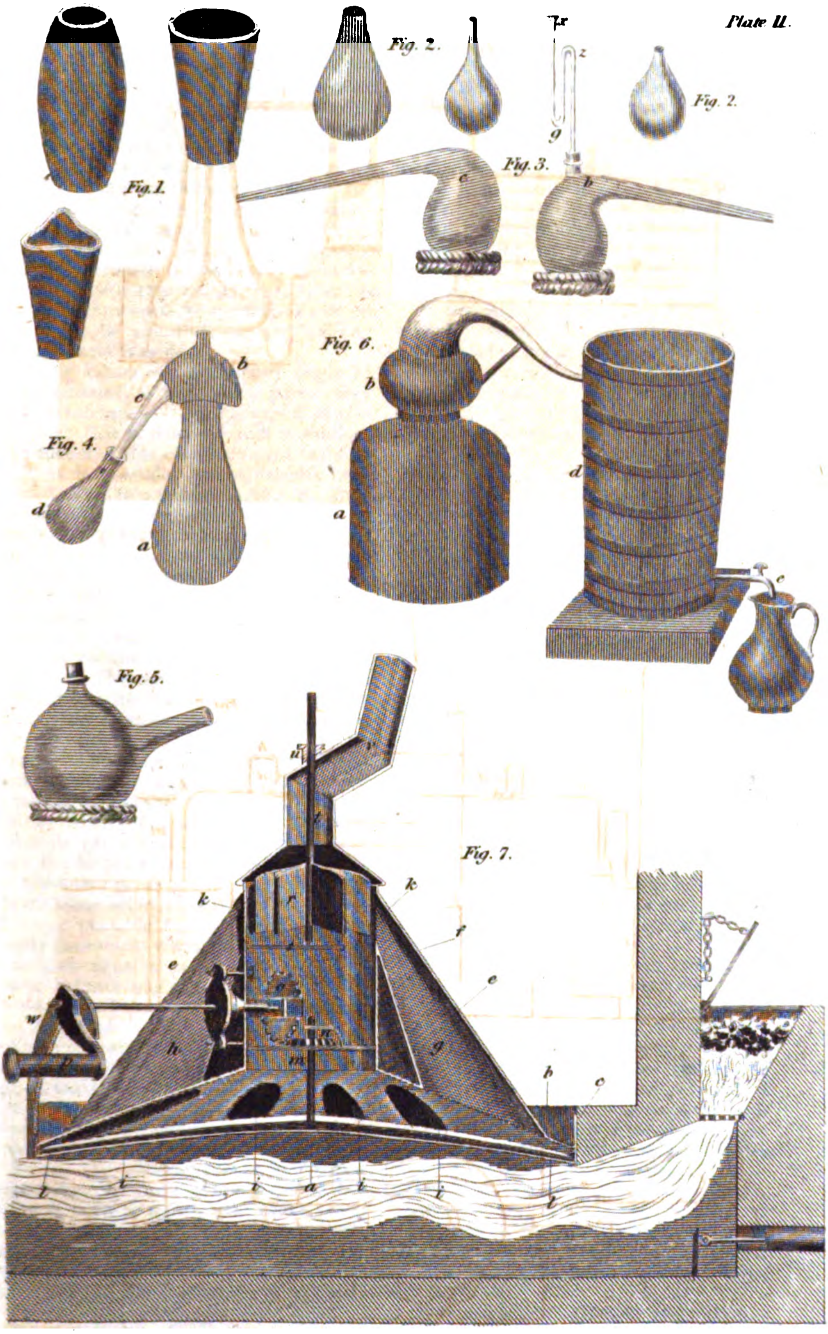


Cooper sculp.

Published May 1, 1808, by Rich^d Phillips, Bridge Street, Blackfriars, London.

CHEMICAL APPARATUS.

Plate II.



Published May 2, 1808, by Richd. Phillips, Bridge Street, Blackfriars, London.

Cowper sculp.

o subject to very great inconvenience
oisture.

stant moisture, though not very con-
le and sensible in many respects, is a
great inconvenience in a chemical
tory. In such a place, most saline
s become moist in time, and the in-
ons fall off, or are effaced; the bel-
ot; the metals rust; the furnaces
er, and every thing almost spoils. A
tory, therefore, is more advanta-
placed above than below the
, that it may be as dry as possible.
must have free access to it; and it
ven be so constructed, that, by means
or more opposite openings, a current
nay be admitted, to carry off any
s vapours or dust.

ne laboratory a chimney ought to
structed, so high that a person may
tand under it, and as extensive as is
e; that is, from one wall to another.
nnel of this chimney ought to be as
s is possible, and sufficiently con-
to make a good draught. As char-
ly is burnt under this chimney, no
ollected in it; and therefore it need
so wide as to allow a chimney-
to pass up into it.

er this chimney may be constructed
ick furnaces, particularly a melting
, a furnace for distilling with an
, and one or two ovens like those in
. The rest of the space ought to
up with stands of different heights,
foot to a foot and a half, on which
furnaces of all kinds are to be
These furnaces are the most con-
from the facility of disposing them
ure; and they are the only furnaces
are necessary in a small laboratory.

e pair of bellows of moderate size
o be placed as commodiously under
nney, or as near as the place will
hese bellows are sometimes mount-
a portable frame; which is suffi-
onvenient when the bellows are not
an eighteen or twenty inches long.
ellows ought to have a pipe di-
oward the hearth where the forge
placed.

necessary furnaces are, the simple
for distilling with a copper alem-
amp furnace; two reverberatory
of different sizes, for distilling with
an air or melting furnace, an essay
and a forge furnace.

r the chimney, at a convenient
must be a row of hooks driven into
and side walls; upon which are to
small shovels; iron pans; tongs;
crooked, and circular pincers;
iron rods, and other utensils for dis-
he fuel and managing the crucibles.

e walls of the laboratory ought to
ned shelves of different breadths and
, or these shelves may be suspended

by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, there cannot be too many shelves.

The most convenient place for a stone or leaden cistern to contain water is a corner of the laboratory, and under it a sink ought to be placed with a pipe, by which the water poured into it may discharge itself. As the vessels are always cleaned under this cistern, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it.

In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, small filtrations; in a word, whatever does not require fire, excepting that of a lamp.

In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar; another to support a middle-sized marble, or rather hard stone mortar; a third to support an anvil. Near the mortars are to be hung searces of different sizes and fineness; and near the anvil a hammer, files, rasps, small pincers, scissars, sheers, and other small utensils, necessary to give metals a form proper for the several operations.

Two movable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place.

Charcoal is an important article in a laboratory, and it therefore must be placed within reach; but as the black dust which flies about it whenever it is stirred is apt to soil every thing in the laboratory, it had better be in some place near the laboratory, together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things, which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quick-lime, sand, and many other things necessary for chemical operations.

Lastly, a middle-sized table, with solid feet, ought to be enumerated among the large movables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard and dense grit-stone, together with a muller made of the same kind of stone.

The other small movables or utensils of a laboratory are, small hand mortars of iron, glass, agate, and Wedgwood's ware, and their pestles; earthen, stone, metal, and glass vessels, of different kinds, funnels, and measures

Some white writing paper, and some unsized paper for filters; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels.

Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and glass.

Thin pasteboards, and horns, very convenient for collecting matters bruised with water upon the levigating stone, or in mortars: corks of all sizes; bladders and linen strips for luting vessels.

A good portable pair of bellows; a good steel for striking fire; a glue pot, with its little brush; lastly, a great many boxes of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves.

Beside these things, some substances are so necessary in most chemical operations, that they may be considered as instruments requisite for the practice of this science. These substances are:

All metals and semimetals, which ought to be very pure.

Sulphuric acid, some of which ought to be concentrated and rectified, and also some of that sort commonly sold by druggists.

Aqua fortis, such as is commonly sold, and is cheap; also nitric acid moderately strong, but very pure: the same acid very pure, concentrated, and smoking.

Common muriatic acid; some of the same acid very pure, very strong, and smoking. All these acids ought to be kept in glass bottles, and closed with glass stoppers.

Some distilled vinegar, which may be kept in an ordinary bottle; some acetic acid, which ought to be kept in a bottle with a glass stopper; some cream of tartar, in an earthen or glass vessel, or in a box.

Common fixed vegetable alkali, very dry, such as potash, which must be kept in a well closed bottle. The same alkali in a liquid state.

Very pure subcarbonat of potash, some dry, and some liquid.

A solution of subcarbonat of soda. The same alkali dry and very pure; that is, well formed crystals of soda.

The two fixed alkalis liquid, and rendered caustic by quick lime. Alkalis, particularly those which are caustic, ought to be kept in bottles with glass stoppers. Some prussiat of potash.

Some dry sulphuret of potash kept in a well closed bottle. The same liquid. Some common sulphur.

Carbonat of ammonia, some solid, and some liquid, kept in a bottle with a glass stopper.

Very pure caustic ammonia, as strong as is possible. Some of this may be kept of less strength.

Lime water, and quick-lime, in well closed bottles.

The purest and highest rectified alcohol.

Good sulphuric ether.

Rectified essential oil of turpentine; oil of olives; soap.

Galls; sirup of violets; tincture of litmus, or litmus rags; fine blue paper; river or distilled rain-water.

Beside these substances, most of which are solvents, certain neutral salts ought to be had, which are frequently used in chemical operations, or are difficultly prepared. These are:

Sulphat of potash; alum, and calcined alum: sulphats of iron and copper; nitre; decrepitated common salt; some of the same salt very pure, dissolved in distilled water; purified sal-ammoniac; calcined borax; boracic acid.

A pure solution of silver in nitric acid; a solution of mercury in the same acid; muriat of antimony. All these to be kept in bottles with glass stoppers. Corrosive sublimate.

Ceruss; litharge; minium; sand washed and ground; white marble; washed chalk; glass of lead; glass of borax.

A person provided with the above-mentioned instruments and substances may at once perform any chemical experiment. He may indeed occasionally want several neutral salts, which have not been named; but all these salts with bases of earths, metals, or alkalis, may be easily and instantly prepared, as most of them do not require distillation or sublimation. They may nevertheless, if they be not too numerous, be all previously prepared and kept ready for any occasion.

The general observations of Macquer upon the conducting of chemical processes are truly valuable and judicious. Method, order, and cleanliness, are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place: labels ought to be put upon all the substances. These cares, which seem to be trifling, are however very fatiguing and tedious; but they are also very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly; some seem nearly to decide the matter, and others suggest new ideas: he cannot but proceed to them immediately, and he is led from one to another: he thinks he shall easily know again the products of the first experiments, and therefore he does not take time to put them in order: he prosecutes with eagerness the experiments which he has last thought of; and in the mean time, the vessels employed, the glasses and bottles filled, so accumulate, that he cannot any longer distinguish them; or at least, he is uncertain concerning many of his former products. This evil is increased, if a new series of operations succeed, and occupy all the laboratory; or if he be obliged to quit it some time: every thing then goes into nfusion. Thence it frequently happens, t he loses the fruits of much labour, and t he must throw away almost all the pro- cts of his experiments.

The only method of avoiding these in- nveniences is to employ the cares and at- ntions above mentioned. It is indeed dis- reeable, to stop continually in the middle the most interesting researches, and to ploy time that appears very precious and nsiderable in cleaning vessels, arranging m, fastening labels on them, &c. These ployments are capable of cooling or re- ding the progress of genius, and are te- us and disgustful; but they are never- less necessary. Those persons, whose une enables them to have an assistant rator, on whose exactness and intelli- ce they can depend, avoid many of e disagreeable circumstances; but they ht nevertheless to attend to the execu- of these things. We cannot depend much on ourselves in these matters, ever minute, on account of their con- ences. This becomes even indispensa- when the experiments are to be kept et, at least for a time; which is often essary in chemistry.

When new researches and inquiries are le, the mixtures, results, and products ll the operations ought to be kept a g time, distinctly labelled and registered; these things, when kept some time, fre- ntly present phenomena, that were not ll suspected. Many fine discoveries in nistry have been made in this manner; many have certainly been lost by owing away too hastily, or neglecting products.

cannot be too much recommended to nical operators, to be exceedingly upon r guard against imposing and deceitful riments, which frequently present nselves in practice. A circumstance ingly unimportant, or not easily per- ible, is frequently sufficient to give the earance of a great discovery, by means ertain effects, which, nevertheless, are d to proceed from some other cause. nical experiments depend on so many ssary things, that all of them can sel- be attended to, particularly when the ect is new: hence we frequently find, very different results proceed from the e experiments, and at different times. therefore must not decide after the first ess; but the experiment must be re- ed several times, and even varied, till oubt can remain.

nce chemistry offers many views for the rovement of many important arts; as it ents prospects of many useful and pro- le discoveries; those who apply their urs in this way ought to be exceedingly mspect, not to be led into a useless ex- e of money and time. Those researches h have some analogy with the philosopher's stone, from the hopes of wealth which they suggest, are also attended with similar danger. In a certain set of experiments some one is generally of an imposing appearance, although in reality it is nothing more. Chemistry is full of these half successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expense before the fruitlessness of the search is discovered. By these reflections we do not intend to divert from all such researches those, whose taste and talents render them fit for them; on the contrary, we acknowledge, that the improvement of the arts, and the discovery of new objects of manufacture and commerce, are undoubtedly the finest and most interesting part of chemistry, and which make that science truly valuable; for without these ends what would chemistry be but a science purely theoretical, and capable of employing only some abstract and speculative minds, but useless to society? We acknowledge also, that the successes in this kind of chemical inquiry are not rare; and that their authors have sometimes acquired fortunes, so much the more honourable as being the fruits of their talents and industry. But we repeat, that, in these researches, the more dazzling and near any success appears, the more circumspection, and even distrust is necessary. See ANALYSIS, ATTRACTION, BALANCE.

The plates annexed, with the following explanations of them, will give the student an idea of a large variety of the most useful and necessary articles of a chemical apparatus.

Plate II, fig. 1. Crucibles or pots, made either of earth, black lead, forged iron, or platina. They are used for roasting, calcination, and fusion.

Fig. 2. Cucurbits, matrasses, or bodies, which are glass, earthen, or metallic vessels, usually of the shape of an egg, and open at top. They serve the purposes of digestion, evaporation, &c.

Fig. 3. Retorts are globular vessels of earthen ware, glass, or metal, with a neck bended on one side. Some retorts have another neck or opening at their upper part, through which they may be charged, and the opening may be afterwards closed with a stopple. These are called tubulated retorts. A Welter's tube of safety may be inserted in this opening, instead of a stopple. See Pl. VII, fig. 1, *b* and *e*.

Receivers are vessels, usually of glass, of a spherical form, with a straight neck, into which the neck of the retort is usually inserted. When any proper substance is put into a retort, and heated, its volatile parts pass over into the receiver, where they are condensed. See fig. 5, and Pl. V, fig. 2, *k*.

Fig. 4. The alembic is used for distillation, when the products are too volatile to admit of the use of the last-mentioned apparatus,

The alembic consists of a body *a*, to which is adapted a head *b*. The head is of a conical figure, and has its external circumference or base depressed lower than its neck, so that the vapours which rise, and are condensed against its sides, run down into the circular channel formed by its depressed part, from whence they are conveyed by the nose or beak *c*, into the receiver *d*. This instrument is less simple than the retort, which certainly may be used for the most volatile products, if care be taken to apply a gentle heat on such occasions. But the alembic has its conveniences. In particular, the residues of distillations may be easily cleared out of the body *a*, and in experiments of sublimation, the head is very convenient to receive the dry products, while the more volatile and elastic parts pass over into the receiver.

Fig. 6. Represents the large stills used in the distillation of ardent spirits. *a* represents the body, and *b* the head, as before. Instead of using a refrigeratory or receiver, the spirit is made to pass through a spiral pipe called the worm, which is immersed in a tub of cold water *d*. During its passage it is condensed, and comes out at the lower extremity, *e*, of the pipe, in a fluid form.

The manner in which the excise laws for Scotland were framed rendering it advantageous to the distillers in that country to have stills of small capacity, which they could work very quickly, their ingenuity was excited to contrive the means of effecting this. It was obvious, that a shallow still, with a broad bottom completely exposed to a strong heat, would best answer the purpose: and this was brought to such perfection, that a still of the capacity of 40 gallons in the body, and 3 in the head, charged with 16 gallons of wash, could be worked 480 times in 24 hours. Fig. 7. is a vertical section of this still. *a*, the bottom, joined to *b*. the shoulder, with solder, or rivets, or screws and lute. *c*, the turned-up edge of the bottom, against which, and on a level with *a*, the brick-work of the coping of the flue rests, preventing the flame from getting up to touch *c*. *d*, the discharge pipe. *e e*, the body of the still. *f*, section of the central steam escape pipe. *g*, section of one of the lateral steam escape pipes; *h*, outside view of another. *i i i i*, inferior apertures of lateral steam pipes; *k k k k*, their superior apertures. *l l*, bottom scraper, or agitator, which may either be made to apply close to the bottom, or to drag chains; *m*, the upright shaft of this engine, as it is called; *n*, the horizontal wheel with its supporters; *o*, its vertical wheel; *p*, its handle and shaft; *n*, support of the shaft; *r*, froth and ebullition jet-breaker, resting on the cross bar *s*; *t*, its upright shaft; *u*, its cup-mouthed collar, filled with wool and grease, and held down by a plate and screws. *v*, general steam escape pipe, or head. The charge pipe, and the sight hole, for the man who charges it to see when it is sufficiently full, are not seen in this view.

The best construction of a furnace has not been well ascertained from experience. There are facts which show, that a fire made on a grate near the bottom of a chimney, of equal width throughout, and open both above and below, will produce a more intense heat than any other furnace. What may be the limits for the height of the chimney is not ascertained from any precise trials; but thirty times its diameter would not probably be too high. It seems to be an advantage to contract the diameter of a chimney, so as to make it smaller than that of the fireplace, when no other air is to go up the chimney than what has passed through the fire; and there is no prospect of advantage to be derived from widening it.

Pl. V, fig. 3. exhibits the wind or air furnace for melting. *a* is the ash-hole, *f* an opening for the air. *c* is the fire-place, containing a covered crucible, standing on a support of baked earth, which rests on the grate. *d* is the passage into *e*, the chimney. At *d* a shallow crucible or cupel may be placed in the current of the flame, and at *x* is an earthen or stone cover, to be occasionally taken off for the purpose of supplying the fire with fuel.

Fig. 2 is a reverberatory furnace. *a a* the ash-pit and fireplace. *b b* body of the furnace. *c c* dome, or reverberating roof of the furnace. *d d* chimney. *e e* door of the ash-pit. *f f* door of the fireplace. *g g* handles of the body. *h* aperture to admit the head of the retort. *i i* handles of the dome. *k* receiver. *l l* stand of the receiver. *m m* retort, represented in the body by dotted lines.

Another reverberatory furnace, a little differing in figure, may be seen in Pl. I, fig. 2.

Mr. Chenevix has constructed a wind furnace, which is in some respects to be preferred to the usual form. The sides, instead of being perpendicular, are inverted, so that the hollow space is pyramidical. At the bottom the opening is 13 inches square, and at the top but 8. The perpendicular height is 17 inches. This form appears to unite the following advantages: 1st. A great surface is exposed to the air; which, having an easy entrance, rushes through the fuel with great rapidity. 2d, The inclined sides act in some measure as reverberating surfaces: and 3d, The fuel falls of itself, and is always in close contact with the crucible, placed near the grate. The late Dr. Kennedy of Edinburgh, whose opinion on this subject claims the greatest weight, found that the strongest heat in our common wind furnaces was within 2 or 3 inches of the grate. This, therefore, is the most advantageous position for the crucible, and still more so when we can keep it surrounded with fuel. It is inconvenient, and dangerous for the crucible, to stir the fire often to make the fuel fall, and the pyramidical form renders this unnecessary. It is also more easy to

CHEMICAL APPARATUS

Plate VI.

Fig. 1.

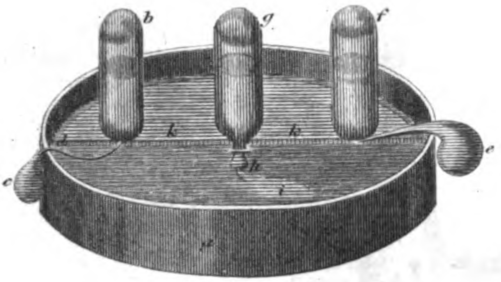


Fig. 6.

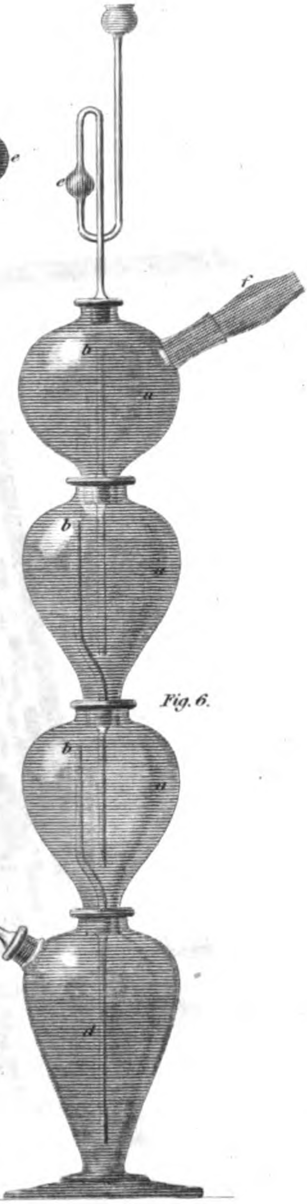


Fig. 4.

Fig. 2.

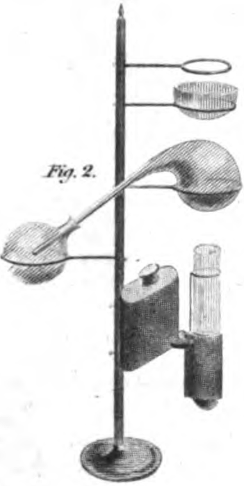
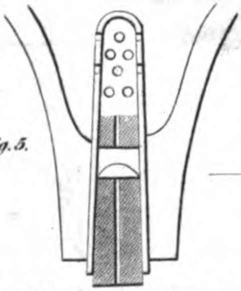


Fig. 3.

Fig. 5.



Cooper Sculp.

Published May 1, 1808, by Rd. Phillips, Bridge Street, Blackfriars, London.

CHEMICAL APPARATUS

Plate VII.

Fig. 1.

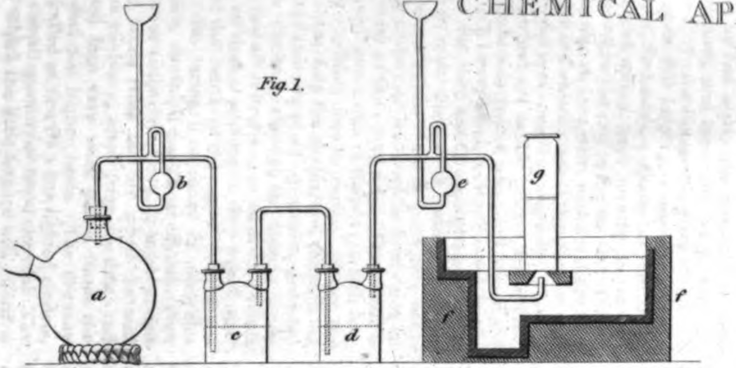
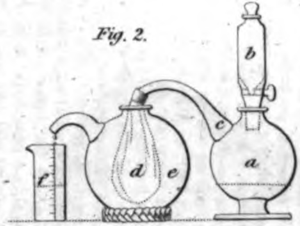


Fig. 2.



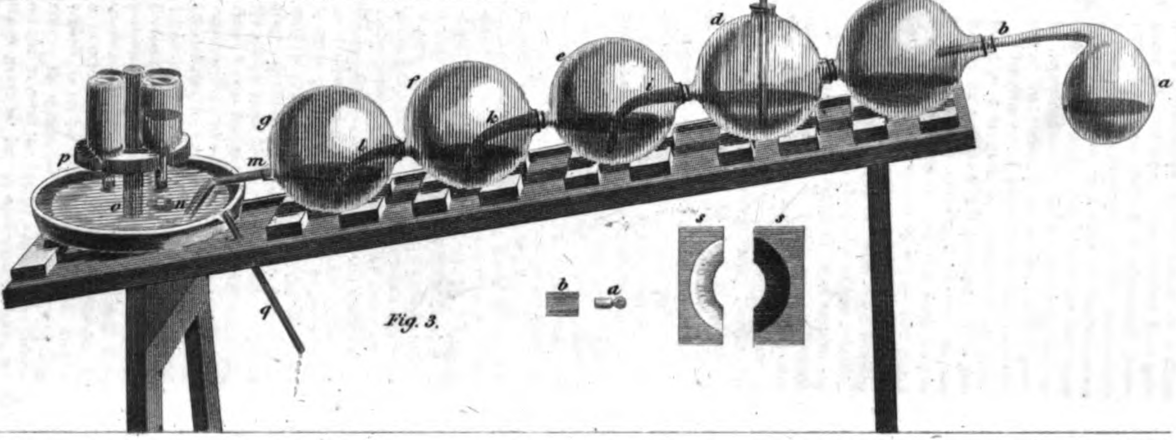


Fig. 3.

Published May 1st. 1808, by — Rd. Phillips, Bridge St. Blackfriars, London.

Couper fculp.

id a sudden bend in the chimney, by the
per part of the furnace advancing as in
construction. In Pl. V, fig. 1, *a* is a
te; *c* and *c* are two bricks, which can be
in at pleasure to diminish the capacity;
another grate, which can be placed
on the bricks *c* and *c* for smaller pur-
es; *d* and *d* are bricks, which can be
ced upon the grate *b* to diminish the up-
capacity, so that in fact there are four
ferent sizes in the same furnace. The
cks should all be ground down to the
pe of the furnace, and fit in with tolerable
uracy. They are totally independent of
pyramidical form of the furnace.

Mr. Aikin's portable blast furnace is com-
sed of three parts, all made out of the
nmon thin black lead melting pots, sold
London for the use of the goldsmiths.
e lower piece *c*, fig. 6, is the bottom of one
these pots, cut off so low as only to leave a
vity of about an inch deep, and ground
ooth above and below. The outside di-
eter, over the top, is five inches and a
f. The middle piece, or fireplace *a*, is a
ger portion of a similar pot, with a cavity
out six inches deep, and measuring seven
hes and a half over the top, outside dia-
ter, and perforated with six blast holes
the bottom. These two pots are all that
essentially necessary to the furnace for
ost operations; but when it is wished to
ap up fuel above the top of a crucible
ntained, and especially to protect the
es from the intolerable glare of the fire
hen in full height, an upper pot *b* is ad-
d, of the same dimensions as the middle
e, and with a large opening in the side,
to allow the exit of the smoke and flame,
has also an iron stem, with a wooden han-
(an old chisel answers the purpose very
ll) for removing it occasionally. The bel-
vs, which are double (*d*), are firmly fixed,
a little contrivance which will take off and
, to a heavy stool, as represented in the
ite; and their handle should be lengthened
as to make them work easier to the hand.
increase their force on particular occa-
ns, a plate of lead may be firmly tied on
wood of the upper flap. The nozzle is
ceived into a hole in the pot *c*, which con-
cts the blast into its cavity. Hence the
passes into the fireplace *a*, through six
les of the size of a large gimlet, drilled at
ual distances through the bottom of the
t, and all converging in an inward direc-
on, so that, if prolonged, they would meet
out the centre of the upper part of the
e. No luting is necessary in using this
rnace, so that it may be set up and taken
wn immediately. Coak, or common cin-
rs, taken from the fire when the coal
ases to blaze, sifted from the dust, and
oken into very small pieces, forms the
st fuel for higher heats. The fire may
kindled at first by a few lighted cinders,
d a small quantity of wood charcoal. The
at which this little furnace will afford is so intense, that its power was at first discovered accidentally by the fusion of a thick piece of cast iron. The utmost heat procured by it was 167° of Wedgwood's pyrometer, when a Hessian crucible was actually sinking down in a state of porcelaneous fusion. A steady heat of 155° or 160° may be depended on, if the fire be properly managed, and the bellows worked with vigour.

The process of cupellation may be exhibited in a lecture, or performed at other times, by means of this furnace. The method consists in causing a portion of the blast to be diverted from the fuel, and to pass through a crucible in which the cupel is placed. This arrangement supplies air; and the whole may be seen by a sloping tube, run through the cover of the crucible.

Charcoal is the material most commonly used in furnaces. It produces an intense heat without smoke, but it is consumed very fast. Coke or charred pit coal produces a very strong and lasting heat. Neither of these produces a strong heat at a distance from the fire. Where the action of flame is required, wood or coal must be burned. Several inconveniences attend the use of coal, as its fuliginous fumes, and its aptitude to stop the passage of air by becoming fused. It is used however in the reverberatory furnaces of glass-houses, and is the best material where vessels are to be supplied with a great quantity of heat at no great intensity, such as in distilleries, &c.

Frequently however the flame of an Argand lamp may be employed very conveniently for chemical purposes. Pl. VI, fig. 2, is a representation of a lamp furnace, as it is perhaps not very properly called, as improved by Mr. Accum. It consists of a brass rod screwed to a foot of the same metal, loaded with lead. On this rod, which may be unscrewed in the middle for rendering it more portable, slide three brass sockets with straight arms, terminating in brass rings of different diameters. The largest measures four inches and a half. These rings serve for supporting glass alembics, retorts, Florence-flasks, evaporating basins, gas-bottles, &c.; for performing distillations, digestions, solutions, evaporations, saline fusions, concentrations, analyses with the pneumatic apparatus, &c. If the vessels require not to be exposed to the naked fire, a copper sand-bath may be interposed, which is to be previously placed in the ring. By means of a thumb-screw acting on the rod of the lamp, each of the brass-rings may be set at different heights, or turned aside, according to the pleasure of the operator. Below these rings is a fountain-lamp on Argand's plan, having a metallic valve within, to prevent the oil from running out while the reservoir is put into its place. This lamp also slides on the main brass rod by means of a socket and thumb-screw. It is therefore easy to bring it nearer, or to move it further, at pleasure, from the vessel, which may remain fixed; a circumstance which, independent of the elevation and depression of the wicks of the lamp, affords the advantage of heating the vessels by degrees after they are duly placed, as well as of augmenting or diminishing the heat instantly; or for maintaining it for several hours at a certain degree, without in the least disturbing the apparatus suspended over it. It may therefore be used for producing the very gentle heat necessary for the rectification of ethers, or the strong heat requisite for distilling mercury. The chief improvement of this lamp consists in its power of affording an intense heat by the addition of a second cylinder, added to that of the common lamp of Argand. This additional cylinder incloses a wick of one inch and a half in diameter, and it is by this ingenious contrivance, which was first suggested by Mr. Webster, that a double flame is caused, and more than three times the heat of an Argand's lamp of the largest size is produced.

Every effect of the most violent heat of furnaces may be produced by the flame of a candle or lamp, urged upon a small particle of any substance, by the blowpipe. This instrument is sold by the ironmongers, and consists merely of a brass pipe about one eighth of an inch diameter at one end, and the other tapering to a much less size, with a very small perforation for the wind to escape. The smaller end is bended on one side. For philosophical or other nice purposes the blowpipe is provided with a bowl or enlargement, *a* (Pl. V, fig. 5), in which the vapours of the breath are condensed and detained, and also with three or four small nozzles, *b*, with different apertures, to be slipped on the smaller extremity. These are of use when larger or smaller flames are to be occasionally used, because a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to describe than to acquire. The effect intended to be produced is a continual stream of air for many minutes, if necessary, without ceasing. This is done by applying the tongue to the roof of the mouth, so as to interrupt the communication between the mouth and the passage of the nostrils; by which means the operator is at liberty to breathe through the nostrils, at the same time that by the muscles of the lips he forces a continual stream of air from the anterior part of the mouth through the blowpipe. When the mouth begins to be empty, it is replenished by the lungs in an instant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the same manner as in pronouncing the monosyllable tut. In this way the stream may be continued for a long time without any fatigue, if the flame be not urged too impetuously, and even in this case no other fatigue is felt than that of the muscles of the lips.

A wax candle of a moderate size, but thicker wick than they are usually made with, is the most convenient for occasional experiments; but a tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side toward the object, so that a part of it should lie horizontally. The stream of air must be blown along this horizontal part, as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof, that the hole is not round or smooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure and duly proportioned, the flame consists of a neat luminous blue cone, surrounded by another flame of a more faint and indistinct appearance. The strongest heat is at the point of the inner flame.

The body intended to be acted on by the blowpipe ought not to exceed the size of a pepper-corn. It may be laid upon a piece of close-grained, well-burned charcoal; unless it be of such a nature as to sink into the pores of this substance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a small spoon made of pure gold or silver, or platina.

Many advantages may be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation. The most expensive materials, and the minutest specimens of bodies, may be used in these experiments; and the whole process, instead of being carried on in an opake vessel, is under the eye of the observer from beginning to end. It is true, that very little can be determined in this way concerning the quantities of products; but, in most cases, a knowledge of the contents of any substance is a great acquisition, which is thus obtained in a very short time, and will at all events serve to show the best and least expensive way of conducting processes with the same matters in the larger way.

The blowpipe has deservedly of late years been considered as an essential instrument in a chemical laboratory, and several attempts have been made to facilitate its use by the addition of bellows, or some other equivalent instruments. These are doubtless very convenient, though they render it less portable for mineralogical researches. It will not, here, be necessary to enter into any description of a pair of double bellows fixed under a table, and communicating with a blowpipe which passes through the table. Smaller bellows, of a portable size for the pocket, have been made for the same purpose. The ingenious chemist will find no great difficulty in adapting a bladder to the blow pipe, which, under the pressure of a board, may produce a constant stream

air, and may be replenished, as it be-
nes empty, by blowing into it with bel-
s, or the mouth, at another aperture fur-
hed with a valve opening inwards.

The chief advantage these contrivances
e over the common blowpipe is, that
y may be filled with oxigen gas, which
reases the activity of combustion to an
onishing degree. The vapour from al-
ol has likewise been employed, and an
enious contrivance for this purpose by
. Hooke is represented, Pl. V, fig. 4. *a* is
ollow sphere for containing alcohol, rest-
upon a shoulder in the ring *o*. If the
tom be made flat instead of spherical,
action of the flame will then be greater.
a bent tube with a jet at the end, to
ivey the alcohol in the state of vapour
o the flame at *q*; this tube is continued in
inside up to *c*, which admits of *a* being
ed nearly, without any alcohol running
er. *d* is a safety valve, the pressure of
ich is determined at pleasure, by screw-
higher or lower on the pillar *e*, the two
lled nuts *f* and *g* carrying the steel arm
which rests on the valve. *i* is an opening
putting in the alcohol. *k* is the lamp,
ich adjusts to different distances from *a*,
sliding up or down the two pillars *l l*.
e distance of the flame *q* from the jet is
ulated by the pipe which holds the wick
ng a little removed from the centre of
brass piece *m*, and of course revolving
a circle. *n* the mahogany stand.

For the various habitudes of bodies when
mined by the blowpipe, see Blowpipe.

Little need be said concerning the man-
of making experiments with fluid bodies
he common temperature of the atmo-
ere. Basins, cups, phials, matrasses, and
er similar vessels, form the whole appa-
us required for the purpose of containing
matters intended to be put together;
l no other precaution or instruction is
uired, than to use a vessel of such mate-
s as shall not be corroded or acted upon
its contents, and of sufficient capacity to
nit of any sudden expansion or frothing
he fluid, if expected. This vessel must
placed in a current of air, if noxious
es arise, in order that these may be
wn from the operator.

The method of making experiments with
manently elastic fluids, or gasses, though
ple, is not so obvious. We live immersed
n atmosphere not greatly differing in
sity from these fluids, which for this
on are not sufficiently ponderous to be
ained in open vessels by their weight.
eir remarkable levity, however, affords
nethod of confining them by means of
er denser fluids. Dr. Priestley, whose
ours have so far exceeded those of his
decessors and contemporaries, both in
ent and importance, that he may with
ice be styled the father of this important
nch of natural philosophy, used the fol-
ing apparatus.

Pl. VI, fig. 1, *a* represents a wooden vessel or tub; *k*, *k*, *k*, is a shelf fixed in the tub. When this apparatus is used, the tub is to be filled with water to such a height, as to rise about one inch above the upper surface of the shelf. *b*, *g*, *f*, are glass jars inverted with their mouths downward, which rest upon the shelf. If these, or any other vessels open only at one end, be plunged under the water, and inverted after they are filled, they will remain full, notwithstanding their being raised out of the water, provided their mouths be kept immersed: for in this case, the water is sustained by the pressure of the atmosphere, in the same manner as the mercury in the barometer. It may without difficulty be imagined, that if common air, or any other fluid resembling common air in lightness and elasticity, be suffered to enter these vessels, it will rise to the upper part, and the surface of the water will subside. If a bottle, a cup, or any other vessel, in that state which is usually called empty, though really full of air, be plunged into the water with its mouth downwards, scarce any water will enter, because its entrance is opposed by the elasticity of the included air; but if the vessel be turned up, it immediately fills, and the air rises in one or more bubbles to the surface. Suppose this operation to be performed under one of the jars which are filled with water, the air will ascend as before; but, instead of escaping, it will be detained in the upper part of the jar. In this manner, therefore, we see, that air may be emptied out of one vessel into another by an inverted pouring, in which the air is made to ascend from the lower vessel *i* to the upper *g*, in which the experiments are performed, by the action of the weightier fluid, exactly similar to the common pouring of denser fluids, detained in the bottoms of open vessels, by the simple action of gravity. When the receiving vessel has a narrow neck, the air may be poured through a glass funnel, *h*.

c (*ibid.*) is a glass body or bottle, the bottom of which is blown very thin, that it may support the heat of a candle suddenly applied, without cracking. In its neck is fitted, by grinding, a tube *d*, curved neatly in the form of the letter *s*. This kind of vessel is very useful in various chemical operations, for which it will be convenient to have them of several sizes. In the figure, the body *c* is represented as containing a fluid, in the act of combining with a substance that gives out air, which passes through the tube into the jar *b*, under the mouth of which the other extremity of the tube is placed. At *e* is a small retort of glass or earthenware, the neck of which being plunged in the water, beneath the jar *f*, is supposed to emit the elastic fluid, extricated from the contents of the retort, which is received in the jar.

When any thing, as a gallipot, is to be supported at a considerable height within a jar, it is convenient to have such wire stands as are represented fig. 3. These answer better than any other, because they take up but little room, and are easily bent to any figure or height.

In order to expel air from solid substances by means of heat, a gun-barrel, with the touch-hole screwed up and riveted, may be used instead of an iron retort. The subject may be placed in the chamber of the barrel, and the rest of the bore may be filled with dry sand, that has been well burned, to expel whatever air it might have contained. The stem of a tobacco-pipe, or a small glass tube, being luted in the orifice of the barrel, the other extremity must be put into the fire, that the heat may expel the air from its contents. This air will of course pass through the tube, and may be received under an inverted vessel, in the usual manner.

But the most accurate method of procuring air from several substances by means of heat, is to put them, if they will bear it, into phials full of quicksilver, with the mouths inverted in the same, and then throw the focus of a burning lens or mirror upon them. For this purpose, their bottoms should be round and very thin, that they may not be liable to fly with the sudden application of heat. The body *c* Pl. VI, fig. 1, answers this purpose very well.

Many kinds of air combine with water, and therefore require to be treated in an apparatus, in which quicksilver is made use of. This fluid being very ponderous, and of considerable price, it is an object of convenience, as well as œconomy, that the trough and vessels should be smaller than when water is used. See Pl. VII, fig. 1, *f f*.

When trial is to be made of any kind of air, whether it be fit for maintaining combustion, the air may be put into a long narrow glass vessel, the mouth of which, being carefully covered, may be turned upward. A bit of wax candle being then fastened to the end of a wire, which is bent so that the flame of the candle may be uppermost, is to be let down into the vessel, which must be kept covered till the instant of plunging the lighted candle into the air.

Where the change of dimensions, which follows from the mixture of several kinds of air, is to be ascertained, a graduated narrow cylindrical vessel may be made use of. The graduations may be made by pouring in successive equal measures of water into this vessel, and marking its surface at each addition. The measure may be afterward used for the different kinds of air, and the change of dimensions will be shown by the rise or fall of the mercury or water in the graduated vessel. The purity of common air being determinable by the diminution produced by the addition of nitric oxide gas, these tubes have been called eudiometer tubes.

Some substances, more especially powders, cannot conveniently be put into a phial, or passed through a fluid. When air is to be extricated from, or added to these, there is no better method, than to place them on a stand under the receiver of the air-pump, and exhaust the common air, instead of excluding it by water or mercury. This process requires a good air-pump, and careful management, otherwise the common air will not be well excluded.

It is frequently an interesting object, to pass the electric spark through different kinds of air, either alone or mixed together. In this case a metallic wire may be fastened in the upper end of a tube, and the sparks or shock may be passed through this wire to the mercury or water used to confine the air. If there be reason to apprehend, that an expansion in the air may remove the mercury or water beyond the striking distance, another wire may be thrust up to receive the electricity, or two wires may be cemented into opposite holes in the sides of an hermetically sealed tube. Holes may be made in glass, for this and other chemical uses, by a drill of copper or soft iron, with emery and water; and where this instrument is wanting, a small round file with water will cut a notch in small vessels, such as phials or tubes, though with some danger of breaking them. In some electrical experiments of the kind here mentioned, there is reason to expect a fallacious result from the wires being burned by the explosion or spark. For this reason, the electricity may be made to pass through the legs of a syphon, containing the air which is under consideration in the upper part of its curvature. One of the vessels, in which the legs of the syphon rest, must therefore be insulated; and if any watery fluid be used to confine the air, it is generally supposed that no combustion takes place.

It is sometimes desirable to impregnate water for medicinal purposes with some gas, as the carbonic acid, and for this the apparatus of Dr. Nooth is very effectual and convenient. It consists of three glass vessels, Pl. VI, fig. 4. The lower vessel *c* contains the effervescent materials; it has a small orifice at *d*, stopped with a ground stopper, at which an additional supply of either acid or water, or chalk, may be occasionally introduced. The middle vessel *b* is open, both above and below. Its inferior neck is fitted by grinding into the neck *h* of the lower vessel. In the former is a glass valve, formed by two pieces of tube, and a plano-convex lens, which is movable, between them, as represented in fig. 5. This valve opens upwards, and suffers the air to pass; but the water cannot return through the tubes, partly because the orifice is capillary, and partly because the flat side of the lens covers the hole. The middle vessel is furnished with a cock *e*, to draw off its contents. The upper vessel *a* is fitted, by grinding, into the upper neck of the middle vessel, ts inferior part consists of a tube that passes lmost as low as the centre of the middle essel. Its upper orifice is closed by a round stopper *f*. When this apparatus is o be used, the effervescent materials are put nto the lower vessel, the middle vessel is lled with pure water, and put into its lace; and the upper vessel is stopped, and kewise put in its place. The consequence , that the carbonic acid gas, passing hrough the valve at *h*, ascends into the up-er part of the middle vessel *b*, where by s elasticity it reacts on the water, and orces part up the tube into the vessel *a*; art of the common air, in this last, being ompressed, and the rest escaping by the topper, which is made of a conical figure, hat it may be easily raised. As more car-onic acid is extricated, more water rises, ill at length the water in the middle vessel alls below the lower orifice of the tube. he gas then passes through the tube into he upper vessel, and expels more of the ommon air by raising the stopper. In this tuation the water in both vessels being in ontact with a body of carbonic acid gas, it ecomes strongly impregnated with this gas, fter a certain time. This effect may be astened by taking off the middle and upper essels together, and agitating them.

The valve is the most defective part of his apparatus; for the capillary tube does ot admit the air through, unless there is a onsiderable quantity condensed in the low-r vessel; and the condensation has in some nstances burst the vessel.

Modern discoveries respecting bodies in he aëriform state have produced several ca-ital improvements in the vessels used for istillation. It was common with the ear-est chemists, to make a small hole in the pper part of their retorts, that the elastic apours might escape, which would other-ise have burst the vessels. By this means ney lost a very considerable part of their roducts. Sometimes too it is requisite, to btain separately the condensable fluid that omes over, and the gasses that are and are ot soluble in water. For this purpose a se-es of receivers, more or less in number as ne case may require, is generally employ-d, as in Pl. VII, fig. 1, which represents hat is called Woulfe's apparatus, though fact its original inventor was Glauber, ith some subsequent improvements. The apour that issues from the retort being ondensed in the receiver *a*, the gas passes on rough a bent tube into the bottle *c*, which half filled with water. The gas not ab-rbed by this water passes through a simi-r bent tube to *d*, and so on to more, if it e thought necessary; while the gas that is ot absorbable by water, or condensable, at s exit from the last bottle is conveyed by recurved tube into a jar *g*, standing in a ercurial trough *f*, *f*.

It often happens in chemical processes, om the irregularity of the heat, or other circumstances, that the condensation is more rapid in proportion to the supply of vapour at some period of the same operation than in others; which would endanger the fluid's being forced backward, by the pressure of the atmosphere, into the receiver, or even into the retort. To prevent this, Mr. Woulfe's bottles had a central neck, beside the two here delineated, for the insertion of a tube of safety, the lower extremity of which opened underneath the water, and the upper communicated with the atmosphere, so as to supply air in case of sudden absorption. See Pl. VII, fig. 3, *h*. Instead of this, however, a curved Welter's tube is now generally used, as more convenient. Into this tube water is poured, till the ball *b*, or *e*, fig. 1, is half full: when absorption takes place, the water rises in the ball till none remains in the tube, and then the air rushes in: on the other hand no gas can escape, as it has to overcome the pressure of a high column of water in the perpendicular tube.

Another contrivance to prevent retrograde pressure is that of Mr. Pepys. This consists in placing over the first receiver a glass vessel, the neck of which is ground into it, and furnished with a glass valve, similar to that in Nooth's apparatus, so that whenever sudden condensation takes place in the receiver, its effect is merely to occasion a vacuum there.

An ingenious modification of Woulfe's apparatus is that of Mr. Knight, Pl. VI, fig. 6. *a a a* represent three vessels, each ground into the mouth of that below it. *b b b* glass tubes, the middles of which are ground into the neck of their respective vessels, the upper extremity standing above the surface of the liquor in the vessel, and the lower extremity reaching nearly to the bottom of the vessel beneath. *e* a Welter's tube to prevent absorption. *f* an adapter ground to fit the receiver; to which any retort may be joined and luted before it is put into its place. *c* a tube for conveying the gas into a pneumatic trough. The foot of the lowest vessel, *d*, slides in between two grooves in a square wooden foot, to secure the apparatus from oversetting. A stopple fitted to the upper vessel, instead of the adapter *f*, converts it into a Nooth's apparatus, the materials being put into the vessel *a*, and in this case it has the advantage of not having a valve liable to be out of order.

A very simple and commodious form of a Woulfe's apparatus is given by the late Dr. W. Hamilton, at the end of his translation of Berthollet on Dyeing: see Pl. VII, fig. 3. *a* is the retort, the neck of which is ground into and passed through the thick collar *b*, represented separately at b, with its ground stopple a, which may be put in when the neck of the retort is withdrawn. The collar *b* is ground into the wide neck of the receiver c, the narrow neck of which is ground into the wide neck of d. *d*, *e*, *f*, and *g*, are connected in a similar manner; and into the small necks of *d*, *e*, and *f*, are ground the tubes *i*, *k*, and *l*, so curved, that their lower extremities nearly reach the bottom of the receiver into which they open. From the last receiver proceeds the recurved tube *m*, opening under an inverted cup *n*, a hole in the bottom of which conveys the gas issuing from it into one of the bottles placed in the movable frame *p*, which has a heavy leaden foot to keep it steady in the centre of a flat pan of water, in which the mouths of the bottles are immersed. In the receiver *d* is a tube of safety *h*. The receivers are placed on a stand a little inclined, and kept steady by slips of wood hollowed out to fit their curvatures, as represented at *s s*. This apparatus requires no lute; has no bent tubes that are difficult to adjust, and liable to break; and the retort may be removed at any stage of the process, either to find the weight it has lost, or for any other purpose, the receiver being meanwhile closed with the stopple. Similar advantages attend Mr. Knight's.

When it is required to pass an aëriform fluid through a redhot substance, such an apparatus as that of Barruel, Pl. I, fig. 2, may be employed. In this three gunbarrels, *b*, *c*, *d*, are placed horizontally in a reverberatory furnace *a*, about two inches distance from each other. From the extremity of the central barrel *c* a bent tube *k* conveys the gas to the jar *m*, in the pneumatic trough *l*. The other extremity of *c* is connected with *d* by the curved tube *i*; *d* with *b* by the curved tube *h*; and the other end of *b* with the bottle *f* by the tube *e*. When this apparatus is employed for obtaining carbonic oxide, the part of each barrel exposed to the fire being filled with charcoal pressed lightly in, but not rammed hard; carbonat of lime diluted with a very little water being poured into the bottle *f*; and the junctures being all well luted, the fire is to be kindled. As soon as the barrels are redhot, sulphuric acid is to be poured into the funnel *g*, and the carbonic acid gas expelled, traversing three portions of redhot charcoal, will completely saturate itself with it before it reaches the receiver *m*.

Pl. VII, fig. 2, represents the different parts of the apparatus required for measuring the quantity of elastic fluid given out during the action of an acid on calcareous soils. The bottle for containing the soil is represented at *a*; *b* the bottle containing the acid, furnished with a stop cock; *c* the tube connected with a flaccid bladder *d*; *f* a graduated measure; *e* the bottle for containing the bladder. When this instrument is used, a given quantity of soil is introduced into *a*; *b* is filled with muriatic acid, diluted with an equal quantity of water; and the stop-cock, being closed, is connected with the upper orifice of *a*, which is ground to receive it. The tube *c* is introduced into the lower orifice of *a*, and the bladder connected with it placed in its flaccid state in *e*, which is filled with water. The graduated measure is placed under the tube of *e*. When the stopcock of *b* is turned, the acid flows into *a*, and acts upon the soil; the elastic fluid generated passes through *c* into the bladder, and displaces a quantity of water in *e* equal to it in bulk, and this water flows through the tube into the graduated measure; the water in which gives, by its volume, the indication of the proportion of carbonic acid disengaged from the soil; for every ounce measure of which, two grains of carbonat of lime may be estimated.

Labrador Stone. A beautiful stone from the coast of Labrador. Its colour is commonly of a light, or of a deep gray, frequently blackish; but when held in certain positions to the light, it exhibits varieties of beautiful internal colours, chiefly consisting of shades of blue and green, seldom yellow, in some parts of a copper red, and violet. These colours have for the most part a flaky or spotted appearance, but sometimes they lie in stripes.

These stones are found of an angular form in pieces of considerable magnitude, their specific gravity is 2·755, their fracture is laminated; the broken parts are rhomboidal, and semitransparent. In other respects this stone agrees with the feldt spar, but is softer.

Lac Is a substance well known in Europe, under the different appellations of stick-lac, shell-lac, and seed-lac. The first is the lac in its natural state, incrusting small branches or twigs. Seed-lac is the stick-lac separated from the twigs, appearing in a granulated form, and probably deprived of part of its colouring matter by boiling. Shell-lac is the substance which has undergone a simple purification, as mentioned below. Beside these we sometimes meet with a fourth, called lump-lac, which is the seed-lac melted and formed into cakes.

Lac is the product of the coccus lacca, which deposits its eggs on the branches of a tree called Bihar, in Assam, a country bordering on Thibet, and elsewhere in India. It appears designed to answer the purpose of defending the eggs from injury, and affording food for the maggot in a more advanced state. It is formed into cells, finished with as much art and regularity as a honeycomb, but differently arranged; and the inhabitants collect it twice a year, in the months of February and August. For the purification, it is broken into small pieces, and put into a canvass bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores; when it is taken off the fire, and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for this purpose; and while

s is doing, the other bag is heating, to be
ated in the same way. The mucilaginous
l smooth surface of the plantain tree pre-
nts its adhering; and the degree of pres-
e regulates the thickness of the coating
ac, at the same time that the fineness of
bag determines its clearness and trans-
rency.

Analysed by Mr. Hatchett, stick-lac gave
a hundred parts, resin 68, colouring ex-
ct 10. wax 6, gluten 5·5, extraneous
ostances 6·5: seed-lac, resin 88·5, colour-
; extract 2·5, wax 4·5, gluten 2: shell-
, resin 90·9, colouring extract 0·5, wax 4,
ten 2·8. The gluten greatly resembles
t of wheat, if it be not precisely the
ne; and the wax is analogous to that of
e myrica cerifera.

In India lac is fashioned into rings, beads,
l other trinkets: sealing-wax, varnishes,
d lakes for painters, are made from it: it
nuch used as a red dye, and wool tinged
h it is employed as a fucus by the ladies:
l the resinous part, melted and mixed
th about thrice its weight of finely pow-
red sand, forms polishing stones. The
idaries mix powder of corundum with it
a similar manner.

The colouring matter is soluble in water;
t 1 part of borax to 5 of lac renders the
hole soluble by digestion in water nearly
a boiling heat. This solution is equal
many purposes to spirit varnish, and is
excellent vehicle for watercolours, as
hen once dried water has no effect on
Lixivium of potash, soda, and carbonat
soda, likewise dissolve it. So does nitric
d, if digested upon it in sufficient quan-
y 48 hours.

The colouring matter of the lac loses con-
erably of its beauty by keeping any
gth of time; but when extracted fresh,
d precipitated as a lake, it is less liable to
ury. Mr. Stephens, a surgeon in Bengal,
at home a great deal prepared in this way,
hich afforded a good scarlet to cloth pre-
ously yellowed with quercitron: but it
ould probably have been better, if, instead
precipitating with alum, he had em-
oyed a solution of tin, or merely evapo-
ed the decoction to dryness.

Lac is the basis of the best sealing wax.—
il. Trans.—Trans. of Soc. of Arts.

LAC (WHITE). Under the article ACID
ACCIC), we have already noticed a sub-
nce resembling bees-wax, and, from the
nner of its production by a species of
ccus, called by Dr. Anderson white lac.
chief properties, not there mentioned,
: when purified by fusion and straining
rough cloth, by which it loses about two-
ths of its weight, it adheres so firmly to
od, paper, tin, and other substances, as
answer the purpose of a good cement:
cannot be bleached by exposure to the
n, or to oxigenized muriatic acid: by
iling with charcoal in water it is absorb-
: with potash it combines very imperfectly, but with ammonia it forms a soap: made into candles it burns with smoke and smell: sulphuric acid turns it black: boiling nitric acid dissolves it, but by cooling, or by pouring the hot solution into water, it separates of a whiter colour: oil of turpentine dissolves one fifth of its weight, by the aid of heat, without appearing to alter it: ether at 80° dissolves one tenth of its weight with some slight change: alcohol takes up about one twentieth: it does not afford a good varnish.

By destructive distillation the products were one fourth butyraceous oil, one half thin oil, and the rest minute quantities of acid, water, and coaly and saline matter, with carbonic acid gas, hidrogen, and azot. —*Phil. Trans. for* 1794, *Part* II.

LACQUER. See VARNISH.

LAKES. This term is used to denote a species of colours formed by precipitating colouring matter with some earth or oxide. The principal lakes are, Carmine, Florence-lake, and lake from Madder.

For the preparation of *Carmine*, four ounces of finely pulverized cochineal are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advise to add, during the boiling, two drachms of pulverized crystals of tartar.) Eight scruples of Roman alum in powder are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, the latter is to be carefully decanted into large cylindrical glasses covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other.

For the preparation of *Florentine* lake, the sediment of cochineal, that remained in the kettle, may be boiled with the requisite quantity of water, and the red liquor likewise, that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequently edulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time two pounds of alum are also to be dissolved in water, precipitated with a lixivium of pot-ash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a *cheaper* sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner.

The red extracted from shreds of scarlet cloth by boiling them in a lixivium of a pound of pearl ashes to two quarts of water, being precipitated by a solution of a pound and half of cuttlefish bone in a pound of aqua fortis, is said to make a very fine carmine. If 1½ lb. of the bone be not sufficient to saturate the aqua fortis, more must be added, till it excites no effervescence. If the lake appear too purple, a little alum may be added to the solution.

For the following process for making a *lake from madder*, the Society of Arts voted sir H. C. Englefield their gold medal. Enclose two ounces troy of the finest Dutch crop madder in a bag of fine and strong calico, large enough to hold three or four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be sufficient. Heat all the liquor in an earthen or silver vessel, till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum dissolved in a pint of boiling soft water has been previously put. Stir the mixture together, and while stirring pour in gently about an ounce and half of a saturated solution of subcarbonat of potash. Let it stand till cold to settle; pour off the clear yellow liquor; add to the precipitate a quart of boiling soft water, stirring it well; and when cold separate by filtration the lake, which should weigh half an ounce. If less alum be employed, the colour will be somewhat deeper: with less than three fourths of an ounce the whole of the colouring matter will not unite with the alumine. Fresh madder root is equal, if not superior, to the dry.

Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum, or oxide of tin; but Guyton-Morveau asserts, that the oxide of tungsten is superior to any other base. If this oxide were boiled in vinegar, so as to give it a blue colour, the tints of the lake were heightened. From the fermented juice of the succotrine aloe he obtained a fine purple-red with this oxide.

Lamp. See Light.

Lampblack. When the parts of organized substances which are of an inflammable nature are burning under circumstances wherein a complete combustion does not take place, part of the coaly matter is carried up through the flame, and forms soot. Common soot contains other matters beside charcoal: but the soot of oily substances is considerably pure. The finest lampblack is actually produced by collecting the smoke from a lamp with a long wick, which supplies more oil than can be perfectly consumed, or by suffering the flame to play against a metalline cover, which impedes the combustion not only by conducting off part of the heat, but by obstructing the current of air. Lampblack, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or else small pieces of fir-wood, are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot remains behind.

Lapis Hepaticus. A stone of a white, gray, yellow, brown, or black colour; it is generally compact, but not so hard as to give fire with steel; of a texture either equable or laminar, scaly or sparry, and which takes a polish as alabaster.

It does not effervesce with acids. When calcined, it is partially reduced to a sort of plaster of Paris. It emits a smell of sulphuretted hidrogen, at least when rubbed. According to Bergman, 100 parts of it afford 38 of sulphat of barytes, 33 of silex, 22 of alum, 7 of gypsum, and 5 of mineral oil. The increase proceeds from the water of crystallization.

Lapis Infernalis. See Infernal Stone.

Lapis Lazuli. The colour of this stone is a beautiful opake blue, which varies a little in intensity, and is generally sprinkled over with yellow, bright, pyritaceous specks or streaks: it obstinately retains its colour in a strong heat, but in that of an enameller's furnace it changes to gray: it is of an equable or very fine granular texture, and takes a beautiful polish; its specific gravity is 3·054. If powdered and not calcined, it effervesces very slightly with acids; but if calcined, it does not effervesce, but becomes gelatinous. In a strong fire it melts without addition into a whitish glass.

Klaproth gives the following as the analysis of 100 parts of this stone. Silex 46, alumine 14·5, carbonat of lime 28, sulphat of lime 6·5, oxide of iron 3, water 2. According to Guyton-Morveau, however, the colouring matter is a blue sulphuret of iron, mixed in some specimens with nothing but silex and sulphat of lime, to which in others barytes is added, and in others alumine and carbonat of lime.

The fine blue colour called Ultramarine, which see, is prepared from this stone.—*Klaproth's Analyses.—An. de Chim.*

Lapis Lydius. A variety of the trap of the Swedes; its colour is black, and it is well known by the name of the touch-stone. The black basaltes, from which this stone

carcely differs in its component parts, is
sed for the same purpose. See ASSAY.

LAPIS NEPHRITICUS. See JADE.

LAPIS OLLARIS. A stone of the magne-
an genus, of a greenish or yellowish gray,
ometimes speckled with red It is easily
rought and turned, so that pots and mor-
ars are often made of it. Spec. grav. from
·769 to 3·023.

LAPIS SPECULARIS. A name given to the
ansparent sulphat of lime.

LAPIS SUILLUS. See LAPIS HEPATICUS.

LAVA. See VOLCANIC PRODUCTS.

LAUDANUM. See OPIUM.

LAZULI, (LAPIS.) See LAPIS LAZULI.

LEAD. Is a white metal, of a conside-
ably blue tinge, very soft and flexible, not
ery tenacious, and consequently incapable
being drawn into fine wire, though it is
sily extended into thin plates under the
ammer. Its weight is very considerabie,
eing rather greater than that of silver.
ong before ignition it melts; and then
egins to be oxided, if oxigen be present.
a strong heat it boils, and emits fumes;
uring which time, if exposed to the air,
oxidation proceeds with considerable ra-
dity. If melted lead be poured into a
ox previously rubbed with chalk to pre-
ent its action on the wood, and be conti-
ually agitated, it will concrete into sepa-
te grains, of considerable use in various
echanical operations, particularly that of
eighing. Lead is brittle at the time of
ngelation. In this state it may be broken
pieces with a hammer, and the crystal-
zation of its internal parts will exhibit an
rangement in parallel lines.

This metal, during the progress of heat,
st becomes converted into a dusky pow-
r, which by a continuation of the heat
comes white, yellow, and afterward of a
ight red, inclining to orange colour,
lled *minium*, or red lead. The process
quires considerable management with re-
rd to the heat, and access of the air, in
e making of red lead. Many days are
quired for this purpose. See MINIUM.
the heat be too great or rapid, the lead
comes converted into a flaky substance,
lled litharge; and a still greater heat con-
rts it into a clear, transparent, yellow
ass, which powerfully dissolves and cor-
des metallic oxides or earths; and on this
count it usually finds its way through the
ucibles in a short time. It acts more dif-
ultly on argillaceous than on siliceous
rths; whence it is found, that vessels
ade of clay mixed with broken pottery
e preferable to those that are composed of
y and sand. The oxide of lead is a prin-
pal ingredient in most of the modern
e white glasses. It is more particularly
lculated to form the dense glass used to
rrect the aberration arising from colour
those telescopes, which are known by
e name of achromatic; because it com-
unicates the property of separating the coloured rays from each other in greater angles than obtained in alkaline glasses at equal angles of mean refraction. See ACHROMATIC, also GLASS. The imperfection which most considerably affects this kind of glass is, that its density is seldom uniform throughout. The irregularities show themselves in the form of veins, which greatly disturb the regular refraction.

According to Dr. Thomson, there are three distinct oxides of lead: the yellow; or *massicot*, which is at the first stage of oxidation, and contains 9 5 per cent. of oxigen; the red, which contains 12 per cent.; and the brown, which contains about 20. The last, which Scheele discovered, may be made by pouring dilute nitric acid on red lead, which dissolves part, and leaves the rest in the state of brown oxide: or by passing a current of oxigenized muriatic gas through water in which red lead is suspended. The ashes of lead, or dusky powder that first appears in its oxidation, consist of the yellow oxide and lead in powder: white lead is the yellow oxide combined with some acid, commonly the carbonic; and litharge is a subcarbonat of lead, consisting of about 93 parts yellow oxide, and 4 carbonic acid, with 3 of oxide of antimony.

Lead is not much altered by exposure to air or water, though the brightness of its surface, when cut or scraped, very soon goes off. It is probable that a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion.

Most of the acids attack lead. The sulphuric does not act upon it, unless it be concentrated and boiling. Sulphurous acid gas escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass remains, a small portion of which is soluble in water, and is the sulphat of lead: it affords crystals. The residue of the white mass is an insoluble sulphat of lead. Descotils says, that, if sulphat of lead be treated with pretty strong muriatic acid, it may be totally dissolved by heat, and on cooling crystals of muriat of lead will fall down, particularly if a little cold water be added. This muriat is soluble in water, and may be almost entirely decomposed again by sulphuric acid.

Nitric acid acts strongly on lead, and converts it into a white powder, if the acid be concentrated; but if it be more diluted, the powder is dissolved, and forms a nitrat of lead which is crystallizable, and does not afford a precipitate by cooling. It detonates on ignited coals. Lime and alkalis decompose the nitric solution of lead. The sulphuric acid added to this solution combines with the metallic oxide, and falls down. The muriatic acid in the same manner carries down the lead, and forms a combination called plumbum corneum, which is more soluble in water than the horn silver. When nitrat of lead has an excess of acid, its colour is yellow.

Muriatic acid acts directly on lead by heat, oxiding it and dissolving part of its oxide. The muriat of lead is crystallizable. If oxigenized muriatic acid gas be passed into a nitric solution of lead, small brilliant cubes of oxymuriat will be formed by slowly evaporating the liquor to two thirds, and cooling. These detonate violently when struck, if a small bit of phosphorus be added.

The acetous acid dissolves lead and its oxides; though probably the access of air may be necessary to the solution of the metal itself in this acid. *White lead*, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered, and exposed for a length of time to a gentle heat in a sand bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the oxigen which is present, corrodes the lead, and converts the external portion into a white substance which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly until they are corroded through. Ceruse is the only white used in oil paintings. Commonly it is adulterated with a mixture of chalk in the shops. It may be dissolved without difficulty in the acetous acid, and affords a crystallizable salt, called *sugar of lead* from its sweet taste. This, like all the preparations of lead, is a deadly poison. According to Dr. Bostock, the common sugar of lead is a superacetat; and the water of acetated litharge, or Goulard's extract, made by boiling litharge in vinegar, a neutral acetat, in which there is little more than half the quantity of acid to a given quantity of oxide. The power of the neutral salt, he adds, as a coagulator of mucus, is much superior. Thenard observes, that the neutral acetat is less soluble, less saccharine in its taste, crystallizes in laminæ, and is slightly efflorescent. If a bit of zinc be suspended by brass or iron wire, or a thread, in a mixture of water and the superacetat of lead, the lead will be revived, and form an arbor Saturni, as the zinc abstracts its oxigen.

Sulphurets precipitate lead from its solutions, the sulphur falling down in combination with the lead. Sulphuretted hidrogen does the same. Pure alkaline solutions dissolve a small portion of lead, and corrode a considerable quantity; the solution is said to give a black colour to the hair.

Oils dissolve the oxides of lead, and become thick and consistent; in which state they are used as the basis of plasters, cements for water works, paints, &c.

In the dry way, lead alone is oxided and vitrified. When fused with fixed alkaline salts, it is converted into a dark-coloured scoria, partly soluble in water. The neutral salts in general are not acted upon by lead. Nitre oxides this metal when treated with it, though scarcely any commotion or apparent flame is produced by its action. Sulphur readily dissolves it in the dry way, and produces a brittle compound, of a deep gray colour and brilliant appearance, which is much less fusible than lead itself; a property which is common to all the combinations of sulphur with the more fusible metals.

The phosphoric acid, exposed to heat together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not greatly differ from ordinary lead; it is malleable, and easily cut with a knife; but it loses its brilliancy more speedily than pure lead; and when fused upon charcoal with the blowpipe, the phosphorus burns, and leaves the lead behind.

Lead decomposes sal ammoniac by the assistance of heat; its oxides unite with the muriatic acid of that salt in the cold, and disengage its volatile alkali. When volatile alkali is obtained by distilling sal ammoniac with the oxides of lead, the residue consists of plumbum corneum.

Litharge fused with common salt decomposes it; the lead unites with the muriatic acid, and forms a yellow compound, at present used in this country as a pigment, for which an exclusive privilege has been granted. The alkali either floats at top, or is volatilized by the heat, if strongly urged. The same decomposition takes place in the humid way, if common salt be macerated with litharge; and the solution will contain caustic alkali.

Lead unites with most of the metals. Gold and silver are dissolved by it in a slight red heat. Both these metals are said to be rendered brittle by a small admixture of lead, though lead itself is rendered more ductile by a small quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is separated from the mercury by agitation, in the form of an impalpable black powder, oxigen being at the same time absorbed. The presence of oxigen is indispensably necessary in this process. Copper and lead do not unite but with a strong heat. If lead be heated so as to boil and smoke, it soon dissolves pieces of copper thrown into it; the mixture when cold is brittle. The union of these two metals is remarkably slight; for, upon exposing the mass to a heat no greater than that in which lead melts, the lead almost entirely runs off by itself. This process, which is peculiar to lead with copper, is called eliquation. The coarser sorts of lead, which owe their brittleness and granulated texture to an admixture of copper, throw it up to the surface on being melted by a small heat. Iron does not unite with lead, as long as both substances retain their metallic form. Tin unites very easily with this metal, and forms a compound, which is much more fusible than lead by itself, and is for this reason used as a solder for lead. Two parts of lead and one of tin form an alloy more fusible than either metal alone: this is the solder of the plumbers. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, will melt in a heat which is not sufficient to cause water to boil. Antimony forms a brittle alloy with lead. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion.

All the oxides of lead are very easily revived. Minium, when exposed to a strong heat, gives out part of the oxigen it absorbed during its oxidation; but, like the other oxides of this metal, it requires the addition of some combustible substance for its complete revival. A familiar instance of this revival is seen by exposing common red wafers to the flame of a candle. These wafers are coloured with minium, which is revived by the heat and the carbon of the wafer, so that it falls down in metallic globules.

Lead is found native, though seldom;
nd also in the form of an oxide called na-
ive ceruse, or lead ochre, or lead spar of
arious colours, red, brown, yellow, green,
lueish, and black. These ores, when
reed as much as possible from earthy mat-
er, may be dissolved in diluted nitric acid.
Oxide of iron is usually thrown down from
he solution by boiling. If the lead be then
recipitated by the subcarbonat of soda,
nd weighed, 132 grains of the dry preci-
itate will correspond with 100 grains of
ead in the metallic state. If the precipi-
ate be suspected to contain copper, it may
e separated by digesting in ammonia. If
be supposed to contain silver and copper,
he precipitate may again be dissolved in
itric acid, and separated by the addition
f muriatic acid; which, combining with
he metal, produces luna cornea, and plum-
um corneum; and the latter of these,
eing soluble in 30 times its weight of boil-
g water, may be washed off, while the
lver remains undissolved; or the silver, if
one in the precipitate, may be taken up
y ammonia, which will leave the oxide of
ad of the same value with regard to
eight as the foregoing. A native minium
as been found lately in Hesse by Mr.
nithson. Lead is also found mineralized
y the sulphuric and the phosphoric acids:
is last is generally of a greenish colour,
ising from a mixture of iron. When un-
ixed with iron it is sometimes brown,
metimes lemon-coloured, and more rarely
ayish white. The sulphat of lead is soluble in about 18 times its weight of water. One hundred and forty-three grains of the dried salt represent 100 grains of lead. The phosphoric lead ore may be dissolved in nitric acid by means of heat, except a few particles of iron, which remain at the bottom. By the addition of sulphuric acid, the lead is thrown down in the form of white flakes of sulphat, which when washed and dried discover the quantity of lead they contain, by the same allowance of 143 grains of the salt to 100 grains of metallic lead. The remaining solution being evaporated to dryness, affords phosphoric acid. The yellow lead ore of Carinthia consists of 2 parts of yellow oxide of lead, and rather more than one of oxide of molybdena. The red lead ore of Siberia has lately been found to be chromat of lead; and oxide of chrome is united with oxide of lead in a green ore.

Lead is abundantly found in combination with sulphur, in the form of heavy, shining, black, or blueish lead-coloured cubical masses, the corners of which are usually truncated; its texture is laminated, and its hardness variable. This is called galena, or potters lead ore. Most lead ores contain more or less of silver. When antimony enters into its composition, the texture is radiated or filamentous. There are also lead pyrites, which contain a considerable proportion of iron and sulphur.

If sulphuretted lead be boiled in nitric or muriatic acid of a moderate strength, the sulphur may be obtained pure, and collected in a filter. When iron or stony particles are contained among the undissolved part, the sulphur may be separated by digestion in a solution of caustic fixed alkali, which converts it into a sulphuret, and leaves the other insoluble matters behind. If the first solution be made with nitric acid, it may contain silver and lead, which, after the precipitation by mild mineral alkali, may be separated by the volatile alkali, as mentioned in the humid analysis of the calciform ores: when the muriatic acid is used for the solution of the ore, a large quantity of plumbum corneum separates, for want of a sufficient quantity of water to dissolve it. This requisite quantity of water must be added to dissolve the salt, before the precipitate is made by the fixed alkali.

All the ores of lead, except the phosphoric, are reducible to the metallic state, by dissipating their volatile contents by the blowpipe on a piece of charcoal. In the large way, they are revived by fusion with charcoal.

The ores of this metal are abundantly found in the mine counties of England, and in various other parts of the globe. Its uses are numerous, and scarcely need be mentioned. Its oxides have been already mentioned as of great use, as pigments, and in the manufacture of glass. Lead is cast into thin sheets for covering buildings, making water-pipes, and various other uses; and this is rolled between two cylinders of iron, to give it the requisite uniformity and thinness. Lead is thought, and with some reason, to be not perfectly innocent even for water pipes, and much less for any other kind of vessels. The workmen in any of the preparations of lead are generally subject to a peculiar colic, and paralytic disorders; which most probably arise from the internal use of the metal: for it is a fact, that these workmen are not sufficiently cautious in washing their hands, or removing such particles of lead, or its preparations, as may casually intermix with their food.

Leather. The skins of animals prepared by maceration in lime-water, and afterward with astringent substances. See Tanning.

Leaves of Plants. Lewis found that the green colour of the leaves of plants is extracted by alcohol, and by oils. The spirituous tinctures are generally of a fine deep green, even when the leaves are dull coloured, yellowish, or hoary. These colours are seldom lasting in the liquor. Alkalis heighten both the tinctures and the green juices. Acids weaken, destroy, and change it to a brownish. Lime-water improves both the colour and durability. By means of lime, not inelegant green lakes are procurable from the leaves of acanthus, lily of the valley, and several other plants.

Few plants communicate any part of their green colour to water, and perhaps none that give a green of any considerable intensity. It is said, however, that the leaves of some plants give a green dye to woollen, without the addition of any other colouring matter; particularly those of the wild chervil, or cow-weed, the common rag-wort and devil's bit. Lewis gives the process from Linnæus as practised by the peasants in Sweden with the last. It consists in boiling the leaves with their woollen yarn for a short time, and leaving the whole together for a night, after which the yarn is taken out, hung in the steam of the liquid, and again made to boil over the fire. It is then wrung, the leaves are taken out of the liquor, a little fresh water added, and the wool frequently dipped therein till sufficiently dyed.

Many kinds of leaves afford a yellow dye to woollens previously boiled with alum and tartar, weld in particular, which see. Indigo and woad afford blue. Lewis tried, without success, to obtain blues by macerating the leaves of other plants in water.

Lees, (Soap). See Potash. Also Soap.

Lemnian Earth, See Earth, (Fullers.)

Lemons. See Acid, (Citric).

Lepidolite. A stone first brought into notice by the name of *lilalite*, and considered as a species of gypsum, and afterward classed as a zeolite by Born. It is of a violet colour, or purple, in the mass, separable into laminæ, which have the lustre of mother of pearl. It is capable of some polish, though soft enough to be scratched with the nail. Spec. grav. 2·816. It fuses into a dense white glass. Analysed by Klaproth, 100 parts gave silex 54·5, alumine 38·25, potash 4, oxides of manganese and iron 0·75.—*Klaproth's Analyses.*

Leucite. A fossil often occurring in the lavas and other mingled masses of rocks in Italy, remarkable for its determinate specific fissure, which consists of low double octahedral pyramids, flatly sharpened off to four terminating surfaces, so as to form a roundish crystal bounded by 24 trapeziums. It has been called white garnet, vesuvian garnet, and garnet-shaped schorl. Mr. Klaproth analysed several, most of them of the size of a nutmeg or upward, and of the spec. grav. of 2·455. They gave silex 53·75, alumine 24·63, potash 21·35. This was the first stone in which potash was discovered. —*Klaproth's Analyses.*

Levigation. The mechanical process of grinding the parts of bodies to a fine paste, by rubbing the flat face of a stone called the muller upon a table or slab called the stone. Some fluid is always added in this process. The advantage of levigation with a stone and muller, beyond that of triturating in a mortar, is, that the materials can more easily be scraped together, and subjected to the action of the muller, than in the other case to that of the pestle; and, from the flatness of the two surfaces, they cannot elude the pressure.

Lichen, Liverwort. Several species of this genus are useful in the arts, particularly dyeing, or as food or medicine. Under the word Archil we have already noticed one. To wool, previously prepared with a bath of lycopodium complanatum, l. clavatum, or l. alpinum, the lichen Westringii is said to give a fine orange, superior to that of annotta. The lichen cinereus does the same. The chlorinus gives a bright yellow, and the vulpinus a lemon colour. Brasil gives to wool thus dyed with the l. Westringii a very deep blue black; to that with the chlorinus a fine green black, or raven's wing colour; and to that with the vulpinus a blueish green. The lichen parellus, from which archil has been said by some to be prepared, affords only a blue, which is so fugitive as to be useless.

Lord Dundonald has lately taken out a patent for the use of lichen as a substitute for gum. Lichens that grow on trees and shrubs afford this gum, and apparently different species of them. The lichen is scalded two or three times with boiling water, to remove the outer skin and resinous matter, washed in cold water, and then left ten or twelve hours on a stone or brick floor; after which the gum is extracted by boiling some hours in water, with about half or three quarters of an ounce of alkali to each pound of lichen. According to the report, 1lb. of dry lichen will do as much work in calico-printing as 1¾lb. of gum Senegal; and the difference of price makes a saving of 45*l.* on each table or press in war time, and half that in peace.

The lichen islandicus has been much recommended in consumptions. It is certainly nutritious, and according to prof. Proust, after its bitter principle is extracted by cold or hot water, a quarter of an hour's boiling makes it a very agreeable vegetable for the table. If after this boiling it be dried, it will keep any length of time, and may be made fit for the table instantly by pouring boiling water on it; or even by steeping in cold water, either fresh or salt. Its decoction in milk or whey makes a very nutritious jelly. It consists of 64 parts fleshy or pulpy substance, 3 bitter matter, and 33 gummy matter soluble in hot water but not in cold.—*Bullet. des Sciences.—Phil. Mag.—Journ. de Phys.*

Light. Philosophers are not agreed as to the independent existence of light, or the cause by which we see; that is to say, whether light be a body, or a property. If light be a body, it must consist of particles of extreme minuteness, projected with a very great degree of velocity from luminous bodies; if on the other hand light be nohing more than a modification or property, t must subsist in some other matter universally diffused through every part of known space. The philosophers who mainain this last opinion consider the universe o be occupied by a fluid of extreme rarity and elasticity, permeating all bodies; the undulations of which, transmitted in all diections from the luminous body, or exiting cause, produce the sensation and other effects of light. Though much ingenious reasoning has been employed on his subject, we have not obtained possession of any decisive facts; but each hypothesis may without inconsistency be applied to very natural appearance hitherto observed. t is difficult, however, to speak of these acts, without considering light accordiug o one or the other of these suppositions. This is not the place for discussing their espective merits. I shall therefore assume he hypothesis, which admits of the independent existence of light, not only because t is more generally admitted and known, ut because it appears best calculated to xplain some of the appearances, more esecially the various refrangibility of the ays of light.

It is observed, that whenever light passes hrough a space occupied by a medium of niform density, it describes a right line. These lines, or rather prisms, are called the ays of light. They rebound, or are reected by bodies against which they strike, t is sufficiently ascertained, that this reflecion is caused by a repulsive power in the ody itself, exerted at a considerable ditance; so that the light is driven back without coming into contact with the matter which repels it. When light is made to pass near a body in such a direction, or under such circumstances, as that it may come nearer the limit of repulsion, it is attracted, and alters its course by deviating towards the attracting body. If the body possess a very narrow surface, such for example as the edge of a knife, this deviation in the ray of light may be measured by attending to the course of the ray after it has passed the body. But if the surface be broader, the attractive power usually causes the light to pass into the body, where it is absorbed and lost, if the body be opaque, or passes through, if the body be transparent. The change produced in the course of a ray of light, by the attraction of a body into which the light does not enter, is called inflection; but when the light does enter the body, this change is called refraction. It is found, that the light of the sun from which we derive the sensation of whiteness is composed of an admixture of rays possessing the property of exciting sensations of every possible colour, each according to its respective nature. The attractive and repulsive powers of bodies differ in their intensities with regard to these several rays, and accordingly they are separated from each other by reflection, refraction, or inflection. A like separation is also made in the rays of light by the thickness or distance between the two surfaces of the medium through which they pass. It is more particularly observable in thin plates of glass, or water blown into bubbles, and the like. The colours of bodies depend on a power possessed by them of reflecting some of the rays of light, and absorbing others, and this power in all probability depends upon the principles here sketched out.

The velocity of light is so extremely great, that in all common experiments it appears to be instantaneous. Astronomers have nevertheless found, that its progress across the regions occupied by the solar system requires so much time, that in computing the eclipses of Jupiter's moons they are under the necessity of making an allowance for the greater or less distance of that planet, which occasions the time of any eclipse to be later when seen from a greater distance than from a less. Other observations upon the fixed stars show, that there is a sensible proportion between the velocity of light, and that of the earth in its annual orbit. From these acute investigations it is deduced, that light passes from the sun to the earth in little more than eight minutes, which gives a velocity of about 167000 geographical miles in one second.

Optical writers may be consulted for a great number of curious and useful deductions made from these principles, and applied to the doctrine of vision, the nature of colours, the construction of mirrors, telescopes, and other instruments, not immediately within the province of chemistry.

Light comes to our eyes under five different circumstances. 1. It is emitted from bodies in a rapid state of combustion: or, 2. from other bodies at an elevated temperature, which are then said to be ignited. 3. It also comes to us by reflection; or 4, refraction: and 5, there are very few bodies which being exposed to a strong light, and afterward taken into the dark, do not remain luminous for a considerable time. Hence it seems, that we experimentally know of no other source of light, than combustion; and from this fact it is, that many writers have considered fire, heat, and light, to be the same thing. But these objects differ in various remarkable particulars. The heat of a fire is by no means proportional to the light it gives. The light will pass through transparent bodies swiftly, and without impediment, but the heat remains attached to the body, and is not transmitted in any other way, than it would have passed through an opaque substance, viz. by raising the temperature of the body itself. Heat, with access of oxigen, causes bodies to be burned, and to lose their combustible property. Light in many instances produces a contrary effect. The effect of light in chemical experiments is so considerable, that the operator ought to be constantly aware of the influence it may have upon his products. It appears to be particularly active in disengaging oxigen from its combinations; but whether by uniting with the air, or otherwise, has not been explained. Every chemist knows that pure pale nitric acid cannot be preserved but in bottles quite full, or in the dark. For the light expels oxigen from the acid, if there be any space into which it can escape, and leaves the residue yellow and fuming, in consequence of the redundant portion of the basis of the acid. Mere heat is so far from effecting this, that it restores the purity of the acid by expelling the redundancy. So likewise the black oxide of manganese, which contains nitrogen and oxigen, emits the former at a low heat, but does not give out the latter until light is present by the ignition of the vessels. Light appears to be the great agent in the production of combustible matter on the surface of the globe. It extricates oxigen from the leaves and other parts of vegetables, most probably by decomposing their aqueous part, and leaves the combustible matter, or hidrogen, which enters into the composition of mucilages, oils, and resins, the most inflammable of which are the products of such climates as possess the greatest intensity of solar light. The consequences of a want of light in vegetation are remarkably shown in the properties and chemical products of plants of the same kind, reared in the open day, or in the dark. The tendency of plants growing in a room, which turn themselves toward the aperture that admits the light, or even toward the thinnest side of a wooden box wherein they are included, is a striking effect, and has been ascribed to a degree of sensibility in these organized beings. But the evaporation of camphor and of water, the vegetation and crystallization of salts, and of metallic substances, which are considerably modified by light, and incline themselves toward the place of its emission, seem to be instances of the same kind. The metallic oxides, and the salts produced by the oxigenized muriatic acid, undergo a change by the action of light, rendering them nearer the state of combustibility than before.

Various experiments have been made by Dr. Herschel, Sir H. C. Englefield, Dr. Wollaston, and Mr. Ritter of Jena, on the heating and chemical effects of light, when separated by the prism into the several coloured rays. It appears from these, that the heat is totally independent of the rays; and that the effect produced on the thermometer varies from one extremity of the spectrum to the other, that of the red being greatest, and so on diminishing in degree to the other extremity of the spectrum, though not in any regular ratio; so that the calorific rays, like the luminous, are separable by the prism into rays of different intensity. In these experiments it was observable, that the greatest heat was produced so far beyond the red as to be quite out of visible light. On the contrary, the disoxigenating effects of light appear to follow the opposite order. Thus the white muriat of silver is blackened most, just beyond the confines of the violet ray; and if previously a little blackened, according to Ritter, the whiteness is partly restored beyond the confine of the red ray: phosphorus too is kindled in the vicinity of the red ray, and extinguished in the vicinity of the violet. Guaiacum is rendered green in the red rays, and its yellow is restored in the violet; this Dr. Wollaston considers as a proof, that the effect of the invisible rays on the violet side is improperly termed disoxidating. Thus it appears, that the solar light consists of three different orders of rays, one producing colour, a second producing heat, and a third chemical effects the reverse of those occasioned by heat: and that the action of the last two differs in its intensity in proportion to the refraction it undergoes, but in an opposite order. Mr. Ritter is said to have separated the rays of the third order completely from those that produce colour.

Whence comes the light afforded by ignited bodies; whether it have been previously imbibed by them; whether the commencement of ignition be distinctive of the same temperature in all bodies; whether the great planetary sources of light be bodies in a state of combustion, or merely luminous upon principles very different from

y which our experiments can point out;
hether the momentum of the particles
light, or their disposition for chemical
ombination, be the most effectual in the
hanges produced by its agency;—these, and
umerous other interesting questions, must
e left for future research and investiga-
on.

The production of light by inflammation
an object of great importance to society
large, as well as to the chemist. It ap-
ears to arise immediately from the strong
nition of a body while rapidly decom-
osing. Most solid bodies in combustion
e kept, partly from a want of the access
air, and partly from the vicinity of con-
ucting bodies, at a low degree of ignition.
ut when vapours rapidly escape into the
r, it may, and does frequently happen,
at the combustion, instead of being car-
ed on merely at the surface of the mass,
enetrates to a considerable depth within,
nd from this, as well as from the imper-
ct conducting power of the surrounding
r, a white heat, or very strong ignition, is
roduced. The effect of lamps and can-
es depends upon these considerations. A
ombustible fluid, most commonly of the
ature of fat oil, is put in a situation to be
osorbed between the filaments of cotton,
nen, fine wire, or asbestos. The extremity
this fibrous substance, called the wick, is
en considerably heated. The oil evapo-
tes, and its vapour takes fire. In this si-
ation the wick, being enveloped with
ame, is kept at such a temperature, that
e oil continually boils, is evaporated,
urns, and by these means keeps up a con-
ant flame. Much of the perfection of
is experiment depends on the nature,
uantities, and figure of the materials made
e of. If the wick be too large, it will sup-
y a greater quantity of the fluid than can
e well decomposed. Its evaporation will
erefore diminish the temperature, and
onsequently the light, and afford a fuligi-
ous column, which will pass through the
entre of the flame, and fly off in the form
smoke. The magnitude of the wick may,
om time to time, in candles, be reduced, as
length, by snuffing; but this operation
ill not remedy the evils, which arise from
o great a diameter. If the oil be not suf-
ciently combustible, the ignition will be
ut moderate, and the flame yellow; and
e same effect will be produced, if the air
e not sufficiently pure and abundant. An
xperiment to this effect may be made by
cluding the flame of a small candle or
mp in a glass tube of about one inch in
ameter, standing on the surface of a ta-
e. The air which passes between the
ass and the table, will be sufficient to
aintain a very bright flame; but if a me-
llic covering, perforated with a hole of
oout a quarter of an inch diameter, be laid
oon the upper orifice of the tube, the com-
ustion will be so far impeded, that the
flame will be perceptibly yellower. The hole may then be more or less closed at pleasure by sliding a small piece of metal, for example a shilling, over it. The consequence will be, that the flame will become more and more yellow, will at length emit smoke, and if the hole be entirely closed, extinction will follow.

The smell arising from the volatile parts, which pass off not well consumed from a lamp or candle, must be different according to the nature of those parts. This depends chiefly on the oil, but in some measure upon the wick. When a candle with a cotton wick is blown out, the smell is considerably more offensive, than if the wick be of linen, or of rush; but less offensive than if the supply of the combustion had been oil. Whenever a candle or lamp is removed, the combustion is in some measure impeded by the stream of cold air, against which it strikes. Smoke is accordingly emitted from its anterior side, and the peculiar smell is perceived. From this imperfection, lamps are much less adapted to be carried from place to place than candles.

From the necessity of the access of air, there will be more light produced from a lamp with a number of small wicks, than with one large one, or from a number of small candles, than the same quantity of tallow used to make a single large one. In the lamp of Argand, the wick consists of a web of cloth in the form of a pipe or tube, the longitudinal fibres of which are thicker than the circular ones. This is passed by a suitable contrivance into a cylindrical cavity, which contains the oil; and there are other precautions in the construction of the apparatus, by which the oil is regularly supplied, the access of air is duly permitted, as well within as without the circle formed by the upper edge of this cylindrical wick, and this edge can be raised or lowered at pleasure. Hence the possessor has it in his power to regulate the surface of the wick, so that the greatest flame consistent with perfect combustion may be produced; and the steadiness of the flame is secured by a glass shade or tube, which surrounds it, and in a certain degree accelerates the current of air.

In the illumination by candles, where the fused matter is contained in a cup or cavity of the matter not yet fused, it is of some consequence, whether the substance be fusible at a high or low temperature. The difference between wax and tallow candles arises from this property. Wax being less fusible will admit of a thinner wick, and needs no snuffing; but in a tallow candle it is absolutely necessary to have a large wick, capable of taking up the tallow as it melts.

The difference of effect in illumination between a thick and a thin wick cannot be better shown, than by remarking the appearances produced by both. When a candle with a thick wick is first lighted, and the wick snuffed short, the flame is perfect and luminous, unless its diameter be very great; in which last case, there is an opake part in the middle, where the combustion is impeded for want of air. As the wick becomes longer, the space between its upper extremity and the apex of the flame is diminished; and consequently the oil, which issues from that extremity, having a less space of ignition to pass through, is less completely burned, and passes off partly in smoke. This evil continues to increase, until at length the upper extremity of the wick projects beyond the flame, and forms a support for an accumulation of soot, which is afforded by the imperfect combustion. A candle in this situation affords scarcely one tenth of the light, which the due combustion of its materials would produce; and tallow candles, on this account, require continual snuffing. But on the contrary, if we consider the wax-candle, we find, that as its wick lengthens, the light indeed becomes less, and the cup becomes filled with melted wax. The wick however, being thin and flexible, does not long occupy its place in the centre of the flame; neither does it, when there, enlarge the diameter of the flame, so as to prevent the access of air to its internal part. When its length is too great for the vertical position, it bends on one side; and its extremity, coming into contact with the air, is burned to ashes, excepting such a portion as is defended by the continual afflux of melted wax, which is volatilized and completely burned by the surrounding flame. We see therefore, that the difficult fusibility of wax renders it practicable to burn a large quantity of fluid by means of a small wick; and that this small wick, by turning on one side in consequence of its flexibility, performs the operation of snuffing upon itself, in a much more accurate manner than it can ever be performed mechanically. Mr. Walker has suggested an ingenious contrivance to effect this in tallow candles. It consists in placing the candle in such a position, as to be inclined in an angle of about 30° from the perpendicular; by which means the wick will come out at the side of the flame when it is long enough to require snuffing, and there burn to ashes. The light thus produced remaining nearly equable at all times, must be less injurious to the eye.

Mr. Henry made some experiments on the light afforded by the combustion of different gasses, and found, that it was apparently in the ratio of the oxigen that entered into combination with the hidrogen they contained. Thus 100 parts of pure hidrogen gas required from 50 to 54 of oxigen: 100 of gas from oak 42: from moist charcoal, and from dried peat, each 50: from lamp oil 136: from coal 140: from wax 166: pure olifiant gas 210. Tallow is nearly on a par with oil. The production of light from the first four was so trifling, that they did not appear applicable to economical purposes.—*Phil. Trans.*—*Journ. de Phys.*—*Journ. of the Roy. Ins.*—*Nick. Journ.*

Lime. See Earths; also Cement.

Linen Fossil. The fibrous amianthus. See Asbestos.

Linseed. See Oil.

Liquefaction. A chemical term not much used. In some instances it is synonymous with the word fusion, in others with the word deliquescence, and in others again with the word solution. It may easily be imagined, therefore, that accurate writers will use these terms respectively, because more definite.

Liquid Amber. A resinous juice, which flows from a large tree (Liquidambar styraciflua Lin.) growing in Virginia, Mexico, and other provinces in America. This juice is at first about the consistence of turpentine, but by long keeping hardens into a resin: it is of a yellow colour inclining to red, of a warm taste, and a fragrant smell, not unlike that of storax heightened with a little ambergris. It was formerly of great use as a perfume, but is at present a stranger to the shops.

Liquor of Flints. The preparation of this liquor consists in uniting, by fusion, powdered flints or sand with a sufficient quantity of fixed alkali, so that a compound results from it, in which the properties of the alkali prevail, and particularly a total solubility in water. For this purpose, one part of ground flints or sand is to be well mixed with three or four parts of fixed alkali. The mixture is to be put into a crucible, which ought to be very large, in proportion to the quantity of matter. The crucible is then to be placed in a forge or good melting furnace, and gradually heated. When this mixture has acquired a certain heat, a considerable boiling and swelling are observable, occasioned by the action of these two matters upon each other. To prevent the matter in this state from flowing over the crucible, this ought to be large, and the fire gradually raised. A part only of the mixture may be put into the crucible at once; and when its effervescence is over, the rest may be added at different times, taking care that each portion to be added be previously heated, to prevent explosion from any moisture which it might contain, when mixed with red-hot melted matter. When the effervescence of all the mixture is over, it is to be kept in a good fusion during a quarter of an hour, and is then to be poured upon a greased stone or plate of iron. The matter when cold is brittle, and seems vitrified. It is even transparent like glass, when the quantity of alkali is only double or nearly double the quantity of flints. It quickly and strongly attracts moisture from the air, and is entirely soluble in water, except a very small portion of earthy matter. But a similar earth is also separated from considerably pure fixed alkali, during its solution in water.

The filtrated solution is at first clear, and limpid; but it afterward becomes turbid, and forms an earthy sediment, like that formed by solutions of fixed alkali, only the former seems more copious. This liquor has all the properties of liquid fixed alkali. All these properties of alkaline salts, and particularly its total solubility in water, are caused by the quantity of fixed alkali which enters into this kind of vitrified matter. As compound bodies partake always of the properties of their component principles, and as the properties of the principle which predominates in the composition of any body do also predominate in that body, we may perceive why the properties of the fixed alkali in the present combination should be more sensible than those of the earthy matter, or flints. The alkali communicates to the earthy matter some of its strong disposition to unite with water. The flints are really kept dissolved in water, and by this experiment they are consequently reduced into a liquor, and hence it has been called the liquor of flints. If any acid be added to the liquor of flints, so as to saturate the alkali, the flint which was kept dissolved in water by means of this alkali will be now precipitated in the state of a fine earth. Macquer mentions a singular fact from Pott, that the earthy precipitate will be entirely taken up, if a redundancy of acid be added: but this is contrary to the results of experiment by Bergman, Klaproth, and other eminent chemists; though an inquiry into the cause that seems to have misled Pott, Baumé, and others, certainly deserves to be investigated. The liquor has been said to increase the quantity of gold precipitated by it from solution.

Glasses which contain too much alkaline salt in their composition, or which have not sustained a fire long or strong enough to unite the earth intimately with the fixed alkali, are partly soluble in acids, have sometimes even an alkaline taste, tarnish, and moisten in the air.

Liquor of Libavius. See Tin.

Liquorice. The saccharine extract from liquorice is prepared by strong decoction in water. It is prepared in the large way in Spain and some parts of Germany. That of our own growth is considered by some as superior. It is chiefly cultivated near Pontefract, in Yorkshire; and its extract is met with in the shops under the name of Pomfret cakes. The black colour arises from coal produced by the empyreuma toward the end of the process. Neumann found, that of one ounce of the Spanish extract water dissolved seven drachms two scruples, leaving a residue from which spirit extracted nothing. Alcohol, first applied, dissolved four drachms two scruples out of an ounce, which consisted of nearly the whole of the sugar; for though water took up three drachms of the remainder, it was nearly tasteless.

Lithanthrax. Pit coal, or stone coal: a black, solid, compact, brittle, inflammable substance, of a moderate hardness, laminated texture, more or less shining, but in few specimens capable of a good polish. See Coal.

Litharge. A subcarbonate of lead in an imperfect state of vitrification. When silver is refined by cupellation with lead, this latter metal, which is scorified, and causes the scorification of the imperfect metals alloyed with the silver, is transformed into a matter composed of small semitransparent shining plates, resembling mica; which is litharge. Litharge is more or less white or red, according to the metals with which the silver was alloyed. The white is called litharge of silver, and the red has been improperly called litharge of gold.

Litharge may be easily revided into lead; accordingly much of that which is produced by refining in the large way is reduced, by being melted upon burning coals. The part of it which is least altered by mixture with other metals is thus reduced, and by this method good and saleable lead is obtained. The rest of the litharge of these refineries is sold and used for various purposes. Potters use much of it for glazing their ware. It is employed for the preparation of some plasters, and other external remedies; and also in painting, to render linseed oil drying. Lastly, it is added in the composition of some glasses, for it is very fusible, and assists the fusion of other substances. It has in general the same properties as the other oxides of lead. All the litharge which is commonly sold comes from refineries. The quantity formed there is more than sufficient for the demand. See Lead.

Lithology. The systematical arrangement of stones.

Lithomarga. See Earth, (Fullers).

Litmus. See Archil.

Liver of Antimony. See Antimony.

Liver of Arsenic. See Arsenic.

Liver of Sulphur. See Sulphurets.

Liver Stone. See Lapis Hepaticus.

Lixivial. Those salts are called lixivial, which have been extracted by lixiviation, and these chiefly are fixed alkalis; which are therefore called lixivial salts.

Lixiviation. The application of water to the fixed residues of bodies, for the purpose of extracting the saline part.

Lixivium. A solution of residual salts, obtained by lixiviation.

Loadstone. An iron ore, the constitution of which has not yet been properly examined. It is of a dark or black lead colour, generally of considerable hardness, weight, and closeness of texture. It is supposed to contain much iron in the metallic state, or nearly so. It attracts iron or steel filings, by which criterion it is easily known.

Loam. A natural mixture of clay and sand. The coloured clays and loams participate of iron; hence many of these melt in a strong fire, without any addition: both clay itself, and mixtures of it with crystalline earths, being brought into fusion by ferruginous oxides, though the fusible mixtures of clay and calcareous earths are by the same ingredient prevented from melting. The bricks made from some loams, particularly the Windsor, are, when moderately burnt, remarkably free, so as to be easily rubbed smooth, cut, sawed, grooved, &c. Hence their use in building furnaces, &c. They bear a considerably strong fire, but have been frequently melted in a vehement one.

Lodestone. A name given by the Cornish miners to stones likewise called tinstone. They consist chiefly of stones or sand of different kinds, through which oxide of tin is invisibly disseminated. They are heavy, and of various colours, but blue, gray, black, and brown are the commonest.

Logwood. India, Jamaica*, or Campeachy wood has received those names from the places where it grows most plentifully. It is very common at Jamaica, and on the eastern shore of the bay of Campeachy; and is found also at St. Croix, Martinico, and Granada.

The tree is called by Linnæus Hæmatoxylum campechianum. It grows very high and large in a good soil: the bark is thin, smooth, and of a bright gray, or sometimes yellowish: the trunk is straight and prickly: the leaves somewhat resemble those of the bay-tree in appearance, and also in their aromatic qualities, whence the tree has been called aromatic bay, or Indian bay: its seeds have been improperly called clove seeds, from their flavour, and in England are known by the name of Jamaica pepper, or all-spice.

Logwood is so heavy as to sink in water, hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black.

For use, its juice as it is commonly called may be extracted by decoction with water. It yields its colour both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dyes is a fine red, inclining a little to violet or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow: alkalis deepen its colour, and give it a purple or violet hue. Sulphuric, nitric, and muriatic acids produce in it a small quantity of a precipitate, which is some time in separating, and its colour, with the sulphuric acid, is a dark red; with the nitric, feuillemort; with the muriatic, a lighter red. The supernatant liquor is transparent, of a deep red colour with the sulphuric and muriatic acids, and yellowish with the nitric. The oxalic acid forms a light marron precipitate; the liquor remaining transparent, and of a yellowish red. The acetous acid acts nearly in the same manner, except that the colour of the precipitate is a little deeper. Tartar gives the same precipitate as vinegar, but the liquor remains turbid, and more inclined to yellow. Fixed alkali occasions no precipitate, but changes the decoction to a deep violet, which afterward becomes nearly brown. Alum produces a pretty copious precipitate, of a lightish violet colour; the liquor remaining violet, and nearly transparent. Alum and tartar occasion a dark red precipitate in tolerable quantity; the liquor remaining transparent, and of a yellowish red. Sulphat of iron gives it instantly a blueish black colour, like that of ink; a pretty copious precipitate of the same colour is produced, and the liquor remains turbid a long while; but if it be sufficiently diluted, and especially if there be a small excess of the sulphat, all the black matter is at length deposited. Sulphat of copper produces a very copious precipitate, of a browner and less bright black than the preceding: the liquor remains transparent, and of a very deep brownish or yellowish red. Sugar of lead instantly occasions a black precipitate, with a slight reddish tinge; the liquor remaining transparent, and of the colour of very pale beer. Lastly, tin dissolved in aqua regia forms immediately a precipitate of a very fine violet or purple, almost prune de Monsieur: the supernatant liquor is very clear, and perfectly colourless.

Stuffs would take only a slight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet.

A blue colour may be obtained from logwood, by mixing verdegris with the bath, and dipping the cloth till it has acquired the proper shade.

The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast, and for grays of certain shades. It is also of very extensive use for different compound colours, which it would be diffi-

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* In England, the name of Jamaica wood is commonly applied to the better species of mahogany, the inferior kind being brought from Honduras.—*Hamilton.*

cult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye.

Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired.

Logwood is used for dyeing silk violet. For this the silk must be scoured, alumed, and washed; because without aluming it would take only a reddish tinge, that would not stand wetting. To dye silk thus, it must be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven.

Bergman has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions, a great number of fine shades, more or less inclined to red, from lilac to violet.

If decoction of logwood be substituted for that of brasil in the process communicated by Mr. Brown, a fine violet colour will be obtained; and if the two be mixed, we shall have shades of puce colour, and prune de Monsieur, more or less inclining to red. See Brazil Wood.

The remarks made on brasil are also applicable to logwood, the colouring matter of which exhibits similar properties.—*Berthollet.*

Lorication. The same with Coating, which see.

Ludus Helmontii. An indurated marle, composed of various pieces of a whitish brown colour, separated into a great number of polygonous compartments, the boundaries of which are formed of matter of a lighter colour than the rest. According to Bomare, the ludus stellatus Helmontii, found in the county of Kent, is covered with a kind of striated selenite, resembling the zeolite. It is for the most part of a globose figure, seldom flat, but often convex on the outside. And sometimes with a concave surface.

Lumachella. A conglutinated, calcareous stone, composed of shells and coral, united together by a cement of the same nature. When they have many colours, they are called marbles, and employed as such. In the island of Gottland there is found one of this kind of one colour only, which on that account is not called marble.

Luna. The alchymist's term for silver.

Luna Cornea. Muriat of silver. See Silver.

Lunar Caustic. Nitrat of silver, fused in a low heat. See Silver.

Lute. In many chemical operations, the vessels must be covered with something to preserve them from the violence of the fire, from being broken or melted, and also to close exactly their joinings to each other, to retain the substances which they contain, when they are volatile and reduced to vapour. For this purpose several matters are employed, called in general lutes.

The lutes with which glass and earthen ware retorts are covered ought to be composed of nearly equal parts of coarse sand and refractory clay. These matters are to be well mixed with water, and a little hair, or cut tow, so as to form a liquid paste, with which the vessels are to be covered, layer upon layer, till it is of the required thickness. See Coating.

The sand mixed with the clay is necessary in this lute, to prevent the cracks which are occasioned by the contracting of clay during its drying, which it always does when it is pure. The hair serves also to bind the parts of the lute, and to keep it applied to the vessel: for, notwithstanding the sand which is introduced into it, some cracks are always formed, which would occasion pieces of it to fall off. This lute is applicable to the junctures of vessels requiring much heat, but it must be quite dry before they are used.

Mr. Willis has recommended as a coating for earthen retorts a solution of borax in 8 parts of boiling water brought to the thickness of cream with slaked lime; which when dry is to be covered with a thin paste of slaked lime and linseed oil.

The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels.

When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flower-paste. In such cases also slips of wet bladder are very conveniently used.

Almond powder, mixed with water or mucilage to the consistence of a stiff paste, makes a good lute.

When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quick-lime slaked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm. The whites of eggs with their yolks, and about half their weight of powdered chalk, or lime, thoroughly slaked in the air, applied in this manner, is sufficient, according to prof. Paysse for the oxigenized muriatic acid. Of this lute vessels may be formed hard enough to bear polishing on the wheel.

Gluten and lime make a strong lute.

Lastly, when saline, acid, and corrosive vapours are to be contained, we must then have recourse to the lute called fat lute.

This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with pack-thread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone.

Fine porcelain clay, mixed with a solution of borax, is well adapted to iron vessels, the part received into an aperture being smeared with it.

LYCOPODIUM. The fine dust of lycopodium, or clubmoss, is called by some, on account of its great inflammability, vegetable sulphur. The dust is properly the seeds of the plant. There are sundry other vegetables, as polypodies, ferns, coniferous trees, &c., the seeds of which are like a yellow, impalpable farina, so subtle as to be blown away by the least motion of air: it is this dust which has given rise to some reports of showers of brimstone.

The dust of lycopodium, diffused or strewed in the air, takes fire from a candle, and burns off like a flash of lightning. It is used in the London theatres. A quantity laid together upon burning coals does not flame, but smokes away with a fetid smell: burned in a red-hot crucible, it leaves a very small proportion of a light cobweb-like matter. It does not, as some report, take fire from flint and steel, nor explode like gunpowder; nor does it seem to detonate more violently with nitre than other inflammable matters do. Olearius relates, that the Russians employ much of it in fire-works, but does not inform us in what manner.

There is a curious experiment of taking a shilling from the bottom of a vessel of water without wetting the hand. It is said to be done by strewing a small quantity of the dust of lycopodium on the surface of the water, which it so strongly repels, as to form a covering for the hand, and defend it from the contact of the water. If a handkerchief be strewed over with this dust, water may be tied up in it.

Neumann examined this substance. It appears to contain a resinous matter, and an oily one of the expressible kind, intimately combined together, so as to be both extracted, at least in part, by alcohol: on inspissating the tincture, the oil separated, remained permanently fluid, and would not unite again even with the resinous extract: it is remarkable, that alcohol would no longer touch this resin any more than the oil. The quantity thus extracted from an ounce of the powder amounted only to a drachm: water did not take up near so much; it was with great difficulty he obtained by water eight grains of extract from an ounce. Both the water and spirit arose in distillation unchanged.

By destructive distillation in an open fire, he gained a large proportion of empyreumatic oil, no less than two ounces and a half from four: this was preceded, not by an acid liquor, which most vegetables yield on the same treatment, but by an alkaline one: the black coal remaining in the bottom of the distilling vessel weighed five drachms.

Some of the species of lycopodium are good dyes. Wool or silk boiled in a decoction of the l. complanatum, or l. clavatum, and then immersed in a weak infusion of brasil, acquires a good and very fast blue. All acids however redden it; but the colour is again restored by alkalis. By increasing the quantity of brasil the colour may be brought to a puce. The l. annotinum treated in the same way produces grays; as do the l. selago, and selaginoides, more or less inclining to blue or violet.

All the species appear to be good mordants. The bark of the young shoots of plumtrees affords by their means a fine carmelite, and that of the populus dilatata a permanent yellow. See also LICHEN.

M.

MACE, one of the exterior coverings of the nutmeg, is at first of a purplish red colour, which changes before it arrives among us to an orange yellow, and by long keeping grows paler and paler. Mace is a warm aromatic, like the nutmeg, accompanied with a degree of bitterishness; and like that spice also contains both an essential and expressible oil.

From sixteen ounces of mace, Neumann obtained with alcohol four ounces and a half of extract, which retained some of the expressible, and the more ponderous part of the essential oil, the lighter arising towards the end of the inspissation, and impregnating the distilled spirit: from the residuum were obtained two ounces and a half of gummy extract, with five drachms f essential oil, which arose during the In- pissation, and sunk to the bottom of the stilled water. Water applied first ex- acted four ounces and a half: the resi- uum gave with alcohol three ounces of an ly extract, eight ounces and a half re- aining undissolved. The watery extract as an unpleasant somewhat saline taste, hich that of nutmegs has nothing of. On xpression, mace yields au oil less consistent han that of nutmegs, which is usually sold r it. The genuine is commonly brought rom the East Indies in glass or porcelain essels.

Maceration. The steeping of a body a cold liquor. It does not differ from Di- **estion**, excepting that the term is never sed when the temperature of the mass is aised beyond that of the surrounding air. is obvious, that maceration, or digestion ithout heat, must be used in all requisite ases wherein the fugitive nature of some of he component parts of the subject of exa- nination, or its disposition to become hanged by heat, renders the process of di- estion, assisted by heat, unfavourable to he intended analysis.

Madder, a substance very extensively mployed in dyeing, is the root of the rubia inctorum.

Although madder will grow both in a tiff clayey soil, and in sand, it succeeds etter in a moderately rich, soft, and some- vhat sandy soil: it is cultivated in many of he provinces of France, in Alsace, Nor- nandy, and Provence: the best of Euro- ean growth is that which comes from Zealand.

There are various methods of cultivating nd preparing madder, and many treatises ave been written on the subject: that of Mr. Duhamel may be consulted, but more articularly that of Mr. le Pileur d'Apli- gny, published at the end of his Art of Dyeing Threads and Cotton Stuffs.

The madder prepared for dyeing is di- tinguished into different sorts: that obtain- ed from the principal roots is called crop madder; the non crop is that which is produced from the stalks, which by being ouried in the earth are transformed into roots, and are called layers: each of these kinds is sub-divided into fine, bale, bunch, and short, or mull.

When the madder roots are gathered, he layers are separated from them, to form he non crop; and such of the fibres of the roots as do not exceed a certain degree of hickness are added, as are also those roots which are too thick, and which contain a great deal of heart or ligneous part: the best roots are about the thickness of a goose quill, or at most of the little finger; they are semi-transparent, and of a reddish colour; they have a strong smell, and the bark is smooth.

When the madder is gathered and picked, it must be dried, in order to render it fit for grinding and being preserved: in warm climates it is dried in the open air; in Holland, by means of stoves, which sometimes communicate too great a degree of heat, and change its colour by an admixture of fuliginous particles. Hellot ascribes the superiority of the madder which comes from the Levant to the circumstance of its having been dried in the open air.

After the root has been dried, it must be shaken in a sack, or lightly beaten on a wooden hurdle, after which it must be sifted or winnowed. In this way the earth is separated from it, and the billon is removed, a name by which the small roots and their bark are distinguished. After this, nothing remains but to reduce it to powder, which may be done by a vertical millstone, or by pestles, or even by a common snuff-mill.

All the parts of the madder cannot be powdered with equal facility; the outer bark and ligneous parts are more easily pounded than the parenchymatous parts. Advantage is taken of this circumstance in order to separate those parts, as they do not all give the same colour; the outer bark, as well as the wood within, affords a yellowish colour, which spoils the red we wish to obtain. This separation established the distinction of madder into robée, mirobée, and courte. After the first operation of the mill, the madder is passed through a sieve, with a cover fitted to it, by which means what is called the short madder, which is intended for tan and modoré colours, is obtained; the remainder is again ground and sifted, and thus the mi-robée is obtained; and a third operation affords the robée. The madder thus powdered is to be preserved in a dry place, well packed in casks, where from its natural unctuosity it concretes into lumps.

Mr. Beckmann agrees with Mr. Hellot in opinion, that the heat of stoves injures the colour of madder, and that it would be better to dry it in the air only, the effect of which might be promoted by various means. He finds that common ovens, immediately after the bread is taken out, may be used instead of the Dutch stoves, when artificial heat is to be employed. Mr. d'Ambourney has made some interesting experiments upon madder; he thinks, that the fresh root may be used in dyeing with as much advantage as the powdered. He observed that four pounds of the fresh are equal to one of the dried, although in the drying seven-eighths of its weight are lost; the expense of stoving, packing, and sifting is saved; and it is only necessary to take care, that the roots be thoroughly washed in a current of water as soon as they are taken out of the ground; they are afterward cut into pieces, and bruised by the vertical mill. In dyeing with the fresh roots, on account of the quantity of water they contain, we must take care not to put too much water into the bath. Mr. Beckmann subscribes to Mr. d'Ambourney's opinion, though he has constantly made one observation, which seems to contradict it, that madder is more fit for dyeing, after having been preserved for two or three years, than when fresh.

In the neighbourhood of Smyrna, and in the island of Cyprus, a kind of madder is cultivated, which affords a more lively red than that raised in Europe; on which account it is employed in the preparation of the Adrianople red. In the countries where it grows it is called chioeborza, and hazala, but it is commonly known by the name lizari. It is now cultivated in Provence, and Mr. Beckmann has raised it with great success at Gottingen.

The red colouring matter of madder may be dissolved in alcohol, and on evaporation, a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn-coloured, and the sulphat of potash a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, sugar of lead, and the muriat of tin,

When madder is macerated in several portions of cold water successively, the last receives only a fawn colour, which appears entirely different from the peculiar colouring particles of this substance, and resembles that which is extracted from woods and other roots: this fawn-coloured substance does not perhaps belong to the pulp, but is peculiar to the ligneous and cortical parts.

After Berthollet had by repeated boiling exhausted the madder of such colouring parts as are soluble in water, it still retained a deep colour, and alkali extracted from it much colouring substance: the residuum which still remained coloured was very inconsiderable; so that the pulp appears to be entirely composed of colouring matter, a large part of which is not soluble in simple water.

Oxigenized muriatic acid, employed in sufficient quantity to change an infusion of madder from a red to a yellow colour, produces a small quantity of a very pale yellow precipitate; and the supernatant liquor is transparent, retaining a greenish yellow colour, more or less deep according to the quantity and strength of the oxigenized muriatic acid.

The quantity of this liquor required to destroy the colour of a decoction of madder, is double what is necessary to destroy that of a decoction of an equal weight of brasil wood; which proves, that the colouring particles of madder are much better calculated to resist the influence of the air, than those of brasil wood. They would be easily changed, however, if not rendered fixed by mordants. On this subject, Berthollet relates some experiments made by the celebrated Mr. Watt upon the best Zealand madder, and communicated to him.

A. This madder is of a brownish orange colour, and of the consistence of a coarse powder, possessing a slight degree of cohesion; it attracts moisture, in which case it loses its properties, so as to become unfit for the purposes of dyeing.

B. With water it affords an infusion of a brownish orange colour; its colour cannot be extracted without a copious addition of water. Margraff directs three quarts of water for two ounces of madder. Its colouring particles may be extracted either by hot or cold water; to the latter it appears to give a more beautiful colour; its decoction is brownish.

C. When an infusion or decoction of this drug is slowly evaporated in an open vessel, a pellicle is formed on the surface, which gradually falls to the bottom; after which fresh pellicles are successively formed until the evaporation is finished.

D. The extract thus prepared is of a dark brown; it partly dissolves in water, to which it communicates a lightish brown colour.

E. The infusion set to digest for some days in an open vessel, which should be of such a height that the liquor reduced to the form of vapour may fall back again, deposits dark brown pellicles. The liquor remains of a brownish colour, and the pellicles are soluble in water, but with difficulty.

F. Alum forms in the infusion B, a deep brownish red precipitate, composed of pellicles, and the supernatant liquor is of a yellow colour inclining to brown.

G. Fixed alkalis precipitate from this last liquor a lake of a blood red colour, which has greater or less intensity, according to the quantity of alum that has been dissolved in it. In this way, a blood red lake may be obtained; but we cannot, by any means hitherto known, give it the brightness of cochineal lake: in oil it is transparent, but in water it is opake and without beauty.—See LAKE.

H. If a superabundant quantity of alkali be employed, the precipitate is redissolved, and the liquor becomes red.

I. The lake precipitated by potash is of a more beautiful colour than that by soda.

K. Calcareous earth precipitates a more dark and brown coloured lake than alkalis, particularly if it form lime water.

L. If a few drops of alkali be added to the water employed in making the infusion B, the infusion extracts many colouring particles of a deep red bordering on brown. 1st. Alum precipitates a deep brown lake from this infusion 2dly. Acids added in small quantity change it to a yellowish colour, and in greater quantity render it a brown yellow, but they precipitate nothing from it. 3dly. This infusion evaporated to dryness forms a gummy extract, which easily dissolves in water.

M. If the infusion B be made with water very slightly acidulated with a mineral acid, it is yellowish. 1st. This liquor by long digestion becomes of a greenish brown, and the yellow appears to be destroyed. 2dly. The addition of an alkali restores the red colour; and the infusion then affords, on evaporation, an extract, which readily dissolves in water.

N. If carbonat of magnesia be added to the water used for the infusion B, the infusion is of a clear blood red, and on evaporation forms a blood red extract, which readily dissolves in water. 1st. A solution of this extract, which is employed as a red ink, when exposed to the light of the sun becomes yellow. 2dly. Alum precipitates from this infusion a small quantity of an ill-coloured lake. 3dly. Alkalis give it a redder and more fixed colour.

O. If the infusion be made with a solution of alum, it is of an orange yellow. This infusion precipitated by an alkali affords a lake resembling that of F, but its colour is not so good.

P. A solution of sugar of lead added to the infusion B forms a brownish red precipitate. 1st. A solution of mercury in the nitric acid, gives a purple brown precipitate. 2dly. A solution of sulphat of iron, a fine bright brown precipitate. 3dly. A solution of sulphat of zinc has not been tried. 4thly. A solution of sulphat of manganese, a purple brown precipitate. 5thly. A solution of iron in aqua regia has not been tried.

Q. The infusion B being mixed while hot with the infusion of cochineal, a brownish red precipitate, bordering on a deep purple, was formed, of difficult solubility in water; by continuing the digestion, a greater quantity of this precipitate appeared. 1st. A pattern soaked in the preparation which the linen-printers use, having been dyed in this mixture, took a brownish red colour; and after having been boiled in a solution of soap, the colour appeared pretty good. 2dly. The solution of soap became very red, but communicated a very indifferent colour to paper.

Wool would receive from madder, as has been already stated, only a perishable colour, if its colouring particles were not fixed by a base, which occasions them to combine with the stuff more intimately, and which in some measure defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain; they are then slightly wrung and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days.

The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced, because, as we have seen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Mr. Poerner somewhat diminishes the proportion of tartar: he directs, that it should be only one seventh of the alum. Schaeffer, on the contrary, directs, that the quantity of tartar should be double that of the alum; but Berthollet found, that, by employing one half tartar, the colour sensibly bordered more on the cinnamon, than when the proportion was only one fourth of the alum.

In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn-coloured particles, which are less soluble than the red, and the colour would be different from that which we wish to obtain.

When the water is at a degree of heat which the hand can bear, Hellot directs us to throw in half a pound of the best crop madder for each pound of wool to be dyed, and to stir it well before the wool is put in, which must remain for an hour without boiling; but in order to be more certain of the dye, it may be boiled for four or five minutes toward the end of the operation. Mr. Beckmann advises the addition of a little alkali to the madder bath; Berthollet approves this plan in the dyeing of thread and cottons.

By this process reds are obtained, which are never so beautiful as those produced even by kermes, much less those from lake and cochineal; but as they cost but little, they are used for common low-priced stuffs. The madder reds are sometimes rosed with archil and brasil wood, in order to render them more beautiful and more velvety; but the brightness given them in this way is not lasting.

The quantity of madder which Mr. Poerner employs is only one third of the weight of the wool, and Schaeffer advises only one fourth. Mr. Poerner says, that having added to the alum and tartar a quantity of solution of tin of equal weight with the tartar, and, after two hours boiling, having let the cloth remain in the bath that had been left to cool for three or four days, he dyed it in the usual way, and obtained a pleasing red. He describes another process, in which, after having prepared the cloth by the common boiling, he dyed it in a bath but slightly heated with a larger quantity of madder, tartar, and solution of tin; he let the cloth remain twenty-four hours in the bath, and after it had become cold, he put it into another bath made with madder only, and there left it for twenty-four hours: in this way he obtained a pleasing red, somewhat clearer than the common red, and bordering a little on a yellow. According to Schaeffer, by boiling wool with a solution of tin, the quantity of which he does not mention, with one fourth of alum, and by dyeing with one fourth of madder, an orange red is obtained.

Bergman says, that if, without boiling the wool, it be dyed with one part of a solution of tin, and two parts of madder, it acquires a cherry colour, which when exposed to the air acquires a deeper tinge.

If wool be boiled for two hours with one fourth of sulphat of iron, then washed, and afterward put into cold water with one fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergmann adds, that, if the wool have not been soaked, and if it be dyed with one part of sulphat of iron and two of madder, the brown obtained borders upon a red.

According to these chemists, by employing sulphat of copper as a mordant, we obtain from madder a clear brown bordering on yellow. A colour of the same kind will be produced, by dyeing the wool simply soaked in hot water, with one part of sulphat of copper and two of madder: if equal parts of these two substances be used, the yellow will be somewhat more obscure, bordering on a green; in both these cases, the colour does not become darker by exposure to the air.

Berthollet employed a solution of tin in various ways, both in the preparation and in the maddering of cloth. He used different solutions of tin, and found that the tint was always more yellow or fawn-coloured, though sometimes brighter than that obtained by the common process.

Madder does not afford a colour sufficiently bright for dyeing silk; but de la Folie has given us a process for employing it for this purpose.

Half a pound of alum is to be dissolved in each quart of hot water, to which two ounces of potash are to be added: after the effervescence has ceased, and the liquor has begun to grow clear, the silk must be soaked in it for two hours; it is then to be washed, and put into a madder bath. Silk dyed in this way becomes more beautiful by the soap proof. Schaeffer gives us a somewhat different process; the silk is to be alumed in a solution of four ounces of alum with six drachms of chalk for each pound of scoured silk; when a sediment is formed, the solution is to be decanted; and after having become quite cold, the silk is to be put into it, and to be left eighteen hours: it is then to be taken out and dried, after which it is to be dyed with an equal weight of madder, when it takes a pretty good, but rather dark red. Mr. Guhliche also describes a process for dyeing silk with madder: for one pound of silk he orders a bath of four ounces of alum, and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the silk carefully soaked in it, and left for twelve hours; and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to boil for two minutes. When taken from the bath, the silk is to be washed in a stream of water, and dried in the sun. Mr. Guhliche compares the colour thus obtained, which is very permanent, to the Turkey red. If the galls be left out, the colour is clearer. A great degree of brightness may be communicated to the first of these, by afterward passing it through a bath of brasil wood, to which one ounce of solution of tin has been added: the colour thus obtained, he says, is very beautiful and durable.

Madder is used for dyeing linen and cotton red, and even for giving them many other colours by means of different admixtures; it is the most useful of all the colouring substances employed in this kind of dyeing. It is proper to enter into a somewhat minute detail of the different means by which this kind of dye may be rendered more certain, more beautiful and varied. Thread does not so easily take a colour from madder as cotton, but the processes which succeed best for the one are likewise preferable for the other.

The madder red of cotton is distinguished into two kinds: one is called simple madder red; the other, which is much brighter, is called Turkey or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists.

Madder reds likewise differ very much in brightness and permanency according to the processes employed. We are indebted to Mr. Vogler for some very interesting experiments on this subject. He first considers the mordants, and afterwards the preparation of the madder bath.

The first mordant he tried, consisted of a solution of three drachms of Roman alum in fourteen ounces of water. Thread and cottons boiled for some minutes in this solution, and afterward passed through the different madder baths, which will be hereafter described, took a slight poppy-coloured red. Our author observed in this, and many other experiments, that Roman alum was much better than common alum, and gave greater brightness to the colours. He always used yellowish thread and cotton, which he first leyed, then washed and dried.

The above proportion of alum appeared to him the best; yet, though he repeated the aluming three times, he was not able to give the thread and cotton a good colour. The addition of the smallest quantity of any kind of acid rendered it paler; the addition of arsenic produced no effect; sheep- and cow-dung, and album grecum, added to the mordant, as also urine employed instead of water to dissolve the alum, contributed somewhat, but not much, to strengthen the colour. Common salt and sal ammoniac had more effect, but these salts rendered the colour more dull; lime-water acted very much in the same way. The substances which had the best effect were gum arabic, starch, fenugreek seed, and, above all, glue. The author says he has attempted to impregnate thread and cotton with fish-oil, hogs' lard, and olive oil, but without success. The gastric juice and the serous part of the blood of animals act like the glue.

The thread and cotton may be soaked alternately in a solution of glue and a solution of alum, or the glue may be dissolved with the alum, in the proportion of from one drachm and a half to four drachms, with the quantity of alum directed: It is necessary to choose fine glue. This substance used with alum produces a more saturated colour, but without alum the red is dusky.

The muriat and nitrat of alumine not only produce a more intense and durable red than the sulphat, but the tint is pleasanter, more especially when the nitrat is employed. In general, muriats render the colour darker, more saturated, and more durable. Corrosive muriat of mercury produces the same effect.

Having dissolved in a strong lie of potash as much powdered white arsenic as it would take up with the assistance of heat, and mixed this solution, which had been diluted with two parts of water, with a saturated solution of alum, the mixture became turbid, and of the consistence of jelly; it recovered its transparency on adding gradually a solution of alum.

Thread and cotton soaked for twelve hours in this mordant, when washed and dried, received from madder a beautiful well saturated colour. Thread and cotton, which had been for six hours in aqua regia, and afterward washed and dried, took from madder a more beautiful and durable colour than that which dyers obtain from annotta; some bad madder, by means of this mordant, afforded a yellowish brown, of an agreeable shade.

This colour may be changed into a poppy coloured red, which may be compared with the most beautiful colours of this hue, obtained from brasil wood and cochineal, by first soaking the stuff in a solution of alum and common salt, and boiling it a second time with madder.

Mr. Vogler macerated for a night three drachms of potash with an equal quantity of common madder in a pound of water; he then applied a boiling heat, and put into it some thread and some cotton, and after half a quarter of an hour's boiling, he took it out, rinsed and dried it, then soaked it in a solution of alum and common salt, after which he passed it through a solution of glue, and at last dipped it in a madder bath: it took a fine full red.

If to the preparation of madder and potash annotta be added, the thread and cotton take in this bath a beautiful orange colour: it is thus that the dyers in many places prepare that colour, but it is not so durable as that above described.

If instead of potash Roman alum be employed, a colour is obtained which is at first weak, though more lively than the potash, and on going on with the process a fine full red is obtained.

By giving a weak madder colour to thread and cotton that have been alumed, by afterward soaking them in a solution of alum and salt, impregnating them with glue, and dyeing them a second time in the madder bath, they take a beautiful very lively red.

The red of thread and cotton coloured by two madderings was very much weakened by the nitric, sulphuric, and muriatic acids diluted with two parts of water, and became more or less pale and yellow. The action of the nitric acid was the most powerful, and that of the muriatic the weakest; this last turned the colour brown. The vegetable acids have a much weaker action; a solution of alum powerfully dissolved the colour, rendered it clearer, and at the same time brighter; potash and lime-water have the property of extracting much of its colour, and changing it to a deep red.

Galls dispose thread and cotton to receive the madder colour. Mr. Vogler's preparation for galling consisted of five drachms of black galls, kept for twenty-four hours in a pound of water, which was then boiled for ten minutes, and sometimes he added six drachms of common salt. The galled thread and cotton, after having received the mordants of alum and salt, took with the madder a perfectly saturated colour, but which was of a dark red. Thread and cotton successively impregnated with a solution of tin and glue, steeped in an infusion of cochineal and galls, washed and dried, and afterward impregnated with the alum and salt mordant, and last of all dyed in a madder bath, received an uncommonly beautiful colour, which was very bright and considerably durable. The mordant of alum and corrosive muriat of mercury, and that of alum and salt, gave a somewhat deeper colour.

Mr. Vogler was equally successful, when instead of galls he used several other vegetable astringents, such as the ground bark of the alder and oak, the powdered bark of walnut-tree root, flowers and bark of pomegranate, the leaves, bark, and tops of the sumach. He made many experiments with metallic and earthy salts, all of which, except the aluminous and the solution of tin, appeared to him to be but little adapted, or entirely hurtful in the dyeing of red: the principal results were as follow:

The solution of nitrat of lead, employed as a mordant, produced a very loaded dirty red inclining to brown. In general, solutions of lead, used as mordants for thread and cotton, dispose them abundantly to receive colours from all vegetable colouring substances, but they have always a dark and dirty appearance These mordants may be employed for brown or black colours; the bad brown just mentioned, for instance, will change to a perfect brown of a very beautiful shade, if passed through a mordant of alum and salt, and boiled a second time with madder. Mr. Vogler obtained a very fine black, by galling thread and cotton impregnated with salt of lead, and then putting them into a solution of sulphat of copper, and boiling them in a bath of logwood.

Cobalt dissolved in aqua regia produced a very pleasant colour nearly resembling a very saturated violet. A solution of sulphat of copper gave a bad lilac. Verdegris dissolved in vinegar produced the same effect.

The nitrat of copper produced a much more beautiful and saturated colour,

Thread and cotton, that have received the mordant of sulphat of copper or iron, take in the madder bath a dirty dull violet colour.

Mr. Vogler having added the alkaline solution of arsenic above mentioned to a moderately saturated solution of sulphat of copper or iron, produced a turbid mixture, which effervesced; and he rendered it transparent by adding sulphat of iron. Thread and cotton impregnated with this preparation received a beautiful saturated puce colour, which penetrated them deeply.

The nitrat and muriat of iron produced a better effect than the sulphat and acetat of the same metal. They afforded a beautiful well-saturated violet colour. The alkaline solution of arsenic mixed with earthy and metallic salts generally renders them better mordants for all colours. This likewise renders the effect of the mordants into which it enters more lasting; so that the stuff impregnated with it many years before may be dyed without disadvantage; a circumstance we do not remark respecting any other mordant, excepting a solution of tin. Sulphat of zinc afforded a weaker violet than sulphat of copper. Sulphat and nitrat of lime produced no effect. Sulphat of manganese discovered some though but little action. Mr. Vogler remarks, that it is always necessary to rinse the cotton and thread when they come out of a mordant; if this precaution be neglected, a weak colour only is frequently obtained, where a strong one was expected; because the particles of the mordant, dispersing through the bath, combine with the colouring particles, and are precipitated with them: this precaution is especially necessary, when we dye with substances which do not contain much colouring matter.

Mr. Vogler prepares the madder-bath in different ways. He put three drachms of madder into sixteen or eighteen ounces of water; he macerated it for twenty-four hours, then boiled it for a quarter of an hour, introduced the thread and cotton, and boiled them for half a quarter of an hour; he afterward washed them in two or three waters, and then dried them in the shade: he remarks, that the colour of the stuff is taken away and destroyed by long boiling.

Fresh urine substituted for water affords more lasting colours; but in summer it is apt to become very soon putrid, so as to render the infusion incapable of giving the dye.

One drachm of sheep's dung, or of album grecum, produced the same effect as the urine.

Three drachms of common salt, or one drachm of sal ammoniac, produced a fuller but less bright colour. Sulphat and nitrat of potash had no effect.

Three drachms of white sugar afforded a more beautiful and saturated colour; on the addition of four drachms of long pepper, it was found to have become more capable of resisting the nitric acid.

One drachm or one and a half of starch or gum arabic thrown into the bath just as it begins to boil, and before the cotton is put in, gives a finer and more saturated colour; one drachm of fenugreek seed produced very nearly the same effect.

If in the beginning of the digestion four drachms of Spanish pepper be added, we obtain from the liquor colours that are more durable than the preceding, especially if we afterward add three drachms of common salt.

From one ounce to one ounce and a half of glue, in the state of jelly, thrown into the liquor as the ebullition commences, affords a particularly beautiful full colour; and the addition of three drachms of common salt not only renders the colour more lasting, but preserves the infusion from becoming putrid.

The most beautiful colour of all, however, is obtained by mixing four drachms of oxgall with the decoction; but at the same time it must be observed, that this colour is more easily destroyed by the nitric acid than any other.

All the madder baths, except those prepared with urine, glue, and animal dung, may be preserved for a long time without losing their power. Mr. Vogler kept some till they became mouldy and fetid, and yet they dyed very well; nay, he observes, that they produced more durable colours, or, at least, colours which resisted the action of the nitric acid more powerfully.

On putting from thirty-six to forty grains of crystals of tartar into the bath just as the linen was thrown in, the colour produced was found capable of resisting the nitric acid. The sulphuric, nitric, and muriatic acids, in very small quantity, produced the same effect; in too large a quantity, they weakened the colour and rendered it pale. One drachm and a half of powdered alum made the colour finer, but not more durable; twenty-four drachms of corrosive muriat of mercury rendered it more obscure, but more permanent. White arsenic employed in different proportions never occasioned the least change, though dyers frequently use it as well as orpiment, with a view of making the colour more durable.

In Mr. Vogler's experiments, cotton always took the colour better than thread; the difference, however, was not very great, when he employed linen or hempen cloth that had been a little worn, and that had become soft to the touch, and when its texture was loose and the thread slightly twisted.

The red in printed stuffs is likewise produced by madder, but it must be fixed by a mordant. Mr. Wilson describes that which is used for this purpose, as follows: In four pounds of hot water (some employ lime water), three pounds of powdered alum, and one pound of sugar of lead, are to be dissolved; this solution is put into a vessel sufficiently large to allow of the effervescence which takes place, and two ounces of powdered chalk, two ounces of potash, and two ounces of corrosive muriat of mercury, are to be added. This mixture must be well stirred, and suffered to settle; the clear liquor must then be decanted, or, which is better, filtered.

With this liquor, coloured with the decoction of brasil wood, and thickened with gum, they print, and pass the stuff through hot water in which cows' dung has been diffused, in order to take away the starch or gum used to give consistence to the mordant; they then carefully wash it, and put it into a madder bath. All the stuff becomes coloured; but that which has not been fixed by the mordant is destroyed, by alternately boiling with bran, and exposure on the grass.

Mr. Oberkamf uses the same ingredients for the mordant, except that he does not put into it any muriat of mercury. We have seen by Mr. Vogler's experiments, that this metallic salt rendered the colour of the madder more durable, and at the same time deeper.

The reader may here recollect, that alum is decomposed by sugar of lead, and that there results from the decomposition an acetit of alumine, while the lead combined with the sulphuric acid forms an insoluble salt, which remains in the sediment. The alkali and the chalk serve to take up the superabundant acid, which would weaken the colour of the madder, and give it a yellow tinge.

Mr. Wilson directs the use of this mordant, which is known by the name of printers' mordant, and which is the same which Mr. Watt refers to in the experiments above mentioned, relative to the dyeing cotton red: according to his process, it must be galled, dried, impregnated with the mordant, diluted with hot water, dried a second time, maddered, washed, and dried again.

The Adrianople red possesses a degree of brightness, which it is difficult for us to approach by any of the processes hitherto mentioned; it has likewise the property of resisting much more powerfully the action of different re-agents, such as alkalis, alum, soap, and acids. Mr. Vogler confesses, that, by his numerous processes, he has not been able to obtain a red of a degree of permanency equal to that of the Adrianople red, though he has much excelled in this respect the false Adrianople reds, used for Siamese (siamoises) and other stuffs. It is necessary to remark, that soap-suds weaken and destroy the most durable madder colours, even that of the Adrianople cotton: hence it appears, that we ought as much as possible to be sparing in the use of soap, in the washing of thread and cotton of this colour. The only difference between the true and false Adrianople red is this, that the one resists these influences much longer than the other. Aquafortis, or dilute nitric acid, is according to Mr. Vogler the best and most expeditious test, for distinguishing the true Adrianople red from the false. If we immerse a thread of the latter dye in it, it soon becomes pale, and in less than a quarter of an hour white; while the true Adrianople red will remain in it for an hour without any alteration, and indeed never entirely loses its colour, which acquires an orange hue.

Some years ago a Mr. Papillon set up a dyehouse for this red at Glasgow; and in 1790 the commissioners for manufactures in Scotland paid him a premium, for communicating his process to the late prof. Black, on condition of its not being divulged for a certain term of years. The time being expired, it has been made public, and is as follows.

Step. I.—For one hundred pounds of cotton, you must have 100 lb. of Alicant barilla, 20 lb. of pearl-ashes, 100 lb. of quick lime.

The barilla is to be mixed with soft water in a deep tub, which has a small hole near the bottom of it, stopped at first with a peg. This hole is to be covered in the inside with a cloth supported by two bricks, that the ashes may be prevented from running out at it, or stopping it up, while the lie filters through it. Under this tub must be another, to receive the lie, and pure water is to be passed repeatedly through the first tub, to form lies of different strength, which are kept separate until their strength is examined. The strongest required for use must float an egg, and is called the lie of six degrees of the French hydrometer. The weaker are afterward brought to this strength by passing them through fresh barilla; but a certain quantity of the weak, which is of two degrees of the above hydrometer, is reserved for dissolving the oil, the gum, and the salt, which are used in subsequent parts of the process. This lie of two degrees is called the weak barilla liquor; the other the strong.

Dissolve the pearl ashes in ten pails, of four gallons each, of soft water, and the lime in fourteen pails.

Let all the liquors stand till they become quite clear, and then mix ten pails of each.

Boil the cotton in this mixture five hours, then wash it in running water, and dry it.

Step. II. Bain bis, or Gray steep.—Take a sufficient quantity (ten pails) of the strong barilla water in a tub, and mix with it two pailfuls of sheep's dung; then pour into it two quart bottles of sulphuric acid, one pound of gum arabic, and one pound of sal ammoniac, both previously dissolved in a sufficient quantity of weak barilla water; and, lastly, twenty-five pounds of olive oil, previously dissolved, or well mixed with two pails of the weak barilla water.

The materials of this steep being well mixed, tread down the cotton into it until it is well soaked; let it steep twenty-four hours, then wring it hard and dry it.

Steep it again twenty-four hours, and again wring and dry it.

Steep it a third time twenty-fours, after which wring and dry it; and, lastly, wash it well and dry it.

Step. III. The white steep.—This part of the process is precisely the same with the last in every particular, except that the sheep's dung is omitted in the composition of the steep.

Step. IV. Gall steep.—Boil twenty-five pounds of bruised galls in ten pails of river water, until four or five are boiled away; strain the liquor into a tub, and pour cold water on the galls in the strainer to wash out of them all their tincture.

As soon as the liquor is become milk-warm, dip your cotton hank by hank, handling it carefully all the time, and let it steep twenty-four hours. Then wring it carefully and equally, and dry it well without washing.

Step. V. First alum steep.—Dissolve twenty-five pounds of Roman alum in fourteen pails of warm water, without making it boil: scum the liquor well, add two pails of strong barilla water, and then let it cool until it is lukewarm.

Dip your cotton, and handle it hank by hank, and let it steep twenty-four hours; wring it equally, and dry it well without washing.

Step. VI. Second alum steep.—This is in every particular like the last; but after the cotton is dry, steep it six hours in the river, and then wash and dry it.

Step. VII. Dyeing steep.—The cotton is dyed by about ten pounds at once, for which take about two gallons and a half of bullocks' blood, mix it in the copper with twenty-eight pails of milk-warm water, stir it well, add twenty-five pounds of madder, and lastly stir all well together. Then, having beforehand put the cotton on sticks, dip it into the liquor, and move and turn it constantly one hour, during which gradually increase the heat until the liquor begins to boil at the end of the hour. Then sink the cotton, and boil it gently one hour longer; and lastly wash it and dry it.

Take out so much of the boiling liquor, that what remains may produce a milk-warm heat with the fresh water with which the copper is again filled up, and then proceed to make up a dyeing liquor, as above, for the next ten pounds of cotton.

Step. VIII. The fixing steep.—Mix equal parts of the gray steep liquor and of the white steep liquor, taking five or six pails of each. Tread down the cotton into this mixture, and let it steep six hours; then wring it moderately and equally, and dry it without washing.

Step. IX. Brightening steep.—Ten pounds of white soap must be dissolved very carefully and completely in sixteen or eighteen pails of warm water; if any little bits of the soap remain undissolved, they will make spots in the cotton. Add four pails of strong barilla water, and stir it well. Sink the cotton in this liquor, keeping it down with cross sticks, and cover it up; boil it gently two hours, then wash it and dry it, and it is finished.

We have seen that Mr. Vogler had not succeeded by impregnating the cotton with oil; and yet without a greasy substance, we cannot obtain a colour like the Adrianople red. The intestinal liquor of sheep, employed in the Adrianople process under the name of sickiou, seems to act by means of the grease which it contains, and by a substance analogous to the serosity and gluten found in all animal substances. The bullocks' blood in Mr. Papillon's must have a similar effect.

Mr. Pallas relates, that the Armenians, whom the troubles in Persia obliged to retire to Astracan, dye Turkey red by alternately impregnating the cotton with fish oil, and drying it, for seven days; that they have observed that other oils do not succeed; and that they do not even use the oil of all fish indiscriminately, but choose that which becomes milky upon being mixed with an alkaline solution. After these repeated impregnations and exsiccations, they wash the cotton and dry it: they then give it an astringent bath, of sumach and galls, to which a little alum is added; they dye it in a madder bath with which sheep's blood has been mixed; finally, they digest it for twenty-four hours in a solution of soda. It would seem that Mr. Vogler had not remarked, that the cotton should be deprived of the oil only to a certain degree by means of the lie.

The following observations prove, that, in the Adrianople red, the cotton has retained a little of the oil. A skein of cotton having been soaked in soap-suds, and wrung slightly, was dried, and then immersed in a mordant of alum saturated with potash, afterward dried, and dyed; it had only a well saturated madder colour: after two minutes boiling in weak soap-suds, it came out with the shade of Adrianople red: its durability was not examined.

If cotton dyed with madder in any way be boiled for some minutes in soap-suds, it acquires a rose colour; if it be then squeezed, a greasy matter is pressed out, which has the colour of Adrianople red, and which fixes on white cotton. Mr. Oettingen had observed in 1764, that oil had the property of dissolving the colouring matter of the Adrianople red, so that, if it be moistened with oil, its colour is communicated to white cotton when rubbed with it for some time. He had thence concluded, that oil must enter into the preparation of Adrianople red; and the Abbé Mazéas has long ago proved, that the use of oil in that dye was indispensable.

The kind of madder employed has great influence on the colour produced. It appears absolutely necessary to employ that which is called lizary, in order to obtain a colour equal to the Adrianople red.

With respect to the choice of madder, we must recollect, that D'Ambourney and Beckmann recommend the use of fresh madder; but it is generally supposed that it gives a more beautiful colour, when kept for a year or two before it is used; and Mr. Guhliche says, that the old madder gives a colour nearly as beautiful as lizary. There are cases perhaps in which the use of fresh madder would be advantageous; the choice of the young roots would certainly be proper.

Mr. Wilson makes an observation which is worthy of attention. He says, that stuffs made of cotton which has not been spun by Mr. Arkwright's machines cannot be dyed by the Adrianople process, because the filaments of the cotton are made to bristle up in the numerous operations of this process; but that these filaments preserve their parallelism much better when the cotton has been spun and carded by these machines, and that the stuffs can then undergo the same operations without injury to their texture.

Berthollet also tried the oxide of tin in dyeing wool. The decoction of madder acquires a more clear and lively red by the addition of this oxide; its colouring particles became fixed much more quickly and more abundantly, upon cloth which had been prepared by a decoction of alum and tartar in the ordinary manner. The cloth came out of the dye bath of a much more saturated and beautiful red, than a similar pattern dyed with an equal weight of madder, without oxide of tin; the advantage, however, does not appear to me so great, as to render the process worthy of being commonly employed.

Oxide of zinc, used instead of tin, produced a fine orange colour in the cloth; oxide of lead, a dull brick colour; that of iron had no sensible effect.

Madder root is sometimes employed in medicine as an emmenagogue. Its effects in dyeing the bones of animals, when taken internally, have been noticed under the article Bone.—*Trans. of Gotting. Soc.*—*Mem. of the Agric. Soc. of Rouen.*—*Journ. de Phys.*—*Guhliche's Vollst. Farbekunst.*—*Crell's Neueste Entdecking.*—*An. de Chim.*—*Mem. des Sçav. Etrang.*—*Neue Noerd. Beytr.*—*Wilson on Light and Colours.*—*Berthollet on Dyeing.*

Magistery. Chemists formerly applied this term to almost all precipitates: at present it is applied only to a few, which have retained the name from habitual usage.

Magistery of Bismuth. See Bismuth.

Magistery of Coral. This name has been given to the calcareous powder obtained by dissolving coral, crabs-claws, chalk, or other substances of the like nature, in nitric acid, precipitating with a fixed alkali, and washing the precipitate in a sufficient quantity of water.

Magistery of Sulphur. The powder of sulphur which is thrown down from a solution of sulphuret, by the addition of an acid.

Magnesia, or Magnesia Alba. See Magnesia, Art. Earths.

Magnesia (Black). Modern chemists are agreed in using the denomination manganese for this substance; which see.

Magnet. The loadstone. When a bar of iron or steel is rendered magnetical, it is called an artificial magnet. The usage of modern writers has almost entirely confined the word magnet to this last instrument. It is useful to the chemist in making an accurate separation of substances containing iron from pulverized mineral matters, after a slight calcination.

Magnetism. The property by which iron exhibits a peculiar and strong attractive and repulsive power upon other iron, according to circumstances. For the general facts, recourse must be had to writers on natural philosophy, as they do not particularly appertain to the chemical department. All iron, the dimensions of which in length greatly exceed its other dimensions, is very evidently magnetical, while held in a vertical position in high latitudes; but the property diminishes and disappears the more that position is altered. Properly speaking, the position most favourable for this magnetism is not the vertical one, but that which a magnetical bar truly poised, and at liberty to assume any position, is disposed of itself to take, when this power is communicated to it. It is observed, that the magnetism of mere position becomes permanent in bars of iron which have long remained vertical; and that heating and cooling, indentation by blows, filing, the electrical shock, or any other cause which may agitate the whole mass, while in this situation, will render the magnetism permanent; and accordingly it is found, that the poker, tongs, and other similar utensils, soon acquire a fixed magnetism by use. The magnetism of three equal bars of steel may be rendered much more considerable by a manipulation called the touch, which appears to depend on this principle, that a single weak bar will become stronger in its power by being rubbed at the same time by two other weak bars; that one of the two touching bars being then subjected to the touch from both the others, will become stronger than the bar first touched, by reason of the superior power of the touching bars, one of which had its energy increased by the preceding operation; that if the untouched bar be then laid down and subjected to the touch from the two others, it will, upon the same principle, become the strongest of the three: and, by repetitions of this process, all the bars may be brought to a greater degree of magnetical power than they are capable of retaining. What happens in these processes, as well as in every thing else relating to magnetism, is so entirely unknown, that we do not possess even a probable hypothesis on the subject.

It has been asserted, that nickel and cobalt, when pure, are likewise attractable by the magnet.

Malachite. A solid green copper ore, which is sometimes cut and polished as a gem. It has the appearance of green jasper; but is not so hard, since it does not strike fire with steel. It is either of a radiated or uniform texture, generally of an oval form, and of the size of an egg; but sometimes it is formed of capillary filaments, like satin, and shows a kind of concentric stripes, or shreds, of paler colours, when cut and polished; its external appearance is like a thick shell, with various protuberances of a mammillary form. The silky-green copper ore of this kind from China, in the form of solid bundles, is the purest. It is found also in great quantity on the Vosges, mountains so called in Lorraine, and in the mines of the Hartz in Saxony.

According to Kirwan, the purest malachite contains 75 parts of copper, and 25 of carbonic acid. A Siberian malachite analysed by Klaproth gave copper ·58, carbonic acid ·18, oxigen ·125, water ·115. Its specific gravity, according to Musschenbroeck, is from 3·500 to 3·994 It is sometimes mixed with calcareous earth and gypsum, and is found in Norway and Siberia.——*Kirwan.*—*Klaproth's Analyses.*

Maltha, *or* Mineral Pitch. See Bitumen.

Manganese. A semimetal of a dull whitish colour when broken, but which soon grows dark by oxidation from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; so difficultly fusible, that no heat yet exhibited has caused it to run into masses of any considerable magnitude, and it appears to be more disposed to oxidation than any other metallic substance, unless we may except tungsten. Its oxides are white when imperfect, but black, or dark green, when perfect: the white are soluble in acids. When broken in pieces, it falls into a powder by spontaneous oxidation; and this powder is magnetic, though the masses were not possessed of that property. It seems as if manganese were capable of depriving a small proportion of iron of its magnetism, but that the effect ceases as soon as the metal is converted into oxide: a strong heat expels oxigen gas from the oxide of manganese.

Concentrated sulphuric acid attacks manganese, but much more readily when diluted with two or three times its weight of water; at the same time that hidrogen gas is disengaged. A black spongy substance remains undissolved, which is a carburet of iron. The solution is colourless, and affords crystals by evaporation. Mild alkalis precipitate a white oxide soluble in acids; but pure alkalis afford an oxide, which soon grows black in the air, and is scarcely soluble. The black oxide of manganese, when old, or well made, is altogether insoluble in acids, unless some combustible substance be added. It appears, therefore, that the metal in this state is too far oxided, and requires to be reduced again in a certain degree toward the metallic state, to be dissolved. If sulphuric acid be added, and drawn off by distillation several times from the black oxide, by a heat nearly approaching to ignition, in a glass vessel, it is found, that oxigen gas is disengaged toward the end of each process, and part of the oxide is dissolved. The solution of the sulphat made from the metal itself is colourless. If it be made from the black oxide, it is a purplish red; but this colour is destroyed by the light of the sun, and again restored by removing the solution into the dark. Hence Bergman infers, that there are three oxides of manganese: the white, the red, and the black.

Sulphurous acid dissolves the oxide, taking part of its oxigen, which converts it into sulphuric acid, and thus forming a sulphat with the remaining oxide.

Nitric acid dissolves manganese with effervescence, and the escape of nitrous gas. A spongy, black, and friable matter remains, which is a carburet of iron. The solution does not afford crystals. The oxide is more readily soluble in nitrous acid.

Manganese is dissolved in the usual manner by muriatic acid. The black oxide is likewise soluble; but adheres so weakly to the acid, as to be separated even by the mere addition of water: but, if this solution be exposed to a digesting heat for some hours, an intestine motion, like an effervescence, takes place; the smell of oxigenized muriatic acid is perceived, and the combination becomes more perfect, so as not to afford a precipitate, unless an alkali be added. The solution of manganese in muriatic acid scarcely affords crystals; but a deliquescent saline mass by evaporation, which is soluble in alcohol.

In the permanent solution of black oxide of manganese by muriatic acid, it is seen, that the acid itself must communicate the property to the oxide, on which its solubility depends: that is to say, it absorbs oxigen from it: and accordingly the red vapours which escape are distinguished by the name of oxigenized muriatic acid.

Other acids likewise dissolve this metallic substance: the fluoric acid, and also the phosphoric acid, form compounds of difficult solubility, which envelop and defend it from their further action in a short time.

In the dry way, the oxide of manganese combines with such earths and saline substances as are capable of undergoing fusion in a strong heat. These experiments are most advantageously performed by the blowpipe, on small quantities of matter; because in this way the whole of the phænomena are clearly seen. The most remarkable property of the solutions is, that a due proportion of combustible matter renders them colourless; for which reason, the oxide of manganese is used by the glass manufacturers to destroy the colours of glass. If a globule of microcosmic salt be fused by the blowpipe upon charcoal, and a small portion of the black oxide of manganese be added, the colour will be of a blueish red; or of a deep red, if the quantity of oxide be greater. If the fusion be continued by the interior blue flame, the colour at length disappears; but may be easily revived again, by softening the globule with the exterior flame. A small particle of nitre instantly restores the red colour; but inflammable matter, or sulphuric salts, contribute to discharge it. If the globule, after being deprived of all colour, be fused in a silver spoon, it recovers its redness; and the colour is not discharged by any management of the fusion, unless some inflammable matter be added.

These remarkable changes of colour, which may be repeatedly produced, depend evidently on the presence or absence of combustible matter; or, which amounts to the same thing, on the degree of oxidation of the manganese which is held in solution. When the highly oxided or black oxide of manganese is first added, it produces a coloured globule; if inflammable matter be added, the oxide is partly disoxided, and forms a colourless combination: nitre restores the colour by its well-known property of oxiding metals. When the fusion is performed by the interior flame, the globule may be considered as if heated in a close vessel, in contact with charcoal; because the surrounding flame prevents the access of air, and disoxidation therefore ensues, and the colour vanishes. But when the external flame is used, its apex or point only touches the globule; and the surrounding air promotes or maintains the oxidation more effectually than the charcoal can produce the contrary effect; the consequence therefore is, that the colour again appears. Sulphuric salts seem to be acted upon by the charcoal, which abstracts their oxigen, and their sulphur in turn takes oxigen from the oxide: and the colour remains fixed in the spoon, because there is no combustible substance present, which is sufficiently so to promote the revival of the oxide.

Nearly similar changes are produced when the oxide is fused with borax or an alkali. If highly oxided manganese be fused with an alkali, as when a mixture of manganese and nitre is thrown into a red-hot crucible, the compound dissolved in a little water appears green; more water changes it blue; a little more, purple; and a still larger quantity, a fine deep purple. Hence this has been called the mineral chameleon.

Manganese does not appear to combine with sulphur; but eight parts of the oxide combine with three of sulphur, and produce a yellowish green mass, which is acted upon by acids; the metal being dissolved with effervescence, and the disengagement of sulphuretted hidrogen. The remaining sulphur may be collected on a filter. Pelletier obtained a phosphuret, by heating equal parts of the glacial acid and manganese with an eighth of charcoal.

This semimetal melts readily with most of the other metals, but rejects mercury. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish.

Metallic manganese has been found native among the powdery or calciform ore of this metallic substance. Its properties, in this state, perfectly resemble the metal produced by art. Manganese appears to exist in the oxided state in all its ores; though contaminated with admixtures of earths, or other metallic matters. They are white, red, brown, or black; either pulverulent, indurated, or crystallized. Vegetable ashes likewise afford indications of manganese.

To analyse the ores of manganese in the humid way, they must be reduced to a subtile powder, and immersed in a mineral acid, with a piece of sugar to assist the solution. If nitric acid be repeatedly abstracted to ignition from the ore, the iron it contains will be rendered nearly insoluble from oxidation, and the manganese may be taken up by strong concentrated vinegar, or diluted nitric acid. This, when precipitated by subcarbonat of soda, affords 180 grains of precipitate for every 100 grains of manganese: or if the metals be precipitated from superabundant nitric acid by prussiat of potash, the manganese will be totally dissolved by pure water, while the iron remains behind.

The ore of manganese, which is known in Derbyshire by the name of black wadd, is remarkable for its spontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterward suffered to cool for about an hour; and it be then loosely mixed or kneaded with two ounces of linseed oil; the whole, in something more than half an hour, becomes gradually hot, and at length bursts into flame. This effect wants explanation. It seems, in some measure, to resemble the inflammation of oils by the nitric acid.

The presence of manganese may be ascertained in the dry way by the blowpipe, from the singular changes of colour already described, when fused with microcosmic salt, or borax. The reduction of the ore is effected by mixing it with pitch, making it into a ball, and putting it into a crucible lined with powdered charcoal, one tenth of an inch thick at the sides, and one quarter of an inch thick at the bottom; then filling the empty spaces with powdered charcoal, and luting on a cover. This must be exposed to the strongest heat of a forge, or furnace, for an hour, or more. As the oxide of manganese is strongly disposed to vitrification, fluxes rather impede than forward the reduction. The reduced globules of manganese are usually enveloped in a vitrified crust, which either partly or completely defends them from the action of the air; but, when they are broken, they lose their metallic brilliancy and consistence in a very short space of time.

Manganese was used chiefly by glassmakers and potters; but the important discovery of the uses of oxigenized muriatic acid has greatly extended its utility. See Acid, (Muriatic, Oxigenized); also Bleaching.

Manna. Several vegetables afford manna: it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c.; but the ash, the larch, and the alhagi, afford it in the largest quantities. Lobel, Rondelet, and others, have observed at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of oeliomeli. Tournefort collected it from the same trees at Aix and at Toulon.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree; or at least it is only in these countries that it abundantly furnishes the juice called manna in commerce.

The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer: the manna flows through these apertures upon the trunk of the tree, from which it is detached with wooden instruments. Care is likewise taken to insert straws, or small sticks of wood, into these incisions; and the stalactites, which hang from these small bodies, are separated, and known in commerce by the name of Manna in Tears: the smallest pieces form the manna in sorts or flakes, and the common or fat manna is of the worst quality, because the most contaminated with earth and other foreign substances.

The larch, which grows abundantly in Dauphiny and the environs of Briançon, likewise affords manna. It is formed during the summer on the fibres of the leaves, in white friable grains, which the peasants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauseous smell.

The alhagi is a kind of broom, which grows in Persia. A juice transudes from its leaves in the form of drops of various sizes, which the heat of the sun indurates. An interesting account of this tree may be seen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Tereniabin.

The manna most frequently used is that of Calabria. Its smell is strong, and its taste sweetish and slightly nauseous: if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar.

Manna affords, by distillation, water, acid, oil, and ammonia: its coal affords fixed alkali.

This substance forms the basis of many purgative medicines.

Manures. The subject of manures has yet been but little investigated scientifically; and in fact, wherever vegetable or animal life is concerned, Chemistry is able to guide us at present but a very short way. With regard to inanimate bodies she treads with a firm and sure step; and on many of the processes of animal life her torch has thrown a much clearer light, though these seem more remote, than on those of vegetation; probably because they have been more sedulously studied, on account of our nearer concern in them. Some curious hints have indeed been given in the article Gluten; and under the head Soils the subject will be considered scientifically, at least with regard to some articles that come under this general head. In a work intended to be subservient to the purposes of the arts, however, we cannot pass over an article of so much importance to that of agriculture; and we conceive its ends will be best promoted here by availing ourselves of the experience of the practical farmer, which at the same time will point out the path, that the chemist may pursue with most advantage, to bring it within the domains of science.

Under the term manures may be included chalk, lime, shells, bones, gypsum, marl, clay, sand, pond mud, pond weeds, ashes, soot, sea-weed, salt, rape dust, malt dust, yard dung, pigeons' dung, rabbits' dung, night soil.

Chalk is used to great advantage as a manure on some wet, stiff soils having no calcareous earth; in quantity, from fifty to eighty cart-loads per acre. Its beneficial effects are said to last twenty years, and the value of it is often estimated between outgoing and in-coming tenants, when lately laid on, as high as *5l.* per acre.

There are many soils, however, where chalk is in plenty, which derive no benefit from it. Some farmers, from observing the beneficial effects of chalk as a manure at other places, have been tempted to use it on their lands; where it has proved to be of no kind of use, and much time and expense have been entirely thrown away.

The best method of using it, is to spread it early in the autumn, in order that it may be thoroughly drenched with rain, that the frost may have its full operation upon it; by which means it is well pulverized when the thaw comes on, and will mix the more readily with the soil.

Old grass-lands on wet sandy or clay soil, over-run with furze or rushes, are greatly improved by chalk.

But it is to be observed, that land once completely chalked, after its fertilizing powers appear to be exhausted, is reckoned to be inferior to land that never was chalked.

Lime not only acts as chalk, into which it is converted, but it destroys and decomposes weeds, when laid on fallows. It may likewise be mixed advantageously with green weeds, in alternate layers, for this purpose, and the result will be a beneficial manure.

Turf-ashes, if spread on poor chalky thin lands for turnips, at the rate of about twenty cart-loads of thirty bushels each per acre, will seldom fail to produce a good crop: and it is well known, that if once a good crop of turnips can be obtained on such poor lands, a good foundation is laid for future improvements.

Could *bone dust* be procured in sufficient quantity, and at a reasonable price, few substances would be more advantageous as a manure. Its effects upon the soil, though not immediately apparent, are in the highest degree beneficial; and their durability does not constitute the least portion of their value.

The term *marl* is employed in a very comprehensive sense, including a variety of substances, very different in external appearance, and varying greatly, if not in the nature of their constituent parts, at least in the proportions in which these are arranged in the mass. The most common varieties are distinguished by the appellations of clay marl, slate marl, and stone marl; the first of these kinds is met with in the greatest abundance, and is perhaps the most generally beneficial. In some instances however the farmer mistakes a brown shining clay for this description of marl; by putting which on his clay land, he throws away his labour, and rather injures than benefits the soil. The criteria of the excellence of marl must, of course, have a reference to the different kinds employed. Generally speaking, that may be esteemed good, which is of a dark brown colour, intersected with veins of either a blue, or light yellow shade; it should be greasy to the touch, when moist; and friable, when dry. Marl of this description, when put into water, will fall to pieces, allowing a considerable portion of sand to sink to the bottom of the vessels; from the application of which simple test the farmer might, in many instances, derive much advantage. There is an excellent kind of marl sometimes met with, which is vulgarly called dove dung, from its resembling in appearance the dung of pigeons.

The quantity of marl used in Cheshire varies according to its quality, and the nature of the soils on which it is used. On a light or sandy soil, two cubic roods of marl, each rood containing 64 solid yards, is reckoned a good covering for a statute acre. On strong retentive clay land, one rood is generally found sufficient for the same extent of surface. The usual time of marling is in the summer months; beginning in May, when the ploughing is over, and continuing till the commencement of harvest. It is sometimes laid on the green sward in winter; and, after being acted upon by the frost, is ploughed in the following spring, generally for oats. Marling on fallows is also practised to a very considerable extent.

That marl is actually productive of the greatest benefit to the lands on which it is used, is a fact which can admit of no doubt. Much variety of opinion however exists, as to the mode of operation by which this benefit is effected. Several intelligent persons consider the calcareous matter, which it contains, as the principal, if not the sole agent, in the improvement of the land. Others have stated it as their opinion, that the principal advantage derived from marl is the addition of bulk or quantity which it makes to the soil; while others again regard its action as of a mechanical nature; considering the improvement of the land, on which it is applied, as the consequence of an alteration which it makes in the texture or disposition of the soil. Upon an attentive consideration of the subject, it appears in the highest degree probable, that marl may derive a certain portion of its utility as a manure, from each of the three causes which have been assigned. From analysis of the substance, it is found to be an intimate mixture of the aluminous and siliceous earths, usually combined with a certain portion of carbonate of lime, and not unfrequently deriving a tinge from the presence of an oxide of iron. The latter substance however, from the smallness of its quantity, cannot be supposed to produce effects, either beneficial or the reverse. With respect to the calcareous earth contained in the marl, it must undoubtedly have, to a certain extent, the same action that would be produced by the direct application of lime as a manure; but as it is rendered clear, by actual experiment, that some descriptions of marl which are used with advantage, do not contain any portion whatever of carbonate of lime, we cannot certainly attribute the efficiency of marl to this cause alone.

The application of *sand* as a manure is of the greatest advantage in many respects. When there is a piece of strong clay land in tillage, and the farmer has an opportunity of covering it over with sand, about twice as thick as in a common set of manure, the soil will be pulverized and opened by this means, will give better crops when in tillage, and when laid down, will produce a finer herbage, less liable to be parched in dry, or trod down in wet seasons. It is excellent management in the farmer, before he ties up his cattle for the winter, to lay a coat of sand, at least a foot in thickness, where he intends to throw his dung out of the cow-houses. The dung should be repeatedly levelled on the sand, and a second coat of the latter laid on toward the end of February; upon which should be put the remainder of the dung procured before the cattle go to grass. As soon after this time as possible, the compost should either be turned, and mixed well where it lies; or cut down in *breasts*, filled into the dung carts, and taken away to some situation near the land on which it is intended to use it. Here it should be laid in a heap of at least two yards in thickness. After remaining two or three months in this state, it is in excellent condition for putting upon the land; and will be found, upon the whole, one of the most advantageous manures the farmer can employ, particularly on soils where there is a considerable predominance of clay.

Turf-ashes are often used for wheat, and sometimes for other crops; but there is no application of them so advantageous as that of using them for turnips.

Coal-ashes are a good manure for the same purpose; but not so much used, on account of their consumption in the manufacture of bricks. They are sown on the land in the spring, at the rate of four or five chaldrons per acre. Cold, wet, clay meadows are much improved by them.

Soot is a valuable manure for a top-dressing on sainfoin, clover, lucerne, and meadows: it is usually sown on the land at the rate of forty or fifty bushels per acre, early in the spring.

Sea-weed is a very excellent manure, being a mass of vegetable matter strongly impregnated with salt.

Though various experiments have been made, with a view to ascertain the utility of *common salt* as a manure, yet, from the difference which has been experienced in their results, no very decisive or satisfactory conclusion has hitherto been obtained on the subject.

Rape dust is another excellent manure, and has been used in several instances with the greatest advantage. The large proportion of oily and mucilaginous matter, which it contains, might indeed induce a belief, *à priori*, that this would be the case.

Refuse leather, soap suds, woollen rags, &c., have each been used, to a certain extent, as manures in some counties; and with different degrees of success.

The *dung* of those animals which are fed upon the substances constituting in a great measure the subsistence of man, is esteemed more valuable than that procured from animals whose food is of a different description. The dung of swine, of horses fed upon corn, &c., is said to be more beneficial as a manure, than that of cows, sheep, or horses fed entirely upon grass or hay.

The following is a comparative experiment made with potatoes and different kinds of dung, exhibiting the proportions per acre of the manure, and the crops of potatoes, on a poor gravelly loam.

No.		*Crop,* Bush.
1.	No manure, - - -	120
2.	Night-soil, 10 waggon-loads, each 96 bushels, - -	600
3.	Ditto, 6 loads, - -	650
4.	Ditto, 2 ditto, - -	500
5.	Bones, 10 ditto, - -	650
6.	Ditto, 6 ditto, - - -	640
7.	Ditto, 2 ditto, - -	560
8.	Hog-dung 60 one-horse cart-loads	480
9.	Ditto, 30 ditto, - -	480
10.	Yard compost, 60 ditto -	200
11.	Ditto, 120 ditto, - -	480
12.	Ditto, 30 ditto, - -	140

In the April following, they were planted again with potatoes; and their produce was as follows:

1.	- - - -	140
2.	- - - -	640
3.	- - - -	500
4.	- - - -	300
5.	- - - -	640
6.	- - - -	560
7.	- - - -	240
8.	- - - - -	300
9.	- - - -	160
10.	- - - -	240
11.	- - - -	300
12.	- - - -	140

he principal featnre of the trial is the
effect of bones and night-soil.
rom the analysis of different vegetable
tances, and from experiments made
n the growth of plants, it would appear,
the siliceous and aluminous earths, car-
ic acid, water, oxigen, and the remains
animal and vegetable matters, are the
erials most essential to the growth and
rition of vegetables. Analysis would
wise seem to indicate, that some of the
s constitute a necessary part of the food
plants; though the variety in the nature
proportion of these salts is greater than
prevailing among the other materials
vegetable nutriment. That a certain
portion of the mould, produced by the
refaction of animal or vegetable matters,
sential to the fertility of every soil, has
n proved by the experiments of Giobert,
o found that the siliceous, aluminous,
areous, and magnesian earths, though
ed together in the proportions usual to
ile soils, and moistened with pure water,
er produced a vigorous vegetation, till
employed the water exuding from a
ghill, to give moisture to the soil. We
at present too little acquainted with the
le of vegetable nutrition and growth to
gn, with precision, the immediate causes
this fact. It would appear, however,
n the experiments of Hassenfratz, Saus-
e, and other inquirers into this subject,
t the value of putrid animal and vegeta-
matters, as ingredients in soil, depends
ncipally, if not entirely, upon the pecu-
state of combination in which the con-
uents of such substances exist; a state
arently the most favourable to their re-
anization by the vegetative process. The
eriments made by Saussure, on the
uld procured from the decay of different
etable matters, have shown, that the
st usual constituents of this substance are
ouretted hidrogen gas, carbonic acid,
er, frequently containing a small por-
n of ammonia combined with a vegetable
l, charcoal, and an empyreumatic oil.
s probable, that the decomposition of
mal substances by putrefaction furnishes
erials very similar for the process of ve-
ation, and that the fertility of any soil is
ived principally from the due admixture
such substances with the simple earths;
perhaps also from the proportion of
n capable of being held in solution by
er. A general knowledge of these cir-
stances, and of the superior value of
rid animal and vegetable substances as
itions to his soils, must induce every ju-
ous agriculturist to bestow much of his
ntion upon the collection and preserva-
n of all such manures, as well as upon
ir proper application and distribution to
lands.

Marble. All calcareous stones, which
hard, of a close texture, and beautiful
earance, from the clearness and uniformity of their colour, or from its variety and admixture, are distinguished by the name of marble. For an enumeration of the several kinds, Cronstedt's Mineralogy may be consulted. The different names apply chiefly to circumstances of outward appearance, much more important to the statuary and the builder than to the chemist.

Marcasite. This name has long been given indifferently to all sorts of minerals, to ores, pyrites, and to semimetals. At present it seems to be confined to pyrites; and Wallerius proposes to apply it only to such pyrites as are regularly formed. This appears to be better than to leave it to a vague and indeterminate signification, from the ambiguity and obscurity which might thereby be introduced. The word is little used. See Pyrites.

Margodes. A blueish gray stone, entirely resembling clay in its outward appearance, but so hard as to cut spars, or even zeolites, though not to such a degree as to give fire with steel; dull in its fracture, its texture thick laminæ, and of a conchoidal form; its specific gravity 2·877; it effervesces with acids. Kirwan found it to contain 50 per cent. of lime, about 32 of alumine, 15 of silex, and 2 of iron.

Marl. There are two kinds of marl; the one consisting of clay divided by a very fine fuller's earth; and the common marl, consisting of clay divided by calcareous earth. Common marl participates in the properties of its respective component parts. When crude, it effervesces with acids; but does not after it has been burned. It hardens in the fire like clay, and the more so, the larger the quantity of clay which enters into its composition; but it falls into powder by exposure to the air like lime, and this the more readily, the greater the quantity of lime. A strong heat converts it into glass. See Earth (Calcareous).

It is found either loose and friable, or more or less indurated. The semi-indurated marl is nearly as hard as a stone, when first dug up, but falls to pieces in the open air.

Marl is of excellent service for the improvement of lands, which it appears to do by altering the proportion of its component parts. See Arable Land, and Earth (Vegetable).

The English farmers distinguish five sorts of marl: 1. The coroshut marl, which is brown mixed with fragments of chalk and blue veins. 2. Stone, slate, or flag marle: it resembles blue slate, and crumbles easily when exposed to the air. 3. Pont marl, or delving marl; it is brown, and rough to the touch. 4. Clay marl: which contains much clay. 5. Steel marl: its colour is black, its consistence like that of bits of paper.

Marmor Metallicum. Native sulphat of barytes.

Mars. Chemists have distinguished iron

by the name of the planet Mars, whence the term martial is still much used to denote compounds containing that metal.

Massicot. Yellow oxide of lead. See Minium; and Lead.

Mastic. A resinous substance in the form of tears, of a very pale yellow colour, and farinaceous appearance, having little smell, and a bitter astringent taste. It flows naturally from the tree, but its produce is accelerated by incisions. The lesser turpentine tree and the lentiscus afford the mastic in commerce.

No volatile oil is obtained from this substance when distilled with water. Pure alcohol almost totally dissolves it; water scarcely acts upon it; though by mastication it becomes soft and tough, like wax. When chewed a little while, however, it is white, opake, and brittle, so as not to be softened again by chewing. The part insoluble in alcohol much resembles in its properties caoutchouc. It is used in fumigations, in the composition of varnishes, and is supposed to strengthen the gums.

Matrass. See Laboratory.

Matrix. The earthy or stony matters which accompany ores, or envelop them in the earth, are called the matrixes of those ores. They are various, and the information they afford to miners is not easily reducible to rule. It has been remarked, that tin is generally found among crystalline or siliceous stones, and lead among those of the calcareous order.

Matt. Certain metallic ores, particularly that of copper, are distinguished by this name when partly deprived of sulphur, and fused into a mass with the remaining portion of that substance.

Matter. When philosophers speak of the substance which composes the things around us, in the most general way, they use the term *matter*. This term is more abstract than the word *body*, which includes the consideration of limit; but it is less abstract than the words *being* or *thing*, which are applicable to substances that do not possess all the common properties of bodies, if indeed it be true, that any such substances exist.

Mead. A fermented liquor made from honey and water.

Measures. The English measures of capacity are according to the following table.

One gallon, wine measure, is equal to	four quarts.
One quart - -	two pints.
One pint - -	28·875 cubic inches.

The pint is subdivided by chemists and apothecaries into 16 ounces.

The gallon, quart, and pint, ale measure, are to the measures of the same denominations, wine measure, respectively, as 282 to 231.

The French measures of quantity used by chemists:

The quarte is equal to two pintes.
The pinte - two chopines.
The chopine is equal to two demi-setiers.
The demi-setier two porçons.
The porçon - four Paris ounces of water at the freezing point. The proportion of the Paris ounce to the English troy ounce is, as 65 to 64.

As to the measures of length, it is sufficient to observe here, that the Paris foot is equal to 12·789 English inches, or to the English foot, as 114 to 107. For measures of weight, see Balance.

Meerschaum. See Keffekil.

Melasses. The juice of the sugar cane. See Sugar. Treacle, or the residue after the separation of the crystals of sugar at the works, is exported to America and Europe, from the sugar islands, where it is fermented and distilled. The spirit thus obtained is termed Melasses' spirit, as treacle is frequently called Melasses.

Mellilite, *or* **Honeystone.** This stone, named from its colour, generally crystallizes in octaëdra. Spec. grav. about 1·7. Exposed to heat it first becomes white, and then burns without being sensibly charred. It leaves a white residuum, that effervesces slightly with acids. It was supposed by Born to be crystallized amber.

It was analysed about the same time by Abich and Lampadius. According to the former, 100 parts consist of carbon 40, water of crystallization 28, carbonat of alumine 16, benzoic acid 5, benzoat of alumine 5, oxide of iron 3, resin 2. According to the latter, carbon 85·5, petroleum 13·5, silex 2, water of crystallization 5. Mr. Klaproth on the contrary has found in it 46 parts of a peculiar acid, see Acid (Mellitic), 18 alumine, 38 water of crystallization. In the dry way however he obtained 2 parts of an aromatic oil, and found a little silex with the alumine.—*Klaproth's Anal.*—*An. de Chim.*

Menac. A name proposed for a genus of fossils containing the new metal titanium, first discovered by Mr. Gregor in menachanite, of which there are five species.

Menachanite. A granular fossil hitherto found only in a rivulet in the vale of Menachan in Cornwall with fine quartz sand. It is of a dark gray colour, approaching the black of iron, with a rough glimmering surface, brittle, and slightly attracted by the magnet. Sp. grav. 4·427. It is infusible by the heat of a porcelain furnace in a coal crucible, but melts when in contact with a clay one. Before the blowpipe with oxigen gas it melts quickly into a black bead. It consists of about equal parts of the oxides of iron and titanium.—*Irish Trans.*

Menilite. A stone found at Menilmontant, near Paris, in a stratum of the polishing slate of Werner. It is chiefly in nodules, externally of a dirty blue, but in its fracture of a hair brown, with some greasy lustre. It was formerly considered as argillaceous, and classed as a blue pitchstone; but by the analysis of Klaproth 100 parts gave silex 62·5, oxide of iron 4, alumine 0·75, carbon 0·75, magnesia 8, lime 0·25, water 22. He considers it, therefore, as a variety of the semiopal approaching to flint. *Klaproth's Anal.*

Menstruum. A word synonymous with solvent.

Mercury is distinguished from all other metals by its extreme fusibility, which is such, that it does not take the solid state untill cooled to the thirty-ninth degree below 0 on Fahrenheit's thermometer; and of course it is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than silver. In the solid state it is malleable*; its specific gravity is greater than that of any of the other metals, platina and gold excepted. It is volatile, and rises in small portions at the common temperature of the atmosphere, as is evinced by several experiments, more especially in a vacuum, such as obtains in the upper part of a barometer tube. At the temperature of about 656° it boils rapidly, and rises copiously in fumes. Few of the other metals melt at so low a temperature as the boiling point of mercury. When exposed to such a heat as may cause it to rise quickly in the vaporous form, or about 600°, it gradually becomes converted into a red oxide, provided oxigen be present. This was formerly known by the name of precipitate *per se*. A greater heat however revives this metallic oxide, at the same time that the oxigen is again extricated. In the production of this oxide, it is required that air be present, and the metal kept in a state of brisk evaporation. On this account it is found convenient, that the vessel should be so deep, and its aperture so small, that the fumes may not make their escape. Ten days or a fortnight's constant heat is required to convert a few grains of mercury into precipitate *per se* in the small way.

From this volatility of mercury, it is commonly purified by distillation: but the following simple mode, discovered by Dr. Priestley, will often be found convenient. Let a strong 10- or 12-ounce phial with a ground stopper be a quarter filled with foul quicksilver: put in the stopple, hold the bottle inverted with both hands, and shake it violently, by striking the hand that supports it against the knee. After twenty or thirty strokes, take out the stopple, and blow into the phial with a pair of bellows, to change the air. The surface will become black in a short time, and, if the mercury were very foul, appear coagulated. Invert the phial, stopping it with the finger, and let out the running mercury. Put the coagulated part into a cup by itself, and press it repeatedly with the finger, so as to get out the mercury entangled in it. Put both portions of mercury into the phial again, and repeat the process till no more black powder separates.

Mercury is not perceptibly altered by mere exposure to the air; though by long agitation, with access of air, it becomes converted into a black powder or oxide, which gives out oxigen by heat, the metal being at the same time revived.

This metal is disposed to attract moisture; and cannot, for this reason, be used in the construction of barometers and thermometers, until it has been first boiled in an open vessel for the space of about half an hour.

When mercury is agitated in a dry glass bottle, the friction between the metal and the glass produces electricity. If the bottle be imperfectly exhausted, this electricity passes into the vacuum, and produces a light, which was formerly thought to be a proof of the perfection of the vacuum in the upper part of barometer tubes; but which, in fact, does not appear in such barometers as have been cleared of air by careful boiling in the tube.

The sulphuric acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with near twice its weight of sulphuric acid. As soon as the mixture is heated, a strong effervescence takes place, sulphurous acid gas escapes, the surface of the mercury becomes white, and a white powder is produced: when the gas ceases to come over, the mercury is found to be converted into a white, opake, caustic, saline mass, at the bottom of the retort, which weighs one third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of oxigen, the mercury being at the same time revived.

The white mass produced by the action of sulphuric acid upon mercury, consists partly of sulphat of mercury, and partly of oxide. Water separates the salt from the oxide, which is then of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, the oxide immediately assumes a bright lemon colour. In this state it is called turbith mineral. The sulphat affords by evaporation small, needly, deliquescent crystals. Sulphat of mercury may be made likewise by adding soluble sulphat to a nitric solution of mercury.

The fixed alkalis, magnesia, and lime,

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* The reader will find an ample account of the freezing of quicksilver in Dr. Blagden's History, vol. lxxxiii. of the Philosophical Transactions.

precipitate mercury from its solution; these precipitates are reducible in closed vessels by mere heat without addition.

The nitric acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous gas is disengaged; and the colour of the acid becomes green during its escape. Strong nitric acid takes up its own weight of mercury in the cold; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved; and a precipitate will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold; and greatly resembles the turbith mineral produced with sulphuric acid: it has accordingly been called nitrous turbith. If acid be added to the solution made with heat, it loses its property of being decomposed by water. This decomposition is not complete, but only deprives the acid of the redundant oxide.

All the combinations of mercury and nitric acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitric acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitric acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitric acid, and becomes converted into a bright red oxide, still retaining a small portion of acid. This is known by the name of red precipitate, and is much used as an escharotic.

When red precipitate is strongly heated, a large quantity of oxigen is disengaged, together with some nitrogen, and the mercury is sublimed in the metallic form.

Nitrat of mercury is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess.

When mercury is dissolved in nitric acid by means of heat, nitrous gas is emitted at first; and afterward it ceases, though the solution still proceeds. If the solution be stopped in the first part of the process, pure alkalis precipitate the yellow oxide; but if the solution be continued after the escape of the elastic fluid has ceased, the precipitate obtained by the same means is black.

Barytes, magnesia, and lime, precipitate the nitric solutions of mercury; and these precipitates, as well as all the other oxides of this metal, are reducible by heat alone without addition.

The precipitates of mercury from acids, by means of alkalis, possess the property of exploding when exposed to a gradual heat in an iron spoon, after having been previously triturated with one sixth of their weight of flowers of sulphur. The residue consists of a violet-coloured powder, which is converted by sublimation into cinnabar. It seems therefore as if the sulphur combined suddenly with the mercury, and expelled oxigen in the elastic state.

Another fulminating preparation of mercury was discovered by Mr. Howard. A hundred grains of mercury are to be dissolved by heat in an ounce and half by measure of nitric acid. This solution being poured cold into two ounces by measure of alcohol in a glass vessel, heat is to be applied, till effervescence is excited. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried with a very moderate heat. This powder detonates loudly by gentle heat, or slight friction. Mr. Accum having made four ounces of this powder, and left it to dry on a chalk stone, where it was forgotten for three months, found it converted into a brilliant black powder; and on collecting it into a heap observed a globule of running mercury. On putting it into a bottle, and shaking it, heat was evolved, and the whole of the metal reduced. Brugnatelli has made this preparation without heat, by pouring an ounce of alcohol on two drachms of yellow oxide of mercury, and adding at twice ten drachms of strong fuming nitrous acid. The alcohol is converted into ether, which escapes in very copious vapours. All the other oxides of mercury were equally convertible into fulminating mercury by the same means. In either way the ether might be saved by a proper apparatus.

The acetous and most other acids combine with the oxide of mercury, and precipitate it from its solution in the nitric acid.

The muriatic acid seizes the mercury dissolved in the nitric acid, and forms a compound which falls to the bottom. This consists of a very caustic salt, which is called corrosive sublimate, and is produced when the nitric solution contains highly oxided mercury; but when that solution is saturated with mercury in a less oxided state, the compound which falls down by the addition of muriatic acid is called white precipitate, and differs little from the preparation which, when made in the dry way, is called calomel, or mercurius dulcis.

The muriatic acid does not act perceptibly upon mercury in the metallic state; but the oxigenized muriatic acid readily dissolves it, and forms the same combination as arises from the direct union of muriatic acid with oxide of mercury; that is to say, corrosive sublimate. This is generally made by mixing sulphat of mercury with muriat of soda, and exposing them to heat gradually raised; when the muriat of mercury sublimes. This muriat being mixed by trituration with three fourths its weight of mercury, and

blimed again; the sublimate powdered,
d resublimed three or four times; and the
oduct well washed; we have the mild
uriat, or calomel. The corrosive muriat
ntains, according to Mr. Chenevix, 69·7
ercury, 12·3 oxigen, and 18 muriatic acid:
e mild, 79 mercury, 9·5 oxigen, and 11·5
id.

The causticity of metallic salts depends
hiefly on the disposition of the oxide to re-
me the metallic state, in doing which it
urns the substance to which it may be ap-
ied by the oxigen it evolves. It is accord-
gly found, that corrosive sublimate pos-
sses this property in a very eminent de-
ree; it is therefore one of the most active
ineral poisons. This salt is soluble in
ater, though sparingly, and also in alco-
ol. It is precipitated of an orange colour
y fixed alkalis. The absorbent earths like-
ise throw down its oxide. Volatile al-
ali affords a white precipitate, which soon
fterward assumes a slate colour.

Corrosive sublimate becomes much more
oluble in water by the addition of sal am-
oniac, with which it forms a triple com-
ound, called sal alembroth by the alche-
ists, which crystallizes by cooling. The
ldition of a fixed alkali throws down a
hite oxide of mercury, called white calx of
uicksilver in the London Dispensatory.

When one part of native sulphuret of an-
mony is triturated or accurately mixed
ith two parts of corrosive sublimate, and
xposed to distillation, the oxigenized mu-
iatic acid combines with the antimony, and
ises in the form of the compound called
utter of antimony; while the sulphur
ombines with the mercury, and forms cin-
abar. If antimony be used instead of the
ulphuret, the residue which rises last con-
ists of running mercury, instead of cinna-
ar.

Mercury combines very readily with sul-
hur. By trituration in a mortar the mer-
ury disappears, and forms a black sul-
huret, which was formerly called ethiops
nineral, or mercurial ethiops. The com-
ination is more speedily made by mixing
luid mercury with melted sulphur. In this
vay three parts of flowers of sulphur unite
vith one of mercury. If the sulphur be set
on fire, the greater part burns, and the re-
nainder is of a violet colour when pulve-
ized. This consists of a more intimate com-
ination of mercury and sulphur. It rises
n a heat nearly approaching to redness;
nd the sublimate, which is called cinnabar,
ontains about one fifth part sulphur, and
he rest mercury. Mr. Accum has made
innabar in the humid way, by mixing equal
arts of concentrated solutions of oxigen-
zed muriat of mercury and fresh prepared
fuming hydrosulphuret of ammonia. A
rownish muddy precipitate is produced,
which, being left undisturbed, turns yellow
n three or four days, then orange, and at
ast the beautiful red of the best vermilion.
Proust says, that mercury, poured into flasks containing sulphuret of potash or of ammonia, unites with the sulphur, and falls down in a black powder, which in the space of a few days becomes red. According to Seguin, cinnabar is composed uniformly of 86⅔ mercury, and 13⅓ sulphur; while in the black sulphuret the proportions are very variable. In the native cinnabar of Japan, however, Klaproth found 14·75 per cent. of sulphur, and in that of Carniola 14·25. The pigment called vermilion consists of artificial cinnabar reduced to a powder. See CINNABAR.

If phosphorus be added to a nitric solution of mercury, the metal will be precipitated on it in globules, which will be converted into a black phosphuret by heating to ebullition.

Mercury unites by trituration with dense oils and mucilages, with which it forms black or deep blue compounds. A small part of the mercury in these seems to be in combination, and the rest in a state of extreme division. Rancid oils combine with mercury better than such as are fresh.

Mercury, being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called amalgams.

It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and antimony; and scarcely at all with platina or iron: it does not unite with nickel, manganese, or cobalt: and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back surface with an amalgam of tin. See SILVERING.

Mercury is found native in slaty or quartzose earths, or visibly diffused through masses of clay or stone. Native red oxide of mercury has also been found; and this metal has likewise been met with in combination with the sulphuric and muriatic acids. Its volatility may probably have caused it to be overlooked in many minerals that may contain it. The greatest quantity of mercury is found in combination with sulphur, in the form of cinnabar. Mercury is a scarce metal. Most of the mercury in commerce is afforded by the mines of Idria in the Austrian dominions, Almaden in Spain, and Guancavellica in Peru. The native mercury requires little more than washing, to separate it from its matrix. Cinnabar in the native state is frequently mixed with calcareous earth; in which case the mercury may be separated by distillation, because the calcareous earth combines with and detains the sulphur. The hidrosulphuretted ore of Idria, analysed by Klaproth, gave in the 100 parts, mercury 81·8; sulphur 13·75; carbon 2·3; silex 0·65; alumine 0·55;

oxide of copper 0·2; copper 0·02; water, that served to form the sulphuretted hidrogen gas that was evolved, and other loss, 0·73. Pure cinnabar may be decomposed by the addition of about one third of its weight of iron. In all cases wherein pure mercury is required, it must be distilled from cinnabar, or its sulphureous combination. For this purpose, the mercury may be converted into ethiops, and distilled with twice its weight of quicklime or iron filings. Mercury in commerce is judged to be pure when it is perfectly fluid, and runs in neat globules, without any pellicle on its surface, or without soiling a funnel of clean white paper, through which it may be poured by a very small aperture at bottom. If it leave nothing behind after evaporation, its purity may be still more depended on.

To analyse native cinnabar, its stony matrix should first be dissolved in nitric acid; and the cinnabar, being disengaged, should be boiled in eight or ten times its weight of aqua regia, composed of three parts nitric and one muriatic acid: the mercury may then be precipitated in the metallic form by the addition of zinc.

The uses of mercury have already been mentioned in the present article, and elsewhere. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, the making of barometers and thermometers, and the preparation of several powerful medicines, are the principal uses to which this metal is applied.

From the importance of the medicinal uses of this metal, and of having it perfectly pure for many other purposes, we shall subjoin the following methods of detecting adulterations, either of the metal itself, or its principal preparations, from Mr. Henry.

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal. Pour off the water, and digest the mercury with a little acetous acid This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or to this acetous solution add a little sulphat of soda, which will precipitate a sulphat of lead, containing, when dry, 72 per cent. of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriat of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

The *red oxide* is rarely found adulterated, as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

The *red oxide* of mercury by *nitric acid* is very liable to adulteration with red lead. This fraud may be discovered by digesting it in acetic acid, and adding to the solution sulphuretted water, or sulphuret of ammonia, which produces, with the compounds of lead, a dirty dark-coloured precipitate. It should also be totally volatilized by heat.

White oxide of mercury. White lead is the most probable adulteration of this substance, and chalk may also be occasionally mixed with it. The oxide of lead may be discovered as in the last article; and chalk, by adding to the dilute solution a little oxalic acid.

Red sulphuret of mercury is frequently adulterated with red lead; which may be detected by the foregoing rules. Chalk and dragon's blood are also sometimes mixed with it. The chalk is discovered by an effervescence on adding acetic acid, and by pouring oxalic acid into the acetous solution. Dragon's blood will be left unvolatilized when the sulphuret is exposed to heat, and may be detected by its giving a colour to alcohol, when the cinnabar is digested with it.

Black sulphuret of mercury. The mercury and sulphur, in this preparation, should be so intimately combined, that no globules of the metal can be discovered by a magnifier; and that, when rubbed on gold, no white stain may be communicated. The admixture of ivory black may be detected by its not being wholly volatilized by heat.

Yellow oxide, or sub-sulphat of mercury, should be wholly evaporable, and when digested with distilled water, the water ought not to take up any sulphuric acid, which will be discovered by muriat of barytes.

Corrosive muriat of mercury. If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows: Dissolve a small quantity of the sublimate in distilled water; add a solution of carbonat of ammonia till the precipitation ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper to this solution, a precipitate of a yellowish green colour be produced, the sublimate contains arsenic.

Sub-muriat of mercury, or calomel, should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with a thirty-second part of muriat of ammonia in ten parts of distilled water. When carbonat of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue. *Priestley on Air.—Phil. Trans.—Journ. de Phys.—Journ. de l'Inst.—Van Mons's Journ.—Nich. Journ.—Henry's Chem.*

Mercury of the Philosophers; and

Mercurification. I take these articles without alteration from the dictionary of Macquer, as the subject does not seem to require, or deserve, any very extensive research. Alchemists have given the name of mercury to many other things beside the metallic substance generally so called. The latter they call ordinary mercury, and value it little. We cannot precisely say what they meant by their mercury, from the obscurity of their writings, and also from their different descriptions of the matter. No term is more frequently used by them than this. In every page of their writings we find the words mercury, mercurification, &c. Probably they had not all the same idea annexed to the term philosophical mercury. The most probable opinion upon this subject is, that this mercury is the metallic principle, which Becher has called mercurial earth. See Earth, Mercurial.

Mercurification is an alchemical operation, by which metals are said to be reduced into a fluid, heavy, opake, and shining liquor, like ordinary mercury: or by which the mercurial principle may be extracted from metals, and obtained in the form of quicksilver. But these mercurified metals, or their mercurial principle rendered sensible, are a kind of philosophical mercury, which, although they resemble ordinary mercury, are nevertheless said, by persons exercised in such studies, to differ from it considerably, by having a greater specific gravity, by more effectually penetrating and dissolving metals, by a stronger adhesion to these, and by a less volatility.

W may find in the books of many authors who, though not alchemists, give more or less attention to these subjects, a great number of processes for mercurification, or for obtaining mercury of metals; most of which are very long, laborious, confused, and consequently subject to fail. The detail of these processes would be too long. An account of the principal of these operations may be seen in Junker's Conspectus Chemiæ. We shall only mention some of the easiest mercurifications extracted from the most modern authors, as Wallerius and Teichmeyert.

If cinnabar of antimony made with corrosive sublimate be distilled, we shall obtain, by reviving the mercury, a larger quantity of mercury than was originally in the corrosive sublimate.

If a corrosive sublimate be prepared with muriatic acid and fluid mercury, and if oxide or filings of silver be several times sublimed together with this corrosive sublimate, a part of the silver will be changed into mercury.

Very fine filings of iron, exposed during a year to the air, and afterward well triturated in a mortar, and cleansed from dust and extraneous matter, then exposed during another year to the air, and lastly distilled in a retort, furnish a hard matter, which attaches itself to the neck of the retort, and with this matter a little mercury.—*Teichmeyert.*

If oxide of copper be mixed with sal ammoniac, and this mixture exposed during a certain time to air, and distilled with soap, mercury will be obtained.

If luna cornea or plumbum corneum be mixed with an equal weight of very concentrated muriatic acid, digested together during three or four weeks, then an equal quantity of black flux and Venice soap added to it, and the whole matter distilled in a glass retort, some mercury will pass into the receiver.

These experiments are important, and easily made, but have not been repeated by modern chemists; for which we see no other reason, than the small hopes of their succeeding. If they should succeed, they would ascertain the existence of a mercurial principle in metals; or would confirm the theory of Becher, as all the experiments above mentioned are made with the muriatic acid, which that chemist supposes to contain the mercurial earth. The conclusion deducible from these experiments would be, that, by introducing a superabundant quantity of mercurial earth into metals, a true mercury might be obtained from them. See Metals.

Many other processes for mercurification may be seen in authors who have treated of this matter, particularly in Junker's book above quoted, in which muriatic acid is not employed, but other saline matters, or sublimation through the burning fuel, with concourse of free air, in Geber's manner. In this latter case, we must look for the mercurial substance in the metallic fumes and flowers; and if any such substance be obtained, it must evidently proceed from the decomposition of the metallic matter employed.

Mr. Grosse says, in the Memoirs of the Academy, that he obtained mercury from lead by an easier and simpler process than those above mentioned. This consists in saturating perfectly some good nitric acid with lead, which may be done effectually by employing more lead than the acid can dissolve; and from this solution, according to Mr. Grosse, a gray powder is precipitated, in which mercury is discovered. This experiment being short, Messrs. Macquer and Beaumé repeated it with due attention in their Course of Chemistry; but they did not find the gray mercurial powder mentioned by Mr. Grosse. As the exactness and veracity of that able chemist are well known, we must believe that the lead which he employed contained some extraneous mercury, which might easily happen in a laboratory. The same thing has possibly happened in other experiments of mercurification; and this proves how circumspect we ought to be in drawing conclusions.

Metals. Metallic substances are very easily distinguishable from all other bodies in nature, by their very great weight, and that opake shining appearance, which is called the metallic splendour or brilliancy. Very few substances have half the specific gravity of the lightest among the metals. They are all fusible, though at very different temperatures; and if the fusion be made in close vessels, they fix again by cold, without having suffered any change but that of external figure, which must be produced in all bodies which have been either liquefied or volatilized; namely, they assume the form of the vessel which contains them. Some of them may be extended considerably by the hammer, without breaking them. This property is called malleability; and the metallic bodies which possess it are called entire metals, or metals, in contradistinction to such as are more brittle, and are called semimetals. Metallic substances are also called perfect and imperfect. The perfect are such as undergo no lasting change of their properties by any heat we can apply to them, at least in common furnaces. The imperfect metals, when exposed to a strong heat, with access of oxigen, are changed, by a process similar to burning, and in some of them with an actual flame, into a brittle dull substance, called an oxide, which is heavier than the metal it came from, though its specific gravity is not so great. Some are even converted into acids. If the oxide of a metal be exposed to strong heat in a closed vessel, with some inflammable matter, it recovers its metallic state. This is called reduction, or reviving of the metal.

A more recent arrangement of metals, and perhaps the best, is that of Dr. Thomson, who divides them into 4 classes. 1. *Malleable metals.* Platina, gold, silver, nickel, mercury, palladium, rhodium, iridium, osmium, copper, iron, tin, lead, and zinc. 2. *Brittle and easily fused.* Bismuth, antimony, tellurium, and arsenic. 3. *Brittle and difficult of fusion.* Cobalt, manganese, chrome, molybdena, uranium, tungsten, and titanium. 4. *Refractory,* or such as have never yet been reduced. Columbium, tantalium, and cerium.

Metals, like other fusible bodies, have each a fixed temperature, or freezing point, at which they become solid. They assume a crystallized figure in cooling, which is different in each, and may be seen by fusing them in melting-pots with a hole in the bottom stopped with a stopper; or better, in many cases, by a dish or flat mould, and tilting it; for, in this case, if the surface be suffered to congeal, and the fluid metal beneath be suffered to run out through the hole, the under surface of the remaining metal will be curiously crystallized. The specific gravity of metallic substances is very considerably affected by the gradual or hasty cooling, or transition from the fluid to the solid state. Hammering renders them harder and more elastic; but this effect is destroyed by ignition.

The affinities of metals to each other are various. Some will not unite at all; others mix very readily, and even combine together. On this property is founded the art of soldering; which consists in joining two pieces of metal together by heating them, with a thin piece or plate of a more fusible metal interposed between them. Thus tin is a solder for lead; brass, gold, or silver, are solders for iron, &c.

Mountainous districts, where the surface of the globe has been thrown up or disturbed, in remote ages, by earthquakes, volcanoes, or other great convulsions of nature, are the most abundant in metallic bodies. In digging into the bowels of the earth, the various metals are mostly found disposed in strata or beds, which in plains lie level, but in mountains are inclined; whence it happens, that in mountainous countries some strata are often exposed to the day, which would else have been too deeply lodged to be come at by human art. It is in the stratified mountains that metals are usually found, mostly in a state of combination either with sulphur or arsenic, or in the state of an oxide. They are also found, though less frequently, in the metallic or native state.

The combinations, or earthy bodies which contain metals in sufficient quantity to be worth extracting, are called ores. Iron ore sometimes forms entire mountains; but in general the metallic part of a mountain is very inconsiderable in proportion to the whole. The ores run either parallel to the stony strata, though far from having the same regularity of thickness, or they cross the strata in all directions. These metallic strata are called veins. The cavity formed by art in the earth, for the extraction of metals or any other mineral bodies, is called a mine. The stone, wherein a metallic ore is usually bedded, is called its matrix. These are not peculiarly appropriated to any meal, though some stones more frequently accompany metals than others.

The general operations by which metals are obtained from ores are—1. The minerals are selected; and such only are taken as from experience are known, by the external figure or appearance, to contain metal. 2. They are reduced to powder; and the ighter parts washed away, by means of water, in a shallow trough. 3. The volatile parts are dissipated by the operation called roasting. 4. The ores are smelted by throwing them into the midst of the fuel of a furnace, with earthy substances, which are disposed to run into glass. In this operation, the glassy matter, called scoria, in some measure produces the effect of rendering the lower part of the furnace a closed vessel; and the fuel revives the metal, which n the ore is usually of the nature of oxide. The revived metal being much denser than the scoria falls to the bottom, and is suffered to run out by proper openings. These are the general operations, but they are not all necessary in all cases; and the particular practice with the several ores of each metal must vary according to the properties of the metal itself, and the different substances it is united with.

The extraction of metals from ores, in the small way, which is necessary to be made in order to ascertain whether the specimens be worth working, is called assaying or essaying. In these small trials, the fusibility of the pounded ore is increased by an addition of black flux, which s an impure alkali, formed by mixing two parts of tartar with one of nitre, and setting them on fire. Metallic ores may be very accurately assayed by solution and precipitation in the humid way. See the several Metals, also Assay.

Most metals will uniformly mix with each other; and the specific gravity of the compound is seldom such, as would have been deduced from the supposition of a mere mixture, or simple apposition of parts. Their fusibility is likewise greatly changed by mixture, and according to no certain rule yet discovered.

Mixtures of metals are frequently called alloys. But the word alloy, or allay, is mostly used to denote a portion of metal which is added to the precious metals, gold or silver.

Metals are mostly soluble in acids, with which they form salts. When a metal is added to an acid, the general effect produced is the same as would have arisen from the addition of any other combustible substance to the acid. If an alkali or earth be added to a metallic solution, the metal falls to the bottom in the form of an oxide. But if a metal, which has a stronger affinity with the acid than the metal already dissolved has, be added to such a solution, the former metal will fall to the bottom in its metallic state, and the latter will be dissolved without causing any of the escape of elastic fluid, and other appearances, which would have taken place if it had been applied to the mere acid; notwithstanding which, the latter metal, if precipitated by an incombustible substance, such as an alkali or earth, will be in the state of an oxide. Phosphorus likewise precipitates them in the metallic state.

It is evident, from these facts, that the action of acids upon metals is similar to that of heat with access of oxigen; and of course may be accounted for in the same manner as combustion itself.

Metals are precipitated by each other in the same order, or nearly so, in all acids. Hence it is inferred, that this effect is produced by the reaction of some common principle, and this the oxigen of the acids.

Acids dissolve metals only in their oxided state; and there is a certain limit near which the solution is best performed. If an acid be of such a nature as to be incapable of oxiding a metal, it will not dissolve it, though the same acid would dissolve the oxide if presented to it; and if the oxidation be carried too far, the oxide will likewise be insoluble. To explain this it may be observed, that the simple metal attracts as much oxigen from the acid as is sufficient to convert itself into an oxide, but not enough to saturate it with that principle; it is therefore suspended, in consequence of its remaining weak attraction for the oxigen of the acid. But if the oxidation be complete, that is to say, if the affinity of the metal for oxigen be perfectly satisfied, the remaining attraction of the metal for oxigen will cease, and it will be insoluble.

The direct action of alkaline salts upon metals is not considerable: but several of the oxides are dissolved by them; and from these solutions the metal may be precipitated in its metallic state, by adding another metal more soluble in the alkali. Sulphur combines with most of them readily in the way of fusion; and the combination of sulphur with an alkali is a powerful solvent of all metals except zinc. Nitre heated with metals acts in the same manner as it does with other inflammable bodies: it deflagrates, and the metals become oxided. The perfect metals resist the action of nitre.

Metallurgy. The characters, from which mineralogists pretend to assert the existence of an ore in the bowels of the earth, are all equivocal and suspicious. The savage aspect of a mountain, the nature of the plants which grow upon it, the exhalations which arise from the earth, all afford characters too doubtful, for a reasonable man to risk his fortune upon such indications alone.—The dipping wand, or divining rod, is the fruit of superstition and ignorance: and the ridicule, which has been successively thrown upon this class of impostors, has diminished their number; at the same time that the numerous dupes of this class of men have rendered their successors more prudent. It is nevertheless used in Cornwall to this day.

The nature of the stones which compose a mountain is capable of furnishing some indications, We know, for example, that ores are seldom found in granite and the other primitive mountains; we know likewise, that mountains of too modern a formation contain them very rarely; and we find them only in secondary mountains, in which the schistus and ancient calcareous stone are void of all impressions of shells.

The presence of ponderous spar, forming a stratum or vein at the surface of the earth, has been considered by many mineralogists as a very good indication. Chaptal shows very good reason for believing, that this stone is the same which Becher has spoken of in his works, under the name of Vitrifiable Earth, which he considered as a principle of metals; and that it has been very unproperly taken for quartz by his readers.

When we possess indications of the existence of an ore in any place, we may use the borer, to confirm or destroy these suspicions, at a small expense.

It frequently happens, that the veins are naked or uncovered: the mixture of stones and metals forms a kind of cement, which resists the destructive action of time longer than the rest of the mountain; and as these parts of rocks, connected by a metallic cement, present a stronger resistance to the action of waters, which incessantly corrode and diminish mountains, and carry away their parts into the sea, we frequently observe the veins projecting on the sides of mountains incrusted with some slight metallic impression, altered by the lapse of time.

The nature of an ore is judged from inspection. A slight acquaintance with this subject is sufficient to enable the observer to form an immediate judgment of the nature of an ore. The blowpipe is an instrument, by the assistance of which we may in a short time become acquainted likewise with the species of the ore. See Blowpipe. This knowledge forms the docimastic art, or docimasia. In order to make the assay of an ore, in general, for all ores do not require the same process, small pieces of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torrified in a vessel larger and less deep than a common crucible. By this means the sulphur, or the arsenic in combination with the metal, is dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This first operation shows the proportion and quantity of sulphur and arsenic, which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight, which the metal has undergone in passing from its metallic state to that of oxide, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree of heat being applied, the metal is precipitated to the bottom of the crucible in a button, the weight of which indicates the quantity of metal contained in the ore.

These fluxes must be varied according to the nature of the ores under examination. It is necessary, that they should all contain carbon, to disengage the oxigen with which these metals are combined. But the nature of the flux must be varied according to the fusibility of the metal. The following will answer all these purposes:

1. The fusible material called black flux is made with two parts of tartar, and one part of nitre, melted together. The carbonaceous and alkaline residue is used to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of slaked lime, and one hundred grains of the ore intended to be assayed, form the flux of Scopoli, which Chaptal found advantageous in the assay of iron ores.

3. The vitreous flux of Guyton-Morveau, made with eight parts of pounded glass, one of borax, and half a part of powder of charcoal, may be employed for the same purpose.

4. Arsenic and nitre, in equal parts, form likewise a very active flux.

The neutral combination of oxide of arsenic and potash has been used with success to fuse platina.

As soon as the existence of a mine and its nature and riches are ascertained, it is in the next place necessary to be assured of a sufficient abundance and continuity of water, to answer the purposes of the works. It is likewise necessary, to be assured of possessing a sufficient quantity of wood or coal, and more especially a good director must be procured: for a poor mine well managed is preferable to a rich one ill conducted.

Those preliminary circumstances being accomplished, the most simple and least expensive processes must be employed in extracting the mineral from the bowels of the earth. For this purpose, shafts or galleries must be dug, according to the position of the vein, and the nature of its situation, When it is practicable to arrive at the side of the vein, and at a certain depth, by a horizontal gallery, the works become more simple and œconomical; the same opening serving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and shafts sunk, which communicate with the open air, as likewise others carried down into the vein. Galleries are likewise constructed, one above the other, and the communication of the works kept up by ladders. When the soil is friable, and defective in solidity, care must be taken to support it with timbers of sufficient strength to prevent its falling in.

Pickaxes, wedges, and levers are used to detach the ore, when the rock is soft; but it is most commonly necessary to employ gunpowder.

Want of air, and the abundance of water, are almost always noxious, and derange mine-works. The water is carried off by fire-engines, wind-mill pumps, and other suitable apparatus.

Currents of air are produced by establishing communications with the galleries, by horizontal apertures. Furnaces erected on the side of a shaft, to which a long tube is adapted at one end, communicating with the ash-hole, and at the other plunging into the shaft to draw up the air, or ventilators placed in the same situation, answer a similar purpose. The foul air is destroyed by exposing to it a caustic lixivium: sprinkling quicklime about the mine likewise produces the same effect.

A prudent company ought to extract the largest possible quantity of ore, before they determine upon constructing the necessary works for the subsequent processes, We cannot see into the bowels of the earth. Appearances are often deceitful; and we have seen companies either ruined or discouraged, because they had employed immense sums to construct the necessary furnaces to work an ore, the existence of which was doubtful. When the proceedings, in an undertaking of this kind, are carried on with proper precaution; and no more expense is entered into, than what the ore extracted, and of a known value, is capable of defraying; the probable losses are very slight, even in the poorest mine.

The works ought to be varied according to the nature and state of the mineral. It is found in three states:—1. In the form of a native metal: in this case, nothing more is necessary than to extract it out of the mine, to clear it of the extraneous substances, and to fuse it. 2. In the form of oxide: and in this state it is sufficient, if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subsequent to the extraction, vary according to the nature of the ore, there are nevertheless certain general operations, to which every kind of ore is subjected.

The first business must be to clear the metal of the stony matter or matrix. For this purpose, when the ore is extracted, children are employed, who examine it, and separate the pure ore, or rich mineral, from that which is mixed with the gangue. As in this second quality the stone is mixed with the ore, the whole is pulverized by means of a stamping mill, consisting of pestles of wood, shod with iron, and armed with cocks, which are raised by levers proceeding from the axis of a wheel which constantly turns. The mineral is by this means crushed and pulverized; and a stream of water, which is made to pass over it, carries away both the metallic and stony particles; the former being deposited in the first vessels through which the water is made to circulate, while the latter, or stony part, is carried to a greater distance, on account of its comparative lightness.

This pulverized ore is called slich; and in order to separate all the earthy parts, it is washed upon tables slightly inclined, over which a constant stream of water is made to flow. The slich is agitated with brooms; the water carries away all the fragments of stone, and leaves the pure ore upon the table.

The roasting of the mineral succeeds the washing. In this operation, the mineralizer is carried off. Fire is always the agent made use of. Sometimes the pounded mineral is disposed in piles upon heaps of fuel, which being set on fire heat the ore strongly, and drive off the mineralizer. This calcination possesses the double advantage of disposing the metal for fusion, as well as clearing it of the mineralizing substance. When the ore is more friable, it is spread out in a reverberatory furnace; and the flame which reverberates upon it deprives it of its mineralizer, at the same time that it partly fuses it.

Mr. Exchaquet has proposed to destroy the sulphur by nitre in assays. This process is excellent for copper ores: the quantity of nitre varies according to the quantity of sulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for some minutes.

The fusion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a trompe. See Trompe.

Meteors, and

Meteorology. The state and condition of the great fluid mass, in which we breathe, and the changes which take place therein, are objects of no small importance to the chemical philosopher. Among the variety of experiments on permanently elastic fluids, it is found, that most of them are capable of uniformly mixing together, when their nature is such as not to act per ceptibly upon each other. But in the extensive mass of the atmosphere, it seems likely, that considerable separations of its component parts take place, in consequence of their different specific gravities. This supposition is countenanced by several optical phænomena, such as the double appearance of head lands. In this way some writers account for the appearance of the aurora borealis, shooting stars, and other similar appearances, which they suppose to consist of hidrogen gas, occupying the upper region of the atmosphere, and fired by electricity. It is a remarkable circumstance, that most of these fiery appearances happen at an elevation, which is geometrically determined to be almost twice as great as that which astronomical writers, by deductions founded on the refraction of the light of the heavenly bodies, and the law of dilatation of air near the surface of the earth, have assigned as the sensible limit of the atmosphere. Hence it should follow, that the elasticity of the upper parts exceeds that of the lower; which affords no inconsiderable presumption, that this upper part is chiefly composed of such air as we know to be the most elastic, namely, hidrogen. The composition of water, out of the two ingredients, oxigen and hidrogen, has also afforded ground for meteorological induction. It has been concluded, that water is not only condensed and precipitated by the agency of electricity, in thunder storms. but that it is likewise composed out of its elements by the combustion of these two airs, in every case where atmospherical corruscation is exhibited.

The phænomena of winds, though chiefly depending on the hydrostatical change in the density of the air by alteration of temperature, well deserve the attention of the chemist. The effect of furnaces, the clearing of laboratories, burial vaults, houses of office, mines, and other excavations, from noxious effluvia, are all governed by general laws of the same nature, as those which cause the currents of air around us. Even the sudden and frequently impetuous current of air, which accompanies a fall of rain, or squall, though it is merely produced by the mechanical action of the falling drops of water, has afforded ground for useful meditation. There is no doubt, but we are indebted to considerations on this natural appearance for the cheap and useful blowing-machine, which the French call a trompe. See TROMPE.

It may seem at first sight, as if observations on the standing of the barometer and thermometer were of no very immediate use to the practical chemist But if it be considered, that the effect of an air furnace depends on the difference of the density of the air in the chimney, and that which enters the ash-hole; and that the mere difference indicated by the barometer amounts to one fifteenth part, in its extremes, of the whole quantity of the external air, in a given place; not to mention the effect pointed out by the thermometer; it will not appear strange, that these causes should greatly influence the results in metallurgical operations, and be very perceptible in the burning of our culinary fires. The philosophical chemist is no less interested in the state of the air, as shown by these instruments. For it cannot but be of great consequence to his deductions, to know the external pressure, which is constantly acting upon the elastic fluids he may either weigh or measure. If this and the temperature be not carefully attended to, he will scarcely find any two results, made at distant times, agree.

The presence of moisture, or rather its disposition to be absorbed, or given out, as shown by the hygrometer, must be of considerable importance. It affects the elasticity of every kind of air, and there is no doubt but combustion and its products will vary accordingly as it is maintained by an air, which is moister or more dry. It is probable, that the quantities of finery cinder afforded by iron may vary from this cause.

The effects of solution and precipitation, analogous to what happens in denser fluids, have been, perhaps too fancifully, delineated among the atmospheric changes. But there is every reason to think, that, as our knowledge of the great system of nature shall improve, the play of the chemical affinities will show itself more evidently in the atmosphere.

Within these few years the attention of chemists has been particularly called to a very remarkable phænomenon in this department of science. Reports of stones falling from the atmosphere had been generally discredited, from the improbability of the fact. But the progress lately made in science has established so many facts contrary to long received opinions, and so far extended the limits of possibility, that men are become much more cautious of peremptorily refusing to credit a thing, merely on account of its seeming improbable; and are inclined to investigate, before they deny. Thus an inquiry has been instituted, and it appears, that such occurrences have been recorded from time to time from a remote period, that they have happened in various quarters of the globe, that the testimony is corroborated by circumstances, and that in many recent instances it appears incontrovertible.

It is remarkable, that all the stones, at whatever period, or in whatever part of the world, they may have fallen, have appeared, as far as they have been examined, to consist of the same substances; and to have nothing similar to them, not only among the minerals in the neighbourhood of the places where they were found, but among all that have hitherto been discovered in our earth, as far as men have been able to penetrate. For the chemical analysis of a considerable number of specimens we are particularly indebted to Mr. Howard, as well as to Klaproth and Vauquelin, and a precise mineralogical description of them has been given by the Count de Bournon and others.

They are all covered with a thin crust of a deep black colour, they are without gloss, and their surface is roughened with small asperities. Internally they are grayish, and of a granulated texture, more or less fine. Four different substances are interspersed among their texture, easily distinguished by a lens. The most abundant is from the size of a pin's head to that of a pea, opake, with a little lustre like that of enamel, of a gray colour sometimes inclining to brown, and hard enough to give faint sparks with steel. Another is a martial pyrites, of a reddish yellow colour, black when powdered, not very firm in its texture, and not attractable by the magnet. A third consists of small particles of iron in a perfectly metallic state, which give to the mass the quality of being attracted by the magnet, though in some specimens they do not exceed two per cent of the whole weight, while in others they extend to a fourth. These are connected together by a fourth of an earthy consistence in most, so that they may be broken to pieces by the fingers with more or less difficulty. The black crust is hard enough to emit sparks with steel, but may be broken by a stroke with a hammer, and appears to possess the properties of the very attractable black oxide of iron. Their specific gravity varies from 3·352 to 4·281.

The crust appears to contain nickel united with iron, but Mr. Hatchett could not determine its proportion. The pyrites he estimates at iron ·68, sulphur ·13, nickel ·06, extraneous earthy matter ·13. In the metallic particles disseminated through the mass the nickel was in the proportion of 1 part, or thereabout, to 3 of iron. The hard separate bodies gave silex ·50, magnesia ·15, oxide of iron ·34, oxide of nickel ·025: and the cement, or matrix, silex ·48, magnesia ·18, oxide of iron ·34, oxide of nickel ·025. The increase of weight in both these arose from the higher oxidation of the iron. These proportions are taken from the stones that fell at Benares on the 19th of December, 1798.

The solitary masses of native iron, that have been found in Siberia, Bohemia, Senegal, and South America, likewise agree in the circumstance of being an alloy of iron and nickel; and are either of a cellular texture, or have earthy matter disseminated among the metal. Hence a similar origin has been ascribed to them.

Laugier, and afterward Thenard, found chrome likewise, in the proportion of about 1 per cent, in different meteoric stones they examined; but they appear not to have analysed the parts separately.

In all the instances in which these stones have been supposed to fall from the clouds, and of which any perfect account has been given, the appearance of a luminous meteor, exploding with loud noise, has immediately preceded, and hence has been looked to as the cause. The stones likewise have been more or less hot, when found immediately after their supposed fall. Different opinions however have been entertained on this subject, which is certainly involved in much difficulty. Some philosophers imagine them to be formed in the atmosphere by a sudden condensation of the elements of their component parts: others, that they already existed on the spot where they were found, and were merely struck by the electric discharge: and prof. Proust has suggested, that they might be torn from the polar regions by the meteor. Some have supposed them to be merely projected from volcanoes: while others have suggested, that they might be thrown from the moon; or be bodies wandering through space, and at length brought within the sphere of attraction of our planet.

We shall conclude this article with the instances that have occurred during the present century. On the 26th of April 1803, a shower of stones, weighing from 18 lbs to ¼ of an ounce, and supposed to be two or three thousand in number, fell in the neighbourhood of l'Aigle in Normandy, on a space about six miles long and two broad. On the 4th of July a stone struck a house at East Norton, with an explosion, by which the house was much damaged. On the 8th of September a stone fell near Apt, in the country of Avignon. On the 13th of December a stone fell on a barn at a small village in Germany, and broke the rafters of the roof. On the 5th of April, 1804, a stone fell at Possie, about three miles from Glasgow. And on the 15th of March, 1806, one fell at Valence, in the *arrondissement* of Alais, in France.—*Phil. Trans.*—*Journ. des Mines.*—*An. de Chim.*—*J. de Phys.*—*Phil. Mag.*

Metheglin. A fermented beverage made from honey and water.

Mica. This stone in its purest state is colourless; but either from a less intimate combination, or from a mixture of some superfluous ingredient, principally iron, it is found of different colours, white, red, yellow, green, brown, or black (the white and yellow sort have a splendid metallic appearance), smooth, but not greasy to the touch, which distinguishes it from talc. Its texture is always lamellar or scaly, and the lamellæ, or scales, are slightly flexible and often elastic; these scales are sometimes parallel to each other, sometimes interwoven, sometimes wavy or undulated, and sometimes they represent filaments. Its specific gravity is from 2·535 to 3·000, when loaded with iron.

It does not effervesce with acids, and is insoluble in them without particular management; but after it has been calcined with four times its weight of fixed alkali, it effervesces strongly, and is in great measure soluble.

The pure colourless mica is infusible *per se*, and scarcely melts even with mineral alkali, but yields more readily to borax or microcosmic salt, with scarce any effervescence; but the coloured sorts were found by Mr. Saussure to be fusible *per se*, though with difficulty, for they require a stronger heat than shoerl does.

One hundred parts of the colourless kind contain 38 of silex, 28 of alumine, 20 of magnesia, and 14 of highly oxided iron. Martial mica contains, besides, 10 or 12 per cent of less oxided iron, from which its various colours are derived, and a proportionably smaller quantity of the other ingredients.

The white and yellow micas in powder are used to sand writing by the name of gold or silver sand.

Microcosmic Salt. A triple salt of soda, ammonia, and phosphoric acid, obtained from urine, and much used in assays by the blowpipe.

Mild Alkalis, *or* Earths. The alkalis and lime are usually met with in combination with carbonic acid. Heat expels this substance from lime, and the alkalis are deprived of it by the superior attraction of pure quick lime, with which they are treated for this purpose. These practical operations were performed long before the existence and properties of carbonic acid were well ascertained. The alkalis and lime, when combined with carbonic acid, obtained the name of mild, from their slight action upon organized substances, compared with their action when deprived of it. In the latter state, they were said to be caustic. The terms caustic and mild are still frequently applied to the alkalis, and also to lime, magnesia, and barytes.

Milk is a well known fluid, secreted in peculiar vessels of the females of the human species, of quadrupeds, and of cetaceous animals, and destined for the purpose of nourishing their young. Its appearance and component parts are not altogether the same in various species of animals; and a peculiar smell is distinguished in each when fresh drawn, but this soon goes off. The milk of the cow, with which we are best acquainted, is of a beautiful opake white colour, and of a pleasant emulsive taste. Its appearance on the stage of a microscope exhibits an infinity of minute opake globules floating in a transparent fluid. Distilled on a water bath, it affords a tasteless phlegm of a faint smell, which is capable of putrefying. A stronger heat coagulates it. It is sometimes gradually dried into a substance, which is a kind of saccharine extract, and may again be diffused in water.

When milk is left to spontaneous decomposition, at a due temperature, it is found to be capable of passing through the vinous, acetous, and putrefactive fermentations. It appears however, probably on account of the small quantity of alcohol it affords, that the vinous fermentation lasts a very short time, and can scarcely be made to take place in every part of the fluid at once by the addition of any ferment. This seems to be the reason, why the Tartars, who make a fermented liquor, or wine, from mare's milk, called koumiss, succeed by using large quantities at a time, and agitating it very frequently. They add as a ferment a sixth part of water, and an eighth part of the sourest cow's milk they can get, or a smaller portion of koumiss already prepared: cover the vessel with a thick cloth, and let it stand in a moderate warmth for 24 hours: then beat it with a stick, to mix the thicker and thinner parts, which have separated: let it stand again 24 hours in a high narrow vessel, and repeat the beating, till the liquor is perfectly homogeneous. This liquor will keep some months, in close vessels, and a cold place; but must be well mixed by beating or shaking every time it is used. They sometimes extract a spirit from it by distillation. The Arabs prepare a similar liquor by the name of *leban*, and the Turks by that of *yaourt*. Eton informs us, that, when properly prepared, it may be left to stand till it becomes quite dry; and in this state it is kept in bags, and mixed with water when wanted for use.

The saccharine substance, upon which the fermenting property of milk depends, is held in solution by the whey, which remains after the separation of the curd in making cheese. This is separated by evaporation in the large way, for pharmaceutical purposes, in various parts of Switzerland. When the whey has been evaporated by heat, to the consistence of honey, it is poured into proper moulds, and exposed to dry in the sun. If this crude sugar of milk be dissolved in water, clarified with whites of eggs, and evaporated to the consistence of sirup, white crystals, in the form of rhomboidal parallelopipedons, are obtained.

Sugar of milk has a faint saccharine taste, and is soluble in three or four parts of water. It yields by distillation the same products that other sugars do, only in somewhat different proportions. It is remarkable, however, that the empyreumatic oil has a smell resembling flowers of benzoin. It contains an acid frequently called the saccholactic; but as it is common to all mucilaginous substances, it has more recently been termed mucous. See Acid, Mucous.

Thenard, who is one of the latest chemists who have examined milk, gives the following as its component parts: 1. Water. 2. Acetous acid. 3. Caseous, 4. Butyraceous, 5. Saccharine, and 6. Extractive matter. 7. 8. Muriats of soda and potash. 9. Sulphat of potash. 10. 11. Phosphats of lime and magnesia. The acid, now ascertained to be the acetous, was considered as peculiar to milk, and termed lactic.

The principles of milk appear to be united together partly in a chemical, and partly in a mechanical manner; and the butter seems to rise to the top, in consequence of the greater specific gravity of the whey, through which it is dispersed. Cream consists of butter mixed with much whey and curd. It is generally thought, that the separation of the butter by churning is effected simply by the agitation, which causes the fatty particles to strike against each other, and coagulate into larger masses. There seems, however, some reason to think, that a chemical effect takes place in this operation; in which, the intimate mixture of atmospheric air with the fluid may perhaps have some effect. For BUTTER and CHEESE see those articles.

The kinds of milk that have been chemically examined are mare's, woman's, ass's, goat's, sheep's, and cow's. We have here placed them according to the proportion of *sugar* they afforded; and this, Parmentier observes, was precisely of the same quality in all, while all the other parts varied in quality as well as quantity in the different milks. With regard to the *whey*, they rank in the following order; ass's, mare's, woman's, cow's, goat's, sheep's: to *cream;* sheep's, woman's, goat's, cow's, ass's, mare's: to *butter;* sheep's, goat's, cow's, woman's: to *cheese;* sheep's, goat's, cow's, ass's, woman's, mare's. Parmentier could not make any butter from the cream of woman's, ass's, or mare's milk; and that from sheep's he found always remained soft. From their general properties he has divided them into two classes, one abounding in serous and saline parts, which includes ass's, mare's, and woman's: the other rich in caseous and butyraceous parts, which are cow's, goat's, and sheep's.—*An. de Chim.—Soc. Philom.—Eton's Survey.—Journ. de Phys.*

MILLEPEDES. The millepedes, aselli, porcelli, onisci, &c., presented certain peculiar circumstances in their analysis, made by Mr. Thouvenel. By distillation on the water bath, without addition, they afford an insipid and alkaline phlegm, sometimes effervescing with acids, and converting the sirup of violets to a green: in this operation they lost five eighths of their weight. By treatment with water and alcohol, they afterward afforded two drachms of soluble matter in the ounce; of which more than two thirds was extractive matter, and the residue an oily or extractive substance. These two matters were easily separated by ether, which dissolves the latter without touching the extract; they differ from those of cantharides, and ants, in affording more carbonat of ammonia, and no acid in their distillation.

The neutral salts contained in these insects are very small in quantity, and very difficult to be extracted. Mr. Thouvenel affirms, that the millepedes, earth worms, and lumbrici, constantly afforded him the muriats of lime and potash; while in ants and cantharides, these two bases, the first of which always appeared to him the most abundant, are united with an acid, which has the character of the phosphoric. It is necessary to be observed here, that this chemist, in his Dissertation, has not described either the methods of extracting these salts, or the processes he made use of to ascertain their nature.

MINERAL KINGDOM. Every substance, which does not possess organisation, or is not the immediate product of some organised body, belongs to the mineral kingdom. Among the numerous variety of materials, which demand the attention and exercise the ingenuity of the chemist and the manufacturer, some are compounded of such principles, and formed under such circumstances and situations in the earth, that it is difficult to distinguish them without recurring to the test of experiment. Others are formed with considerable regularity as to the proportion of their principles, their colour, fracture, specific gravity, and crystallized figure. Every practical mineralogist is naturally disposed to avail himself of the external figure and obvious characters of bodies, to distinguish them from each other; and we daily see instances of great skill in this method of discrimination. It happens unfortunately however for the acquisition of this branch of knowledge, that the differences depend upon circumstances, which, for the most part, are scarcely communicable by mere description, without the exhibition of specimens. Hence it has in many instances happened, that chemists have obtained possession of quantities of minerals, the names of which they could not with any degree of certainty ascertain, until they had made some experiments to determine their component parts. Much industry has been employed with success in simplifying the experiments with reagents, and with the blowpipe for this purpose. Thus it has arisen, that mineralogy has been assiduously cultivated by two different descriptions of men. The one have noted the figures, measured the angles, described the colours, transparency, opacity, texture as ascertained by fracture, hardness, and the like evident properties; the other have passed slightly over these indications, and have attended chiefly to such component parts as chemical analysis exhibits. The best system for the classification of minerals must be that in which the external characters, as well as the component parts, are noticed; for there is no reason why we should neglect any of the means of obtaining an accurate knowledge of bodies. The component parts or principles of minerals afford the great outlines for classing them under general species and varieties; and their external appearances, when not sufficiently decisive to the observer, will always be useful to point out the experiments he must make to ascertain their place. The modern systems of Bergman, Kirwan, Chaptal, Schmeisser, and Babington, are grounded on considerations of this nature. See ANALYSIS and BLOWPIPE.

MINERALIZER. Metallic substances are said to be mineralized, when deprived of their usual properties by combination with some other substance. The commonest mineralizers are sulphur, arsenic, and carbonic acid. Oxigen is as common as any, but is not usually reckoned among mineralizers. Arsenic is likewise excluded from mineralizers by some writers, who affirm that it is always united to metals in its metallic state. But as there are good reasons to conclude, that it exists in such combinations in the form of oxide or acid, the argument cannot be admitted as conclusive. The sulphuric and muriatic acids are less common mineralizers. The phosphoric acid exists in the green lead ore, and less evidently in some of the ores of iron. Lead is found mineralized likewise by the molybdic and chromic acids. Carbonic acid exists in many of the calciform ores.

MINES. See METALLURGY.

MINIUM. Red lead, or minium, may be made directly from lead, and also from litharge, which can be had cheaper from various processes where lead is employed. But the latter red lead is not so good as the former, on account of the scoria of other substances mixed with the litharge. The makers of flint glass, who use much red lead in the composition of that glass, find, that it does not flux so well as that made from the direct oxidation of the metal, as practised in the county of Derby, where no less than nine mills or furnaces are kept on this operation. These furnaces are very like a baker's oven, with a low vaulted roof, and two party walls, rising from their floor, which leave a middle space, where the pit coal is burned: the flame, being drawn over the party walls, strikes on the roof, and is thence reflected on each side, by which the lead there kept is melted. The surface of lead, by its exposition to air, becomes instantly covered with a dusky pellicle; this is successively removed, and the greater part of the metal is converted into a yellowish green powder: this is afterward ground fine in a mill, and washed; the heterogeneous particles of lead, still remaining, are separated by passing the wash through sieves; the yellow colour becomes uniform, and is called massicot by the painters. The yellow oxide, being well dried, is thrown again into the furnace, where it is constantly stirred in a continual heat; so that in about 48 hours this oxide acquires a vivid red, inclining to orange colour, and is known by the name of minium, or red lead. Mr. de Machy was certainly mistaken, when he asserted, that the oxidation alone, without the contact of the flame and smoke, was capable of producing a good colour. But the red lead made in France is of a considerably worse quality than what is made in England or Holland. A ton of lead generally gives twenty-two hundred weight of minium. It is said, that at Nuremberg the increased weight of red lead amounts to one fifth of the metal; this may probably depend on the method employed, as Watson thinks. Neumann says, that the best Venetian minium is made out of ceruse, or white lead.—*Magellan.*

MIRABILE, SAL. Sulphat of soda.

MIRACLE, CHEMICAL. If to a concentrated solution of muriat or nitrat of magnesia, a like solution of fixed alkali be added, the magnesia is separated immediately in so large a quantity, that the mixture becomes nearly solid. This sudden conversion of two fluids into a solid has been called the chemical miracle.

MIRRORS. See SPECULUM; also SILVERING.

MISPICKEL. An ore of iron consisting of that metal mineralized by arsenic. It is called speiss by the Bohemians. Its colour is generally of a bright white, resembling a mixture of silver and tin, sometimes, though seldom, variegated like a pigeon's neck, and is not easily altered by exposure to the air. Its form is either granular, cuspidated, cuneiform, prismatic, or rhomboidal. It is magnetic neither before nor after calcination, is soluble in acids, affords arsenic by distillation in the proportion of 30 or 40 per cent, and sometimes contains a small proportion of copper and silver. It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shoerl, &c.

A marcasite found near Dublin, called Irish diamond, is of this species.

MIXTURE. This term was formerly used to denote what chemists now mean by combination. At present it is applied to distinguish that aggregation, which takes place when powders or liquids, not disposed to combine from defect of temperature, or any other cause, are added together. Thus sand and an alkali may be mixed together, without any perceptible combination or change of their respective properties; but if the temperature be raised to that of strong fusion, they combine, and form glass, the principles of which are no longer in a state of mere mixture.

MOCHA or **MOCHO STONE.** The agate, when it contains arborizations, or small figures of trees or moss, is called the mocho stone.

MOCK LEAD. An ore of zinc. See BLENDE.

MOLYBDENA has not yet been reduced into masses of any considerable magnitude;

but has been obtained only in small separate globules, in a blackish brilliant mass. This may be effected by making its acid into a paste with oil, bedding it in charcoal in a crucible, and exposing it to an intense heat. The globules are gray, brittle, and extremely infusible. By heat it is converted into a white oxide, which rises in brilliant needle-formed flowers, like those of antimony. Nitric acid readily oxides and acidifies the metal. Nitre detonates with it, and the remaining alkali combines with its oxide.

Molybdena unites with several of the metals, and forms brittle or friable compounds. No acid acts on it but the nitric, nitromuriatic, and oxigenized muriatic. Several acids act on its oxide, and afford blue solutions

This mineral is scarce. It is distinguishable from black lead by its more shining scaly appearance, and marks paper with a more brilliant stroke; and, as it resembles no other substance, it does not require to be assayed. See Acid, Molybdic.

Moon Stone. The moon stone is of a clear white colour, approaching to that of milk. When looked at in a certain position, it reflects a strong light, like the mother of pearl; and some specimens exhibit spots of a carnation colour. It is found in obtuse-angular pieces, which sometimes have a quadrangular figure. Its fracture is evidently foliated. It is very hard, and in other respects agrees with common feltspar.

Moor-Stone. See Granite.

Mortar. See Cement; and Lime, article Earths. Also a well-known instrument for pulverizing.

Mosaic Gold. See Tin.

Moss. See Archil.

Mother Water, or **Mother Lie.** When sea-water, or any other solution containing various salts, is evaporated, and the crystals taken out; there always remains a fluid containing deliquescent salts, and the impurities, if present. This is called the mother-water, and requires to be variously treated according to the nature of its contents. Inflammable matters are destroyed by evaporation to dryness and ignition in an open vessel. The saline matters may be afterward taken up by the addition of pure water. In other instances the mother-water is largely diluted, and such additions made as may either precipitate part of its contents, or form such new combinations as the operator is desirous of procuring. See Magnesia, article Earths; also Analysis.

Mould. See Arable Land, Earth Vegetable, and Marl.

Mountain. When we contemplate the surface of the globe in populous districts, our attention is chiefly directed to the agency of man, and those energies of social life which produce, modify, and change the prospect around us. But when we enter the wild and romantic scene of a mountainous country, we are every where struck with the vestiges of operations carried on by the powers of nature, through a long series of ages, and upon a scale prodigiously greater than any to which the works of man can be extended. We meditate on the surrounding scene with an emotion resembling that produced by the view of a pile of ruins long since gone to decay. We endeavour to investigate what may have been the original state of the pile; and, for want of information, our conclusions are for the most part little better founded than those of an amusing reverie. If the life of man had permitted the philosopher to follow, during the revolution of centuries, that variety of changes produced on the surface of the earth by the numerous agents which alter it, we should at this time have been in possession of the most valuable information respecting these great phænomena: but confined as we are to a small spot of the universe, we fix our attention for the transient moment of our existence upon operations of prodigious duration, far remote from their commencement, or termination. It is no wonder then, that in many instances we find it difficult to comprehend, and in many more to imitate, these vast processes.

In whatever manner the original formation of this globe may have been accomplished; by what processes of fire, or water, it may have been chiefly modified; to what secondary circumstances its particular place in the solar system, and its great movements, may be owing;—these subjects have employed the pens of religious writers, as well as of the bold constructors of imaginary systems. It is but too easy to accommodate facts imperfectly known to a favourite hypothesis: but it becomes the philosopher, rather to analyse, than to combine too hastily; and though knowledge may be considered as the classification of facts, it is certain, that too much haste in this classifying is productive of error. The investigator of natural appearances ought not to be impatient under a state of doubt and obscurity. The first step to solid knowledge is to consider what now exists, and thence to deduce what may have heretofore existed.

It appears from a great variety of observations, that the internal part of the globe consists of the stone called granite. It is this which shows itself as the limit of all the excavations made on the surface of our planet, either by natural causes or the art of man. The degradations and subsequent changes, which this rock undergoes by the action of the water, and which therefore it must have undergone in times past, are so well delineated by Chaptal, that I shall extract his observations in this place.

This fluid, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir.

Such an uninterrupted motion and fall must gradually attenuate and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varying temperatures of the atmosphere, facilitate the attenuation and the destruction of these rocks. Heat dries their surface, and renders it more accessible, and more penetrable to the water which succeeds; cold divides them, by freezing the water which has entered into their texture; the air itself affords the carbonic acid, which attacks the lime-stone, and causes it to effloresce; the oxigen air unites to the iron, and oxides it; insomuch that this concurrence of causes favours the disunion of principles; and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature.

The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised, when we observe peaks that have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers or streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course.

These stones rolled along by the water, must strike together, and break off their projecting angles; a process that must quickly have afforded those rounded flints, which form the pebbles of rivers. Those pebbles are found to diminish in size, in proportion to the distance from the mountain which affords them: and it is to this cause that Mr. Dorthes has referred the disproportionate magnitude of the pebbles, which form our ancient worn stones, when compared with those of modern date: for the sea extending itself formerly much more inland, in the direction of the Rhone, the stones which it received from the rivers, and threw back again upon the shores, had not run through so long a space in their beds, as those which they at present pass over. Thus it is, that the remains of the Alps, carried along by the Rhone, have successively covered the vast interval comprised between the mountains of Dauphiny and Vivarais; and are carried into our seas, which deposit them in small pebbles on the shore.

The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, the transparency of which they impair: and when these said waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata gradually become drier by the agglutination of their principles; they become consistent, acquire hardness, and form siliceous clays, silex, petrosilex, and all the numerous class of pebbles, which are found dispersed in strata, or in banks in the ancient beds of rivers.

Mr. Pallas has observed the transition of clay to the state of silex in the brook of Sunghir, near Wolodimir. Mr. G. W. Baumer has likewise observed it in Upper Hesse.

The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement, that becomes hard, and constitutes the compound stones known by the name of pudding-stones and grit-stones: for these two kinds of stone do not appear to me to differ but in the coarseness of the grain which forms them, and the cement which connects them together.

We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles, or component parts, are disunited and separated, and they are gradually carried away by the waters. Chaptal observed near Mende, towards Castelnuovo, the most beautiful kaolin on the surface of a granite, in a state of decomposition; and this same rock is decomposed in several other places. It appeared to him that the feldtspar was particularly subject to be altered the first.

Most siliceous stones, formed by the deposition of fluviatile waters, and hardened by the lapse of time, are easily subjected to a second decomposition. Iron is the principal agent of these secondary alterations; and its oxidation, determined by air or water, produces a disunion of principles. Nature may be observed in this process, by an attentive examination of such alterations as gun flints, variolites, porphyries, jaspers, and the like, are subjected to.

The decomposition of flints, chalcedonies, agates, and generally all stones of this kind, which possess a certain degree of transparency, appears to Chaptal to be re-erable to the volatilization of the water, which forms one of their principles, and is he cause of their transparency.

These stones may be considered as commencements of crystallization; and when he water is dissipated, they effervesce after he manner of certain neutral salts. Hence t arises, that the decomposition is announced by opacity, a white colour, loss of consistence and hardness; and terminates by forming a very attenuated powder, sometimes of extreme whiteness. It is this decomposition more particularly, which forms clays.

There are flints, the alterations of which form effervescent marls. These do not appear to Chaptal to be of the nature of primitive rocks: they have the same origin as the calcareous stones, from which they differ only in consequence of a very considerable proportion of clay. The stones which we so abundantly find of this nature around us, among calcareous decompositions, may be considered as of this kind.

Water filtrating through mountains of primitive rock frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, stalactites, agates, rock crystal, &c.

These quartzose stalactites, differently coloured, are of a formation considerably analogous to that of calcareous alabasters; and we perceive no other difference between them than that of their constituent parts.

Thus far we have exhibited, in a few words, the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not observed either germination or life: and the metals, sulphur, and bitumens, have not hitherto presented themselves to our observation. Their formation appears to be posterior to the existence of this primitive globe; and the alterations and decompositions, which now remain to be inquired into, appear to be produced by the class of living or organized beings.

On the one hand we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of lime-stone, in which we very often perceive impressions of those shells to which they owe their origin.

On the other hand we observe a numerous quantity of vegetables, that grow and perish in the sea; and these plants likewise, deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of pit-coal, and secondary schistus, is usually attributed; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schisti and coal, and likewise on the presence of shells and fish in most of these products.

It appears to Chaptal, that the formation of pyrites ought to be attributed to the decomposition of vegetables: it exists in greater or less abundance in all schisti and coal. He found a wooden shovel, buried in the depositions of the river De Ceze, converted into jet and pyrites. The decomposition of animal substances may be added to this cause: and it appears to be a confirmation of these ideas, that we find many shells passed to the state of pyrites.

Not only the marine vegetables form considerable strata by their decomposition; but the remains of those that grow on the surface of the globe ought to be considered among the causes or agents, which concur in producing changes upon that surface.

We shall separately consider how much is owing to each of these causes; and shall follow the effects of each, as if that cause alone were employed in modifying and altering our planet.

1. The calcareous mountains are constantly placed upon the surface of the primitive mountains; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks, which have changed the primitive disposition. It must be observed also, that the disorder is sometimes merely apparent; and that some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces, as it were, through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base.

Sometimes even the lime-stone fills to a very great depth the crevices or clefts formed in the granite. In Gevaudan, towards Florac, there is a profound cavity in the granite filled with calcareous stone. This vein is known to possess a depth of more than three hundred yards, with a diameter of about five or six.

It likewise happens frequently enough, that such waters as are loaded with the remains of the primitive granite heap them together, and form secondary granites, which may exist above the calcareous stone.

These calcareous mountains are decomposed by the combined action of air and water; and this fluid, which does not possess the property of holding it in solution, soon deposits it in the form of gurhs, alabasters, stalactites, &c. Spars owe their formation to no other cause. Their crystallization is posterior to the origin of calcareous mountains.

Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains: their remains being very light, are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature; from which process calcareous grit and breccias arise. These calcareous remains formerly deposited themselves upon the quartzose sand; and the union of primitive matter and secondary products gives rise to a rock of a mixed nature, which is common in many places.

2. The mountains of secondary schistus frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, silex, alumine, magnesia, carbonat of lime, and iron; principles which are more or less united, and consequently accessible in various degrees to the action of such agents as destroy the rocks hitherto treated of.

These same principles, when disunited, and carried away by waters, give rise to a great part of the stones comprised in the magnesian genus. The same elements worn down by the waters, and deposited under circumstances proper to facilitate crystallization, form the schorls, tourmaline, garnets, &c.

Chaptal does not pretend by this to exclude and absolutely reject the system of such naturalists as attribute the formation of magnesian stones to the decomposition of the primitive rocks. But he thinks, that this formation cannot be objected to for several of them, more especially such as contain magnesia in the greatest abundance.

It frequently happens, that the secondary schisti are interspersed with pyrites; and in this case, the simple contact of air and water facilitates their decomposition. Sulphuric acid is thus formed, which combines with the various constituent principles of the stone; whence result the sulphats of iron, of magnesia, of alumine, and of lime, which effloresce at the surface, and remain confounded together. Schisti of this nature are wrought in most places where alum works have been established; and the most laborious part of this undertaking consists in separating the sulphats of iron, of lime, and of magnesia from each other, which are mixed together. Sometimes the magnesia is so abundant, that its sulphat predominates: Chaptal observed mountains of schistus of this nature. The sulphat of lime being very sparingly soluble in water, is carried away by that liquid, and deposited to form gypsum; while the other more soluble salts, remaining suspended, form vitriolic mineral waters.

The pyritous schisti are frequently impregnated with bitumen, and the proportions constitute the various qualities of pitcoal.

It appears to Chaptal, that we may lay it down as an incontestable principle, that the pyrites is abundant in proportion as the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels by converting them into pyrites. The focus of volcanoes appears to be formed by a schistus of this nature; and in the analyses of the stony matters which are ejected, we find the same principles as those which constitute this schistus. We ought not therefore to be much surprised at finding schorls among volcanic products; and still less at observing, that subterranean fires throw sulphuric salts, sulphur, and other analogous products, out of the entrails of the earth,

3. The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less coloured by iron: we may therefore consider these as a matrix, in which the seeds of all stony combinations are dispersed. The earthy principles assort themselves according to the laws of their affinities; and form crystals of spar, of plaster, and even the rock crystals, according to all appearance; for we find ochreous earths in which these crystals are abundantly dispersed; we see them formed almost under our eyes. We may frequently observe indurated ochres full of these crystals terminating in two pyramids.

The ochreous earths appear to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action that nature employs; and it is even in earths nearly similar to these, that she elaborates the diamond, in the kingdoms of Golconda and Visapour. If it were allowable, says our author, to indulge in a fiction purely poetical, we might affirm, that the element of fire, so far from being lost by the dispersion of the combustible principles of vegetables, becomes purified to form this precious stone so eminently combustible; that nature has been desirous of proving, that the terms destruction and death are relative only to the imperfection of our senses; and that she is never more fruitful, than when we suppose her to be at the moment of extinction.

The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes, which we assign to explain the various changes our planet is subject to. We find bones in a state of considerable preservation in certain places; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is, that some writers have endeavoured to explain the disappearance of certain species; and thence to draw the conclusion, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth. The phosphoric salts and phosphorus, which have been found, in our time, in combination with lead, iron,

&c., prove that in proportion as the principles are disengaged by animal decomposition, they combine with other bodies, and form the nitric acid, the alkalis, and in general all the numerous kinds of nitrous salts.

Mountain Blue. An ore of copper of a blue colour, most frequently of a loose pulverulent form, but sometimes indurated and even crystallized, but then it is mixed with quartz. According to Proust it differs from the green carbonat only in containing a large proportion of water, the simple loss of which changes its colour from blue to green.

Mountain Green is likewise a carbonat of copper, generally found in a loose and friable state, rarely crystallized and indurated, often mixed with calcareous earth and iron, and some arsenic. See Malachite.

Mucilage. A general term used to denote a substance soluble in water, whether hot or cold, with which it forms a transparent adhesive or gluey mass. When obtained from vegetables, it is distinguished by the name of Gum; when from animal substances, it is called Glue, or Gelatine. Consult these articles.

Mucus. This, according to Dr. Bostock, is one of the primary animal fluids, perfectly distinct from gelatine, of which some have considered it merely a modification, differing only in not becoming a jelly by evaporation and cooling. Recent saliva being agitated with cold water, and filtered, the water dissolved $\frac{1}{10}$ of its weight. An oyster being treated in the same manner, the filtered liquor was slightly opake and glutinous, and had taken up $\frac{1}{20}$ of its weight: in this however there was a small portion of gelatine. A solution of the neutral acetat of lead, or Goulard's extract, produced an immediate opacity in each liquor, and after some time threw down a white flaky precipitate. This acetat does not affect gelatine· on the other hand tannin, which is a delicate test of gelatine, does not affect mucus. Both these reagents however precipitate albumen: but the oxymuriat of mercury, which will indicate the presence of albumen dissolved in 2000 parts of water, precipitates neither mucus, nor gelatine. Thus we have three distinct and delicate tests for these three different principles.

Gum appears to resemble mucus in its properties. One grain of gum arabic, dissolved in 200 of water, was not affected by oxymuriat of mercury, or by tannin, but was immediately precipitated by acetat of lead. See Hair. *Nich. Journ.*

Muffle. A small earthen oven made and sold by the crucible manufacturers. It is to be fixed in a furnace, and is useful for cupellation, and other processes which demand access of air.

Mumia. The mineral tallow, a species of bitumen, has been called by this name.

Muriacite. A stone from the salt-pits at Hall, in Tyrol, called there scaly gypsum, and described by Fichtel as a muriat of lime in a dry and compact state. By Klaproth's analysis however it appears to consist of sulphat of lime ·27, carbonat of lime ·05, muriat of soda ·15, and ·53 micaceous sand. Klaproth's Analyses.

Muscovy Glass consists of broad, elastic, flexible, transparent leaves, and differs externally from mica, only in being softer, and more soapy to the touch. It is capable of being split into laminæ of the two or three hundredth part of an inch thick, and the plates naturally exhibit a strong electric state, and sparks, when torn asunder in the dark, even though previous friction be carefully avoided. Few specimens are as transparent as glass.

Muscular Fibre. See Analysis *of Animal Substances.*

Mushroom Stone. A stone used in Italy for producing mushrooms by keeping it moistened with water in a cellar. There appear to be two kinds of it; one found in the chalk hills, near Naples, resembling a white stalactite, intermixed with fine roots of shrubs: the other is a hardened turf from some volcanic mountains near Florence. This loses by calcination about 15 per cent.; and the residuum gives ·46 silex, ·23 alumine, ·07 lime, ·20 oxide of iron, with some traces of magnesia and potash. To render these stones more productive, and prevent their quality of producing mushrooms from being exhausted, it is necessary to water them with water in which mushrooms have been washed. *Trans. Swedish Acad.* 1797.

Musk. See Civet.

Must. The juice of the grape previous to the commencement of fermentation. The word is likewise occasionally used to denote other saccharine juices in the same state.

Myrrh. A gum resin, brought from the East Indies, and likewise from Alexandria, Smyrna, and Aleppo. It is hard, dry, glossy, of various colours, yellowish, reddish, brown, yellowish-brown, reddish-brown, blackish intermixed with whitish specks or tears, transparent like agate, or opake like pitch, of a peculiar strong smell, and a bitter somewhat biting taste. The best is that which is of a reddish-brown colour, not verging too much to yellowish or blackish; uniform on the outside, internally specked or streaked with white, clear and bright, somewhat unctuous to the touch, but not tenacious, so as to stick to the fingers.

This gummy resin is liable to great abuses; the larger masses in particular are frequently no other than some artificial composition, skilfully incrustated on the outside with a solution of myrrh. Some report that bdellium is nearly allied to myrrh, and not easily to be distinguished from it; the differences however are sufficiently obvious, bdellium being darker coloured and less transparent than good myrrh, internally soft and tenacious, (which myrrh never is,) yielding a quite different smell, and wanting its bitterness.

From sixteen ounces of myrrh Neumann obtained, by means of water, twelve and a half of gummy extract; and from the residuum, by alcohol, one and a half of resin. On treating the same quantity first with spirit, and afterward with water, he obtained five ounces of resinous and eight ounces six drachms of gummy extract. The indissoluble matter amounted in both operations to two ounces, or one eighth of the myrrh.

In distillation with water, an essential oil arises, to the quantity of three drachms from a pound. This oil smells and tastes extremely strong of the myrrh, and contains all that part in which the peculiar qualities of the juice reside: it differs remarkably from that of the other gummy resins, in not being hot or pungent, in being so ponderous as to sink in water, and in not being in the least elevated by alcohol; highly rectified spirit, distilled from myrrh, receiving no sensible impregnation either in smell or taste.

It is farther observable, that, whether myrrh be digested in water or in spirit, the whole of its smell and taste is taken up by the menstruum applied first: the extract made by water after spirit has performed its office, as well as that by spirit after water, is inodorous and insipid. Both the tincture and the extract made by pure spirit at first contain all the active parts of the myrrh. The watery infusion or decoction, if made in such a manner as to prevent evaporation, does the same; but on exhaling it to the consistence of an extract, all the flavour of the myrrh is lost, and nothing but its bitterness remains: no one can distinguish in the watery extract any thing of the specific characters of the myrrh. From these experiments we learn in what manner this juice is to be treated to the best advantage, and in what preparations its virtues are preserved or lost.

On enclosing some powdered myrrh in the white of a hard boiled egg, and setting it in a moist cellar, the liquor into which the egg is by degrees resolved extracts nearly all the smell and taste of the myrrh. This liquor, commonly Oleum myrrhæ per deliquium, is precipitated or coagulated by alcohol; and the unctuous coagulum, separated from the spirit, dissolves again in pure water. This process has been applied likewise to mastich and other pure resins; but from these the white of eggs extracts nothing. This oil of myrrh has been highly praised as a cosmetic.

Myrtle Wax. This substance, obtained from the myrica cerifera, has in part the tenacity of bees-wax, without its unctuosity, and along with it in some degree the brittleness of resins. Its colour is a pale green. Spec. grav. about 1·015. It melts at 109°; and at a temperature sufficiently high burns with a peculiarly clear, white flame, producing little smoke, and emitting an agreeable aromatic smell, Water has no action upon it. About ⅘ of it are soluble in 20 times their weight of alcohol at a boiling heat; but are deposited by cooling and standing a few days. Oil of turpentine softens it, and by the assistance of heat dissolves it. Caustic potash by boiling converts it into a soap. The mineral acids act upon it, though feebly. From all its habitudes Dr. Bostock infers, that it is a fixed vegetable oil rendered concrete by the addition of oxigen.—*Nich. Journ.*

N.

NANKIN DYE. See **Iron**, toward the end.

Naphtha. A fine thin fragrant colourless oil, which issues out of white, yellow, or black clays in Persia or Media, is known by this name. It burns with a blueish yellow flame; is as inflammable as ether; and, like it, extracts gold from aqua regia. It is not decomposed by distillation; and yet, if long exposed to the air, it changes colour, thickens, and degenerates into petrol. Its smell is very different from that of vegetable oils; it dissolves resins and balsams; but neither gum resins, nor caoutchouc. It dissolves the essential oils of thyme and lavender; but is insoluble in spirit of wine and ether. Its specific gravity is 0·708.

Naples Yellow. According to prof. Beckmann this colour is prepared by calcining lead with antimony and potash in a reverberatory furnace. The proportions are different, but the antimony appears never to exceed four fifths of the lead, or be less than half: and the potash varies from two fifths the weight of the metals to an eighteenth. Sometimes too common salt is added.—*Beckmann's Hist. of Invent.*

Nard, Indian, or **Spike-Nard,** consists of a number of slender brittle filaments, supposed by some to be the root, by others, the pedicle of the leaves of a plant of the grass or rush kind; but which are properly the head of a root; for Pomet mentions and figures a specimen, which had great part of the root adhering. According to sir W. Jones it is a species of valerian.

Spikenard has a very strong, not agreeable smell and taste, scarce to be concealed or overpowered by a large admixture of other substances. In the Theriaca Cœlestis, a composition of many drugs of strong smells and tastes, spikenard enters but in small quantity, and yet it prevails over all the others. It contains, however, only a small proportion of essential oil: on distilling an ounce, there was only an appearance of some oily particles on the surface of the water. Alcohol brings over nothing: the spirituous extract possesses both the smell and taste of the spikenard in a much greater degree than the watery. An ounce yielded a drachm of spirituous, and afterward forty-six grains of watery extract: water applied at first extracted from the same quantity four scruples, and spirit afterward twenty-five grains: the indissoluble residuum weighed in both cases six drachms ten grains.

Natrolite. A stone of a dirty yellow, sometimes brownish, intersected with concentric white lines, compact, but not very hard, extremely brittle, and of a silky lustre in its fracture. Spec. grav. 2·2. Analysed by Klaproth 100 parts gave silex 43, alumine 24·25, oxide of iron 1·75, soda 16·5, water 9. It is deposited in the clefts or cavities of sonorous porphyry.—*Trans. of the Ac. of Berlin.*

Natron, *or* **Natrum.** A native salt, which is found crystallized in Egypt, and other hot countries, in sands surrounding lakes of salt water. That of Trona, analysed by Klaproth, gave in 100 parts, soda 37, carbonic acid 38, sulphat of soda 2, water of crystallization 22·5. There is no doubt but the common salt is decomposed, and loses its acid; but whether by the action of the air, of the mere heat of the sun, or, which is more probable, the effect of its light, has not been determined. In the new nomenclature of our College of Physicians, the mineral alkali is called natron.

Nautilites. A calcareous stone, or petrifaction of the nautilus. Some writers, who have called these serpent-stones, and supposed them to have been produced by a petrifaction of that creature, have expressed their surprise, that the head is always wanting.

Nephritic Stone. See Jade.

Nephritic Wood. This wood gives to alcohol, or to water, a colour that appears blue by reflected light, yellow by refracted. The blue is changed to a yellow by acids, and afterward restored to a blue by alkalis. Dr. Lewis observes, that it is the only woody matter, which gives a blue tincture; and that this is the only vegetable blue, which is thus destructible by acids.

Neutral Salts. This term is applied to all salts which contain an acid saturated with an alkali, an earth, or a metal. Bergmann confined it to salts containing alkali; and he called the earthy and metallic salts, middle salts. It is most usual to call the alkaline salts with an acid neutral, and to distinguish the others by the respective appellations, earthy and metallic.

Nickel is a metal of great hardness, of a uniform texture, and of a colour between silver and tin; very difficult to be purified, and always magnetical, whence it has been supposed to contain iron in its purest state. It even acquires polarity by the touch. It is malleable, both cold and redhot; and is scarcely more fusible than manganese. Its oxides, when pure, are reducible by a sufficient heat without combustible matter; and it is little more tarnished by heating in contact with air, than platina, gold, and silver. Its specific gravity when cast is 8·279; when forged, 8·666.

We do not know that this metallic substance has been applied to any use; yet from tons of it being occasionally found in the druggists' shops at Paris, Fourcroy supposes it is employed in colouring porcelain or enamels.

Nickel is commonly obtained from its sulphuret, the kupfernickel of the Germans, in which it is generally mixed also with arsenic, iron, and cobalt. This is first roasted to drive off the sulphur and arsenic, then mixed with two parts of black flux, put into a crucible, covered with muriat of soda, and heated in a forge furnace. The metal thus obtained, which is still very impure, must be dissolved in dilute nitric acid, and then evaporated to dryness; and after this process has been repeated three or four times, the residuum must be dissolved in a solution of ammonia perfectly free from carbonic acid. Being again evaporated to dryness, it is now to be well mixed with 2 or 3 parts of black flux, and exposed to a violent heat in a crucible for half an hour or more.

According to Richter, the oxide is more easily reduced without any flux; and Thenard is of a similar opinion. Richter however says it is effected more speedily by moistening the oxide with a little oil. Thenard too advises, to pour oxigenized muriatic acid saturated with lime on the oxide of nickel, and shake them well together, before the ammonia is added; as thus the oxides of cobalt and iron, if present, will be so much saturated with oxigen, as to be insoluble in the ammonia, and consequently may be separated.

Mr. Chenevix observed, that a very small portion of arsenic prevents nickel from being affected by the magnet. Richter found the same. When it is not attractable, therefore, we may be pretty certain that this is present. To separate the arsenic, Mr. Chenevix boiled the compound in nitric acid, till the nickel was converted into an arseniat; decomposed this by nitrat of lead, and evaporated the liquor, not quite to dryness. He then poured in alcohol, which dissolved only the nitrat of nickel. The alcohol being decanted and evaporated, he redissolved the nitrat in water, and precipitated by potash. The precipitate, well washed and dried, he reduced in a Hessian crucible lined with lampblack, and found it to be perfectly magnetic; but this property was destroyed again, by alloying the metal with a small portion of arsenic. Alloying it with copper weakens this property.

The sulphuric and muriatic acids have little action upon nickel. The nitric and nitro-muriatic are its most appropriate solvents. The nitric solution is of a fine grass green colour. Carbonat of potash throws down from it a pale apple green precipitate, which, when well washed and dried, is very light. One part of metal gives 2·927 of this precipitate, which by exposure to a white heat becomes blackish gray, barely inclining to green, and weighing only 1·285. By continuing the fire it is reduced.

When ammonia is added in excess to a nitric solution of nickel, a blue precipitate is formed, which changes to a purple red in a few hours, and is converted to an apple green by an acid. If the precipitate retain its blue colour, copper is present. Prussiat of potash precipitates nickel of a sea-green colour.—*Van Mons's Journ.—An. de Chim.—Nich. Journ.—Henry's Chemistry.*

Nickeline. Mr. Richter had long conjectured, that the cobalt ores of Saxony contained another metal beside those commonly known, and in many of its properties resembling nickel; and he conceives he has lately obtained it separate. Having about half a pound of oxide of nickel, which he had purified as far as he could in the liquid way, he attempted to reduce it *per se* in two crucibles. In each however he found only a button of two drachms and a half, the remainder forming a hard mass, of a blackish gray colour, and in some degree resembling scoriæ. This mass, weighing about 4½ ounces, being pulverised, and mixed with charcoal powder, was exposed for eighteen hours to the heat of a porcelain furnace in a crucible with a luted cover, afforded a well fused button of 2¼ ounces, under a scoria of a deep blackish brown colour.

This metal had the gray colour of steel, inclining a little to red. It differed from nickel in the inferiority of its magnetic property and malleability; in the green colour of its solutions being less beautiful; in being incapable of reduction *per se*; in being attacked and oxidated more easily by nitric acid; in its salts, when deprived of water, being reddish instead of buff-coloured, and the nitrat not parting with its water without being decomposed. From cobalt it differs still more decidedly. As it has in many respects a resemblance to nickel, Mr. Richter has named it nickeline.—*An. de Chimie.*

Nigrine. Nigrin of Werner. An ore of titanium, containing, according to Klaproth and Lampadius, about 8 or 9 per cent of the oxide of this metal, though Dr. Mitchel thinks this is overrated, and 1 or 2 of oxide of iron. It has been found only in the stream works at Ohlapian, in Transylvania. It is harder than menacanite, has superior lustre, is not at all magnetic, of a dark brownish black colour, and with borax is fused by the blowpipe into a hyacinthine red bead.—*Irish Transact.*

Nihil Album. A name formerly given to the flowers or white calx of zinc.

Nitre. The common name of the nitrat of potash.

Nitro-Muriatic Acid. The compound acid formed by uniting the nitrous and marine acids. It is commonly known by the name of Aqua Regia; which see.

Nitrous Acid. See Acid, Nitrous.

Nitrous Air. See Air, Nitrous.

Nitroxides. Combinations of the different bases with nitrous oxide.

Noble Metals. This absurd name has been bestowed on the perfect metals, gold, silver, and platina.

Nomenclature. Whenever a new substance or thing comes under our notice, we give it a name, and in this denomination we seldom fail to recur to some of the properties or habitudes of the thing. If this were invariably done, and the knowledge of the property or habitude alluded to were perfect, it is evident, that a knowledge of the derivation of names would, in almost every instance, convey a large portion of knowledge. On the other hand it is no less evident, that names founded upon mistaken inferences respecting the properties of things will be received and used as the characteristic marks of those properties, and will greatly tend to disseminate and perpetuate error. Hence the advantages of an accurate nomenclature, especially in the science of matter of fact, which chemistry may be peculiarly termed. Every writer has been more or less sensible of the advantages of accurate denomination. Many have attempted to improve the nomenclature of chemistry, as opportunity offered. Old names have been rejected, and new ones adopted from time to time; and this to such an extent, that the common terms of philosophical chemistry had become considerably remote from those used in pharmacy, till the late reformation of the Dispensatory of the College of Physicians.

The French chemists, when they rejected phlogiston, displayed the most active zeal in propagating the systematical doctrine, of which the absorption and extrication of oxigen, and the composition and decomposition of water, are the leading features; and with this view were particularly attentive to the reformation of chemical nomenclature. Messrs. de Morveau, Lavoisier, Berthollet, and de Fourcroy, published a method of chemical nomenclature at Paris, in the year 1787; which has since undergone some improvements, and is now pretty generally followed, or at least adopted as the ground-work of chemical language in most countries.

In the plan these chemists proposed, simple bodies, viz., such as had not hitherto been decomposed, were entitled in the first place

	NEW NAMES.	ANCIENT NAMES.
1	Mucus.	*Mucilage.*
14	Caoutchouc.	*Elastic gum.*
26	Gallic acid.	*Acid of gall-nuts.*

POSITION.

11	12	13
Extract.	Extracto-resinous matter, *when the extract predominates.*	Resino-extractive matter, *when the resin predominates.*
xtractive matter.		

23	24	25
zoic acid.	Camphoric acid.	Citric acid.
ers of benzoin.		*Acid of lemons.*

36	37
cic acid.	Alkaline soaps. Earthy soaps. Acid soaps. Metallic soaps. Saponule of turpentine, &c.
d of fat.	*Alkaline soaps.* *Earthy soaps, &c.* *Combinations of the volatile oils with different bases.*

to their attention, because the denomination of substances reduced to their elements by accurate analysis would be naturally determined by uniting the signs of these elements.

These undecomposed substances are divided by them into five classes.

The first class comprehends those principles which, though they do not exhibit any remarkable analogy to each other, have nevertheless this common property, that they appear to approach in an eminent degree to that state of simplicity, which enables them to resist the methods of chemical analysis, at the same time that it renders them highly active in combinations.

In the second class they place all those substances which are capable of being converted into acids.

The third class comprehends all those substances which can be exhibited under the metallic form. The regulus, or metal itself, is the simple substance. See METALS.

The fourth class comprehends the earths, and

The fifth the alkalis.

At the end of these five classes, they point out, in an appendix, certain substances of a more compounded nature, which combine in the manner of more simple bodies, without undergoing any observable decomposition. It appeared necessary that these bodies should enter into the table of methodical nomenclature, to complete the system.

The substances of the first class are four in number, viz. light; caloric, or the matter of heat; oxigen; and hidrogen.

The second class, containing substances the principal character of which is that of passing to the state of acidity, is much more extended.

In this class it may be observed, that some of the acidifiable bases are known, but that of the greater number of acids the constituent parts have not yet been separated. The known acidifiable bases are azot, or nitrogen, the base of nitric acid; carbon, or that principle which constitutes the greater part of vegetable coal, and forms the basis of carbonic acid; sulphur, or the basis of sulphuric acid; and phosphorus, or the basis of phosphoric acid. Beside arsenic, molybdena, and chrome, which, however, from their other properties, are classed with the metals. The combinations of these bases are the most numerous, the most familiar, and the most easy to be pursued; for which reasons the French chemists established their nomenclature by attending to them. With regard to the others, such as the bases of the muriatic, boracic, and other acids, they were contented merely to denote the substance that modifies the oxigen by the expression *acidifiable basis*, or, more concisely, the *radical of the acid*. Morveau suggested the probability, that many of these acids might have compounded bases; or that their bases might no otherwise differ from each other than in the proportion of the same principles. This has since been shown to be the fact; the greater part of them consisting of carbon and hidrogen, with the addition in one or two instances of nitrogen, though the proportions are not ascertained. These in consequence require to be removed to the appendix.

Morveau accordingly proceeds to explain the nomenclature of the products or combinations which have sulphur for their origin.

Since sulphur, by combining with oxigen, produces an acid, it is evident, that the name ought to be derived from the name of the base. But as this acid is exhibited in two states of saturation, in each of which its properties are different, it became necessary to apply a name to each of these states, which, constantly preserving the primitive root, should, nevertheless, mark this difference. It was equally requisite, that the same demarcation should follow all the saline compounds of these two acids. Again, it was necessary to attend to sulphur in its other direct combinations, as for example, with earths, alkalis, and metals. Five different terminations, adapted to the same radical word, will distinguish these five states of the same principle.

The *sulphuric* acid will denote sulphur in the utmost degree of saturation with oxigen. It is the vitriolic acid, as formerly denominated.

The *sulphurous* acid will express sulphur united with a smaller proportion of oxigen. It is the volatile sulphureous vitriolic acid, or the phlogisticated vitriolic acid, formerly so called.

Sulphat will be the generic name of all the salts formed by the sulphuric acid.

Sulphit will be the name of the salts formed of the sulphurous acid.

Sulphuret will be the name of all the combinations of sulphur not in the state of acidity. In this way one uniform denomination will be substituted instead of the improper and discordant names of liver of sulphur, hepar, pyrites, mat, &c.

From this explanation, and the general table annexed, it will be readily seen, how the other combinations of the acid bases are arranged and denominated.

The third division of the general table comprehends all the metallic substances at that time known. To which those since discovered are now added. There were cogent reasons not to change the names of those substances. The metallic calces are called oxides. Such as are capable of acidification follow the general rule of other acid bases in their terminations, as may be seen in the articles ARSENIC, MOLYBDENA, and CHROME. Compounds of metals with metals are called alloys.

The fourth general division comprehends the five well-known earths, to which those since discovered are added. The combinations of these with the preceding substances have been already spoken of.

The three alkalis occupy the fifth and last principal division.

In the appendix of more compounded substances, we find mucus, gluten, sugar, starch, fixed oil, volatile oil, aroma, or the principle of smell in plants and flowers, resin, extract, extracto-resinous matter, resino-extractive matter, fecula, alcohol, the compounds of alcohol, ethers, soaps, and the acids with compound bases.

It will be observed in the table, that it is divided into six vertical double columns, under the title of 1. Substances not decomposed. 2. Converted into the state of gas by caloric. 3. Combined with oxigen. 4. Gazeous oxigenized. 5. Oxigenized with bases. 6. Combined without being converted into the acid state. These columns are double, in order that the first compartment may contain the new name, and the second the correspondent old name. Every horizontal division exhibits the different states and compounds of the simple substance which is at its head or commencement.

Norka. A compound stone of the siliceous genus, being a variety of the granite or moor-stone. It is either gray or reddish, and consists of quartz, garnet, and mica. It is used for mill-stones.

Nutmegs. This fruit contains two kinds of oils, namely, a gross sebaceous oil, and a volatile essential fluid oil; in which last the peculiar taste and smell of nutmegs reside. The essential oil also appears to be of two kinds; one of which is so light as to swim upon water, and to rise in distillation with alcohol; and the other is so gross and ponderous, that it sinks in water, and is with difficulty capable of being distilled with water, and not at all with spirit.

Sixteen ounces of nutmegs yielded, by distillation, half an ounce of essential oil; and afterward four or five ounces of the gross sebaceous oil were found floating on the surface of the water in the still. Alcohol dissolves all the essential oil, and a part of the expressible oil. From four ounces of nutmegs nine drachms of a concrete oil were expressed. This oil contains a considerable portion of the essential oil. It is brought from India in form of cakes, and is sold as oil of mace.—*Neumann.*

Nux Vomica, so called, is not a nut, but the seed of a fruit like an orange, growing in the East Indies: it is called by the Germans kræhenaugen, crows'-eyes, from its having somewhat of the appearance of a gray eye, and from its being poisonous to crows. The tree is described and figured in the *Hortus Malabaricus*, under the name of Caniram. The seeds brought to us are of different sizes, and produced by different species of the plant. The tree which yields the smaller sort is that whose roots are the lignum colubrinum of the shops. They are commonly of a roundish flat figure, variously bent, with a navel or prominence in the middle covered all over with fine short hairs like velvet; the kernel is nearly of the consistence of horn, but harder and more brittle, so as to be beaten in pieces by a hammer.

Nux vomica is poisonous to dogs, to other carnivorous animals, and such as are born blind. It does not hence follow, indeed, that it should be poisonous to men, and some have recommended it as a diaphoretic and astringent: but it has been known to prove fatal.

O.

Oak. The uses of the wood of the oak tree are sufficiently known. Every part of this vegetable abounds with astringent matter; but the substances more particularly attended to by chemists are, the excrescence of the oak, called the nut gall, of which we have already treated under the articles Acid, (Gallic), and Ink; and the bark of the tree, used in the process of tanning; which see. The bark has sometimes been given as an astringent medicine.

Ochre. An earthy substance with which some metallic oxide is mixed, commonly of a yellow, brown, or red colour. It is used as a pigment. The colour of such specimens as are dark, may be rendered of a brighter red by calcination; which alters the state of the metal. The ferruginous ochres, which are most common, appear to have been produced by the decomposition of the martial pyrites, which consist of sulphur and iron. By the combined action of the air and water, the sulphur becomes acidified, and the iron may be deposited upon calcareous earths, which seize the acid: or more commonly, by the more complete oxidation of the iron, by the air, which then becomes less soluble and falls down, as is seen in a solution of common sulphat of iron left in an open vessel. In many places the iron is extracted from this ore.

Ochroites. Cerites, so called by Klaproth, who imagined it contained a new earth.

Oculus Mundi. See Hydrophanes.

Odour. See Smell, Principle of.

Offa Alba, or **Offa Helmontii.** Carbonat of ammonia precipitated from its solution in water by alcohol.

Oil. The distinctive characters of oil are inflammability, insolubility in water, and fluidity, at least in a moderate temperature. Oils are distinguished into fixed or fat oils, which do not rise in distillation at the temperature of boiling water; and volatile or essential oils, which do rise at that temperature.

Fixed oils are obtained by pressure, sometimes assisted by heat, or by boiling in water, from the emulsive seeds or kernels of vegetables; and likewise from the fatty parts of animals. They are generally fluid in the temperature of the atmosphere, but some of them have a considerable degree of firmness or solidity. They have a very smooth feel; require a degree of heat much superior to that of boiling water, to cause them to rise in ebullition; and cannot be set on fire, unless heated to this degree. The use of the wick of a lamp consists in bringing small portions of oil to its extremity, by the capillary attraction; where they become successively volatilized and inflamed. Oils are remarkably less sonorous than water, when poured out. Fat oils, not being at all dissipated by the heat of the atmosphere, make a permanent greasy spot, when they fall on porous substances.

These oils are decomposed by distillation, and afford a small quantity of water loaded with a peculiar acid, a light oil, a dense oil, hidrogen, and carbonic acid gas. The residue consists of a small quantity of charcoal.

In the last analysis of organised substances the results are, hidrogen, oxigen, nitrogen, and carbon, which appears to be their basis. By what combinations or super-compositions they are made to exhibit the variety of products which come under our observation, can in few respects be ascertained by any experiments we are yet capable of making. Lavoisier, in the Memoirs of the French Academy for 1784, collected the products of olive oil burned in an apparatus properly constructed to ascertain their nature and properties. He obtained 79 parts of carbon, and 21 of hidrogen, from 100 of the oil. From these component parts, inferences may be formed respecting the acid, the water, the carbonic acid, and the hidrogen gas, afforded by the partial decompositions or combustions of this fluid.

The light oil, produced by distillation of fat oils, is naturally more disposed to fly off by heat, and leaves less coal behind it, than the fat oil itself. This property renders it useful in some of the arts, as those of lapidaries, seal engravers, and others, who grind precious stones with fretting powders. The oil used for this purpose is known by the name of oil of bricks, which is made by igniting pieces of brick, quenching them in olive oil, and afterward distilling the oil from the pieces of brick which had imbibed it. In order to form a proper notion of the advantage of this fluid, it must be remarked, that all grinding produces heat; that this heat would speedily evaporate water, and render common oil thick; that, if neither water nor oil were present, the heat would very soon increase to strong ignition, and injure both the tool and the substance operated on. The oil of bricks possesses neither of the bad qualities of the two fluids here mentioned, in so considerable a degree, and is therefore preferred for such work as can afford the expense.

Fat oils, by exposure to the air, become rancid, and exhibit a disengaged acid, which may be washed off by water. When they are exposed to the air, in a thin coat, upon the surface of water, they become more consistent, like wax, by absorbing the oxigen of the atmosphere. The oxigenized muriatic acid produces this change more speedily. Agitation in water, particularly if acidulated, separates a mucilage from them. They combine with barytes, strontia, magnesia, and lime, which convert them into saponaceous compounds. With the pure alkalis they form common soap. They do not unite with ammonia but by long trituration.

The mineral acids unite with fat oils, and form compounds, or imperfect soaps. Fuming nitrous acid causes them to take fire, as has already been observed. Sulphur is soluble in fat oils, by a digesting heat; and is gradually deposited in part from them, in a crystalline form, by cooling.

Fixed oils seem not to be susceptible of combination with pure metallic substances, excepting iron and copper, upon which they act in a sufficiently distinct manner. But they combine with metallic oxides, and form with them thick concrete combinations, of a soapy appearance, as is observable in the preparation of unguents and plasters. These preparations have not yet been chemically examined. Metallic oxides are likewise boiled in oils to give them the quality of drying quickly.

Mr. Sheldrake has observed, that oils thus prepared dry by forming a superficial skin, and the more of this quality they possess, the more colours mixed with them are liable to change by keeping. He therefore recommends, to dissolve amber, or copal, in the oil, which will cause the oil to dry by uniform inspissation; and with this to mix the colours previously ground in oil of turpentine.

Mr. Vanherman has lately laid before the Society of Arts a method of rendering fish-oil applicable to painting; and it appears to make a good and cheap vehicle for colours exposed to the weather, though it dries but slowly. To thirty-two gallons of vinegar he adds 12 lbs. of litharge and 12 lbs. of sulphat of zinc, shaking the mixture well twice a day for a week. The mixture is then put into a tun of fish-oil, with which it is well shaken and mixed; and the next day the clearer part, about ¾ of the whole, is poured off. Twelve gallons of linseed oil, and two of oil of turpentine, are then added to the clear part; and this, being well shaken together, is left to settle for two or three days, when it will be fit to grind white lead and all fine colours in. These however are to be thinned for use with linseed oil and oil of turpentine.

For cheap paints exposed to the weather, whiting and road dirt finely sifted are to be mixed with limewater to the consistence of mortar; to this may be added almost any pigment ground with the sediment of the prepared oil, in the proportion of one part to two of the limewater already used; and the whole is to be thinned for use by adding to every eight pounds a quart of linseed oil, and as much of a mixture of the prepared oil with limewater. The proportions of this mixture are not mentioned.

If two ounces of litharge be added to a gallon of linseed oil, and well shaken every day for a fortnight; and the clear part, mixed with half a pint of oil of turpentine, be exposed to the sun for three days in shallow pans, Mr. Vanherman informs us, it will be as white as nut-oil. If half a pound of frankincense be dissolved in a quart of oil of turpentine, and added to a gallon of this bleached oil; and white lead, ground in oil of turpentine, be thinned for use with this mixture; he asserts that it will be quite dry and void of smell in four hours.

It is likewise desirable to purify the coarse fish oils for the purposes of burning and of some manufactures. This may be effected to a certain degree, by shaking it with limewater, or with a little chalk and slaked lime and water. But to purify it thoroughly an ounce of powdered chalk, a quarter of an ounce of lime slaked in the air, and half a pint of water, should be well mixed with a gallon of the stinking oil; and when it has stood some hours, a pint of water and two ounces of pearl ashes should be added, and the mixture kept simmering over the fire, till the oil appears of a light amber colour: then add an ounce of salt dissolved in half a pint of water, boil half an hour longer, and let the mixture stand till the oil separates. If it be required still purer, the oil after being poured off may be treated in a nearly similar manner, but without heat, with an ounce of chalk, a quarter of an ounce of pearl ashes, and half an ounce of salt. If an oil of somewhat more consistence be wanted, kitchen stuff may be added to it while it continues hot.

To purify rape oil for burning in lamps, Curaudeau advises, to add to 100 parts of oil one part of sulphuric acid, diluted with 6 of water; shake the mixture well; and then let it settle: or one part of wheat flour, mixed with 10 of water, and expose it to a heat not exceeding 212°, till the water is evaporated.

In the assaying of metals, fixed oils are sometimes employed to reduce the metallic oxides. Berthollet has given an ingenious and simple process for effecting instantaneously a real combination between fixed oil and any metallic oxide, that is, for preparing a metallic soap. It consists in pouring a metallic solution into a solution of common soap. The acid of the metallic solution combines with the fixed alkali of the soap; and the metallic oxide is then precipitated in union with the oil, to which it communicates a colour. In this manner, soap of a beautiful green colour may be prepared with sulphat of copper; and with sulphat of iron, a clear deep brown soap. Fourcroy thinks these compounds might be very useful in painting.

Scheele discovered, that when oil of sweet almonds, olives, rapeseed, or linseed, is combined with oxide of lead, with the addition of a little water, there is a matter separated from the oil, which swims on the surface of the liquor, and to which he gave the name of the mild principle. On evaporating this supernatant water, the principle dissolved in it causes it to assume the consistency of sirup: when exposed to a strong heat, it takes fire: one part is volatilized in distillation, without burning: the coal which it leaves is light: it does not crystallize; nor does it seem to be susceptible of fermentation. Nitric acid, distilled on this matter four times successively, changes it into oxalic acid. This mild principle of Scheele's appears to be a sort of mucilage.

The dense animal oils, such as butter, tallow, fat, the oil of the whale, and the like, exceedingly resemble vegetable fixed oils. They appear, however, to contain a proportion of nitrogen, or animalized matter, probably in the state of serum or gelatine. The volatile oil obtained by attenuating animal oil, by a number of successive distillations, is called Dippel's animal oil. Macquer observes, that it may be rendered almost as white, thin, and volatile as ether, and is then capable of acting upon the brain and nervous system, in a dose of from four to ten or twelve drops, incorporated with some proper vehicle. Rouelle recommends, to rectify it by distillation with water.

It is much more difficult to obtain this oil in a pure state from fixed oils, than from gelatinous matters, of which hartshorn is to be preferred. It is necessary to change the vessels at each successive distillation, or else to clean them perfectly, because a very small part of the thicker and less volatile oil is sufficient to spoil a large quantity of that which is more highly rectified. Beaumé has observed, that this operation may be greatly abridged by taking care to receive none but the most volatile part in each distillation, and to leave a large residuum, which is to be neglected, and only the more volatile part is to be further rectified. By this method, we may obtain in three or four distillations a considerable quantity of fine oil of Dippel, which could not be obtained after 50 or 60 distillations, without attending to this circumstance. And Monnet asserts, that, by mixing acids with animal oil, their rectification may be very much facilitated.

The oil of Dippel must be kept in clean glass bottles with ground stopples, and exposed as little as possible to the air, because its volatile parts fly off, and the remainder becomes coloured.

Fourcroy distinguishes vegetable fat oils into three classes. In the first, he places such as are congealable by cold, thicken very slowly by exposure to air, form soaps with acids, and require an addition of sulphuric acid to that of nitre in order to inflame them. Such are,

1. Oil of olives, obtained by bruising that fruit between two mill-stones, and pressing it in bags made of rushes. That which runs first is called virgin oil: that which is obtained from marc sprinkled with water is not so pure, and deposits dregs; that ob-

tained from unripe olives is the *oleum omphacinum* of the ancients. Oil of olives freezes at 36°, and will stand about twelve years without becoming rancid.

2. Oil of sweet almonds, extracted without the application of heat, becomes very soon rancid; it freezes at 18½°.

3. Oil of rapeseed.

4. Oil of ben, extracted from the ben nut of Egypt and Arabia; it is very acrid, and destitute of smell; it freezes very easily.

The second class comprehends oils subject to become dry, which are very easily rendered thick, are not fixed by the action of cold, are kindled by the nitric acid, and form with sulphuric acid a sort of resin. Such are,

1. Linseed oil, obtained by pressure from the seed of flax; it is used for oily varnishes, and in painting.

2. Oil of nuts, applied to the same uses.

3. Oil of poppy-seed; which, as has been fully proved by the Abbé Rozier, is not at all narcotic.

4. Oil of hemp-seed, which is very drying.

Under the third genus, he comprehends concrete fixed oils, or vegetable butters; among which may be distinguished the following:

1. Butter of cacao, extracted from the cacao nut.

2. The cocoa nut affords a similar butter.

3. Vegetable wax is of the same nature, only more solid.

Volatile or essential oils have usually a strong aromatic smell, are sufficiently volatile to rise with the heat of boiling water, and are in general soluble in alcohol and acetic acid. They exist in almost all fragrant vegetables; and in the various plants which supply them, they are found either in the wood, the root, the bark, the leaves, the flowers, the fruits, &c. They differ very much in the degree of fluidity they possess at a common temperature, and their colours are various. They are obtained either by expression, as from the peel of oranges and lemons, or by distillation with water. Some essential oils, such as those of cinnamon, sassafras, and other foreign plants, sink to the bottom of the water with which they come over; others float at the top. It is easy to distinguish the adulteration of volatile oils, either by pouring alcohol upon them, which will not dissolve the fat oil they may be contaminated with; or if they be dropped on paper, and held to the fire, in this case they leave a greasy spot behind. If oil of turpentine be fraudulently added to them, its smell betrays its presence when treated in this manner.

Volatile oils are very inflammable: by exposure to air they become thick in process of time, and assume the character of resins.

They unite with difficulty to lime and alkalis. The sulphuric acid converts them into bitumens; but, if diluted, it renders them saponaceous, as does likewise the muriatic acid. Nitric acid inflames them.

They unite very readily with sulphur, and form balsams. Mucilages and sugar render them soluble or diffusible in water.

These oils not only contain all the smell, but sometimes likewise the taste of the body from which they have been extracted; in consequence of which the residuum has lost these sensible qualities. There are indeed several vegetables, that have an agreeable flavour, and notwithstanding yield no volatile oil on being distilled with water, of which lilies, hyacinths, clove-july-flowers, violets, the bloom of the lime- or linden-tree, lilies of the valley, &c., are usually adduced as instances; a fact which might be opposed to what has been asserted just above. But this objection in the opinion of Wiegleb is easily overturned, as he thinks he is able to prove, that the reason why none of these substances yield volatile oil is only because they contain but a small, though a strong-scented portion of this oil, which is imbibed by the water employed in the distillation; in consequence of which, this likewise acquires the same smell as was originally possessed by the vegetable itself. Roses, orange-flowers, and several other similar substances, which contain but very little oil, were formerly ranked among these, as they also yield no oil, when in small quantities; but it is now certainly known, that in large quantities they afford a small portion of oil. We find likewise that vegetables, which are certainly known to contain volatile oil, yield, when distilled in small quantities, an odorous distilled water only, in which frequently not the least vestige of such oil is discoverable. Wiegleb very rationally supposes, that, if those vegetables which produce an odorous water were submitted to distillation by the hundred weight, they would yield a volatile oil just as well as the others; and that we should necessarily be convinced, that the whole of their smell is derived from a small quantity of a strong-scented volatile oil.

The presence of volatile oils is discoverable by the smell. They are commonly in appropriated vessels, which, however, are sometimes so small, that they cannot be distinguished by the naked eye; yet in some they may be observed by the assistance of microscopes; as for instance, in nutmeg, angelica, and master-wort.

Volatile oils are found in very different proportions in the substances which contain them. It is scarcely practicable to determine with accuracy the quantity of oil yielded by each substance; but it is a very desirable thing even to know the proportions of them nearly. In this view, the following table from Wiegleb may be of use, which at least will furnish much information to such as may wish to prosecute the subject.

TABLE

Exhibiting the Quantity of VOLATILE OIL obtained from different VEGETABLES.

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
AGALLOCHUM wood	10 lb	4 drachms	Hoffmann
Angelica root	1 lb	1 drachm	Cartheuser
Aniseed	1 lb	2 drachms	Neumann
Assafœtida	4 ounces	1 drachm	
Balm, common	6 baskets	1 drachm	Dehne
—— Turkey	ditto	2 ounces	
Cajaput seeds	1 lb	15 grains	
Calamus aromaticus	50 lb	2 ounces	Hoffmann
————	1 lb	2 scruples	Neumann
Camomile flowers, common	1 lb	½ drachm	Cartheuser
————	6 lb	5 drachms	Lewis
————	200 baskets	1 lb	Dehne
Camomile flowers, wild	1 lb	20 grains	Cartheuser
————	6 lb	2½ drachms	Lewis
———— Roman	30 lb	1¼ ounces	Dehne
Caraway seeds	4 lb	2 ounces	Lewis
————	2 lb	9 drachms	
————	1 cwt	83 ounces	
Cardamum seeds	1 ounce	1 scruple	Neumann
Cariophilli Plinii	½ lb	½ ounce	Dehne
Carline thistle root	1 lb	2½ scruples	Neumann
Carrot seeds	2 lb	1½ drachm	Lewis
Cascarilla bark	1 lb	1 drachm	Cartheuser
————	30 lb	4 ounces	Dehne
Cassiæ flores	1 lb	½ drachm	Cartheuser
————	30 lb	4 ounces	Dehne
Cedar wood	1 lb	2 drachms	Margraff
Chervil leaves	9 lb	½ drachm	Neumann
Cinnamon	1 lb	1 drachm	Sala
————	1 lb	2½ scruples	Neumann
————	4 lb	6 drachms	Lemeri
————	1 lb	2 drachms	Cartheuser
————	1 lb	8 scruples	
————	3 lb	4 drachms	Dehne
Clary (garden), the seeds	4 lb	2 drachms	Lewis
—— in flower, fresh	130 lb	3½ ounces	
Cloves	1 lb	1½ ounce	Teichmeyer
————	1 lb	2¼ ounces	Cartheuser
————	2 lb	5 ounces	Hoffmann
————	2 lb	5 ounces	
————	1 lb	1 oz 6 drach.	Dehne
————	1 lb	2½ oz	
————	1 lb	2 oz 2 drach.	
Copaiba balsam	1 lb	6 ounces	Hoffmann
————	1 lb	8 ounces	Lewis
Culilabani cortex	1 lb	1 drachm	Vogel
Cummin seed	1 lb	5 drachms	
————	1 bushel	21 ounces	Lewis
Dill seed	4 lb	2 ounces	
———— with the tops	6 baskets	8 ounces	Dehne
Dittany of Crete	1 lb	30 grains	Lewis
Elecampane root	2 lb	3½ scruples	Neumann
———— dry	12 lb	3½ drachms	Dehne
Elemi (gum)	1 lb	1 ounce	Neumann
Fennel seed (common)	1 lb	8 scruples	
———— sweet	1 bushel	18 ounces	Lewis
Feverfew flowers	1 basket	2 drachms	Dehne

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
Galangal root	1 lb	1 drachm	Cartheuser
Garlic root, fresh	2 lb	30 grains	Neumann
Ginger	1 lb	1 drachm	
Horse-radish root	1 lb	15 grains	Vogel
———	8 ounces	15 grains	Neumann
Hyssop leaves	2 lb	1½ drachm	
———	1 lb	ditto	Cartheuser
———	1 lb	2 drachms	
———	2 cwt	6 ounces	Lewis
———	10 lb	3 drachms	
———	30 lb	9 drachms	
Juniper berries	8 lb	3 ounces	Hoffmann
———	1 lb	3 drachms	Cartheuser
———	48 lb	6 ounces	Dehne
———	60 lb	6¼ ounces	
——— wood	15 lb	2 ounces	
Lavender, in flower, fresh	48 lb	12 ounces	Lewis
———	30 lb	6¾ ounces	
———	13½ cwt	60 ounces	
———	2 lb	4 drachms	Hoffmann
——— dry	4 lb	2 ounces	Lewis
———	2 lb	1 ounce	Hoffmann
———	4 lb	3 ounces	
——— broad-leaved dry	4 lb	1 ounce	
———	1 lb	1 drachm	Cartheuser
Lovage root	1 lb	1 drachm	
Mace	1 lb	5 drachms	Neumann
Marjoram in flower, fresh	85 lb	3¼ ounces	Lewis
———	13½ lb	3½ drachms	
———	34 lb	1½ ounce	
——— leaves, fresh	18½ lb	½ ounce	
——— dry	4 lb	1 ounce	Hoffmann
Masterwort root	1 lb	½ drachm	Neumann
Milfoil flowers	18 baskets	4½ ounces	Dehne
——— dry	14 lb	4 drachms	Lewis
Mint in flowers, fresh	6 lb	4½ drachms	
——— leaves, dry	4 lb	1½ ounce	Hoffmann
——— fresh	30 baskets	1¼ lb	Dehne
Mother of thyme	45 lb	4 drachms	
Myrrh	1 lb	2 drachms	Hoffmann
———	1 lb	3 drachms	Neumann
Nutmegs	1 lb	1 ounce	Hoffmann
———	1 lb	1 ounce	Geoffroy
———	1 lb	½ ounce	Neumann
———	1 lb	¼ ounce	Sala
———	1 lb	5 drachms	Cartheuser
Parsley seeds	2 lb	1 drachm	Lewis
——— leaves, fresh	238 lb	2 ounces	
——— leaves, with the seeds	15 baskets	14½ ounces	Dehne
Parsnep seeds	8 lb	2 drachms	Lewis
Pennyroyal, in flower, fresh	13 lb	6 drachms	
Pepper, black	2 lb	ditto	
———	1 lb	2½ drachms	Gaubius
———	1 lb	3 drachms	
———	1 lb	2½ drachms	Neumann
———	1 lb	4 scruples	Cartheuser
——— Jamaica	1 ounce	30 grains	Neumann
Peppermint, fresh	4 lb	3 drachms	Lewis
Rhodium wood	1 lb	3 drachms	Neumann
———	1 lb	2 drachms	Sala
———	1 lb	3 drachms	
———	1 lb	3 drachms	Cartheuser
———	1 lb	4 drachms	
Roses	1 cwt	4 drachms	Tachenius
———	1 cwt	1 ounce	Homberg

Name of the Vegetable.	*Quantity.*	*Weight of the Oil.*	*Maker of the Experiment.*
Roses	12 lb	30 grains	Hoffmann
Rosemary, in flower	1 cwt	8 ounces	Lewis
———— leaves	1 lb	2 drachms	Sala
————	1 lb	3 drachms	
————	3 lb	3¼ drachms	Neumann
————	1 lb	1 drachm	Lewis
———— fresh	70 lb	5 ounces	Cartheuser
Rue leaves	10 lb	2 drachms	Hoffmann
————	10 lb	4 drachms	
——— in flower	4 lb	1 drachm	Lewis
————	60 lb	2½ ounces	
——— with the seeds	72 lb	3 ounces	
Saffron, Oriental	1 lb	5 scruples	Cartheuser
Sage leaves	34 lb	1½ ounce	Lewis
——— in flower, fresh	27 lb	6 drachms	
——— of virtue, in flower	1 lb	1½ drachm	Vogel
Sassafras wood	6 lb	1¼ ounces	Hoffmann
————	6 lb	2 ounces	Neumann
————	30 lb	7 oz 1 drach.	Dehne
————	24 lb	9 ounces	
Savin bark	2 lb	5 ounces	Hoffmann
————	29 lb	9 ounces	Dehne
——— wood	32 lb	½ ounce	
Saunders yellow	1 lb	2 drachms	Cartheuser
Scurvy grass, in flower, fresh	6 baskets	6 drachms	Dehne
Smallage seeds	1 lb	10 grains	Neumann
Stachas, in flower, fresh	5¼ lb	2 drachms	Lewis
Thyme, in flower, fresh	2 cwt	5½ ounces	
———— dry	3½ lb	1½ drachm	
——— (lemon) in flower, fresh	51 lb	1¼ ounce	
————	98 lb	2½ ounces	
———— a little dried	104 lb	3 ounces	
Wormwood leaves, dry	4 lb	1 ounce	
————	18 lb	1½ ounce	
Zedoary root	1 lb	1 drachm	Neumann
————	7 lb	1 ounce	Dehne

When the quantity of oil inherent in any particular substance is to be ascertained, it cannot be done directly on the first distillation, unless water were to be employed for this purpose, that is already impregnated with oil; because the water that is distilled from an oleaginous body for the first time always imbibes a considerable portion of its volatile oil, and thus renders the calculation erroneous.

Neither are vegetables impregnated with the same quantity of oil at all seasons of the year; but herbs should be applied to this purpose only when they are in full blossom, and many of them when they are run to seed. The roots are most impregnated with oil just before they send forth their radicles in the spring, but woods at the beginning of the winter. The maceration of green vegetables is needless, and indeed rather detrimental than otherwise; whereas, on the contrary, with dry and solid bodies it may be more useful, in which case some common salt is added, in order to prevent fermentation taking place. When fresh vegetables possess no particular volatile smell, it is rather of use to let them wither a little. Oils that yield a volatile odour must be distilled over with a gentle heat; but, on the other hand, such as at the same time are distinguished by a greater specific gravity, require a somewhat stronger fire for their distillation.

Most volatile oils, it is true, swim upon the water with which they have come over in distillation; there are some, however, that sink in it. The method of separating the former is, first to leave the glass filled with the oily water at rest for some days, and then, by shaking it gently, to bring the oil up to the surface of the water. It may then be taken off either with a tea-spoon, or with a small glass syringe. The best method, however, is to convey it by means of a short and slender skane of cotton, from the glass in which it is first received, into another glass tied to the upper part of this, by which means, at the same time, all the impurities, which are frequently to be found in these oils, adhere to the cotton, and the oil is obtained pure and clear. With respect to the other species of these oils, which sink to the bottom in water, and are consequently heavier than water, this latter fluid must be made heavier by another body; for which purpose, nothing more is necessary to be done, than to impregnate the water strongly with common salt, till the oil which lies at the bottom of the vessel rises to the surface, whence it may then be separated in the manner above-mentioned.

When volatile oils, brought nearer to the resinous state by time, but not yet entirely deprived of their peculiar smell, are distilled with the heat of boiling water, a part of them rises in distillation, which has all the properties of volatile oil freshly distilled. As this portion of oil is renewed by this operation, it is frequently practised on volatile oils, which begin to be altered by age; and this second distillation is called the rectification of volatile oils. We find in the cucurbit, after rectification, the resinous portion of the oil, which is no longer capable of being raised by the heat of boiling water. This oily residuum may, however, be attenuated by distilling with a stronger heat, and even all the volatility and thinness of volatile oils may be given to it, as in the oil of Dippel, as well as other oily matters, by distillations sufficiently repeated. But such oils have never the peculiar aromatic smell of the original volatile oil.

Volatile oils are employed in painting; in spirituous liquors, used at the table and at the toilette; in perfumes; and in medicine. As they act very powerfully, small doses only are given internally, as from one drop to four or five, incorporated with sugar, so as to form an oleosaccharum, or with other drugs in form of pills.

Oils, Fetid Empyreumatic. Under this name are comprehended all the oils of vegetable and animal matters obtained by distillation with a heat superior to that of boiling water; because these oils have a disagreeable, burnt, or empyreumatic smell.

From this definition it is seen, that empyreumatic oils are not a distinct class: that they may be very different from each other, and may have nothing in common, but that they are all half-burnt; for when any vegetable or animal matter is exposed to a degree of heat superior to that of boiling water, all the oils which they contain, of whatever kind they may be, pass in distillation; but are altered, by the fire, in their colour, smell, and in many other of their peculiar properties. Besides, if the matter thus distilled contain several kinds of oil, they are all mixed together when they are rendered empyreumatic. If, for example, a vegetable matter be distilled, which contains an oil that is sweet and not volatile, and also an oil in a resinous state, the fetid empyreumatic oil obtained will be only a mixture of these two oils half-burnt. The same may be said of animal matter, with regard to the oil properly called animal oil, and to the adipose oil which they contain.

No general properties, then, can be established as belonging to empyreumatic oil: they all vary according to the nature and proportion of the oils of which they are composed. Hence, in order to know the properties of any empyreumatic oil, it is necessary previously to know the kinds and proportion of oils contained in the substance from which it has been obtained, and also the changes suffered by each of these oils from the degree of heat requisite to render them empyreumatic. It will be only necessary here to observe, that all empyreumatic oils are acrid, and more or less soluble in alcohol; that the portion of these oils which rises first in distillation is always the thinnest; that by repeated distillations they may be rendered more and more thin and volatile; and that by a sufficient repetition of these rectifications, they may be almost entirely deprived of their empyreumatic smell, so that only a pungent and penetrating smell shall remain; which seems to be common to all oils treated in this manner.

Oils, *improperly so called*. Many preparations were by the ancient chemists called oils, merely from their consistence, although in other respects they were entirely different from oil. These improper names ought to be abolished, and they have accordingly fallen into disuse among modern chemists. Nevertheless, as they are found in most chemical books in the time of Lemeri, and as many of them are still frequently employed in the arts, we shall explain in few words the chief of them.

Oil of Antimony. By this name the butter of antimony, and some other solutions of antimony by acids, are called. See Antimony.

Oil of Arsenic. This is a combination of oxigenized muriatic acid with arsenic, and is made precisely in the same manner as butter of antimony. Equal parts of arsenic and of corrosive sublimate are mixed and distilled together, by which a liquor comes over similar to the butter of antimony. This is a very powerful, but, at the same time, very dangerous caustic. This shows, that arsenic, like antimony, and several other metallic substances, is capable of decomposing corrosive sublimate, by seizing its acid. Accordingly, mercury is revived in this as in all the similar operations. These combinations resemble the liquor of Libavius, which Adet has well explained. See Tin.

Oil of Mercury. When water is added to a solution of mercury in sulphuric acid, to form the precipitate called turbith mineral, the acid thus diluted still retains a portion of mercury dissolved, which is properly a sulphat of mercury. This salt, which is crystallizable, may be obtained by evaporating the water which keeps it dissolved. When exposed to a moist air, it deliquiates into a liquor, which Lemeri calls oil of mercury.

Lemeri also gives the name of oil of mercury to a solution of corrosive sublimate in alcohol.

Oil of Lead. This is a solution of acetat of lead in oil of turpentine. This salt is to be put into a matrass, and upon it oil of turpentine is to be poured, till it covers the salt with a thickness of some fingers, and the whole is to be digested during ten or twelve hours. The liquor, says Lemeri, acquires a red colour. The author directs, that the solution should be concentrated, by distilling from it a part of the oil of turpentine; and he recommends it for its utility in cleansing and cicatrising ulcers, particularly those which are putrid. This preparation, which Macquer says is certainly a powerful antiseptic, must be very proper for these purposes.

Among the oils improperly so called, this is one of those to which the name of oil has been with least impropriety given; for the basis of it is actually oil, and that oil really keeps the lead in solution. Lemeri affirms, that we may thus entirely dissolve a given quantity in oil of turpentine. This preparation, which has only been made for medicinal purposes, is interesting also in chemistry, and deserves a particular examination.

Oil of Sulphur. Some chemists have given this name to the concentrated sulphuric acid.

Oil of Tartar by Deliquium. A name formerly given to carbonat of potash resolved into a liquor by the moisture of the air, or even to a solution of that salt in water.

Oil of Venus. Lemeri gives this name to the salt formed by the union of copper with the nitric acid, when it is resolved into a liquor by the moisture of the air. It is a caustic and escharotic, like all other similar combinations of metallic matters with any acids to which the name of oil was formerly given.

Oil of Vitriol. This name is very commonly, but improperly, given to concentrated sulphuric acid.

Ointment. A compound of oily or unctuous matter, with or without powders or other substances, made of the consistence of butter, for medical use.

Oleosaccharum. This name is given to a mixture of oil and sugar, incorporated with each other, to render the oil more easily diffusible in watery liquors. Sugar and all saccharine matters have in general a quality somewhat saponaceous, and consequently are capable of producing this effect in some measure. These oleosaccharums are used in pharmacy, as a method of administering volatile and other oils.

Oleum Vini. In the distillation of sulphuric ether, after the ether has come over, sulphurous acid rises, and with it a light, yellowish oil, which is called *sweet oil of vine*. Fourcroy says, that the formation of this oil may be prevented, by keeping the temperature between 200° and 208°, and carefully adding a few drops of water in the retort. According to him, it differs from ether only in containing more carbon, and from alcohol in containing less; so that it is a mean between the two. This oil, mixed with the ether as it first comes over without rectification, or the dulcified spirit of vitriol of the old dispensatories, makes the anodyne mineral liquor of Hoffmann.

Olibanum. A gum resin, the product of the Juniperus Lycia Linn., brought from Turkey and the East Indies, usually in drops or tears. The ancients distinguished various sorts of olibanum, as, 1. Olibanum, or thus masculum, melax, melason, testiculatum, or the purest, yellowish-white, round tears, which were frequently joined two together. 2. Thus fœmineum, or the yellower and more impure. 3. Thus mammosum, or larger oblong roundish masses, somewhat resembling a woman's breasts. 4. Thus granulosum, or small granules. 5. Thus corticosum, or such masses as have pieces of the bark of the tree adhering. 6. Thus orobæum, or mica thuris; small fragments, or particles broken off in carriage, &c. 7. Manna thuris, the finer dust. 8. Thus indicum, or large masses, composed of different coloured tears, white and blackish, joined together.

At present only two kinds are distinguished: the finer and purer tears are called olibanum in grains; the more impure fragments and masses, common olibanum, or olibanum in sorts. The best is of a yellowish white colour, solid, hard, and brittle: when chewed for a little time, it renders the spittle white, and impresses an unpleasant bitterish taste; laid on burning coals, it yields an agreeable smell.

Out of an ounce of the pure tears, alcohol dissolved five drachms two scruples and six grains: from the remainder, water took up two drachms and five grains. Another ounce gave out to water at first three drachms and a scruple; and afterward to spirit, four drachms thirty-three grains. The indissoluble matter, in the first operation, weighed twelve grains; in the other, fourteen. Both the distilled spirit and water tasted pretty strongly of the olibanum, but no separable oil could be obtained. Olibanum is accounted corroborant, and supposed to be particularly serviceable in disorders of the head, stomach, and breast. Its principal use is in plasters, unguents, and in fumigations.

Olibanum is not, in any of its states, what is called thus or frankincense in the shops. The common frankincense is a solid, brittle resin, brought to us in little balls or masses, of a brownish or yellowish colour on the outside, internally whitish or variegated with whitish specks; of a bitterish, acrid, not agreeable taste, without any considerable smell. It is supposed to be the produce of the pine tree, which yields the terebinthina communis; and to concrete on the surface of the terebinthinate juice soon after it has issued from the plant.

Olives. The oil of this fruit is well known; it is obtained by expression. The process used in the south of France, as described by Chaptal, is very simple. The olive is crushed by a mill-stone, placed vertically, rolling upon a horizontal plane. The paste thus formed is strongly pressed in a press; and the first oil which comes out is called virgin oil. The marc or pulp is then moistened with boiling water; the mass is again pressed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumstances likewise establish other differences. If the olive be not sufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous. The method of extracting the oil has a very great influence on its quality. If the oil-mills be not kept sufficiently clean, the mill-stones, and all the utensils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In some countries it is usual to lay the olives in heaps, and suffer them to ferment before the oil is drawn. By this management the oil is bad; and this process can only be used for oil intended for the lamp or for the soap-boiler.

Olivine. This stone, which has been considered as a chrysolite, and distinguished by the epithet volcanic, or basaltic, is of a grayish green, or brownish or reddish green inclining to yellow, and specific gravity 3·265. Werner and others make it a distinct species; but Klaproth deems it too much like the chrysolite in its ingredients and their proportions, to be classed as any thing more than a variety. It afforded him from 100 parts, silex 50, magnesia 38·5, oxide of iron 12, lime ·25.—*Klaproth's Analysis.*

Ollaris Lapis. See Lapis Ollaris.

Onions. Neumann examined this root; he could not obtain any oil by distillation from twelve pounds of onions sliced, and treated with water in the usual manner. The water which came over contained all the active parts of the onions.

This root contains much aqueous moisture. It lost near four fifths of its weight by drying, and the onions when half dry smelt like rue.

An ounce of the dry root yielded to Neumann with alcohol six drachms of extract, and afterward with water one drachm eighteen grains. Another ounce, treated first with water, gave six drachms thirty-five grains, and afterward with spirit half a drachm; the indissoluble residuum weighed in the first case two scruples sixteen grains, in the latter eight grains more. The distilled spirit is somewhat impregnated with the oil of the onion, discoverable rather by its taste than by its smell; the more subtile odorous parts having been dissipated in the previous exsiccation. The spirituous extract tastes strongly of the onion: this is the strongest preparation in point of taste, and the distilled water in smell. This root, beside its culinary uses, has been employed medicinally, as a resolvent and diuretic, in cachexies, dropsies, nephritic cases, &c.

Onyx. An agate generally opake, or but slightly transparent, consisting of differently coloured veins, parallel to each other, sometimes in straight and sometimes in curved lines.

Opal. Opalus, pædros Græcorum, the girasole of the Italians.

It is the most beautiful of all the flint kind, owing to the changeable appearance of its colours by reflection and refraction, and must therefore be described under both these circumstances.

Cronstedt distinguishes two kinds of opal: the opal of Nonnius, or the sangenon of the Indians. It loses its colour and transparency in fire; and in other respects is affected by it as a quartz or flint. It fuses with borax, though difficultly; and its specific gravity is 1·900 and upwards.

This opal appears olive-coloured by reflection, and seems then to be opake; but when held against the light, is found transparent, and of a fine ruby red colour.

That opal is supposed to have been of this kind, which Pliny mentions in his Natural History, book xxxvii. chap. 6, and which, he says, was in the senator Nonnius's possession, who rather chose to suffer banishment than part with it to Antony.

This stone was in Rome at that time valued at 20,000 sesterces. The stone here particularly described was found in the ruins of Alexandria: it is about the size of a hazel nut, and was bought for a trifle of a French drogoman* named Roboly, and presented to the French general consul Lironcourt, who afterward offered it to sale in several places for the sum of 40,000 rix dollars. See Hasselquist's Travels to the East, under the article opal.

There is, however, another of the same kind in Sweden, which by reflection appears rather brown; but by refraction it is red with violet veins. 2. The white opal; its ground is white, of a glasslike complexion, whence are thrown out green, yellow, purple, and blueish rays; but it is of a reddish or rather flame-colour, when held against the light.

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* That is to say, interpreter and broker, in Turkey.

Of this white opal there are three species. 1. Of many colours, or the oriental opal. 2. Of a milky colour, from Elbenstock in Saxony. 3. Blueish and semitransparent: this is not so much valued as those which are more opake, because it is easier to be imitated by art.

Not only this, but also some of the other kinds of opals have been well imitated by art, there being found compositions of glass, which show very different colours by refraction from what appear by reflection. A curious ancient one of this kind is to be seen in the royal abbey of St. Denis, near Paris, which is green on the outside, and shows a fine ruby colour when viewed against the light. Magellan makes mention of glass pastes, some made in London, by Edward Delaval, Esq. F. R. S., and some others by Mr. More, Secretary to the Society of Arts, which appeared of a yellow brown, or other colour by reflection; but when held against the light, transmitted a fine blue, or a purple and red colour, like sapphires, rubies, garnets, hyacinths, &c. Wallerius points out the proper ingredients to make these pastes.

The principal effect of the opal, namely, that of reflecting one colour and transmitting another, is observable in a variety of coloured, or imperfectly transparent pastes. It is common to all solids or fluids, on account of their imperfect transparency, but is not perceived in the greater number of them, because a large mass is in general required to intercept any considerable portion of the rays of light. Thus the sea-water is blue by reflected light, and red by transmitted, as Dr. Halley observed in the diving-bell. So likewise the common colour of the air by reflection is blue. and this blue colour tinges the images of distant mountains, in the clear elevated regions of Switzerland and elsewhere; but it is red by transmitted light, as is seen by the colour of the setting sun, or moon, and that of the rays which fall on the clouds in the morning or evening, which differ according to the length of the portion of air through which the light passes. There is, however, another property of the opal, which has not been well imitated by art, and affords the chatoyant effect, or variation of colour according to the position. This seems to arise from the foliated texture of the natural stone, which may be supposed to produce numerous extremely minute fissures, in certain determinate directions. The true opal may therefore be distinguished by this property whenever it appears; or more generally by its hardness, for none of the artificial stones resist the file.

An opal from Hungary, analysed by Klaproth, gave in the hundred parts—90 silex, 10 water, and about 0·1 of oxide of iron. A brown red semiopal from Telkebanya gave oxide of iron 47, silex 43·5, water 7·5: this therefore Klaproth classes among the iron-stones.

The oculus mundi, or hydrophanes, is a curious species of the opal. See Hydrophanes.

Opium. On wounding the heads or stalks of the white poppy, a milky juice exudes, which exsiccated proves a fine kind of opium. In Natolia, Cilicia, Cappadocia, in the neighbourhood of Cairo, and in several other parts of the Turkish dominions, poppies are cultivated for this use in fields, as corn among us. The method of collecting the juice by incision is described by Kæmpfer, in his Amœnitates Exoticæ. This process, however, is now but rarely practised, the consumption of this drug being too great to be supplied by that method of collection. The best sort of the officinal opium is the expressed juice of the heads, or of the heads and the upper part of the stalks, inspissated by a gentle heat: this was formerly called meconium, in distinction from the true opium, or juice which issues spontaneously. The inferior sorts (for we find considerable differences in the quality of this drug) are said to be prepared by boiling the plant in water, and evaporating the strained decoction; but as no kind of our opium will totally dissolve in water, the juice is most probably extracted by expression. Neumann was informed by some Turks at Genoa and Leghorn, that in some places the heads, stalks, and leaves are committed to the press together, and that this juice inspissated affords a very good opium.

On this head Dr. Lewis remarks, that the point has not yet been fully determined. It is commonly supposed, that, whatever preparations the Turks may make from the poppy for their own use, the opium brought to us is really the milky juice collected from incisions made in the heads, as described by Kæmpfer. It is certain, that an extract made by boiling the heads, or the heads and stalks, in water, is much weaker than opium; but it appears also, that the pure milky tears are considerably stronger.

The principles separable from opium are, a resin, gum, a minute portion of saline matter, water, and earth. The resin is of two kinds; one more truly resinous, of a solid consistence, in its nature more fixed, and in its operation more sluggish; the other softer and thinner, more volatile, and of much more speedy and powerful activity. The saline matter is of the acidulous kind, analogous to the essential salts of other vegetables: its proportion is so small, that it is not easily separable in its proper form, though it has sometimes happened, that actual crystals have concreted in a watery solution of opium. The resin, the gum, and the salt, are very intimately combined together, insomuch that all the three dissolve almost equally in water and in spirit: it is probably to the saline principle, in this and other vegetables, that this intimacy of union is in great measure to be ascribed.

Four ounces of opium, treated with alcohol, yielded three ounces and four scruples of resinous extract, five drachms and a scruple of indissoluble impurities remaining. On taking four ounces more, and applying water at first, Neumann obtained two ounces five drachms and one scruple of gummy extract; and, by digesting the residuum in alcohol, three drachms and one scruple of resinous extract; the indissoluble part amounting here to seven drachms and a scruple. In distillation, alcohol brought over little or nothing; but the distilled water was considerably impregnated with the particular ill smell of the opium.

The subtile soft kind of resinous matter discovers itself in great measure in the bare watery solution of opium, generally rising to the surface in form of a fat, unctuous, frothy substance. This is the strongest and most active part of the opium; a few grains are sufficient to kill a dog, who could bear a whole drachm of crude opium. From a pound of opium we may collect two or three drachms of this balsam-like substance; but we are not to imagine, that this is the whole quantity which the opium contains: beside what thus spontaneously separates, a part remains combined with the rest of the juice, and probably is the principle, or the direct seat of the principle, that gives activity to the whole.

As opium in substance is frequently found to be productive of unfavourable consequences, different methods have been contrived for correcting or rendering it more universally safe, but none have produced a medicine better than the pure opium itself.

Opium has been made from poppies in England equal to that imported from abroad: and Dr. Coxe of Philadelphia asserts, that the inspissated milky juice of the common garden lettuce is precisely similar in its effects to the opium from Turkey. The reverend Mr. Cartwright too is said to have found the same thing.

Opobalsam. The most precious of the balsams is that commonly called Balm of Gilead, Opobalsamum, Balsamæleon, Balsamum verum album, Ægyptiacum, Judaicum, Syriacum, è Mecca, &c. This is the produce of the amyris opobalsamum, L.

The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable, aromatic smell, and a slightly bitterish pungent taste: by age it becomes yellower, browner, and thicker, losing by degrees, like volatile oils, some of its finer and more subtile parts. To spread, when dropped into water, all over the surface, and to form a fine, thin, rainbow-coloured cuticle, so tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalsam. Neumann, however, had observed, that other balsams, when of a certain degree of consistence, exhibit these phænomena equally with the Egyptian. According to Bruce, if dropped on a woollen cloth in its pure and fresh state, it may be washed out completely and readily with simple water.

Mr. Geoffroy observes, that a solution of balsam of Gilead made in alcohol, turns milky on being poured into water, but does not deposit any precipitate; and that this mixture is used in France as a cosmetic. He says, an equal quantity of oil of almonds is previously mixed with the balsam; but this ingredient can be of no use, as it totally separates and falls to the bottom, while the balsam dissolves in the alcohol.

Opodeldoc. A solution of soap in alcohol, with the addition of camphor, and volatile oils. It is used externally against rheumatic pains, sprains, bruises, and other like complaints.

Opopanax. A concrete gummy resinous juice, obtained from the roots of an umbelliferous plant, the pastinaca opopanax, Lin., which grows spontaneously in the warmer countries, and bears the colds of this. The juice is brought from Turkey and the East Indies, sometimes in round drops or tears, but more commonly in irregular lumps of a reddish yellow colour on the outside, with specks of white, inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar strong smell, and a bitter, acrid, somewhat nauseous taste. Its virtues are those of an attenuating and aperient medicine.

An ounce of opopanax, treated with alcohol, gave two drachms two scruples and six grains of resinous extract, and afterward with water, three drachms of gum; two drachms and a scruple remaining undissolved. Another ounce treated first with water, yielded three drachms two scruples and six grains of gummy extract; and afterward, with alcohol, one drachm of resin, the indissoluble part amounting to three drachms and a scruple. Both the distilled water and spirit are impregnated with the flavour of the opopanax; but no actual oil can be separated, at least on distilling small quantities of the juice.

Orange. The flowers of orange trees afford, by distillation, a very fragrant essential oil. From the rind of the fruit an essential oil may be obtained by expression. The juice of the fruit contains an essential acid salt, mixed with much mucilage. This salt may be obtained in crystals, by diluting the juice, clarifying it with whites of eggs, and evaporation. The juice not depurated from its mucilage, is apt to become mouldy; but by the above-mentioned method of depuration, a saline extract may be made, capable of being preserved, and possessed of the same medicinal qualities as the juice, which is said to be very powerful in the scurvy; or it may be advantageous to treat it in the same manner as lemon juice. See LEMONS.

The essential oil may be procured by pressure of the peeling against an inclined glass. In Provence and in Italy the peeling is rasped; by which means the vesicles are torn, and the oil flows into the vessel destined to receive it: this oil suffers the parenchyma which goes along with it to subside, and becomes clear by standing.

If a lump of sugar be rubbed against these vesicles, it imbibes the volatile oil, and forms an oleosaccharum, soluble in water, and very proper to give an aromatic flavour to certain liquids.

ORAT OF AMMONIA. A name which some neologists have applied to fulminating gold.

ORES are native substances, containing the metals in an altered state, in all cases, either combined with some foreign substance, which deprives them of malleability and metallic brilliancy, or else so intimately mixed, that the particles of metal cannot be discerned. In all cases wherein the metallic substance is clearly distinguishable, it is not called an ore, but a native metal.

The metal in most ores is in the state of oxide. When ores contain nothing but the oxide of the metal with the addition of more or less carbonic acid, they were formerly said to be calciform; but when they are combined with other substances, they were said to be mineralized. The mineralizers are either arsenic or sulphur. Beside the mineralizers there are various stony matters, which accompany ores in a certain peculiar way with regard to crystallization and appearance; which has occasioned miners to consider them as possessing an affinity to the ore. This stony accompaniment, of which a better notion may be formed by inspection of ores than from any general description, is called the matrix of the ore. The rocks that lie over the veins are called the roof; those that lie under them the floor, and by some the hading. The matrix is almost always a finer species of stone than the surrounding rocks, though of the same genus. Even the rocks themselves are of a finer grain as they approach the vein. There is no matrix peculiarly appropriated to any metal: it has only been remarked, that tin is generally found among stones of the siliceous genus, and lead very frequently among those of the calcareous. See METALLURGY, and the several metals.

Ores therefore consist, 1. of metallic substances in the state of oxide; or, 2. of these substances combined with other matters, with which they are said to be mineralized.

Mineralized ores are,—1. Simple, containing only one metallic substance; or, 2. Compound, containing two or more metallic substances.

Of the simple, and also of the compound ores, four kinds may be distinguished:

1. Ores consisting of metallic substances mineralized by sulphur, or sulphurets. Such is the lead-ore, called galena, composed of lead and sulphur.

2. Ores consisting of metallic substances mineralized by arsenic. Such is the white pyrites, containing iron and arsenic.

3. Ores consisting of metallic substances mineralized by sulphur and by arsenic. Such is the ruby silver-ore, containing silver, arsenic, and sulphur.

4. Ores consisting of metallic substances mineralized by saline matters. Such is the native sulphat. Such also is the corneous silver ore, which is silver combined with muriatic acid. To this class also may be referred the silver mineralized by an alkaline substance, which Mr. Von Justi says he has discovered.

Henckel, and after him Cramer and Macquer affirm, that in mineralized ores, beside the above-mentioned metallic and mineralizing substances, are also contained a metallic and an unmetallic earth. But Wallerius affirms, that the existence of such earths cannot be shown, and that sulphur is incapable of dissolving unmetallic earths, and even the oxides of all metallic substances, excepting those of lead, bismuth, and nickel.

Metals and metalliferous ores are found in various places.

I. They are found under water, in beds of rivers, lakes, and seas, and chiefly at the flexures of these: such are the auriferous and ferruginous sands, grains of native gold, ochres, and fragments of ores washed from mines.

II. They are found dissolved in water: such are the mineral waters containing sulphats of iron, copper, or zinc.

III. They are found upon the surface of the earth. Such are many ochres; metalliferous stones, sands, and clays; and lumps of ore. Mr. Gmelin says, that in the northern parts of Asia ores are almost always found upon or near the surface of the ground.

IV. They are found under the surface of the earth. When the quantity of these collected in one place is considerable, it is called a mine.

Subterranean metals and ores are differently disposed in different places.

1. Some are infixed in stones and earths, forming nodules or spots diversely coloured.

2. Some are equally and uniformly diffused through the substance of earths and stones, to which they give colour, density, and other properties. Such are the greatest part of those earths, stones, sands, clays,

crystals, flints, gems, and spars, which are coloured.

3. Some form strata in mountains. Such are the slates containing pyrites, copper-ore, lead-ore, silver-ore, or blend. These lie in the same direction as the strata of stones, betwixt which they are placed; but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metalliferous stratum is often very various; whereas the thickness of the stony strata is known to be generally very uniform.

4. Fragments of ores are frequently found accumulated in certain subterranean cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not adherent to the contiguous rocks or strata immediately, or by intervention of spar or of quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described.

5. Large entire masses of ores are sometimes found in the stony strata of mountains. These are improperly called cumulated veins, because their length relatively to their breadth and depth is not considerable.

6. Some instances are mentioned of entire mountains consisting of ore. Such is the mountain Taberg in Smoland; and such are the mountains of Kerunavara and Luosavara in Lapland, the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron ore.

7. Lastly, and chiefly, metals and ores are found in oblong tracts, forming masses called veins, which lie in the stony strata composing mountains.

The direction of veins greatly varies, some being straight and others curved. Their position also respecting the horizon is very various; some being perpendicular, some horizontal, and the rest being of the intermediate degrees of declivity.

The dimensions, the quality, and the quantity of contents, and many other circumstances of veins, are also very various. Miners distinguish the several kinds of veins by names expressive of their differences. Thus veins are said to be deep; perpendicular; horizontal, or hanging, or dilated; rich; poor; morning, noon, evening, and night veins, by which their direction toward that point of the compass where the sun is at any of these divisions of the natural day, is signified.

Some parts of veins are considerably thicker than others. Small veins frequently branch out from large veins, and sometimes these branches return into the trunk from which they issued. These veins, from which many smaller veins depart, have been observed to be generally rich.

Veins are variously terminated: 1. by a gradual diminution, as if they had been compressed, while yet soft, by superincumbent weight, or by splitting and dividing into several smaller veins: or, 2. they are terminated abruptly, together with their proper strata in which they lie.

This abrupt termination of veins and strata is occasioned by their being crossed by new strata running transversely to the direction of the former; or by perpendicular fissures through the strata; which fissures are frequently filled with alluvial matters, or with water, or are empty. These perpendicular fissures seem to have been occasioned by some rupture or derangement of the stratum through which the vein passes, by which one part of it has been raised or depressed, or removed aside from the other, probably by earthquakes. Where the vein is terminated abruptly it does not cease, but is only broken and disjoined; and is often recovered by searching in the analogous parts of the opposite side of the deranged stratum. A principal part of the art of miners consists in discovering the modes of their derangements from external marks, that they may know where to search for the disjoined vein.

The contents of veins are metals and metalliferous minerals, as the several kinds of ores, pyrites, blends, guhrs; the several kinds of spars, quartz, horn-blend, in which the ores are generally imbedded, or enveloped, and which compose the matrix of the ore; stalactites; crystallizations of these metalliferous and stony substances, encrusting the small cavities of the circumjacent rock; and lastly, water, which flows or drops through crevices in that rock.

In a vein, ores are found sometimes attached to the rock or stratum through which the vein runs, but more frequently to a matrix which adheres to the rock; and sometimes both these kinds of adhesion occur in the same vein at different places. Frequently between the matrix and the rock a thin crust of stone, or of earth, is interposed, called by authors the fimbria of the ore.

The matrix, or the stone in which the ore lies enveloped, is of various kinds in different veins. And some kinds of stone seem better adapted than others to give reception to any ore, or to the ores of particular metals. Thus quartz, spar, fluats, and hornblend, give reception to all ores and metals, but slates chiefly to copper and silver, and never to tin; calcareous and sparry matrices, to lead, silver, and tin; and mica to iron.

Veins lie in strata of different kinds of stone; but more frequently in some kinds of stone than in others. Thus, of the simple or uncompounded stones, which compose strata, the following are metalliferous: calcareous stones; slaty sand stone; feltspar; quartz, sometimes jasper, frequently slates, and chiefly micaceous or talky stones, and horn-blend. No veins have been found in gypseous or siliceous strata, though cherts and flints frequently contain metallic particles, and some instances have been observed of ores of silver and tin in alabaster. Of compound stones, those are said to be chiefly metalliferous which consist of particles of horn-blend. Veins have also been found in the red granite; but seldom, if ever, in any other granite, or in porphyry. In general, veins are more frequently found in soft fissile, and friable strata, than in those which are compact and hard.

A vein sometimes passes from one stratum into the inferior contiguous stratum. Sometimes even the veins of one stratum do so correspond with those of an inferior stratum, the contiguity of which with the former is interrupted by a mass of different matter, through which the veins do not pass, that they seem originally to have been continued from one stratum to the other.

Thus, in the mines of Derbyshire, where the veins lie in strata of lime-stone, the contiguity of which strata with each other is interrupted in some places by a blue marl or clay, and in other places by a compound stone called toadstone, the veins of one stratum frequently correspond with the veins of the inferior stratum of lime-stone; but are never continued through the interposed clay or toadstone. But we must observe, that these interposed masses, the blue marl, clay, and toadstone, have not the uniform thickness observable in regular strata, but are (especially the toadstone) in some places a few feet in depth, and in others some hundreds of yards.

The above disposition seems to indicate, that these several strata of limestone have been originally contiguous; that the veins now disjoined have been once continued; that these strata of limestone have been afterward separated by some violent cause, probably by the same earthquakes which have in a singular manner shattered the strata of this mountainous country; that the interstices thus formed between the separated strata have been filled with such matters as the waters could insinuate, probably with the mixed comminuted ruins of shattered strata; or with the lava of neighbouring volcanoes, of which many vestiges remain.

To the above historical sketch of mines it may not be improper to add some conjectural remarks concerning their formation:

Those ores which are found under water (I); upon the surface of the earth (III); in fissures of mountains and subterranean cavities, accumulated, but not adherent to the contiguous rocks (IV); seem from their loose, unconnected, broken appearances to have been conveyed by alluvion.

All martial ochres have probably been separated from ferruginous waters (II), either spontaneously or by calcareous earth; and these waters seem to have acquired their metallic contents by dissolving the sulphat which is produced by the spontaneous decomposition of martial pyrites. The ochres of copper, zinc, and perhaps of several other metals, have probably been precipitated from waters containing their sulphats by some substance, as calcareous earth, more disposed to combine with acids; and these waters have probably been rendered metalliferous, by dissolving the sulphats produced by a combustion of cupreous pyrites, and of the ore of zinc called blend; for these minerals are not, as martial pyrites is, susceptible of decomposition spontaneously, that is, by air and moisture.

The metalliferous nodules and spots (IV, 1,) seem to have been infixed in stones while these were yet soft. Perhaps the metalliferous and lapideous particles were at once dissolved and suspended in the same aqueous menstruum, and during their concretion crystallized distinctly, as different salts do when dissolved in the same fluid.

The earths and stones uniformly coloured by metals (IV, 2,) were also probably in a soft state while they received those tinges. The opake coloured stones seem to have received their colour from metallic oxides, mixed and diffused through the soft lapideous substance; and the transparent coloured stones have probably received their colours from salts, or from metallic particles dissolved in the same water which softened or liquefied the stony substance; which metallic salts and particles were so much diffused, that they could not be distinctly crystallized. That all stones have been once liquid and dissolved in water appears probable, not only from their regular crystallized forms, but also from the solubility of some stones, as of gypseous and calcareous earths, in water; and from the water which we know is contained in the hardest marbles, as well as in alabasters; to which water these stones owe the crystallization of their particles.

The veins called cumulated (IV, 5,) and the entire metalliferous mountains (IV, 6,) are believed by Wallerius to be analogous to the nodules (IV, 1). These metalliferous substances seem to have been originally formed or concreted in the places where they are found.

The metalliferous strata (IV, 3,) have probably been insinuated between the lapideous strata, after the separation of these from each other by some violent cause; in the same manner in which it was supposed, that the clay and toadstone have been insinuated betwixt the several strata of limestone in Derbyshire. The matters thus insinuated may have been either fluid, which would afterward crystallize, and form entire regular masses; or they may have been the ruins of shattered strata, and veins brought by waters, and there deposited: in which case they will appear broken and irregular. The metalliferous strata, though frequently confounded with the horizontal or dilated veins, may be distinguished, according to Wallerius, from these by the following properties:—

1. They are generally thinner and much broader than the veins called dilated.

2. They are seldom found at a greater depth than 100 perches, and generally in the neighbourhood of veins, from which they probably have received their contents.

3. From their want of the thin incrustations called fimbriæ, which, as has been observed, are frequently interposed betwixt the rock and the ore, or its matrix; and from their want of the other properties of veins.

But in veins properly so called the strongest marks exist of ores having been there concreted, and not carried thither and deposited in their present state. Their regular, unbroken appearance, their adhesion to the contiguous rock, either immediately or by intervention of a matrix, the regular appearance of this matrix enveloping the ore, the frequent crystallization of the ore, and of the other contents of the vein, indicate that ores, as well as the other solid contents, have been there concreted from a fluid to a solid state.

Most authors believe, that veins, and the perpendicular clefts in the stony strata of mountains, called fissures, have been produced by the same cause; or, rather, they consider veins only as fissures filled with metalliferous matters. They farther believe, that fissures have been occasioned by the exsiccation of strata, while these were passing from a fluid to a solid state. Wallerius imagines, that fissures have been formed from exsiccation; but that veins were channels made through the strata, while yet soft and fluid, by water, or by the more fluid parts of the strata, penetrating and forcing a passage through the more solid parts. He conceives, that these fluid parts conveyed thither their metalliferous and stony contents, which were then coagulated or concreted. He supports his opinion by observing, that all the veins of the same stratum generally run parallel to each other; that they frequently bend in their course; that the same vein is sometimes contracted and sometimes dilated; that veins are frequently terminated by being split or divided into inferior veins; that veins are frequently wider at bottom than at top, whereas fissures are always widest at top, and are very narrow below: all which appearances, he thinks, could not have been produced by exsiccation.

From these reasons, fissures appear to have had a different, and from the disjunction and rupture of veins crossed by fissures, they seem to have had a later origin than veins. Whether fissures could have been produced by the very gradual exsiccation of these large masses, or strongly coherent matter; or whether they have been produced by the same violent causes, namely, earthquakes, by which the strata in which fissures are generally found have been broken and deranged, and by which metalliferous mountains themselves have been formed, or their strata raised above their original level, as some others have with great probability conjectured, cannot with certainty be determined.

Veins are seldom, if ever, found but in mountains; the reason of which may not improbably be, that in metalliferous mountains we have access to the more ancient strata of the earth, which in plains are covered with so many deposited, alluvial, and other later strata, that we can seldom if ever reach the former. That these mountains consist of strata which have been originally lower than the upper strata of adjacent plains, appears from an observation which has been made, that the strata of mountainous countries dip with more or less declivity as they approach the plains, till they gradually sink under the several strata of those plains, and are at last immersed beyond the reach of miners. This leading fact in the natural history of the earth has been observed by a sagacious philosopher, Mr. Mitchell, in his Conjectures concerning Earthquakes, &c. Philos. Trans. 1760.

That the inferior strata of the earth contain large quantities of pyritous, sulphureous, and metalliferous matters, appears,

1. From the subterranean fires in those inferior strata, (which produce volcanoes, and probably earthquakes (as Mr. Mitchell ingeniously conjectures).

2. From the observation, that all kinds of mountains are not equally metalliferous; but that veins, especially, are only found in those mountains, which, being composed of very ancient strata, are called primæval, which form the chains and extensive ridges on the surface of the earth, which direct the course of the waters, and which consist of certain strata, the thickness of each of which, its genuine qualities, and its position relatively to the other strata, are, in different parts of the chain of mountains where that stratum is found, nearly uniform and alike, notwithstanding that the numbers, and the inclinations of the strata composing contiguous mountains, or even different parts of the same mountain, are often very various; and therefore that veins are seldom, if ever, found in the mountains called by authors alluvial and temporary, which are single, or detached, which consist not of strata uniformly disposed, but of alluvial masses, in which fragments of ores may be sometimes, but veins never, found. Nevertheless, single, and seemingly detached, mountains in small islands have sometimes been found to be metalliferous. But we must observe, that these mountains

consist of uniform strata; that islands themselves, especially small islands, may be considered as eminent parts of submarine ranges of mountains; and that the mountains of such islands may be considered as apices or tops only of inferior mountains.

Those mountains are said to be most metalliferous, which have a gentle ascent, a moderate height, and a broad basis, the strata of which are nearly horizontal, and not much broken and disjoined. In these mountains, at least, the veins are less interrupted, more extended, and consequently more valuable to miners than the veins in lofty, scraggy, irregular, and shattered mountains.

Authors dispute concerning the time in which ores have been formed, some referring it to the creation of the world, or to the first subsequent ages; and others believing, that they have been gradually from all times, and are now daily, forming. From the accretion of ores and of their matrices to their proper rocks, and from the insertion of metalliferous nodules and striæ in the hardest stones, it seems most probable, that the matter of those veins and nodules is nearly coeval with the rocks and stones in which they are enveloped.

Nevertheless, it cannot be doubted but that small quantities, at least, of ores are still daily formed in veins, fissures, and other subterranean cavities. Several well attested instances confirming this opinion are adduced by authors: Cronstedt mentions an incrustation of silver ore, that was found adhering to a thin coat of lamp-black, or of soot, with which the smoke of a torch had soiled a rock in a mine at Koningsberg, in Norway; and that this incrustation of silver ore has been formed by a metalliferous water passing over the rock. Lehman affirms, that he possesses some silver ore attached to the step of a ladder, found in a mine in the Hartz, which had been abandoned two hundred years ago; and that several steps of ladders similarly incrusted had been found. Many other instances are mentioned by authors, of galena, pyrites, silver ores, and other metalliferous substances having been found adhering to wood, to fossil-coal, to stalactitical incrustations, to oyster shells, and other recent substances.

From these, and from similar instances, it seems probable, that not only ochres and fragments of ores may, with other alluvial matters, be now daily deposited, but also that small quantities of mineralized ores are recently formed; although many histories mentioned by Becker, Barba, Henckel, and other authors, of the entire renovation of exhausted veins, and especially those of the growth and vegetation of metals and of ores, appear to be at least doubtful.

Various opinions have been published concerning the formation of mineralized ores. According to some, these ores were formed by congelation of the fluid masses found in mines, called gurhs. Other authors believe, that ores have been formed by the condensation of certain mineral, metallic, sulphureous, and arsenical vapours, with which they suppose that mines abound. Some have even affirmed, that they have seen this vapour condense, and become in a few days changed into gold, silver, and other metallic matters.

It has been above observed, that, from several appearances which occur in veins, there is great reason to believe, that ores have not been carried thither and deposited in their present state, but have been there concreted and crystallized, that is, changed from a fluid to a solid state. But the fluidity of the metalliferous matters at the time of their entrance into veins may have been occasioned either by their having been dissolved in water, if they were capable of such solution, or by their having been raised in form of vapour by subterranean fires. For the disposition to crystallize is acquired by every homogeneous substance that is fluid, whether it have received its fluidity by being melted by fire, or by being dissolved in a liquid menstruum, or by being reduced to the state of vapour. Thus, crystals of sulphur have been observed to be daily formed by the sulphureous vapours which exhale in the neighbourhood of volcanoes.

The volatility of the two mineralizing substances, sulphur and arsenic, and the power which volatile bodies possess of elevating a certain portion of any fixed matter which happens to be united with them, render it probable, that the greatest part at least of mineralized ores have been formed of vapours exhaled from subterranean fires through the cracks in the intervening strata, occasioned by those earthquakes which have in a singular manner broken and deranged the strata of metalliferous countries, and which, as has been above remarked, have been probably occasioned by, at least have certainly been always accompanied with, subterraneous fire.

ORES OF ANTIMONY. Antimony has been found in the native state of a silver colour, and its texture composed of moderately large, shining plates. It has the same habitudes in acids, as the metal reduced from the sulphuret and aqua regia more particularly dissolves it very well. The solution does not lose its transparency in the cold. Alkalis throw down a white precipitate. The prussiat of potash affords a green precipitate with small blue specks, which shows the presence of iron. In the fire, native antimony melts and is volatilized in white flowers; but a substance of a fat and oily appearance is formed round the fused metal in much greater abundance than with the pure metal. Mongez asserts, that this is the oxide converted into glass of antimony. On the first impression of the heat, a slight smell of arsenic is emitted, which quickly disappears. Mr. Sage, in fact, found sixteen per cent of arsenic in the native antimony from Chalances, near Allemont, in Dauphiny. If this native ore be fused in a crucible without any reducing matter, a very neat button is obtained, susceptible of crystallization, more brilliant and clear in its fracture, which exhibits larger plates than before.

The appearances of this native metal, before the blowpipe, correspond with those observed in the larger process. It evaporates in smoke with a smell of garlic; a white powder is deposited on the charcoal, of which the arsenical portion becomes black and fixed, on application of the interior cone of the flame. The fluxes acquire a faint hyacinth tinge.

There is a native antimony at Andrensberg, from 100 parts of which Klaproth obtained 98 antimony, 1 silver, and 0·25 iron. Its specific gravity was 6·72.

Mongez likewise acquaints us with a native oxide of antimony, observed by him, upon a piece of the native antimony from Chalances. It is usually crystallized in very white, slender needles, in some portions confused with the plates of the antimony, and in others, radiated from a centre exactly like the crystallized zeolite. These did not contain arsenic. The white earthy ore of Tornavara in Gallicia is an oxide apparently produced from the decomposition of native sulphuret.

There is likewise a white antimonial ore, in which the oxide appears to be combined with muriatic acid; but it is very rare.

The most common and abundant ore of antimony is known in commerce simply by the name of antimony, and consists of the ore in combination with sulphur. It is composed of filaments, or needles, adherent to each other, either parallel, or divergent from a centre These are friable, brilliant, usually of a shining metallic blueish-gray colour; sometimes of a lively chatoyant appearance, according to Mongez; but I think on recollection, not having a specimen of the sort before me, that these colours, though variegated, do not change their position with the eye of the observer, or at least exhibit none of that internal appearance denoted by the word chatoyant. They should therefore rather be called iridescent.

When this ore of antimony possesses a less determined internal structure, it may be mistaken for the small grained lead ore, or white silver ore, or iron glimmer; but it may be distinguished by the smell of sulphur it exhibits when broken or rubbed, and still more effectually by its fusibility, which is such that it runs in the flame of a candle. The sulphur may be easily separated, and its quantity ascertained by aqua regia, which dissolves the metal, and leaves the sulphur floating at the surface. The aqua regia, according to Kirwan, ought to consist of one part nitric, and four muriatic acid.

The specific gravity of this ore of antimony is for the most part from 4 to 4·2, and after fusion from 4·7 to 5. There are several varieties:

1. The gray striated ore of antimony.

2. Plumous ore of antimony. This has the form of small, silky, gray or blueish filaments, almost always efflorescent. There are some specimens of a deep red, and of a pulverulent reddish colour, in prisms efflorescent upon the gray ore. The ore from Tuscany is of this kind. Mr. Sage considers the red plumous ore of antimony as a native golden sulphur, and the pulverulent reddish ore as a native kermes mineral.

3. The solid gray ore of antimony. This is a uniform mass, of the colour of polished iron or lead, very brittle, and its fracture exhibits small brilliant facets, and sometimes filaments. It melts and is volatilized by the flame of a candle.

The sulphuret of antimony urged by the flame of the blowpipe is liquefied, flows on the charcoal, soaks into it, and at length entirely disappears, except a portion of flowers, which are deposited circularly. One hundred parts of the ore contain twenty-four parts of antimony slightly oxided, and twenty-six of sulphur. For the analysis in the dry way, see ANTIMONY.

The red ore of antimony has the same texture with the common sulphureous ore, but its fibres are not so coarse. Wallerius distinguishes three varieties found in Hungary and Saxony, viz. the red, the violet, and the pale red.

ORES OF ARSENIC. Arsenic is found native in Saxony, Bohemia, Hungary, and elsewhere, but particularly at St. Marie aux Mines in Alsatia. It is often found of no determinate figure, friable, and pulverulent; but sometimes compact, divided into thick, convex plates, with a needle-formed or micaceous surface. It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens by exposure to the air. In hardness it seems to exceed copper, but is brittle like antimony. It burns with a small flame, and goes off in smoke. Cronstedt says nothing of the residue, but Bergman remarks, that he never found native arsenic without iron.

Native arsenic before the blowpipe takes fire, emits a white smoke, and covers the charcoal with flowers of arsenic, which quickly become black. A strong smell of garlic is emitted. If the portion of iron it contains be considerable, it remains on the coal; if not, it disappears. It communicates a yellowish colour to the flux, which disappears in proportion as the arsenic is volatilized.

Native oxide of arsenic is in general scarce. It is either in a loose or powdery form, or else in white semitransparent crystals. Like the artificial oxide, it is volatilized by heat, emitting a smell of garlic, and possesses the same solubility in water. See Arsenic. It does not detonate with nitre, though an effervescence arises. It is scarcely soluble in the sulphuric acid, something more in the muriatic, but most perfectly in the diluted nitric acid. Before the blowpipe, it evaporates in white flowers, which cover the charcoal. The peculiar smell of garlic appears to be sufficiently distinctive of this semimetal; but Mongez observes, as the characteristic marks of the respective flowers of arsenic, antimony, and zinc, that the first, when distributed upon the charcoal, become suddenly black if touched with the interior part of the flame, the second remain white, and the third become yellow.

The combinations of arsenic with sulphur are either *orpiment* or *realgar*. These are also produced by art. See the words. Native orpiment is of a yellow colour, inclining to red in some specimens, and green in others. It is frequently mixed with yellow mica and spar, which cause it to appear as if compounded of facets of greater or less magnitude. In the fire its colour becomes obscure, a white blueish flame appears, with a considerable mixed smell of garlic and sulphur. By an open fire it is almost entirely volatilized, and leaves only a greenish earthy residue; but in a close vessel it melts, and in cooling becomes the reddish mass called realgar. It is easily distinguished from artificial orpiment, because its figure is almost always that of small, silky, light crystals, or granulated.

Native realgar has a more lively colour, and possesses every degree of transparency, from that of the clear red crystals, called the ruby of arsenic, which is compact and hard, to that of perfect opacity. Its habitudes before the blowpipe are the same as those of orpiment.

Bergman's method of analysing these ores consists in digesting them in muriatic acid, adding the nitric by degrees, to help the solution. The sulphur will be found on the filter, and the arsenic will remain in the solution, from which it may be precipitated in its metallic form, by zinc, adding alcohol to the solution.

Mr. Chenevix gives the following, as the most certain mode of ascertaining the quantity of arsenic. Digest the ore, finely powdered, in nitric acid enough to acidify and take up all the arsenic. Pour off the liquor; boil the residuum in a little water, filter, and mix the two solutions. Neutralize the excess of acid by potash, taking care not to use it in excess, and add nitrat of lead, as long as any precipitate takes place. Wash the precipitate in cold water, dry, and weigh it. As the arsenical ores often contain sulphur, a little sulphat of lead may be mixed with the arseniat; and to decide this digest the powder in warm dilute muriatic or nitrous acid, and the arseniat will be dissolved, leaving the sulphat behind. One hundred parts of arseniat of lead contain oxide of lead 63, water 4, arsenic acid 33, which are equivalent to 22 of the metal.

Arsenical ores, containing the other metals, are in general distinguished by their respective denominations. The arsenical pyrites, or marcasite, contains sulphur and iron. It is of a gray ash colour, inclining to blue, either solid or composed of small brilliant particles. It tarnishes in the air, gives fire with steel, and emits a smell of garlic. Sometimes it effervesces with the nitric acid, which partly dissolves it. In the fire it is volatilized, and forms a true realgar, which distinguishes it from mispickel, which contains iron and arsenic without sulphur, and might easily be confounded with it. See Mispickel, also Arsenic.

Ores of Bismuth. Bismuth is the most common of all native metallic substances. It is generally found either in cubes or octagons, or of a dendritical form, or else in thin laminæ investing the ores of other metals, particularly those of cobalt. As it is very fusible, it may easily be extracted by exposing the minerals which contain it to a gentle heat. It then exsudes in small white globules, the more readily in proportion to its purity. It effervesces with nitric acid, forming a solution at first milky, but which afterward becomes clear. It is said to be sometimes alloyed with silver, in which case a separation may easily be made, by adding water to the nitric solution, which throws down the bismuth in the form of magistery.

Oxide of bismuth is found of a whitish or greenish-yellow colour, frequently upon the other ores of bismuth, probably formed by decomposition. It is then called flowers of bismuth, and may be distinguished from the flowers of cobalt by the red colour of the latter; for the flowers of bismuth are never red, nor become so. This oxide is readily dissolved in nitrous acid, and may be precipitated by water.

The oxide of bismuth is reducible on charcoal by the blowpipe, and melts in the spoon. With microcosmic salt it affords a globule of a dull yellow colour, which becomes paler and rather more opake by cooling. With borax, a mass is obtained in the spoon which is gray upon the charcoal, and not easily cleared of small bubbles. This glass fumes when kept in a state of fusion, and forms a circle of a greenish-yellow colour around it, produced by the volatilization of part of the bismuth.

Bismuth is mineralized by sulphur. It resembles galena or potters' lead ore in colour and appearance, is brittle, easily cut with a knife, and does not effervesce with acids, though soluble in aqua fortis. The solution is clear, and sometimes greenish. It is said to contain also cobalt and arsenic, but Mongez denies the latter. It is very fusible, and the sulphur mostly separates in scorification. There are two varieties; the one tessular like galena, from Bastnas in Sweden, and Schneeberg in Saxony, which is very scarce; the other striated, composed of scales or small needles, like the sulphureous ore of antimony, but does not soil the fingers. It comes from Schneeberg and Johann-Georgenstadt in Saxony.

Before the blowpipe this ore speedily melts, and affords a blue flame with a smell of sulphur, but the perfect reduction is rather long and difficult. Bergman advises to precipitate the bismuth with a small quantity of cobalt, which penetrates the globule by virtue of the sulphur. The mass then swells up, and produces a scoria divided into very evident compartments. This scoria, kept a longer time in the fire, emits globules of bismuth.

Bismuth is also found mineralized with sulphur and iron. This ore is composed of small, thick, uniform scales, of a gray-yellowish colour when recently broken, but more yellow where it has suffered exposure to the air. This species is more difficult to reduce than the preceding, on account of the iron it contains.

Wallerius, Sage, and Romé de Lisle, mention an ore of bismuth mineralized with sulphur and arsenic, which is of a shining appearance, of a whitish-yellow, or ash colour, composed of scales, in general small, hard, sometimes giving fire with a steel, not effervescent with nitric acid, though partly soluble. Mongez is disposed to think it merely the sulphureous ore of bismuth, already mentioned, but observes that the presence of arsenic cannot but show itself by its peculiar smell when heated. See BISMUTH.

ORES OF CERIUM. See CERITE.

ORES OF CHROME. See CHROME, and ACID (CHROMIC).

ORES OF COBALT. Cobalt has not been found in a state of native purity, but the combination of this semimetal with arsenic and iron in the metallic form usually passes for such. The quantity of iron is small. This ore is solid, hard, ponderous, of a gray colour, more or less obscure, sometimes inclining to red. Its fracture is granulated, not unlike some kinds of steel. It commonly gives fire with the steel, and emits a strong smell of garlic. In the fire it becomes black. Nitric acid dissolves it with effervescence, which affords a sympathetic ink by the addition of muriatic acid.

There are two characters which readily distinguish this mineral from the white and gray ores of arsenic.

1. It forms a sympathetic ink with aqua regia; and

2. It affords a blue glass with borax, whereas that of the ore of arsenic is black. There are two varieties, the one solid and compact, the other granulated and easily broken, beside that its colour is of a reddish-white, and sometimes a little hepatic.

Before the blowpipe this ore first emits a strong smell of garlic, then becomes black, and melts into a small globule of the metal. It gives a blue colour to the fluxes.

The oxide of cobalt is commonly found in the earth mixed with arsenic, iron, or copper; but whether mechanically, or more intimately combined, is doubted by Bergman. It is usually of a gray-black; but sometimes so black, that it might be taken for soot. It soils the fingers, and is almost always friable and pulverulent. On breaking a compact specimen, rose-coloured spots may frequently be observed, resembling the flowers of cobalt. It is seldom without a mixture of a small portion of oxide of iron. When solid, it sometimes has the resemblance and form of a vitreous scoria, whence some mineralogists have called it the vitreous ore of cobalt or slag. These are free from sulphur and arsenic. Cronstedt compares the friable ore, or cobalt ore, to the artificial zaffre. Mongez says it contains clay.

Before the blowpipe, as the black oxide of cobalt is always mixed with a small portion of the red oxide, which is arsenical, it emits a slight smell of garlic. The reduction is very difficult. But it dissolves in borax, gives it a blue colour, and is partly reduced in a small metallic globule, which occupies the lower part of the flux.

The arseniat of cobalt, cobalt bloom, or red cobalt ore, generally occurs mixed with other cobalt ores, or as a covering to them. It is sometimes found in crystallized quadrangular prisms terminated by dihedral pyramids.

Baron Born mentions a sulphuret of cobalt, in external characters very like the white cobalt ore, but perfectly free from arsenic and iron. There is likewise a sulphat of cobalt, in transparent stalactitical crystals of a pale rose colour.

ORES OF COLUMBIUM. See COLUMBIUM.

ORES OF COPPER. Copper is not, according to the opinion of Bergman, found native without a mixture of gold, silver, or iron. Some specimens, however, nearly resemble the refined copper in colour, malleability, and ductility. Others, instead of possessing the reddish colour, are rather of a yellow or brown colour, with green or blue spots of rust.

It is found in two different forms: 1. Solid native copper, which is either crystallized or in grains, or thin leaves, threads or dendrites adherent to different matrixes, such as calcareous stones, spars, quartz, petro-silex, jasper, schistus. There are few copper ores, according to Mongez, which do not contain some of these varieties.

2. Native copper in the form of small or imperfectly-coherent grains. This copper appears to have been deposited from mineral waters by means of iron, for which reason it is called cement copper.

Kirwan directs the humid assay of native copper by nitric acid. The gold, if it contain any, remains undissolved in the form of a black powder, which may be taken up and examined by aqua regia. The silver may be precipitated from the nitric solution by muriatic acid, or better by copper; and the iron falls down in the form of an insoluble oxide by sufficient ebullition with water.

The oxided copper ores are either of a red, blue, or green colour.

The red copper ore is rather scarce. In some specimens it is of a beautiful red, or of a brown-reddish liver colour, whence it has obtained the name of hepatic ore. When in a loose form it is called copper ore; but generally it is moderately hard, though brittle, sometimes crystallized and transparent, either in a capillary form, or in cubes, prisms, or pyramids. Mongez says, that the most common form is that of fine grains resembling the flowers of cinnabar. It is easily distinguished by its brightness, and ruddy colour, which approaches that of copper. It effervesces with acids, which dissolve it as well as the other oxides of copper. Another common character of these ores is, that they blacken in a moderate heat, to which may be added, the property of affording a blue colour with ammonia.

According to Fontana, quoted by Kirwan, a hundred parts of this ore contain seventy-three of copper, twenty-six of carbonic acid, and one of water. Bergman also found it to contain carbonic acid. According to Mr. Chenevix, however, the red octaedral copper ore consists of a pure oxide, containing 88·5 per cent of metal; and is therefore highly valuable, not merely for its richness, but for the purity of the metal, which is easily obtained from it. The brown or hepatic ore contains a variable proportion of iron or pyrites, and sometimes sulphuret of copper, and hence affords from 20 to 50 per cent of copper. It is often iridescent.

The blue copper ore most frequently appears in a loose form, though sometimes indurated and even crystallized, but it is then mixed with quartz. It frequently lines the internal cavities of different matrixes. When the blue colour is very lively, it is called azure of copper, when paler, mountain blue, and when abounding with earthy matter, blue chrysocolla. It must be confessed, however, that these terms are by no means accurately applied, but taken for the most part indiscriminately. Morveau, in the Memoirs of Dijon, has inferred from experiment, that the oxides of copper are determined to a blue rather than to a green by a nearer approach to the metallic state; but on this head see VERDITER.

The green copper ore is distinguished by the names mountain green, or green chrysocolla. It is found in two states, either earthy and friable, of a more or less deep green, or else solid and crystallized. The most beautiful specimen is the silky copper ore, so called because its texture exhibits long shining filaments.

The solid green ore is usually called malachite. See MOUNTAIN GREEN, MOUNTAIN BLUE, and MALACHITE.

Analogous to the oxided copper ores is the lapis armenus, a blue stone, that does not admit of a polish, and consisting of calcareous earth or gypsum, penetrated with the blue oxide of copper; hence it sometimes effervesces with acids, and sometimes not; but never gives fire with steel. It loses its colour when well heated in the fire. This stone is very different from the lapis lazuli, since this last contains no copper. See LAPIS LAZULI.

Bergman from Werner mentions a copper ore, consisting of that metal mineralized by carbonic acid, and combined with clay. This is most commonly superficial in small crystals of a beautiful green, or in small scales, and was formerly considered as a variety of mica or talc. Nitric acid dissolves it very well, and the solution takes a green colour. The copper may be precipitated in the usual manner. The blowpipe does not fuse this ore, if the flame be directed against its flat surface; but if the edge be attacked, it speedily melts into a black scoria. With borax it affords a brown yellow glass, and with microcosmic salt a glass of a fine grass green.

Copper mineralized by sulphur is commonly denominated the vitreous copper ore. Its colour is red, brown, blue, violet, or gray; it is generally so soft as to be cut with a knife, and shows a polished gold-coloured surface where cut. As to form, it is sometimes crystallized in regular figures, and sometimes irregular. In its fracture it often shows violet, reddish, and variable colours. It is much more fusible than pure copper, and may even be melted by a candle. Its specific gravity is from 4·129 to 5·338. It is found in the mines of other copper ores, and in lime-stone, spar, quartz, mica, and clay; it is the richest of all the copper ores, and the gray affords sometimes from 80 to 90 per cent of copper, 10 or 12 of sulphur, with a small proportion of iron: the red ores are the poorest, containing most iron.

This ore may be reduced with considerable facility by the blowpipe, but it is not easy to scorify and separate the last portions of iron and sulphur. To analyse the ore, Bergman advises a solution of it in five times its weight of concentrated sulphuric acid by ebullition to dryness, and the subsequent addition of as much water as will dissolve the sulphat thus formed. This solution he precipitates by a clean bar of iron, and thus obtains the copper in its metallic form. If the solution be contaminated with iron, he redissolves the impure copper thus obtained, in the same manner, and so procures a richer solution; which he again precipitates with iron.

The variegated copper ore differs from the vitreous ore only in containing more iron, of which the proportion is from 20 to 50 per cent. Its colour consists of various shades of blue, or reddish blue. It is as hard or harder than the preceding, and its fracture is reddish and polished like glass. It is more difficultly reduced by the blowpipe, and may be analysed in the humid way by the same treatment.

The yellow copper ore, or copper pyrites, contains a large proportion of iron mineralized with sulphur. It is sometimes found crystallized, and sometimes irregularly formed. The crystallized sort contains the smallest portion of copper, which is sometimes so trifling that the ore may be considered as a martial pyrites, though an experienced eye may discern a difference between them. The copper scarcely exceeds 40 per cent, in any of the specimens.

When this metal is sufficiently abundant to be wrought with profit, it may be roasted, and the sulphur preserved toward defraying the expenses. The residue being exposed to the united action of air and water, in a proper situation, will afford the sulphat of copper, which may either be crystallized for sale, or precipitated by fragments of old iron, as is advantageously done at the Paris-mountain mine in the isle of Anglesea, and elsewhere. When rich in copper, it is of a brilliant yellow colour, sometimes approaching to red; in other samples it is greenish, from the admixture of these two colours. The colours are more neat and lively at the place of fracture, than after exposure to the air, which changes them. It is not very hard, is considerably brittle, and scarcely gives fire with the steel. Its friability is greater, the larger the proportion of sulphur, and the less of iron. It affords several varieties:

1. Yellow copper ore, which is solid, ponderous, brilliant, and close in its fracture.

2. The yellow ore, which, though hard, has a laminated fracture; this is the most common of any.

3. Green yellowish copper ore; it contains the largest portion of sulphur, and the least of iron.

4. Crystallized yellow copper ore; it is the copper pyrites, properly so called, containing the least proportion of copper and the most of iron. When this is met with among rich ores, it is thrown aside, because of its difficult reduction and small produce, which does not exceed four or five pounds of copper in the hundred weight of ore. Its colour varies, being sometimes reddish, or resembling a pigeon's neck; when yellow, it is paler than the first variety here mentioned. The management of this ore in the analysis may be gathered from what has already been said. It may readily be fused by the blowpipe into a black matt, but it requires a continuance of the heat for a long time before the globule of copper becomes disengaged.

The gray copper ore appears to owe its character to antimony, which exists in it together with iron and sulphur. It sometimes contains silver, and a large proportion of lead. The copper amounts to between 16 and 32 parts in the hundred.

The colour of this ore is an obscure or blackish gray: it is hard; and the antimony it contains renders it brittle.

The count de Bournon and Mr. Chenevix have lately described and analysed with great minuteness various arseniats of copper.

1. Crystallized in obtuse octaedra; of a beautiful deep sky blue, sometimes inclining to Prussian blue, frequently a fine grass or apple green, and sometimes nearly white with a blue cast. Specific gravity 2·881.

2. In hexaedral laminæ; generally of a fine deep emerald green, but sometimes lighter. Specific gravity 2·548.

3. In acute octaedra; of a brown or bottle green. Specific gravity 4·210. Of this there are several varieties, in one of which, the amianthiform, the colour varies through different shades of a green to a golden brown, straw colour, and even satiny white.

4. In trihedral prisms; of a blueish green, or deep verdigrise colour, but easily decomposed, and then turning black on the outside. Specific gravity 4·28.

The third species above mentioned gave Mr. Chenevix 60 per cent oxide of copper, 39·7 arsenic acid. The rest appeared to be arseniated hidrats of copper, containing from 14 to 29 per cent arsenic acid, and from 16 to 35 water.

There is a bituminous copper ore, or pit-coal containing copper, which is found in Sweden, Hungary, and Alsatia. It takes fire without much difficulty, burns slowly, and leaves ashes, from which copper is extracted. This is probably the same substance mentioned by Brunnich on Cronstedt, p. 698, which is called pitch ore, in the Bannat of Temeswar. Gellert, in his Metallurgic Chemistry, mentions a copper ore of the colour of pitch, which resembles a vitrified scoria, and Raspe informs us, that copper has been found in Cornwall mixed with black pitchy rock oil.

Copper is also obtained from waters in which it is combined with the sulphuric and sometimes muriatic acid, no doubt produced by the decomposition of some of the ores above mentioned. Animal and vegetable substances are sometimes found penetrated with copper.

I shall conclude this article by inserting some processes for the reduction of copper ores in the furnace, taken from Cramer.

Process I.

(Cramer's Art of Assaying, process 36.)

To reduce and precipitate copper from a pure and fusible ore in a close vessel.

Mix one, or, if you have small weights, two docimastical centners of ore, beaten extremely fine, with six centners of the black flux; and having put them into a crucible or pot, cover them one inch high with common salt, and press them down with your finger: but let the capacity of the vessel be such, that it may be only half full; shut the vessel close, put it into the furnace, heap coals upon it so that it may be covered over with them a few inches high; govern the fire in such a manner, that it may at first grow slightly red-hot; soon after you will hear the common salt crackle, which will be followed by a gentle hissing noise. As long as this lasts, keep the same degree of fire till it ceases. Then suddenly increase the fire, either with the funnel and cover put upon the furnace, or with a pair of bellows applied to the hole of the bottom part, that the vessel may become strongly ignited. Thus you will reduce and precipitate your copper in about a quarter of an hour: then take out the vessel, and strike with a few blows the pavement upon which you put it, that all the small grains of copper may be collected into one mass.

Break the vessel, when grown cold, in two, from top to bottom, as nearly as you can: if the whole process has been well performed, you will find a solid, perfectly yellow, and malleable button adhering to the bottom of the vessel, with scorias remaining at top of a brown colour, solid, hard, and shining, from which the button must be separated by several gentle blows of a hammer: when this is done, weigh it, after having wiped off all the impurities.

A soft, dusty, and very black scoria is a sign the fire was not sufficiently strong. Small neat grains of copper reduced, but not precipitated, and adhering still to scorias, especially not very far from the bottom, and an unequal and ramified button, are signs of the same thing. A solid, hard, shining, red-coloured scoria, especially about the button, or even the button itself, when coloured with a like small crust, are signs of an excess in the degree and duration of the fire.

Remarks. All the ores which are easily melted in the fire are not the objects of this process; for they must also be very pure. Such are the vitreous copper ores; but especially the green and azure-coloured ores, and the cæruleum and viride montanum, which are not very different from them. But if there be a great quantity of arsenic, sulphur, or of the ore of another metal and semimetal, joined to the ore of copper, then you will never obtain a malleable button of pure copper, though ores are not always rendered refractory by the presence and these.

Process II.

(Cramer, process 37.)

To reduce and precipitate copper out of ores rendered refractory by earth and stones that cannot be washed off.

Beat your ore into a very subtile powder, of which weigh one or two centners, and mix as much sandiver with them. This done, add four times as much of the black flux with respect to the ore; for by this means the infusible terrestrial parts are better disposed to scorification, and the reducing flux may act more freely upon the metallic particles, set at liberty.

As for the rest, proceed as in the last process: but you must make the fire a little stronger for about half an hour together. When the vessel is grown cold and broken, examine the scorias, whether they be in the state they ought to be. The button will be as fine and ductile as the foregoing.

Remark. As these copper ores contain scarcely any sulphur or arsenic, the roasting would be of no effect, and much copper would be lost. For no metallic oxide, except those of gold and silver, improperly so called, can be roasted without some loss of the metal.

Process III.

(Cramer, process 38.)

To precipitate copper out of an ore that contains iron.*

Act in every respect according to the last process. But you will find, after the vessel is broken, a button by no means so fine, but less ductile, wherein the genuine colour of the copper does not perfectly appear, and which must be farther purified.

Remarks. The fire used in this operation is not so strong as to reduce and fuse iron alone. But copper dissolves iron in the dry way, though of itself very refractory in the fire. And for this reason, while the ore and the flux are most intimately mixed and confounded by trituration, the greater part of the iron will combine with the copper in its metallic state.

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* Cramer still means the calciform ores only, and not the mineralized ores of copper.

Process IV.

(Cramer, process 39.)

The roasting of pyritose, sulphureous, arsenical, semimetallic copper ore.

Break two docimastical centners of the ore to a coarse powder, put them into a test covered with a tile, and place them under the muffle of a docimastical furnace. The fire must be so gentle, that the muffle may be but faintly red-hot: when the ore has decrepitated, open the test, and continue the fire for a few minutes; then increase it by degrees, that you may see the ore perpetually smoking a little: in the mean time, it is also proper now and then to stir it up with an iron hook. The shining particles will assume a dark red or blackish colour. This done, take out the test, and let it grow cold. If the small grains be neither melted, nor strongly adherent to each other, the process has been well conducted: but if they run again into one single cake, it must be repeated with another portion of the ore, in a more gentle fire.

When the ore is grown cold, beat it to a powder somewhat finer, and roast it by the same method as before; then take it out, and if the powder be not yet melted, beat it again to a very subtile powder; in this you are to take care that nothing is lost.

Roast the powder in a fire somewhat stronger, but for a few minutes only. If you do not then find the ore in any respect inclined to melt, add a little tallow, and burn it away under the muffle, and repeat the operation, till, the fire being very bright, you no longer perceive any sulphureous, arsenical, unpleasant smell, or any smoke; and there remains nothing but a fine soft powder of a dark red, or blackish colour.

Remarks. Every pyrites contains iron, with an unmetallic earth, with sulphur, or arsenic, and most commonly both. Besides, as the copper in pyrites is exceedingly variable in quantity, their disposition in the fire must vary accordingly. For instance, the more copper there is in pyrites, the more it inclines to colliquation. The more sulphur and arsenic it contains, the more fusible it will be; and the more iron and unmetallic earth it contains, the more refractory it will prove in the fire.

If such pyrites melt in the roasting, as is the case with some of them, or if they grow but red-hot, the sulphur and arsenic become so strictly united to the fixed part, that it is almost impossible to dissipate them. For in this case, when the matter is again reduced into a powder, a much greater time and accuracy are required in the management of the fire to perform the operation. For this reason, it is much better to repeat it with new pyrites. But you must roast no more than twice the quantity at once of the ore you are inclined to employ in the foregoing experiment; in order that, if the precipitation by fusion should not succeed, there may still remain another portion for use, instead of your being obliged to repeat a tedious roasting.

If you observe the signs of a ferruginous refractory pyrites, the operation must be performed with a stronger fire, and with much greater speed. However, you must be careful not to perform it with too violent a fire: for a large proportion of copper is destroyed not only by the arsenic, but by the sulphur; and this happens even in vessels nearly closed, when the sulphur is expelled by a fire not quite so strong. By repeated and gentle sublimation of the sulphur in a vessel, both very clean and well closed, this fact will be clearly seen.

When the greater part of the sulphur and the arsenic is dissipated, you may make a stronger fire: but then it is proper to add a little fat. Cramer here accounts for the advantage produced by the fat, by observing, that it dissolves mineral sulphur. In fact, it reduces and volatilizes the last portions of arsenic, and at the same time, as he justly remarks, prevents that extreme scorification of the copper, which would greatly impede its subsequent reduction. Hence he adds, the reason is plain, why assayers produce less metal in the trying of veins of copper, lead, and tin, than skilful smelters do in large operations. For the former perform the roasting under a muffle, with a clear fire, and without any oily reducing matter; whereas the latter perform it in the middle of charcoal or of wood, which constantly tend to reduce the oxides.

The darker and blacker the powder of the roasted ore appears, the more copper you may expect from it. But the redder it looks, the less copper and the more iron it affords; for roasted copper dissolved by sulphur, or the acid of it, is very black; and iron, on the contrary, very red.

Process V.

(Cramer, process 40.)

The precipitation of copper out of roasted ore of the last process.

Divide the roasted ore into two parts, and reckon each of them a centner: add to it the same weight of sandiver, and four times as much of the black flux, and mix them well together. Manage the rest of the operation in every respect according to process I. The precipitated button will be slightly malleable, sometimes brittle, now and then very much like pure copper in its colour, but sometimes whitish, and even blackish. Whence it is most commonly called black copper, though it is not always of so dark a colour.

It is easy to conceive, that there is as great a difference between the several kinds of the metal called black copper, as there is between the pyritose and other copper ores accidentally mixed with other metallic and semimetallic bodies. For all the metals, the ores of which are intermixed with the copper ores, being reduced, are precipitated together with the copper; which is brought about by means of the black flux. Hence, iron, lead, tin, antimony, bismuth, are most commonly mixed with black copper in a variety of different proportions.

Indeed, it is self-evident, that gold and silver, which are dissolvable by all these matters, are collected in such a button, when they have previously existed in the ore. And moreover, sulphur and arsenic are not always entirely absent. For they can hardly be expelled so perfectly, by the many preceding roastings, but there will remain some vestiges of them, which are not dissipated by a sudden melting, especially in a close vessel, wherein the flux swimming at top hinders the action of the air. Indeed, arsenic is rather fixed by the black flux, and assumes a semimetallic form, while it is at the same time preserved from dissipating by the copper.

Process VI.

(Cramer, process 44.)

To reduce black copper into pure copper by scorification.

Separate a specimen of your black copper, of the weight of two docimastical centners at least; and perform this in the same manner, and with the same precautions, as if you would detect a quantity of silver in black copper.

Then with lute and coal-dust make a bed in the cavity of a moistened test: when this bed is dry, put it under the muffle of a docimastical furnace, in the open orifice of which there must be bright burning coals, with which the test must likewise be on all parts surrounded. When the whole is perfectly red-hot, put your copper into the fire alone, if it contain lead; but if it be entirely deprived of it, add a small quantity of glass of lead, and with a pair of hand-bellows increase the fire, that the whole may speedily melt: this done, let the fire be made a little less violent, and such as will be sufficient to keep the metallic mass well melted, and not much greater. The melted mass will boil, and scorias will be produced, that will gather at the circumference. All the heterogeneous matters being at last partly dissipated, and partly turned to scorias, the surface of the pure melted copper will appear.

As soon as you perceive this, take the pot out of the fire, and extinguish it in water: then examine it in a balance; and if lead have been at first mixed with your black copper, add to the button remaining of the pure copper, one fifteenth part of its weight which the copper has lost by means of the lead; then break it with a vice; and thus you will be able to judge by its colour and malleability, and by the surface of it after it is broken, whether the purifying of it have been well performed, or not. But whatever caution you may use in the performing of this process, the product will notwithstanding be always less in proportion than what you can obtain by a larger operation, provided the copper be well purified in the small trial.

Remarks. This is the last purifying of copper, whereby the separation of the heterogeneous bodies, begun in the foregoing process, is completed as perfectly as it possibly can be. For, except gold and silver, all the other metals and semimetals are partly dissipated and partly burnt, together with the sulphur and arsenic. For in the fusion they either turn of themselves to scoria or fumes, or this is performed by means of iron, which chiefly absorbs semimetals, sulphur, and arsenic, and at the same time they accelerate its destruction. Thus the copper is precipitated out of them pure: for it is self-evident, that the unmetallic earth is expelled, the copper being reduced from a vitrescent earthy to a metallic state; and the arsenic being dissipated, by means of which the said earth has been joined to the coarser buttons of the first fusion. But there is at the same time a considerable quantity of the copper that mixes with the scorias, though a great part of it may be reduced out of them by repeating the fusion.

The fire in this process must be applied with all possible speed, to make it soon run: for, if you neglect this, much of your copper is burnt; because copper that is only red-hot cleaves much sooner, and in much greater quantity, into half-scorified scales, than it is diminished in the same time when melted. However, too impetuous a fire, and one much greater than is necessary for its fusion, destroys a much greater quantity of it than a fire only sufficient to fuse it. For this reason, when the purifying is finished, the melted body must be extinguished in water together with the vessel, lest, being already grown hard, it should still remain hot for a while; which must be done very carefully to prevent dangerous explosions.

The scoria of the above process frequently contains copper. To extract which, let two or three docimastical centners of the scoria, if it be charged with sulphur, be beaten to a subtile powder, and mix it, either alone, or, if its refractory nature require it, with some very fusible, common, pounded glass, without a reducing saline flux, and melt it in a close vessel, and in a fire having a draught of air; by which you will obtain a button.

But when the scoria has little or no sulphur at all in it, take one centner of it, and with the black flux manage it as you do the fusible copper ore (process I.); by which you will have pure metal.

PROCESS VII.

The following process is translated from Gellert's Elements of Essaying.

To essay copper ores.

Roast a quintal of ore (after the manner described in process IV.); add to it an equal quantity of borax; half a quintal of fusible glass, and a quarter of a quintal of pitch; put the mixture in a crucible, the inner surface of which has been previously rubbed with a fluid paste of charcoal-dust and water; cover the whole with pounded glass mixed with a little borax, or with decrepitated sea-salt: put a lid on the crucible, which you will place in an air furnace, or in a blast furnace: when the fire shall have extended to the bottom of the coals, let it be excited briskly during half an hour, that the crucible may be of a brisk red colour: then withdraw the crucible, and when it is cold break it: observe if the scoria be well made: separate the button, which ought to be semiductile, and weigh it. This button is black copper, which must be purified as in process VI.

If the ore be very poor, and enveloped in much earthy and stony matters, to a quintal of it, a quintal and a half of borax, a quarter of a quintal of pitch, and ten pounds of oxide of lead or minium, must be added. The oxide of lead will be revived, and will unite with the scattered particles of the copper, and together with these will fall to the bottom of the crucible, forming an alloy. When the ores of copper are very rich, half a quintal of borax and a quarter of a quintal of glass will be sufficient for the reduction. If the ore be charged with much antimony, a half or three quarters of a quintal of clean iron filings may be added; otherwise the large quantity of antimony might destroy the copper, especially if the ore contained no lead. If iron be contained in copper ore, as in pyrites, some pounds of antimony, or of its sulphuret, may be added in the essay; as these substances more readily unite with iron than with copper, and therefore disengage the latter metal from the former.

ORES OF GOLD. From the unchangeableness of gold by the solvents usually disengaged in nature, it is comparatively very seldom found but in the native state. In this state it is never absolutely pure, but always mixed either with silver, copper, or iron. It is usually found in rocks of quartz, always in small particles or masses. The sands of several rivers afford it in small plates or leaves. Most great rivers carry gold with them, even such as do not take their rise in mountains where gold is found. In the south of France, in Transylvania, and elsewhere in Europe, this gold is separated by washing off the sand; but the produce is not sufficient in general to pay any rent, or employ capital. It merely affords subsistence to such poor families as apply to this species of industry, particularly after the torrents occasioned by heavy rains. If a hundred pounds of sand contain twenty-four grains of gold, it is said the separation is worth attending to; but in Africa, five pounds of sand often contain sixty-three grains of gold. The heaviest sand, which is often black or red, yields most.

Daubenton distinguishes eight varieties of native gold.

1. In powder.
2. In grains.
3. In small spangles.
4. In masses.
5. In filaments.
6. In branches like vegetables.
7. In small plates; and
8. In octaedral crystals.

Gold is found mineralized by sulphur together with iron, which is supposed to be the connecting medium. This is the auriferous pyrites. It is close and compact, of a brighter and more lively yellow than the ordinary pyrites; notwithstanding which, they are, as Mongez says, very difficult to be distinguished. The gold cannot be extracted by aqua regia, or by amalgamation; but the last-mentioned author gives the following simple method for this purpose: Take a small quantity of this pyrites, and digest it in the nitric acid. All the foreign matters will be dissolved, except the gold and sulphur, which fall to the bottom. Wash the residue under water till nothing more remains but a yellow brilliant powder. This is the gold. According to Mr. Sage, one half as much more gold is extracted from the pyrites by this method than by treatment with lead.

This pyrites, according to Cronstedt, sometimes contains an ounce of gold in the hundred pounds. Some samples contain a portion of zinc as well as iron, and even copper, which gives the mass a greenish tinge. It is found at Adelfors in Sweden, in Hungary, Mexico, the island of Sumatra, Switzerland, and Dauphiny in France. Cronstedt remarks, that no pyrites ought to be despised, which are found in tracts where gold ores are obtained. Brunnich on Cronstedt affirms, that the Transylvanian gold pyrites, in which no gold can be discovered by the eye, contained from fifty to one hundred and ten ounces, and upwards, in the hundred weight; and that those where the gold appears in the pyrites like mixed Spanish snuff, contained two hundred and fifty ounces, but they are very scarce.

Gold is found in Hungary united with mercury and sulphur. It is the auriferous cinnabar.

There is likewise a blend or ore of zinc found at Chemnitz in Hungary, which contains silver and gold. It is usually of a red or black colour.

The auriferous ore of Nagayac in Transylvania is mentioned by Bergman as a compound of gold, silver, lead, and iron, mineralized by sulphur. This ore is of a gray colour, more or less obscure, in irregular masses; but sometimes, also, it is composed of slender, flexible leaves of no great consistency; it may be cut with a knife, is soluble in acids with effervescence, and the solution appears clear and colourless. Its specific gravity is 8·919.

By Ruprecht's analysis 100 parts gave, sulphur 41·66, oxide of lead 25, oxide of iron 16·66, gold 11·66, silver 2·33, oxide of arsenic 1, oxide of antimony 2·08. Some specimens, however, are said to contain 25 per cent. of gold combined with silver. Klaproth however found in it but little sulphur, and a new metal. The foliated sort afforded him in 100 parts, lead 50, tellurium 33, gold 8·5, sulphur 7·5, silver and copper 1. The yellow gold ore of Nagyac gave, tellurium 45, gold 27, lead 19·5, silver 8·5, sulphur an atom. From the white gold ore, or aurum graphicum, of Offenbanya, in Transylvania, he obtained tellurium 60, gold 30, silver 10: and from that called aurum problematicum, or paradoxum, tellurium, 92·55, iron 7·2, gold 0·25.

For other remarks on the treatment of gold and its ores, see the article Gold. The new process of amalgamation, invented by baron Born, has very much engaged the attention of mineralogists; for which reason, as well for its own intrinsic value, I shall here give an account of the process, from Raspe's translation of the baron's work on this subject.

The amalgamation of gold and silver ores, in large operations, as well as in smaller assays, requires the following distinct operations:

Stamping, grinding, and sifting.

Calcination, and repeated grinding and sifting.

Trituration.

Washing of the residuum.

Eliquation of the amalgama.

Heating of the same.

Distillation of the quicksilver pressed from the amalgama.

Refining of the heated quicksilver; and lastly,

Management, use, and refining of such residua as still appear to contain some of the nobler metals.

Stamping, grinding, and sifting.

By these operations the picked ores, black copper, and mixtures of metals and semimetals are reduced into fine powder; and their surfaces being thus increased, they mix and calcine better with the common or rock salt, which is added to them; otherwise, the calcining fire and the air could not act sufficiently on the grosser particles, nor could the sulphuric and muriatic acids* properly penetrate them, or a perfect desulphuration and decomposition of such substances be brought on, in which the gold and silver particles are disguised.

These operations are performed at Glasshutte, near Schemnitz in Hungary, in dry stamps and mills; but at Joachimsthal in Bohemia, wet stamps have been substituted, by which means the loss of dust unavoidable in the dry grinding, and also the injury otherwise done to the health of the workmen, are prevented.

Calcination.

Sulphur can be expelled from ores in open fire and in closed vessels but imperfectly, unless some proper substance be added. Thus, for example, corrosive sublimate is used in order to separate the sulphur from some ores; in this case the concentrated muriatic acid unites with the metallic, semimetallic, and soluble earthy particles, passes into the receiver with the arsenic and oxide of antimony, and the disengaged quicksilver sublimes with the disengaged sulphur in the form of cinnabar.

From this an idea may be formed of the calcination of those ores, which, beside particles of native metal, contain disguised gold and silver, which would never be got entirely by washing or other mechanical contrivances, without some chemical assistance. This is their calcination. By fire and air it decomposes the ores, expels the sulphur, puts the metallic and semimetallic particles into the state of oxide, and, freeing the noble metals from their disguises, exhibits them naked in their metallic form.

If there be sulphur enough, or even a superabundance of it, calcination will produce this desirable effect without any other addition. But as the sulphuric acid acts on the ores, and disengages the gold and silver particles only in proportion as it is produced from the sulphur in more or less quantity, it is safer to depend on the muriatic rather than the sulphuric acid: and though common or rock salt, added in the process of

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* The sulphuric acid is produced in the act of calcination, by the decomposition of the sulphur contained in the ores, and the muriatic acid proceeds from the common salt, which is purposely added to the ores, and which is decomposed by the sulphuric acid. A sulphat is formed by the union of the last-mentioned acid with the basis of the common salt; and the muriatic acid, thus set at liberty, attacks, dissolves, and unites with the earthy matter, and also with the imperfect metals of the ores, by which means the particles of gold ~~and silver are freed from their disguise or heterogeneous coverings. and laid open to,~~ and fitted for combination with the quicksilver. This is in few words the theory of the process.

amalgamation of well calcined ores, answers this end in some respects, yet it will serve better when mixed in proper proportions with the earthy or metallic ores before they go to the calcining fire, thus undergoing with them a similar calcination. The quantity in which it is to be added must be determined by experience.

When picked and halvan ores are calcined with common salt, the sulphur and arsenic, if any, begin first to be disengaged. Part of the sulphur flies off undecomposed, a great part is converted into sulphuric acid, which last, uniting with the alkaline and metallic earths of the base metals and semimetals, but in particular with the mineral alkali of the common salt, forms with the first, different earthy and metallic (more or less soluble) neutral salts, and with the last, sulphat of soda. The muriatic acid thus disengaged begins now to act like the sulphuric, and is absorbed equally by the earths and the metallic oxides.

The muriatic acid consequently penetrates the alkaline and metallic earths more completely than the sulphuric alone; for if there be salt enough, it decomposes all the sulphuric, earthy, and metallic neutral salts, by its different elective attractions, forming therewith various new deliquescent and very soluble earthy and metallic neutral salts, by which all the disguised gold and silver particles are disengaged, laid bare, and fitted for amalgamation.

When auriferous or argentine mixtures of base metals and semimetals undergo calcination, fire and air will produce it in part, but slowly and imperfectly; whereas with common salt, or properly its acid, it succeeds quicker and better. There is no sulphur here, or its acid, to decompose the salt and disengage its acid; but common salt decomposing by continued heat, its acid separates from its alkaline basis, and acts immediately as a solvent of the metallic and semimetallic particles. The elective attraction of these metals and semimetals seems even to assist the decomposition and power of the salt.

The different mixtures of these alloys account for the different muriatic, metallic, and semimetallic neutral salts. For instance, the alloys produced by the fusion of the Hungarian fallow, or gray copper ores, consist of antimony, copper, gold, and silver, and sometimes also of some arsenic and iron, which in the alloys from common antimonial gray copper ores is but in a very inconsiderable proportion. The muriatic acid, disengaged from the salt, unites (gold and silver excepted) with the other metals and semimetals, which by calcination leave the gold and silver bare and undisguised.

The same thing happens in the calcination of auriferous or only argentine black coppers. By the addition of common salt, the copper, iron, arsenic, and sometimes the antimonial particles are not only oxided, but also most of the antimony and arsenic is volatilized and destroyed

The cobalt alloys produced in the treatment of arsenical cobalt and silver ores contain very often a great quantity of bismuth. The calcination with common salt acts upon them in a similar manner; but should they abound in bismuth, which is exceedingly fusible, this semimetal must be taken out by eliquation, before they can be well calcined, otherwise the bismuth would run, and, if not wholly prevent, yet very much hinder the oxidation of the other metallic and semimetallic particles.

In calcining mixtures which abound in antimony, and particularly in arsenic, it has been frequently found, that more or less quantities of silver and copper are carried off by the antimonial and arsenical muriat, chiefly when the calcining heat has been too sudden and brisk for the purpose of a quick oxidation of the antimony, and expeditious expulsion of the arsenic; for these volatile semimetals acquire, by the muriatic acid, a much greater than their natural power to carry off and volatilize even the finest metals.

Whatever these mixtures are, or may be, they must have gone through the stamps and mills, and have been completely pulverised, before they can be committed to the calcining fire, which is a flaming fire kept up by the worst of fuel; or to the calcining furnace, which consists of two hearths, which, taken together, are 11 or 12 feet by five, of a grate, smoke and dust chambers, communicating with a flue, and sliding dust-stoppers or dust-dampers.

The proportion and mixture of the picked and halvan or stamp-stuff is (in Hungary) determined by and depends upon the respective produce of the mines and stamps, which is commonly two in three; and with regard to the silver, upon their average produce. The proportion of the salt is regulated and determined by the more or less quantity of the sulphur of the said picked and halvan ores.

Thus, for example, a whole work, parcel, or stem of a calcining furnace in the quick-mills in Lower Hungary, consists of 30 cwt.; one third, or 10 cwt., of which are pulverised picked ore; and two thirds, or 20 cwt., pulverised stamp or halvan ore. Sometimes it consists of two fifths of the former and three fifths of the latter; and in that proportion it contains, upon an average, three and a half, three and three quarters, or four ounces of silver per cwt. To such a mixture they generally add eight per cent of rock-salt *.

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* If pan-salt should be used, and prove of an inferior quality on account of muriats of

The calcination of mixtures of base metals and semimetals, of silvery black coppers, and of leadish ores, requires, over and above the salt, an addition of quick-lime, from four to ten or twelve per cent. For these metallic mixtures otherwise rise amazingly in the calcining heat, and the speiss and black coppers are in particular apt to turn clammy, and to leave clots, in which many particles remain uncalcined; but both these inconveniences are counteracted by the lime. It prevents the immediate contact of the metallic particles, and their running in the calcining fire: moreover, as it increases the surface of the whole mixture, the single parts of the same are more effectually acted upon, oxided, and laid bare by the fire, air, and muriatic acid.

When the furnace is properly heated, and the doors of the dust-chambers, and the sliding-dampers, or dust-catchers of the flue, are shut, the whole parcel of ore (viz. 30 cwt.) is run by wheel-barrows on the flat top of the furnace; when having been equally spread into an even surface, the proper proportion of salt and lime is sifted over it, and the whole is turned and worked with iron rakes and crooks, in every direction, until the whole is perfectly and equally mixed. Thus prepared, it is spread into a square surface, and marked into equal divisions, which, in due succession, are let down (in 8 cwt. parcels) on the upper hearth, by means of a funnel, which opens upon it through the lower vault or floor of the furnace. On this hearth it must be spread and extended equally, that the moisture of the stamp or halvan ore may be expelled, before it is shoved down on the lower hearth: after which the upper hearth is immediately filled again with another quantity, that exsiccation and calcination may be performed at the same time, by the same fire.

In the calcination, the following phænomena take place: on the surface of the picked and halvan ores, when brought on the lower hearth, and stirred, an undulating motion is observed, and a volatile sulphureous acid smell is perceived; after which the sulphur begins to disengage itself burning, covering the whole (when the ores are very sulphureous) with a blue flame, and flying off at last in the form of a whitish thick suffocating smoke.

Whilst the sulphur is thus disengaged and decomposed in a low or gentle fire, the sulphuric acid, thence produced, decomposes the common salt, combines with its soda, and disengages the muriatic acid, which presently unites with the alkaline and metallic earths. At this time the ore begins to clot, to rise, extend, and increase in bulk and surface. It begins to look like wet ashes, and to diffuse a mixed, sulphureous, saline, acid smell, which proceeds from a lighter whitish or grayish blue smoke flying off from the surface.

From this instant the fire and furnace may be kept a little brighter, yet the ore must be continually stirred and turned over from one side of the furnace to the other; otherwise it would be calcined unequally, and some particles would remain undecomposed. If the furnace and fire were kept too bright, the sulphur, arsenic, and saline acid particles, too briskly expelled, would unavoidably carry along with them, and volatilize, many other nay even metallic particles *.

When the sulphur begins to disengage, the ore changes its colour; it changes again when the calcination is over at its rising and subsidence. The sulphureous acid smell disappears, when the ore that had been rising begins to sink, and the clotting ceases, for then part of the muriatic acid flies off. On taking a ladle full of it for proof, or even on smelling the whitish rarefied smoke near the back-door of the furnace, the smell of pure muriatic acid is perceived.

Most ores and mixtures of ores, chiefly when containing a great proportion of pyrites, or when there happens to be sulphuretted copper ore, show at this period a luminous phosphoric appearance, when suddenly taken from the hearth, and immediately examined in the dark. In a moderate heat and cold weather, they likewise show, during the stirring, bright luminous sparks, flying and scattering about like fireworks.

When the sulphur is sufficiently expelled, and part of the muriatic acid is gone; when the whole begins to subside, and the clotting to be less; and when all the abovementioned phenomena have appeared, then the calcination is deemed to be perfect.

The colour of the calcined ores and halvans is generally red, reddish gray, dark red, or red-brown, according to the pro-

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lime and magnesia, left in it by too brisk boiling, &c., then the proportion must be different. Eight per cent of pan salt will do for silver ore; but copper ore frequently requires ten per cent, and black copper twelve per cent.

* Though the fire be ever so cautiously conducted, some particles of the ore will be carried off and lost. This chiefly happens in the first stage of the fire; for then, during the stirring of the ore, some particles are taken up and carried away by the current of rarefied air, or during the rising of the mixture, by means of the sulphur and muriatic acid. This may be in some measure prevented by keeping the back door of the upper hearth shut; by avoiding to stir the mixture while it dusts, &c.

portion of the earthy and metallic particles, or of the sulphur they contained. They are of a lighter and higher red when very earthy; brown when very coppery, or mixed with manganese; and yellowish red when lead prevails in their mixture.

Copper mixtures, containing a much greater proportion of sulphur, must undergo a longer calcining heat than other mixtures of ores and halvans. When mixed with lead, or antimony, and arsenic, they must be put to calcine not only with common salt, but also with a proportionate quantity of quick-lime, that the excess of muriatic acid may be taken from the muriats of antimony and arsenic, and from the plumbum corneum which are produced during the calcination, and be absorbed by the lime, which prevents the untoward clotting of the particles.

The same cautions must be observed in the calcination of the mixtures of base metals and semimetals, and of the silvery black coppers, for they also contain a considerable proportion of antimony and arsenic. If not calcined with lime, along with the common salt, they pack at the very instant the antimony and arsenic are oxided and volatilized in the form of a white very thick smoke, which is brought about very expeditiously by the disengaged muriatic acid.

The mixtures of metals and semimetals, and the black coppers, containing little or no sulphur, the common salt calcined with them is decomposed by the action of the fire. The muriatic acid, thus set free, promotes their oxidation, and forms with their oxides different perfect or imperfect neutral salts, disengages the disguised gold and silver particles, while the soda remains free and in a caustic state: for, in the dry way, the muriatic acid leaves its alkali, and combines with the metals and their oxides; but, by subsequent solution in water, it returns to the alkali, forming again with it common salt, and consequently lets go the metals, semimetals, and earthy particles, before in solution.

In the calcination of these metallic mixtures and the black coppers, the before-mentioned luminous phosphoric appearance does not take place; but the flame which passes over them affects various colours, and in particular the red and blue, both owing to volatilized particles of copper.

When antimonial stone, black copper, and mixtures of metals and semimetals are put to calcine, the antimony oxides first, forming a white oxide in the flues and other passages; arsenical mixtures diffuse a white smoke and garlic smell; those which abound in lead and zinc (which last require a stronger and longer fire) produce saturnine zincous smoke and white flowers.

When the calcination of these metallic mixtures is perfected, and the remainder is cooled, their oxides appear brownish gray, or dark gray; and those of the stone and copper mixtures of a more or less saturated red colour, except those which abound in lead.

The surest symptoms, however, of their perfect calcination, are collectively the rising and sinking of the mixtures, their colour, and the acrid smell of the muriatic acid. Then only the gold and silver particles may be deemed to be fully disengaged.

Sifting and grinding after calcination.

The grinding and sifting of the stuff is as necessary after as before calcination, because the stamp and halvan stuff, which is mixed up with the picked ore, could not be sifted or ground previous to its calcination, on account of its moisture. This further grinding and sifting serves likewise fully to pulverize and equalize the clots of the mixtures of metals and semimetals.

If these coarser particles were suffered to remain as they are, they might still disguise many gold and silver particles, and guard them against amalgamation.

This repeated grinding and sifting may be dispensed with when the whole stuff is of an equal size and sufficiently fine; but its clots will at any rate require examination, whether they be soluble in water or not, for those of leady and metallic mixtures remain insoluble. If soluble, and not leaving sharp coarse particles between the fingers, they want neither grinding nor sifting, but they must go through both these operations when insoluble, and when they betray such coarse particles on being rubbed between the fingers.

Trituration, boiling, and amalgamation of the calcined stuff.

By amalgamation we understand that mechanical and chemical operation, in which, by means of quicksilver, heat, uninterrupted motion, and successive contact of the particles,—gold and silver (previously disengaged from their disguises by calcination and pulverisation), are extracted from their earthy, metallic, or mineralized matrixes, and combined with quicksilver.

If the ores have been duly pulverised and calcined, the success of trituration or amalgamation mostly depends on the proper proportions of the quicksilver and water which are added to the stuff: it likewise depends on the goodness and construction of the stirring apparatus, by which the whole mixture is kept in constant motion and mutual contact. Even the degree of heat, and the quickness of the trituration or stirring, contribute to the quicker and perfect amalgamation.

To determine the quantity of quicksilver, the weight and bulk of the calcined stuff are to be considered. The lighter the stuff, the more voluminous it will prove, and consequently the gold and silver will be the more dispersed. In this case the quantity of quicksilver must be proportioned to the mass. Thus, for example, 2 cwt. of picked ore and balvans are more bulky than 2 cwt. of calcined copper or other mixtures. The former, therefore, require a larger quantity of quicksilver.

Both in small and great operations, experience has determined, that an excess of quicksilver is never hurtful, and that, on the contrary, a scanty proportion is attended with loss. It may be taken in the proportion of one to two, that is 1 cwt. of quicksilver to 2 cwt. of stuff. In this proportion it does not increase the cost of washing and pressing, nor is any loss of quicksilver incurred; the full produce of noble metal is thus secured, and the residuum is left poorer.

The vessels or boilers, in which the quicksilver and stuff are triturated, are of copper, of an inverted conical form, and with a concave bottom. No boiling heat required: a heat of 50° or 60° is sufficient.

No more water is required than will soak into and make the stuff liquid. Excess of water makes the quicksilver sink too fast, and keeps the lighter and finer particles of the metals floating on the surface; which of course prevents the perfect success of the operation. On the other hand, too little water leaves the stuff too thick, which makes the stirring very troublesome; moreover, the evaporation of the water soon forms a dry and hard crust on the sides of the boiler, which is attended with loss of silver in the residuum. Experience must determine the proper respective measure of water.

The stirring apparatus is put into motion by means of a water-wheel.

The stirrers or stirring-racks (which were at first made of copper, but have since been found to answer better when made of wood) are circular segments, corresponding with the sides and bottom of the boiler.

Experience only can determine how long the respective stuffs must be triturated with quicksilver. It has been found, that some stuff yields its gold and silver to the quicksilver perfectly and completely within eight or ten hours; other mixtures require a trituration of twelve or fifteen hours. Excess of time or longer trituration is never hurtful; too little of it will often lessen the produce.

Washing of the triturated leavings, or residuum.

The object of the trituration already described was to unite the gold and silver particles of the calcined stuff into an amalgama with quicksilver: the object of this washing is the separation of this rich amalgama from the leavings or residuum.

This washing is performed in a large tub, of a conical form, with a rake within it, contrived so as to be thrown into a rotatory motion by a water-wheel, or by hand; with side cocks for drawing off the water; and with a bottom cock for tapping off the amalgama or quicksilver.

The particles of quicksilver and amalgama, kept floating in the whole liquid mass by the continual rotation of the rake, sink by their gravity, and collect in the concave bottom of the tub, above the cock; but the remaining stuff or ore and stony matter, being much lighter, is kept floating. When the whole has been sufficiently stirred about in this manner with the water, the bottom cock of the washing-tub is opened, and the quicksilver and amalgama are thereby let out; after which one (or more) of the side cocks (which are fixed at different heights) is opened to let out the thin liquid stuff.

Eliquation of the quicksilver and amalgama.

The quicksilver, triturated with rich stuffs, is strained through a kind of filtrum, for the purpose of bringing the gold and silver particles into a smaller compass, and of separating them from the excess of quicksilver; although the whole can never be separated but by fire.

This is done by means of a box, on the circular opening of which lies an iron ring, to which is fixed a bag of linen damask. The quicksilver (its surface having been previously cleansed with a sponge from any muddy water or stuff that might adhere to it) is poured in small quantities into this bag by one person, whilst another presses it with his hands, until the ball of amalgama, collecting and forming apace, no longer yields any quicksilver. When the ball becomes too big for pressure with two hands, it is taken out, and another is formed in the same manner, until all the quicksilver has gone through the bag. The balls of amalgama are put into a wooden box.

The quicksilver which has been strained through the bag (and which always contains from twenty to thirty penny-weights of gold and silver per cwt.) is collected in a reservoir under the box, and serves again for trituration with fresh quantities of ore *.

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* It is remarkable, that the greatest part of the gold and silver remains suspended in the quicksilver, when pressed through warm as it comes from the washing tub; and that, when left undisturbed to cool, the amalgama congeals and sinks to the bottom. In freezing cold the amalgama appears crystallized internally, and seems, like antimony, to consist of short crystalline fibres, crossing each other, and even appearing on its surface.

Heating and sublimation or distillation of the amalgama.

The amalgama balls, obtained by pressing or eliquating the quicksilver, consist (according to the different degrees of pressure they underwent) of one part silver, and four, five, or six parts quicksilver. This is expelled from them by fire in close vessels. It is a distillation *per descensum*, performed in large cast-iron pots put over each other. The fire is kept up for five or six hours. The heat, acting through the pots on the amalgama, volatilizes the quicksilver, which rising in the form of vapour, and finding no passage in the inverted upper pot, is forced down into the lower one, and collects there by the way of distillation, being condensed and precipitated by the coolness that is constantly kept up by cold water applied to the outside of the lower pot or receiver.

When no copper has been revived, and the amalgama has been perfectly treated, all the quicksilver is recovered without loss, and the balls are white like silver, and mossy on their surfaces. If coppery, they have a reddish cast; and are brownish, if the copper have undergone a superficial oxidation. If leady, which is seldom the case, they show a dark pearl-gray colour.

Refining and cupellation of the silver.

The amalgams, according to their coppery or leady appearance, or to their purity, are either refined by cupellation, or simply melted down, and run into ingots.

When containing no gold, they may be delivered to the mint, without further fusion or cupellation, notwithstanding their copper alloy; but if auriferous and coppery, then they must be refined, or put to cupellation, that the copper may be destroyed, and the auriferous silver be brought to the standard of 15 loth 15 grains *per marc*, in which it is received at the mint.

Distillation of the quicksilver, separated from the amalgam by heat or pressure.

The quicksilver, separated by heat from the amalgam, contains some of the noble metals, which passed with it through the pressing-bag. This generally amounts to three quarters of an ounce, or one ounce per cwt. But this quicksilver being constantly in hand, and always serving in the subsequent triturations, its contents of gold and silver need only to be ascertained once at the annual balance of the accounts. This may be done, in small assays, by distilling the quicksilver, with granulated lead, in glass retorts; but the operation succeeds best in tubulated iron retorts, with cast-iron receivers, filled with water, and luted to the necks of the retorts. Each of these is sunk half into the furnace, with its neck much inclined into the receivers. They are filled with two cwt. of quicksilver, to which is added half a pound or a pound of granulated lead. The tubulated opening of the retort, and the neck of the receiver, must be carefully luted with refractory clay. The fire should be brisk, and the whole body of the retort be covered with the burning fuel. The quicksilver rises up in the form of vapour, and passes over into the receiver, where it is condensed, collected into drops, and falls to the bottom of the water. All the auriferous silver remains behind united with the lead, which, if it should stick to the bottom of the retort, may be melted in it by a coal-fire, and poured out into an ingot, to be afterward put to the test or cupellation.

Further treatment and use of the triturated residua, which have gone through the process of amalgamation.

The residua commonly contain some gold and silver, more or less, according as they were well or badly pulverized, oxided, sifted, triturated, and washed. If the residuum should contain more than one ounce per cwt., and raw unoxided particles appear in the same, it will be advisable to oxide it once more with an addition of four per cent of salt, and to let it undergo a second amalgamation. If it should be of an equal size, and perfectly oxided, it should be mixed up with new stuff, or triturated once more alone.

If, on the contrary, the residuum is silvery, in consequence of the imperfect washing and separation of the quicksilver and amalgam, it must be washed over again, more abundantly diluted with water.

The lixivia containing copper are precipitated by iron.

The Editors of the Chemical Journal add the following remarks, in a note, on the cold amalgamation:

Considering the complex apparatus for the warm amalgamation, the wear and loss of the copper boilers, the unequal produce, and the expense of firing (all which are now avoided), the cold amalgamation is, as Mr. Raspe observes, a noble improvement of the process. It is what baron Born always aimed at, though his attempts were unsuccessful. Mr. Gellert, at Freyberg, first succeeded in it, using wooden cylindrical churns with perpendicular pistons, laid over with copper sheeting, which, by a quick motion up and down, produce a stronger trituration than the rotatory horizontal motion of barrels, and at the same time prevents the possibility of producing sublimate, or mercurius dulcis, by the excess of muriatic acid acting upon the quicksilver, to which that acid has less affinity than to copper.

His first experiment was attended with uncommon success; for, by cold churning, he extracted the silver from pulverised ore, which contains but three ounces and a quarter per quintal, in the course of sixteen hours, so completely, that the leavings contained but two dwts. (The operation may even be finished in ten hours, which otherwise required twenty-four.) Upon these principles the churning apparatus, in wooden cylinders, has been adopted in Bohemia, with a perforated cast-iron piston, which by a crank motion moves quickly up and down. Though the whole is put in cold, yet, at the end of the operation, it heats, in consequence of the quick trituration and motion of the pistons.

At Freyberg this cold amalgamation is performed in a mill which turns eight large barrels, each holding 10½ quintals of ore. The ores are dressed to contain four ounces per quintal, mixed with 10 per cent of salt, and calcined and sifted in baron Born's manner. When put into the barrels, one fourth per cent of quick-lime, and 34 lbs. of water are added, and turned briskly two hours, thirty-six turns per minute. The lime absorbs the excess of acids. To counteract the decomposition of metallic sulphats, and the precipitation of silver particles (which an excess of lime might occasion), after two hours turning, two per cent of thin rolled iron chips, two inches square, are thrown into the barrels, and turned with the same two hours. Then the quicksilver, half a quintal to one quintal of ore, is added, together with an additional four per cent of iron chips, previously coated with a little copper, by immersion in copper water, in order to prevent the dispersion of the quicksilver, and to catch and attract its smallest particles. After the last coppery-iron chips and the quicksilver have been added, the barrels are turned slower, at the rate of twenty or twenty-five turns per minute. After twelve hours turning, all the silver is extracted, except 1¼ dwt. per quintal, which cannot be farther extracted by amalgamation.

Ores of Iridium. This metal has been found hitherto only in the black powder left after dissolving platina. See Iridium.

Ores of Iron. When we consider the great destructibility of iron by the disengaged acids, and other uncombined agents in nature, it is not to be expected that much native iron should be found. We have, however, indubitable accounts of its existence in various parts of the world. The most remarkable mass of this sort was discovered in Siberia, by professor Pallas, which weighed 1600 pounds. Specimens of this have been sent to all parts of Europe. It is of that species called red short, being malleable while cold, but brittle when red-hot. This has lately been classed with the stones called meteoric. See the conclusion of the article Meteorology.

Bergman considers mispickel as a mixture of native iron and arsenic. For a description of this ore, see Mispickel. It is called Pierre de Santé by the French, but for what reason I know not, and is cut for toys. Thirty or forty years ago a mineral was in common use for this purpose in England. The small stones or pieces were called marcasites, and were, I suppose, mispickel.

The magnet, or loadstone, is an ore containing iron approaching to the metallic state. It has not been much examined, probably on account of the heterogeneous nature of the various stones called by this name. Magnetism is their characteristic property, but they may nevertheless differ exceedingly in their contents, so as scarcely to come under the same mineralogical arrangement. Some contain as much as 75 per cent of iron. See Loadstone, Magnet, and Magnetism.

The black iron ore, or steel ore, is ponderous, of a very dark gray colour, or rather slate black, and affords a black powder when scraped. Some specimens, however, afford a red powder. It is readily attracted by the magnet. Its fracture exhibits grains more or less fine, or else scales or facets, whence it has been improperly called galena of iron. When exposed to heat it gives scarcely any smell, and changes its colour very little, though its shining appearance goes off. A strong heat renders it partly malleable. It gives fire with steel, in consequence of a proportion of quartz it contains. Acids act upon it to a certain degree, but the iron is too much oxided to afford many crystals with the sulphuric acid.

That species of black iron ore, which has the form of octahedrons, nearly resembles the foregoing in its properties.

The ochres are very common, and appear to have been produced by the decomposition of pyrites; see Ochres. There are two varieties: 1. Yellow ochre: this becomes red by calcination. 2. Red ochre. Both these are so common, and so much used in the arts, that it is scarcely requisite to describe the great variations of colour and consistence the several specimens possess.

Earthy, argillaceous, or bog ores of iron are of different colours, reddish, yellowish brown, and sometimes gray, especially after exposure to the air for a time. Internally they have a blueish gray or iron colour. This ore is brittle, and resembles scoriæ, or small rounded or flattened stones, not obedient to the magnet, and in general of inconsiderable hardness. It mostly abounds with foreign sandy argillaceous or calcareous matters.

The crystallized iron ore of the island of Elba is one of the most beautiful of minerals. It has not yet been found except in that island. It is found in different states, in ochres of every shade, in the argillaceous sandy ore, in crystallized ore, and in hematites. The crystallized is the most common, the purest, and most beautiful. Its form, as well as colour, varies much. The shades are green, red, black, yellow, brown, blue, and violet; and some exhibit all the various and lively colours of precious stones, though this brilliant appearance becomes tarnished by the moisture of the air. This ore is very ponderous and hard, and frequently mixed with copper pyrites. Acids do not attack it, neither is it affected by the magnet, at least while in the mass: I do not find that this ore has been well analysed. Some writers pretend, that sulphur is the mineralizer, and others carbonic acid; but from its great resemblance to the combination of iron with water in the experiment of the gun-barrel, it appears likely that that fluid, as one of its principles, enters into the iron ore of the isle of Elba.

Hematites exists in considerable abundance in the iron mines of ancient formation. It is formed in the manner of stalactites and stony concretions. In general it possesses considerable hardness, so as sometimes to give fire with steel. The varieties are,

1. Blackish hematites; fracture, vitreous, and sometimes shining; texture, fibrous or striated; colour, brown black, but reddish when pounded. It gives fire with steel, becomes darker coloured, and as it were scaly, by ignition.

2. Red hematites. This is chiefly entitled to the name of blood-stone, from its colour. It is very heavy, ponderous, striated, and as if crystallized, or in small globules, called kidney-ore.

3. Yellow hematites. This differs from the preceding, from the degree of the oxidation of its metallic part, in the same manner as yellow ochre differs from red.

The specular iron ore, mentioned by Mongez among the oxides of iron, is easily distinguished by its brilliant facets, which often resemble polished steel. It is distinguished from the iron ore of Elba by a small portion of sulphur, which it contains. It is plentifully found at Mount d'Or in Auvergne.

Emery was considered as an ore of iron, which has the appearance of a very compact granular stone, of a blackish, grayish, or brown colour. By calcination it becomes brown or red, and, as Mongez says, harder than before. It is used as a grinding and polishing powder, and is scarcely inferior in hardness to any substance but the diamond. Its specific gravity is from 3·008 to 4·000. The best sort is of a dark gray colour. It is never wrought as an iron ore. Late experiments appear to have classed it with CORUNDUM. See ADAMANTINE SPAR and EMERY.

The white or sparry iron ore, or stahlstein of the Germans, consists, according to Bergman, of the brown oxide of iron united with the white oxide of manganese, and carbonat of lime, in various proportions. Bayen[*] examined a specimen from Germany of the best steel ore, and found it contain two thirds iron, and the rest carbonic acid, except a small portion of zinc. The figure of this ore is either irregular or rhomboidal; frequently transparent; its texture scaly, lamellar, granular, or cellular. Sometimes it possesses a stalactitical form, and is sometimes found in a blackish brown powder. Its colour, when fresh dug, is whitish, but by exposure to the air it becomes gray, brown, reddish, yellowish, or black. Its specific gravity is from 3·6 to 4·0. It does not give fire with steel, unless by virtue of particles of quartz or pyrites, with which it is frequently interspersed. In the fire it decrepitates, grows black, becomes magnetic, and loses about one third of its weight by the extrication of carbonic acid. One hundred parts of this ore from Eisenartz in Stiria, afforded Bergman 38 of the brown oxide of iron, 24 of the white oxide of manganese, and 38 of carbonat of lime. The iron answering to this quantity of oxide is about 32 parts, or one third of the whole.

Iron mineralized by sulphur is mostly distinguished by the name of pyrites. It seldom contains iron in sufficient quantity to be extracted with profit, not only because a long continued heat is required to drive off the last portions of sulphur, but likewise because the iron usually proves of a bad quality. This ore has various degrees of hardness and consistency; is of a pale yellow colour, sometimes approaching that of gold, a circumstance which, added to its considerable weight, often attracts the attention of the unskilful, who imagine it to contain gold. It gives plenty of sparks with the steel, and emits an odour of sulphur. In the fire it cracks or decrepitates, burns with a blue flame, and assumes a dull brown colour: in the air it effloresces, is decomposed, its sulphur becomes acidified, unites with the iron and clay which are present in its composition, and with these forms sulphat of iron and alum, for the obtaining both of which this mineral is wrought. Its varieties are,

1. In irregular masses.
2. In balls of various sizes disseminated in chalk.
3. In stalactites.
4. In cubes, frequently found in clay.
5. In hard crystals called marcasite.

The brown or reddish-brown ferruginous pyrites is called the hepatic iron ore. It is either spherical, or in cubes, or other regular forms; has no metallic lustre, does not easily give fire with steel, and is incapable

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[*] Journal de Phys. vii. 213. As this chemist did not reduce his iron beyond the state of a magnetical powder, I think he overlooked the nickel, which is magnetical, like iron, and also affords a green salt with sulphuric acid.

of being converted to a sulphat. It contains much less sulphur and more iron than the yellow pyrites, but the metal it yields is brittle.

Gray iron ore has a shining metallic appearance, and commonly gives fire with steel. It is not at all magnetic, and, when scratched, gives a red trace. It yields from 40 to 66 per cent of cold short iron. This property is derived from phosphorus, or its acid, which exists in the ore.

Plumbago is a carburet of iron.

A cupreous arseniat of iron, in very brilliant and transparent crystals, of a faint sky-blue colour, has been described by the count de Bournon, and analysed by Mr. Chenevix. It contains in 100 parts, oxide of iron 27·5, oxide of copper 22·5, arsenic acid 33·5, silex 3, water 12. Specific gravity, 3·4. Another, in which Mr. Chenevix considers the copper as merely accidental, was of a dark green, with a brownish tinge, and sometimes yellowish; tolerably transparent; and scarcely so hard as the preceding, being barely able to scratch calcareous spar. This gave oxide of iron 45·5, oxide of copper 9, arsenic acid 31, silex 4, water 10·5. Specific gravity 3. They were both from Cornwall.

A blue combination of iron is found interspersed in clays in Finland, Scania, and elsewhere, Bergman calls it Native Prussian Blue. Sometimes the clays have a blue colour at the surface, and sometimes they assume that colour soon after being dug out of the ground. It is easily seen, that the ore is ferruginous, and highly loaded with combustible matter; for it burns with a flame, and becomes red and magnetical. A mild heat renders this substance green, and a stronger converts it into black scoria. Alkalis, as well as acids, dissolve this blue powder, and destroy its colour, which nevertheless appears again when precipitated from an acid by an alkali, or by an alkali from an acid; but commonly it is greenish, and soon becomes white. If an infusion of tea or nut-galls be poured on this whitish sediment, it resumes its first colour. From these details it appears, as Bergman remarks, that this blue, though analogous to the artificial Prussian blue, differs nevertheless from it in intensity, by the manner of its production, and other peculiar qualities. It preserves its colour in water, but becomes black in oils.

For the methods of analysis of the ores of iron, as well as its chemical properties and several states, see the article IRON. But from the extensive importance of this metal, I shall here add the methods of treatment in the large way.

Most ores of iron require to be roasted previously to their fusion; some more slightly, and others with a more violent and longer continued fire. Those which contain much sulphur, arsenic, or sulphuric acid, require a long continued and repeated roasting, that the volatile matters may be expelled. Of this kind is the black iron ore, from which the Swedish iron is said to be obtained.

Some ores require a very slight roasting, only that they may be dried and rendered friable; such are the ores called bog ores: and others, which being in an oxided state, and containing little sulphureous matter, would, by a farther oxidation, be rendered less capable of being reduced to a metallic state.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, or in furnaces similar to those commonly employed for the calcination of limestone.

The next operation is the fusion or smelting of the ore. This is generally performed in blast furnaces or towers from twenty to thirty feet high, in the bottom of which is a basin for the reception of the fluid metal. When the furnace is sufficiently heated, which must be done at first very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of lime-stone, or whatever other flux is employed. While the fuel below is consumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, sink gradually down, till they are exposed to the greatest heat in the furnace. There the ore and the flux are fused, the metallic particles are revived by the fuel, are precipitated by means of their weight through the scoria formed of the lighter earthy parts of the flux and of the ore, and unite in the basin at the bottom of the furnace, forming a mass of fluid metal, covered by a glassy scoria. When a sufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of sand; and thence into smaller lateral or connected channels, or other moulds. There it is cooled, becomes solid, and retains the forms of the channels or moulds into which it flows.

The piece of iron formed in the large channel is called a sow, and those formed in the smaller channels are called pigs. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of sand or of clay, and is thus formed into the various utensils and instruments for which cast iron is a proper material.

The scoria must be from time to time allowed to flow out, when a considerable quantity is formed, through an aperture made in the front of the furnace for this purpose. A sufficient quantity of it must, however, be always left to cover the surface of the melted iron; else the ore which would fall upon it, before the separation of its metallic from its unmetallic parts, would lessen the fluidity and injure the purity of the melted metal. This scoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, or be precipitated. Accordingly, a scoria, not sufficiently fluid, is always found to contain much metal. If the scoria be too thin, the metallic particles of the ore will be precipitated before they are sufficiently metallized, and separated from the earthy and unmetallic parts. A due degree of fluidity is given to the scoria, by applying a proper heat, and by adding fluxes suited to the ore.

Some ores are fusible without addition, and others cannot be smelted without the addition of substances capable of facilitating their fusion.

The fusible ores are those which contain sulphur, arsenic, or are mixed with some fusible earth.

The ores difficultly fusible are,

1. Those which contain no mixture of other substance. Such are most of the ores which contain iron in a state nearly metallic. As iron itself, when purified from all heterogeneous matters, is scarcely fusible without addition, so the metal contained in these purer kinds of ores cannot be easily extracted, without the addition of some fusible substance.

2. Those which are mixed with some very refractory substance. Some of these refractory ores contain arsenic; but as this substance facilitates the fusion of iron, we may presume, that their refractory quality depends upon a mixture of some unmetallic earth or other unfusible substance. The earth which is mixed with the common calciform ores is in considerable quantity, and is sometimes calcareous, sometimes siliceous, and sometimes argillaceous. Most of the iron stones wrought in this country have a mixture of all three, but in variable proportions, and according as one or other is predominant, a greater or less proportion of flux is required.

Keir thinks it probable, that the fusibility of some ores may greatly depend on the degree of oxidation to which the metal contained in them has been reduced; since we have reason to believe, that, by a very perfect oxidation, some metals, at least, may be reduced to the state of being almost infusible, and scarcely capable of reduction; and since we know, that in every oxidation and subsequent reduction of a given quantity of any imperfect metal, a perceptible part of that quantity is always lost or destroyed, however carefully these operations may have been performed. That some of these ores are already too much oxided, appears from the instance above mentioned of the bog ores, which are injured by roasting; and even the great height of the common smelting furnaces, although advantageous to many ores that require much roasting, is said to be injurious to those which are already too much oxided, by exposing them to a farther oxidation, during their very gradual descent, before they arrive at the hottest part of the furnace, where they are fused.

But, as too violent calcination renders some ores difficultly fusible; so too slight calcination of other ores injures the purity of the metal, by leaving much of the sulphureous or other volatile matter, which ought to have been expelled.

Various substances are added to assist the fusion of ores difficultly fusible. These are:

1. Ores of a fusible quality, or which, being mixed with others of a very different quality, become fusible: accordingly in the great works for smelting ores of iron, two or more different kinds of ores are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called red-short, and another ore which produces iron brittle when cold, or cold-short, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as cold-short as iron obtained solely from one of the ores, and half as red-short as iron obtained only from the other ore.

2. Earths and stones are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct, that, if the earth of the ore be of an argillaceous or siliceous nature, limestone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous or siliceous earth should be added; because these two earths, though singly infusible, yet, when mixed, mutually promote the fusion of each other: but we believe limestone is the only addition ever made, beside the fuel.

The fuel generally used on the continent for the smelting of ores of iron is charcoal: but in almost all the works in England and Scotland, iron ore is smelted by means of pit-coal, previously reduced to cinders or coke, by a kind of calcination similar to the operation for converting wood into charcoal. In France, pit-coal not charred has been tried for this purpose, but unsuccessfully. The use of peat has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality, and also upon the quantity of the fuel employed. Charcoal is fitter than coke for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous and other ores easily fusible require less fuel than ores difficultly fusible. In general, if the quantity of fuel be too small, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin.

This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex on its surface, and liable to great loss of weight by being forged; and lastly, it may be known by observing the colour and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal. both which are darker coloured than when more fuel is used.

When the quantity of fuel is sufficiently large, and the heat is intense enough, the iron is darker coloured, denser, more tenacious, contains less scoria, and is therefore less fusible, and loses less of its weight by being forged. Its surface is also smoother and somewhat concave; and its texture is generally granulated. The scoria in this case is of a lighter colour and less dense. The drops falling from the smelting ore, and the liquid scoria in the furnace, appear hotter and of a brighter colour.

When the quantity of fuel is too great, and the heat too intense, the iron will appear to have a still darker colour, and more conspicuous grains or plates; and the scoria will be lighter, whiter, and more spongy. The drops falling from the smelted ore, and the fluid scoria, will appear to a person looking into the furnace through the black hole to be very white and shining hot.

The quantity of charcoal necessary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation skilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumstances. Mr. Mushet calculates, that, if a calcined iron stone affording 40 per cent of iron, 1 cwt. of coke from clod-coal will smelt 130 lbs., producing 52 lbs. of iron; 1 cwt. of coke from splint coal, 105 lbs., yielding 42 lbs. of iron; and 1 cwt. of coke from hard and soft coal mixed, 84 lbs., giving 33·6 lbs. of iron.

The time during which the fluid metal ought to be kept in fusion, before it is allowed to flow out of the furnace, must be also attended to. In some works the metal is allowed to flow out of the furnace every six or eight, and in some others only every ten or twelve hours. Some workmen imagine, that a considerable time is necessary for the concoction of the metal. This is certain, that the iron undergoes some change by being kept in a fluid state; and that, if its fusion be prolonged much beyond the usual time, it is rendered less fluid, and also its cohesion, when it becomes cold, is thereby greatly diminished. The quantity of iron daily obtained from such a furnace as is above described is from two to five tons, according to the richness and fusibility of the ore, to the construction of the furnace, to the adjustment of the due quantity of flux and of fuel, and to the skill employed in conducting the operation.

The quality of the iron is judged by observing the appearances during its flowing from the furnace, and when it is fixed and cold. If the fluid iron, while it flows, emits many and large sparkles; if many brown spots appear on it while it is yet red-hot; if, when it is fixed and cold, its corners and edges are thick and rough, and its surface is spotted; it is known to have a red-short quality. If, in flowing, the iron seems covered with a thin glassy crust, and if, when cold, its texture be whitish, it is believed to be cold-short. Reaumur says, that dark-coloured cast-iron is more impure than that which is white. The marquis de Courtivron is of a contrary opinion.

But no certain rules for judging of the quality of iron before it is forged can be given. From brittle cast-iron sometimes ductile forged-iron is produced. Cast-iron with brilliant plates and points, when forged, becomes sometimes red-short, and sometimes cold-short. Large shining plates, large cavities called eyes, want of sufficient density, are almost certain marks of bad iron; but whether it will be cold- or red short cannot be affirmed, till it is forged. Whiteness of colour, brittleness, closeness of texture, and hardness, are given to almost any cast-iron by sudden cooling; and we may observe, that in general the whiter the metal is, the harder it is also, whether these properties proceed from the quality of the iron, or from sudden cooling; and that, therefore, the darker-coloured iron is fitter for being cast into moulds, because it seems capable of being filed and polished, especially after it has been exposed, during several hours, to a red heat in a reverberatory furnace, and very gradually cooled. This operation, called by the workmen annealing, changes the texture of the metal, renders it softer, and more capable of being filed than before, and also considerably less brittle.

It is in fact capable of being softened by annealing, and hardened by sudden cooling like steel, through the heat regained, for these changes are greater. Many artists avail themselves of this property to advantage. See IRON.

In Navarre, and in some of the southern parts of France, iron ore is smelted in furnaces much smaller, and of a very different construction from those above described. A furnace of this kind consists of a wide-mouthed copper caldron, the inner surface of which is lined with masonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The space or cavity contained by the masonry is the furnace in which the ore is smelted The depth of this cavity is equal to two feet and a half; the larger diameter of the oval mouth of the cavity is about eight feet; and its smaller diameter is about six feet: the space of the furnace is gradually contracted towards the bottom, the greatest diameter of which does not exceed six feet: eighteen inches above the bottom is a cylindrical channel in one of the longer sides of the caldron and masonry, through which the nozzle of the bellows passes. This channel, and also the bellows-pipe, are so inclined, that the wind is directed towards the lowest point of the opposite side of the furnace. Another cylindrical channel is in one of the shorter sides of the furnace, at the height of a few inches from the bottom, which is generally kept closed, and is opened occasionally to give passage to the scoria; and above this is a third channel, in the same side of the furnace, through which an iron instrument is occasionally introduced to stir the fluid metal, and to assist, as is said, the separation of the scoria from it. The greatest height of this channel is at its external aperture on the outside of the furnace, and its smaller height is at its internal aperture, so that the instrument may be directed towards the bottom of the furnace; but the second channel below it has a contrary inclination, that when an opening is made, the scoria may flow out of the furnace into a basin placed for its reception.

When the furnace is heated sufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previously roasted. They take care to throw the charcoal chiefly on that side at which the wind enters, and the ore at the opposite side. At the end of about four hours a mass of iron is collected at the bottom of the furnace, which is generally about six hundred weight: the bellows are then stopped; and when the mass of iron is become solid, the workmen raise it from the bottom of the furnace, and place it, while yet soft, under a large hammer, where it is forged. The iron produced in these furnaces is of the best quality; the quantity is also very considerable, in proportion to the quantity of ore, and to the quantity of fuel employed. In these furnaces no lime-stone or other substance is used to facilitate the fusion of the ore.

We should receive much instruction concerning the smelting of iron ore, if we knew upon what part of the process or circumstance the excellence of the iron obtained in these furnaces depends; whether on the quality of the ore; on the disuse of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminished; on the forging while the iron is yet soft and hot, as the marquis de Courtivron thinks; or on some other cause not observed.

To separate the impurities from cast iron, and to unite the metallic parts more closely and compactly, and thus to give it the ductility and tenacity which render this metal more useful than any other, are the effects produced by the following operations:

The first of these operations is a fusion of the iron, by which much of its impurities is separated in form of scoria; and by the second operation, a farther and more complete separation of these impurities, and also a closer compaction of the metallic particles, are effected by the application of mechanical force or pressure, by means of large hammers.

Some differences in the construction of the forge or furnace, in which the fusion or refining of cast iron is performed, in the method of conducting the operation, and in some other circumstances, are observed to occur in different places. The following is the German method:

The fusion of the cast iron, which is to be rendered malleable, is performed upon the hearth of a forge similar to that used by blacksmiths: at one side of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fire-place is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep; it is bounded on three sides by three plates of cast iron placed upright; and on the fourth side, which is the front, or that part nearest to which the workmen stand, by a large forge hammer, through the eye of which the scoria is at certain times allowed to flow. The floor also of the fire-place is another cast iron plate. The thickness of these plates is from two to four inches. One of the upright side plates rests against a wall, in an aperture through which a copper tube, called the tuyere, is luted with clay. This tube is a kind of case or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot farther than this pipe into the fire-place, and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is requisite to act. The tube rests upon the upper edge of the side-plate which leans against the wall, nearer to the back part than to the front of the fire-place, and in such an oblique direction, that the wind shall be impelled toward the farthest part of the floor of the fire-place, or where this floor is intersected by the opposite side-plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation it may be shifted till its proper position is found. The more nearly its direction approaches to a horizontal plane, the more intense is the heat; but a larger quantity of fuel is consumed than is even proportional to the increase of heat, because the flame is not then so well confined. When the iron is easily fusible, great heat is not required: the tuyere may then decline considerably from the horizontal plane, and thus fuel may be saved. This tuyere, though made of copper, a metal more easily fusible than iron, is preserved from fusion by the constant passage of cold air through it. It must be carefully kept open, and cleansed from the scoria, which would be apt to block its cavity, by which not only the heat would be too much diminished for the success of the operation, but the tube itself would be melted.

To prepare for the fusion, a quantity of scoria of a former operation is thrown into the fire-place, till one third part of this is full; and then the remaining two thirds of the fire-place are to be filled with smaller scoria, coal-dust, and sparks ejected from hot iron. These matters, being fusible, form a bath for the reception of the iron when melted. Upon this bed of scoria the mass of cast iron to be melted is placed; so that one end of it shall be within the fire-place, opposite to the tuyere, and at the distance of about four or five inches from its aperture; and the other end shall stand without the fire place, to be pushed in as the former is melted. The upper side of the mass of iron ought to be in the same horizontal plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its course, strike upon and pass along the under-side of the mass: but if the iron be difficultly fusible, the tuyere is to be disposed more horizontally, so that the wind shall strike directly upon the mass of iron; and that one part of the blast shall graze along the upper surface, and the other part along the under surface of the iron. The mass of iron weighs generally from 200 to 400 pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being less fusible than the red-short. The iron being placed, charcoal powder is thrown on both sides; and coals are accumulated above, so as entirely to cover the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterward with gradually increased force. The iron is liquefied by degrees, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consuming, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire-place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added, but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire-place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour, or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entirely the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air: at the same time also, they open a passage in the eye of the hammer placed in the front of the fire-place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bellows are stopped, the coals are removed, and the mass is left during an hour; and then the workmen raise it from the fire-place, turn it upside down, and proceed to the second coction or fusion of the iron.

For this second operation, the mass is to be so placed, that one part of it shall rest upon the tuyere, and the other upon the scoria remaining in the fire-place. This scoria is to be disposed in an oblique direction, parallel to the tuyere, by which means the wind of the bellows is obliged to pass all along the under side of the mass of iron. About the sides of the mass, charcoal-powder and burnt ashes are thrown; but toward the tuyere, dry and entire pieces of coals are placed to maintain the fire. When these are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it may pass equally along under the surface of the iron, quite to the farther extremity; and that it do not escape at the sides, or be reverberated back toward the tuyere, by which this copper tube might be melted. During this fusion, pieces of iron are apt to be separated from the mass, and to fall down unfused to the bottom and corners of the fire-place. These are carefully to be searched for, and exposed to the greatest heat till they are melted. When the whole mass is thus brought into perfect fusion, the coals are removed, and the wind blowing on its surface, whirls and dissipates the small remaining pieces of scoria, and sparks thrown out from the fluid iron. This jet of fire continues about seven or eight minutes, and the whole operation about two hours. In this second fusion the scoria is to be thrice removed, by opening a passage through the eye of the hammer. The first time of removing the scoria is about twenty minutes from the kindling of the fire; the second time is about forty minutes after the first; and the third time is near the end of the operation.

The mass is then removed from the hearth, and put upon the ground of the forge, where it is cleansed from scoria, and beaten into a more uniform shape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This mass is to be divided into five, six, or more pieces, by means of a wedge; and these are to be heated and forged till they are reduced to the form of the bars commonly sold.

In some forges the iron is fused only once, and in others it suffers three fusions, by which it is said to be rendered very pure. Where only one fusion is practised, it is called the French method. In this no greater quantity of iron is fused at once, than is sufficient to make one bar. The fire-place is of considerably less dimensions, and especially is less deep than in the German method above described. The fire is also more intense, and the proportion of fuel consumed to the iron is greater. The iron, when melted, is not kept in a state of ebullition, as is above described; but this ebullition is prevented by stirring the fluid mass with an iron bar, till it is coagulated and becomes solid.

By these operations, fusion and forging, the iron loses about $\frac{2}{15}$ parts of its former weight, sometimes more, and sometimes less, according to the quality of the cast iron employed; its metallic particles are more closely compacted, its texture is changed, and it is rendered more dense, soft, and malleable, tough, and difficultly fusible.

The degrees, however, of these qualities vary much in different kinds of iron. Thus some iron is tough and malleable, both when it is hot and when it is cold. This is the best and most useful iron. It may be known generally by the equable surface of the forged bar, which is free from transverse fissures or cracks in the edges; and by a clear, white, small-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called cold-short iron, and is generally known by a texture consisting of large shining plates, without any fibres. It is less liable to rust than other iron. A third kind of iron, called red-short, is brittle when hot, and malleable when cold. On the surface and edges of the bars of this kind of iron, transverse cracks or fissures may be seen; and its internal colour is dull and dark. It is very liable to rust. Lastly, some iron is brittle, both when hot and when cold.

In one bar frequently two or more different kinds of iron may be observed, which run all along its whole length; and scarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together in the smelting, and also from the practice of mixing two or more pigs of cast-iron of different qualities in the finery of these; by which means the red-short and the cold-short qualities of the different kinds are not, as we have already remarked, mutually counteracted or destroyed by each other; but each of these qualities is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other, but not of being intimately united or combined.

The quality of forged iron may be known by the texture which appears on breaking a bar. The best and toughest iron is that which has the most fibrous texture, and is of a clear grayish colour. This fibrous appearance is given by the resistance which the particles of the iron make to their rupture. The next best iron is that the texture of which consists of clear whitish small grains, intermixed with fibres. These two kinds are malleable, both when hot and when cold, and have great tenacity. Cold-short iron is known by a texture consisting of large shining plates, without fibres; and red-short iron is distinguished by its dark dull colour, and by the transverse cracks and fissures on the surface and edges of the bars. The quality of iron may be much improved by violent compression, as by forging and rolling, especially when it is not long exposed to too violent heat, which is known to injure, and at length to destroy, its metallic properties.

In January 1806, Mr. Descotils read to the mathematical and physical class of the French National Institute a memoir, in which he proved by experiments, that the iron spar, which was the subject of it, varied in the proportions of its constituent principles; and hence be explained the differences that the ores require in their metallurgic treatment. The difficulty of fusing some of them constituted at that time the principal object of his research; and the comparative analysis he made led him to the conclusion, that the magnesia, which is frequently found in them in large quantity, was the cause of their refractoriness:

Reflecting on the processes adopted to deprive these ores of the principle of their infusibility, which consist chiefly in exposure to the air and rain, either before or after roasting, Mr. Descotils conjectured, that these processes had no other effect than that of separating the magnesia.

In the first case, that is to say, when these ores were exposed to the air before roasting, he supposed, that this earth was dissolved in the state of carbonat by the rain. In the second, on the contrary, he ascribed this effect to the sulphuric acid developed by the efflorescence of the pyrites, with which the iron spar is almost always accompanied.

Since that period Mr. Descotils has communicated to this assembly a second memoir, in which he furnishes substantial proofs of the explanations he had offered in the former paper as merely conjectural; at the same time avails himself of them to answer some objections, that had been advanced by Mr. Hassenfratz. The latter gentleman, however, after having made some fresh experiments and observations, has withdrawn his memoir, which the class had referred to the same committee: we shall not therefore enter into any discussion of the points on which these two learned chemists differed, but shall consider the facts related by Mr. Descotils, and the conclusion he has deduced from them, as if they had never been disputed.

On this second occasion Mr. Descotils has repeated his former experiments, which gave him the same results. He has likewise made new ones; and all, mutually supporting each other, have only confirmed him in his opinion. But let us relate some of these experiments.

He exposed to the fire a mixture of fifteen parts of magnesia, and a hundred parts of iron ore from the isle of Elba, finely powdered; and the result he obtained was perfectly similar to what every magnesian iron spar had furnished him.

To ascertain whether the division of the particles of the substance had any influence on its fusibility, he made a trial with part of the same specimen of iron ore of Elba, without wasting or powdering it, and he obtained a perfectly compact button, at a degree of heat similar to what would have been requisite for an assay of earthy iron ore with the addition of borax.

This fact shows, says the author, that cohesion does not diminish the fusibility of iron ores; at least if this cohesion can be estimated by the hardness of the ore, and the resistance it offers to the action of acids, for none possess these two qualities in a more striking degree than the iron crystals of the isle of Elba. The committee are of a similar opinion, only the fusion must require so much longer time in proportion as the ore is in fragments of a larger bulk.

Mr. Descotils could have wished to analyse specimens of refractory iron spar comparatively with specimens of the same ore become fusible by exposure to the air: but not having been able to procure any, he thought he might supply their place by two pieces from the same vein, one of which was not altered, the other had passed to the state of a free ore.

Without describing the method he employed for this purpose, which we consider as very accurate, we shall only say, that he found the decomposed ore no longer contained any magnesia or carbonic acid, while the other contained four per cent of carbonic acid and magnesia.

The analysis of five other specimens of free ores, from different places, gave him the same results; whence he concludes, that the separation of the magnesia is complete when the decomposition of the ores is complete.

In some cases he suspects, that it is to the efflorescence of the pyrites, from which scarcely any sparry iron ore is free, that the solution and abstraction of the magnesia of the raw ore is owing; since sulphat of magnesia is sometimes to be observed on heaps of ore of an analogous nature exposed to the air, as well as in the waters with which these ores are washed; and he has obtained similar results in a small way, by putting magnesian iron spar in powder, into a solution of sulphat of iron.

He believes, however, that it is most frequently the carbonic acid, which, disengaged from the iron in proportion as this absorbs oxigen, dissolves and carries off the magnesia by means of water.

As to the change effected in the roasted ore by exposure to air and rain, the conjectures of Mr. Descotils are confirmed by analysing the waters, with which a heap of roasted ore long exposed to the air had been washed. These waters contained nothing but sulphat of magnesia, and a little sulphat of lime; which salts could have been produced only by the action of the sulphuric acid, arising from the pyrites, on the earthy substances contained in the ore.

Mr. Descotils quotes letters of several well-informed persons, and worthy of credit, who, in agreeing on the point that sparry iron ores recently extracted and roasted are more difficult of fusion, and less productive, than those that have remained three or four years in the open air, give still more force to his theory.

Though it is certain, that the presence of magnesia in iron ores diminishes their fusibility more or less, the author of the memoir observes, however, that, if it be accompanied with a sufficient quantity of lime, silex, and alumine, or of oxide of manganese, it is not so injurious, because it becomes fusible by combining with these substances.

Conceiving the advantage iron-masters would find in having an easy method of knowing by simple inspection a free from a refractory ore, Mr. Descotils has examined, whether among the external characteristics of these substances there might not be some, by which these properties could be distinguished: but the strictest scrutiny in this respect was without success. He has been obliged, therefore, to have recourse to chemical means, and what he found most to the purpose was fusing the ore without the addition of any flux.

If after this operation the matter present itself in a grayish, earthy, friable mass, interspersed with small globules of cast iron, it is a proof that the ore is magnesian, and consequently more or less refractory.

But, on the contrary, if a well fused button be obtained, with brown and not very abundant scoriæ, the ore is fusible, and contains but little magnesia.

When the scoriæ are green, they indicate the presence of oxide of manganese, part of which is reduced, and mixes with the cast iron, by a high and long continued heat.

The least altered kinds of sparry ores that Mr. Descotils assayed lost in roasting from 31 to 37 per cent. The altered or free ores lost at most but 14 per cent, and this loss was merely water.

The quantities of magnesia and manganese vary greatly: sometimes there may be 12 per cent of either in the raw ore, and at others there is scarcely any.

From the results of his analyses Mr. Descotils concludes, that a high proportion of one excludes a high proportion of the other, without the absence of the one necessarily indicating the presence of the other; so that the iron, when brought to the state of red oxide, always amounts to 50 per cent at least.

Hence Mr. Descotils explains what takes place in the Catalonian forges, where the different species of ores are treated according to the nature, number, and quantity of the principles they contain. He points out the method that each requires, and the product they afford, according as the operation is conducted. Sometimes it is cast steel, at others malleable iron, or some mixture of the two. On this occasion he expresses his surprise, that no one has yet thought of establishing a manufactory of cast-steel in the Pyrenees.

He thinks justly, that all rich iron ores, which contain but few earthy parts, such as those of the island of Elba, might be fused with advantage in the Catalonian method.

It follows evidently from the experiments of Mr. Descotils, that certain kinds of sparry ores owe their infusibility to the presence of a large quantity of magnesia: and that the principal object of the exposure of these ores to the air and rain, either before or after roasting, is to separate the magnesia, and render them fusible. The various experiments we have witnessed, and the results of which we have seen, leave us no doubt on this head: since on the one hand the ores in which there is no magnesia are easy of fusion, and those which contain a certain proportion are wholly infusible; while on the other the addition of magnesia to fusible ores divests them of this property, and infusible ores, when their magnesia is abstracted from them, become fusible.

From the observations of Mr. Descotils it farther follows, that there is no external character, by which we can distinguish whether a sparry iron ore be fusible or not: but he has pointed out chemical means of determining their nature, which are easy to put in practice.

The following processes from Cramer and Gellert are sufficient to direct the assay of iron ores in the furnace.

Process I.

(Extracted from Cramer's Art of Assaying, process 54.)

To reduce or precipitate iron out of its ore in a close vessel.

Roast for a few minutes in a test under a muffle, and with a pretty strong fire, two centners of the small weight of your iron ore, grossly pulverised, that the volatile matters may be dissipated in part, and the ore itself be softened in case it should be too hard. When it is grown cold, beat it extremely fine, and roast it a second time, as you do the copper ore, but in a much stronger fire, till it no longer emits any smell; then let it grow cold again. Compose a flux of three parts of the white flux, with one part of fusible pulverised glass, or of the like sterile unsulphureous scorias, and add sandiver and coal-dust, of each one half part; add of this flux three times the quantity of your roasted ore, and mix the whole very well together; then choose a very good crucible, well rubbed with lute within, to stop the pores which may remain in different places unseen; put into it the ore mixed with the flux; cover it over with common salt, and shut it close with a tile, and with lute applied to the points.

Put the wind-furnace upon its bottom part, having a bed made of coal-dust. Introduce besides into the furnace, a small grate supported on its iron bars, and a stone upon it, whereon the crucible may stand, as on a support; surround the whole with hard coals, not very large, and kindle them at top: when the vessel begins to grow red, which is indicated by the common salt's ceasing to crackle, stop with gross lute the holes of the bottom part of the furnace, except that in which the nozzle of the bellows is received; blow the fire, and excite it with great force, adding now and then fresh fuel, that the vessel may never be naked at top: having thus continued your fire in its full strength for three quarters of an hour, or for a whole hour, in the next place take the vessel out of it, and strike several times the pavement upon which it is set, that the small grains of iron which happen to be dispersed may be collected into a button, which you will find after having broken the vessel.

When the button is weighed, try its malleability: then make it red-hot; and when it is so, strike it with a hammer: if it bear the strokes of a hammer, both when red-hot and when cold, and extends a little, you may pronounce your iron very good; but if, when either hot or cold, it proves brittle, you may judge it to be not quite pure, but still partly mineralized.

Remarks. The arsenic, but especially the sulphur, must be dissipated by roasting; for the former renders the iron brittle, and the latter not only does the same, but being managed in a close vessel, with a saline flux, turns to an alkaline sulphuret; which acts strongly upon the iron, and prevents its reduction: so that the whole, or great part of it at least, is retained by the sulphureous scoria; in this case therefore it is generally in vain to look for a metallic button.

The iron obtained from this first precipitation has scarcely ever the requisite ductility, but is rather brittle, owing to the carbon it retains.

Process II.

The following process for assaying iron ores, and ferruginous stones and earths, is extracted from Gellert's Elements of Essaying.

Roast two quintals of iron ore, or of ferruginous earth: divide the roasted matter into two equal parts; to each of which add half a quintal of pulverised glass, if the substance be fusible, and contain much metal; but if otherwise, add also half a quintal of calcined borax. If the roasting have entirely disengaged the sulphur and arsenic, an eighth part, or even half a quintal of quicklime may be added. With the above matters mix 12 pounds of charcoal powder.

Take a good crucible, and cover the bottom and sides of its inner surface with a paste made of three parts of charcoal dust, and one part of clay beaten together; in the hollow left in this paste put the above mixture, press it lightly down, cover it with pulverised glass, and put on the lid of the crucible.

Place two such crucibles at the distance of about four fingers from the air-pipe, in such a manner that the air shall pass betwixt them at about the third part of the height from the bottom; fill the space between the two crucibles with coals of a moderate size; throw lighted coals upon them, that the fire may descend, and make them red-hot from top to bottom; at first let the bellows blow softly, and afterwards strongly during an hour, or an hour and a quarter; then take away the crucible, and break it when cold. A button will be found in the bottom, and sometimes some small grains of iron in the scoria, which must be separated and weighed along with the button; then try the button, whether it can be extended under the hammer, when hot and when cold.

Remarks. To disengage a metal from the earthy matters mixed with it by fire, we must change these matters into scoria or glass. This change may be effected by adding some substance capable of dissolving these matters; that is, of converting them into a scoria or glass, from which the metallic matters may, by their weight, separate and form a button at bottom. Fixed alkali, which is an ingredient of the black and of the white flux, is a powerful solvent of earths and stones: but the alkali (by the assistance of sulphur) does also dissolve iron, especially when this metal is in an oxided state; and the solution is so much more complete, as the fire is longer applied. Hence, in ordinary assays, where an alkaline salt is used, little or no iron is obtained. Now, glass acts upon, and dissolves earths and stones; but not, or at least in a very small degree, iron; consequently glass is the best flux for such assays; and experience confirms this assertion. If the ore contain but little iron, we may also add to the glass some borax; but borax cannot be employed singly, because it very soon fuses and separates from the ore before the metal is revived. Quick-lime is added, not only to absorb the sulphur and arsenic remaining in the ore, but also because it dissolves and vitrifies the stony and earthy matters of iron ores, which are generally argillaceous. For which reason, in the large operations for smelting iron ore, limestone, and even, in certain cases, gypsum, are commonly added to facilitate the fusion.

The reduction of iron ore, and even the fusion of iron, require a violent and long-continued heat; and therefore, in this operation, we must not employ an inflammable substance, as pitch, that is soon consumed; but charcoal pulverised, which in close vessels is not sensibly wasted. Too much charcoal must not be added, else it will prevent the action of the glass upon the earthy matter of the ore, and consequently the separation of the metallic part. Experiments convinced Cramer, that one part of charcoal dust to eight parts of ore was the best proportion.

When iron is surrounded by charcoal, it is not decomposed or destroyed: hence the iron of the ore, which sinks into the hollow made of paste of charcoal dust and clay, remains there unhurt. The clay is added in this paste to render it more compact, and to keep the fluid iron collected together.

The air is directed between the crucibles, because, if it were thrown directly upon them they would scarcely be able to resist the heat. The space between the air-pipe and the crucibles ought to be constantly filled with charcoal, to prevent the cold air from touching the crucibles. Ductile and malleable iron is seldom obtained in this first operation.

Mr. Mushet, in the assay of iron-stones, employs only bottle glass, chalk, and charcoal; varying their proportions according to the nature of the stone. Supposing the earths to be in the proportion of clay 9, lime 6, silex 3; to four parts of ore he puts glass 4, chalk 3, charcoal 0·5: when clay 10, silex 7, lime 3; glass 4, chalk 4, charcoal 0·75: when lime 14, clay 6, silex 4; glass 5, chalk 1·5, charcoal 0·75: when lime 10, silex 6, clay 4; glass 4, chalk 2, charcoal 0·5: when silex 12, clay 8, lime 5; glass 3, chalk 4, charcoal 0·75: when silex 10, lime 7, clay 5; glass 3, chalk 3·5, charcoal 0·75: and when neither of the earths predominates; glass 3.5, chalk 2·5, charcoal 0·5.

For other particulars respecting the properties of iron, and the treatment of its ores, see Iron.

Ores of Lead. Lead has been found native in various parts of England and elsewhere, or at least in the metallic state. But most mineralogists question the existence of native lead, and consider the specimens produced as such, to be either the produce of ancient founderies, or purer kinds of lead ore. Hence we may conclude, that the unequivocal specimens of native lead are scarce; but the curious specimen mentioned by Bomare, in the second volume of his Mineralogy, quoted by Magellan, appears to be decisive in favour of the existence of this metal in a native state. It was in the collection of the Abbé Nollin at Paris, and came from the lead mines of Pompean, near Rennes, in Brittany. This metal was very malleable, could be cut with a knife without crumbling, and easily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead ore of a reddish colour, and had a slaty vein, that went through it.

Lead is found mineralized by the sulphuric acid. According to Mr. Monnet, who calls this the pyritous ore of lead, it sometimes occurs in the form of a white ponderous oxide, soluble in 16 or 18 times its weight of water. It does not effervesce, nor is soluble in other acids; it may be reduced by laying it on a burning coal. It originates from the spontaneous decomposition of sulphuretted lead ores. Mon. Mineral. 371. According to Dr. Withering, it is found in great quantity in the island of Anglesea, but united to iron, and not reducible by the blowpipe or charcoal; it contains 70 per cent of lead. This is of a yellow colour, and mixed with clay.

The green lead ore, discovered by Gahn, consists of lead mineralized by the phosphoric acid. It may be analysed in the humid way, by the process mentioned under the article Lead. If urged by the blowpipe, it melts, and affords an opake globule without reduction, which in cooling assumes a polyhedral form, the facets of which, though apparently plain, are in fact composed of concentric striæ, when observed by the microscope.

The red lead spar or ore consists of lead mineralised by chromic acid, and has not hitherto been found elsewhere than at Catherineburgh, in Siberia. Externally it is of a pale, and internally of a deep red colour, and for the most part crystallized in rhomboidal parallelopipeds, or irregular pyramids. According to Vauquelin, it contains nearly 65·12 of oxide of lead, and 34·88 of chromic acid. Mongez mentions a lead ore of a greenish yellow colour, in a matrix of quartz, coming from Siberia, which Vauquelin found to be a chromat likewise. Lehman and Mongez had both supposed the lead in these chromats to be mineralised by arsenic.

The yellow lead ore of Carinthia was found by Klaproth to be a molybdat. By Mr. Hatchet's analysis 100 parts give lead 58·4, molybdic acid 38, oxide of iron 2, with a small proportion of silex. Spec. grav. 5·092.

A beautiful yellow lead, in silky filaments, very slightly flexible, was lately discovered in France by Mr. Champeaux, which is a combination of lead with arsenic acid or oxide.

The calciform lead ores contain carbonic acid, which is considered as the mineralizer. They effervesce with acids, and are easily reduced on the charcoal. Kirwan distinguishes five varieties.

1. White lead spar, lead ochre, or native ceruss. It is sometimes transparent, but generally opake, and crystallized in regular forms, of a laminar or striated texture. Lead ochre, or native ceruss, is the same substance, but in a loose form, or indurated and shapeless; sometimes it is found in a silky form. Both contain a little iron, and sometimes calcareous earth and argill. Both grow red-hot or yellowish when sufficiently heated. They effervesce with acids, and afford from 60 to 80 or 90 per cent of lead; both are found in Brittany, Lorraine, Germany, and England.

2. Red, brown, or yellow. This is also found either regularly crystallized, or in shapeless masses, or in powder. It differs from the former only by containing more iron. That in powder contains a mixture of clay. It affords about 70 or 80 per cent of lead.

3. Green. Either crystallized in needles as in Brittany, or in loose powder as in Saxony, but mostly adhering to or investing quartz. It owes its colour to iron, and seldom contains copper.

4. Blueish. This is also sometimes crystallized, sometimes irregular.

5. Black. The most uncommon of all, and occurs either crystallized, or of an indeterminate form.

Lead mineralized by sulphur is the commonest of all lead ores. It is known by the name of galena, or potter's lead ore, and is of a bluish dark lead colour, formed of cubes of a moderate size, or in grains of a cubic figure the corners of which have been cut off; its texture is lamellar, and its hardness variable: the hardest sort containing a greater mixture of iron or quartz; that in grains is thought to be the richest in silver; but the richest contains only about one or 1·5 per cent; that is, 12 or 18 ounces per quintal; the poorest about 60 gr. Ores that yield about half an ounce of silver per quintal are barely worth the cost of extracting them: the proportion of sulphur to lead in this ore is also variable within the limits of 15 and 25 per cent; that which contains least is called bley schweif, and is in some degree malleable. The proportion of lead is from 83 to 45 per cent by reason of an accidental mixture of quartz, that of iron is generally very small. Dr. Watson remarks, that the ores which are poorest in lead are often the richest in silver. The specific gravity of galena is from 6·565 to 7·786; when melted it yields a yellow slag.

The antimonial lead ore has the same colour and weight as galena, but its structure is commonly radiated like that of the ore of antimony. Beside the more accurate methods of humid solution, the antimony may be easily perceived, though in small quantities, by the white and abundant fumes it emits in roasting.

In the smelting of ores of lead they may be considered either as pure, that is, containing no mixture of other metals, or they are mixed with silver, copper, or pyrites. The methods of treating ores of lead containing silver and copper, are described in the articles ORES of SILVER and of COPPER, which see.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expense of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsberg, or by the following methods.

1. From the lead-ore of Willach in Carinthia a great part of the lead is obtained by a kind of eliquation, during the roasting of the ore. For this purpose, the ore is thrown upon several strata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a basin placed for its reception. The ore which is thus roasted is beaten into smaller pieces, and exposed to a second operation similar to the former, by which more metal is eliquated; and the remaining ore is afterward ground, washed, and smelted in the ordinary method.

The lead of Willach is the purest of any known. Schlutter ascribes its great purity to the method used in extracting it, by which the most fusible, and consequently the purest part of the contained lead is separated from any less fusible metal, which happens to be mixed with it, and which remains in the roasted ore. This method requires a very large quantity of wood.

2. In England lead ores are smelted either upon a hearth, or in a reverberatory furnace, called a cupel.

In the first of these methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fusion is very speedily effected; and the lead flows from the hearth as fast as it is separated from the ore.

3. In the second method practised in England pit-coal is used as fuel. The ore is melted by means of the flame passing over its surface; its sulphur is burnt and dissipated, while the metal is separated from the scoria, and collected at the bottom of the furnace. When the ore is well cleansed and pure, no addition is requisite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fusible spar found in the mines is generally added, to render the scoria more fluid, and thereby to assist the preparation of the metal. When the fusion has continued about eight hours, a passage in the side of the furnace is opened, through which the liquid lead flows into an iron cistern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid mass a quantity of slaked quick-lime, which renders the scoria so thick and tenacious, that it may be drawn out of the furnace by rakes.

Schlutter mentions this addition of quicklime in the smelting of lead-ores in England, but thinks that it is intended to facilitate the fusion of the ores; whereas it really has a contrary effect, and is never added till near the end of the operation, when the scoria is to be raked from the surface of the metal.

ORES OF MANGANESE. From the extreme disposition of manganese to become oxided, it is hardly to be expected that the metal should be found native. But Mr. Peyrouse describes a substance of this kind in the Journal de Physique for 1786, which appears to be native manganese, from the following properties.

1. Its external appearance, colour and figure are the very same as those of the metallic manganese reduced by art.

2. It likewise soils the fingers when handled.

3. Its substance is quite pure, having no particles that are in the least attracted by the magnet.

4. Its texture is lamellated, and the lamellæ seem to affect a kind of divergence among themselves.

5. It has the very same metallic brilliancy as the artificial manganese.

6. It has also a partial malleability: and, when repeatedly hammered,

7. It exhibits a kind of exfoliation, forming itself into very thin leaves.

8. Its opacity and density are so completely similar to that of the artificial regulus,

that, were it not for the natural matrix in which it is imbedded, it could not be at all distinguished from it.

9. This ore is not found in large masses, or in a solid continued body, but only in lumps, and unconnected clots, enclosed and intermixed with the powdery manganese ore.

10. These lumps are somewhat flattened, or compressed in their figure, like the artificial ones, though they are for the most part of a larger size.

11. And this powdery manganesian ore, in which the reguline lumps are imbedded, has an argentine hue, which seems to countenance the suspicion of its having been acted upon by the violent heat of some natural deflagration on the spot.

It was found among the iron mines of Sem, in the valley of Vicdessos, in the county of Foix, near the Pyrenean mountains.

The only ores of manganese yet well known are its oxides, which vary greatly in colour, texture, and other properties, both from their degree of oxidation, and from foreign admixtures. They are likewise crystallized, amorphous, or of various shapes; and vary in spec. grav. from 3·233 to 4·81. One of these ores, the garnet-shaped, is of a deep hyacinthine red; when undecayed, very resplendent, of a fine diamond lustre; and strongly transparent on the edges. It consists of oxide of manganese 35, oxide of iron 14, silex 35, alumine 14·25.

A carbonat of manganese is found in the mines of Nagyag in Transylvania, and it is said also in France, and in Norway. It is in masses of a pale rose colour, which, as it is acted upon by the air, turns to a light yellowish brown. It is void of lustre, hard, and brittle. Lampadius found its component parts to be

Oxide of manganese - - - -	48
Carbonic acid - - - - - - -	49·2
Oxide of iron - - - - - - -	2·1
Silex - - - - - - - - - -	0·9
	100·2

To an[illegible]e these ores, they should be first roasted to oxide effectually the manganese, and iron if any; then treated with diluted nitric acid to dissolve the earths; the residuum should then be treated with muriatic acid assisted by gentle heat; and the solution precipitated by carbonat of soda.

The precipitate will be oxide of manganese and of iron, if the latter were present, which will be known by boiling it in a concentrated solution of potash, as this will dissolve the manganese only. If the ore contained barytes, this will be precipitated from the nitric solution by sulphuric acid: if lime, it may be precipitated by carbonat of potash.

Ores of Mercury. Mercury is found in a native state sufficiently distinguishable from every other metallic substance, by its fluidity in every ordinary temperature of the habitable parts of the globe. Bergman doubts whether it be ever found uncontaminated by any other metal. It is found in the quicksilver-mines in small brilliant globules, disseminated in different gangues. Mongez asserts, that it is mostly in a state of great purity. Sometimes it is collected in the cavities of rocks, as at Idria in Friuli, Almaden in Spain, and in America: and in other instances it is disseminated in the earth, in clays, or adherent to quartzose stones, pot-stone mica, or else mixed with different ores, as the white or red silver ores, galena, white arsenic, or cinnabar.

Mercury has been found in Sweden and elsewhere united to silver in the form of an amalgam sometimes crystallized.

Mr. Sage, in the Journal de Physique for 1784, mentions a native oxide of mercury of a red-brown colour, difficult of fracture, presenting a granulated texture more red than externally. It frequently contains running mercury in its interstices. By distillation it yields of mercury from 20 to 80 per cent. It contains a small part of silver, and comes from Idria.

Mercury was found by Mr. Woulfe at Obermoschel in the duchy of Zweybrueck-en, united with the muriatic and sulphuric acids. These ores have a spar-like appearance, and are either bright and white, or yellow or black mixed with cinnabar in a stony matrix. The muriatic was in the state of corrosive sublimate.

The ore of mercury which is wrought in the large way is Cinnabar. It is a combination of mercury with one fourth of its weight of sulphur. See the article.

There are other impure cinnabars, particularly one containing copper, which is of a blackish gray colour, glassy texture, and decrepitates strongly when heated. The cinnabar may be volatilized by heat, and the remaining copper shows itself by the usual tests. The ore of mercury containing iron, and distinguished by the name of pyritous mercurial ore. is a gray or whitish friable substance found in Dauphiny, and afforded Mr. Monnet one part of mercury, less than half a part silver, and the rest was iron, cobalt, arsenic, and silver.

Process I.

(Cramer, process 8.)

To separate mercury out of an unsulphureous ore by distillation.

Take a lump of the pulverized ore, one common pound, which must stand for one centner: put it into a glass retort perfectly clean, well loricated, or coated up to half the length of its neck: this must be very long, and turned backwards with such a declivity, that a glass recipient may be perpendicularly applied to it: but you must choose a retort small enough, that the belly of it may be filled hardly two thirds with the ore: this retort must be placed so, that nothing of the fluid adherent to the neck of it may fall into the cavity of the belly, but that the whole may run forward into the recipient. Lastly, take a small recipient full of cold water: let it be placed perpendicularly, and receive the neck of the retort in such a manner, that the extremity of it may be hardly one half inch immersed into the water.

Let the retort be surrounded with hot burning coals placed at some distance in the form of a circle, lest the vessel should burst by too sudden a heat: then by degrees bring the burning coals nearer and nearer, and at last surround the whole retort with them and with fresh charcoal, that it may grow slightly red-hot: this fire having been continued for an hour, let the retort cool of itself: then strike the neck of it gently, that the large drops which are always adherent to it may fall into the recipient: let the recipient be taken away, and the water separated from the mercury by filtration, and let the mercury be weighed. This operation may be more conveniently performed in a sand bath; in which case the pot containing the sand must be middling red-hot, and the retort be able to touch the bottom of it immediately; nor is it then necessary that the retort be loricated.

Process II.

(Cramer, process 59.)

To revive mercury from a sulphureous or cinnabar ore.

Beat your ore extremely fine, and mix it exactly with an equal proportion of iron filings, not rusty; and proceed to distil it with the same apparatus as in the former process; but urge it with the strongest fire that can be made.

Cinnabar may be separated from stones by sublimation as follows. Beat it to a fine powder, and put it into a small narrow glass or earthen cucurbit, of the belly of which it must not fill more than one third part: stop the orifice at top; this must be very narrow, to hinder the free action of the air. Put this small cucurbit into an earthen pot above two inches in diameter, and gather sand around this pot about as high as the pulverized ore rises in the cucurbit. Then put it upon burning coals in such a manner, that the bottom of the pot may be moderately red-hot. Thus will your cinnabar ascend, and form a solid ponderous ring, which must be taken out by breaking the vessel,

Ores of Molybdena. See Acid of Molybdenic, also Molybdena.

Ores of Nickel. This semimetal has been found by Rinman in a cobalt-mine in Hesse. The mineral is very ponderous, and of a livid colour. When pulverized and roasted under a muffle it forms a green excrescence, and smokes; but its smoke has no peculiar smell, and no sublimate whether sulphureous or arsenical can be caught. It affords a green solution with acids; but a polished iron plate discovers no indication of copper.

Nickel is also found in the state of oxide, afforded by the decomposition of kupfer nickel. It usually has the form of a green efflorescence, and often covers the ores which contain it. Cronstedt informs us, that it is found at Normark in Warmeland, without any appearance of kupfer nickel, in a clay which contained much native silver.

The ore long distinguished by the name of kupfer nickel, before the discovery of the peculiar metal by Cronstedt, is of a reddish-yellow colour, and of the texture and appearance of a slag, or else of a fine granular texture; or lastly, of a scaly or lamellar texture. Its brilliancy in some measure resembles that of the common pyrites. This ore contains nickel, with iron, cobalt, and arsenic, mineralized with sulphur. See Nickel.

Ores of Osmium. This metal has been found hitherto only in small quantity among the black powder left after dissolving platina. See Osmium: also Iridium.

Ores of Palladium. This too has been found only with Platina. See Palladium.

Ores of Platina. This comes to us in an impure native state. Its ores, if any, are unknown. See Platina.

Ores of Rhodium. Rhodium has yet occurred only in the grains of crude platina. See Rhodium; also Palladium.

Ores of Silver. The great value of this metal has occasioned its ores to be very particularly attended to, and enumerated.

Native silver is found in a granular, lamellar, filamentous, capillary, arborescent, or crystallized form, inhering either in sulphat of barytes, lime-stone, sulphat of lime, quartz, chert, flint, serpentine, gneiss, agate, mica, calcareous spar, pyrites, schistus, clay, &c.; also in separate masses of various sizes, some of the weight of 60 pounds, in or near the veins of most metallic substances, particularly in Peru, and frequently in various parts of Europe, either of a white, brown, or yellowish colour.

It is often diffused through sand and ochre, also in gray lime stone in Lower Austria, and in a greenish clay near Schemnitz, or mixed with ochre, clay, and oxide of nickel.

It is seldom found pure, being generally alloyed with copper, and sometimes with a small proportion of gold, iron, or antimony, and sometimes about five per cent of arsenic; it is separable from gold and antimony by solution in nitric acid; from copper and iron by precipitating it by the muriatic acid; and from arsenic by torrefaction. Cronstedt says its purity is generally approaching to 16 carats. Lewis asserts, that it never exceeds this fineness. The native silver found near Konigsberg contains [illegible] much gold, as to acquire a yellow colour from it.

Horn-silver, or corneous silver ore, is of a whitish-gray or dirty yellow, sometimes semitransparent, easily cut with a knife, fusible even by the flame of a candle, and assuming a violet colour by the sun's rays. One hundred grains contain from 28 to 74 of real silver. In some ores the muriat is mixed with 67 per cent of argil. It is reducible by triturating it with about its own weight of fixed alkali with a little water, then melting the whole in a crucible, the bottom of which is covered with soda well pressed, and covering the mass of horn-silver also with the soda.

The vitreous silver ore (silberglasertz) is mineralized by sulphur. It is found either in solid large lumps, or inhering in quartz, spar, gypsum, gneiss, pyrites, &c.; of a lamellar, granular or capillary form crystallized. It is generally of a lead colour first, but grows black by exposure to the air, but sometimes gray or black, even when first broken; its laminæ are flexible and ductile, and even malleable in some degree, and so soft, that they may be cut with a knife; its specific gravity is 7·200. It is one of the richest of the silver ores, containing about ·85 of metal.

The black silver ore, schwartzguldenertz, silbermulm, is considered as a variety of this.

The brittle vitreous silver ore, analysed by Klaproth, gave in 100 parts, silver 66·5, antimony 10, iron 5, sulphur 12, copper and arsenic about 0·5, extraneous matter from the mine 1.

It is analysed by boiling in moderately dilute nitric acid, using about 25 times its weight, till the sulphur is quite exhausted. The silver is precipitated by muriatic acid, or common salt. The Prussian alkali will show if any other metal is contained in the solution: the gold, if any, will remain undissolved; fixed alkalis will precipitate any other earthy matters contained in the solution.

In the dry way it may be reduced by melting it with the blow-pipe on charcoal; for the sulphur is dissipated, and the silver remains; or by melting it with ¼ of its weight of filings of iron, as the iron will take up the sulphur, and be scorified.

Silver is either mineralized by a small or a large proportion of arsenic. The ore which is mineralized by a small proportion of arsenic is of a yellowish-white colour, and of a striated texture, resembling bismuth, but much harder; it melts very easily; and if kept in fusion, it loses its arsenic, and the silver remains almost entirely pure, as it contains but very little iron; it contains about 90 per cent of silver, and is found near Quadanal canal in Spain.

The proportion of arsenic in that silver ore, which is mineralized by a large proportion of it, is so great, that it would scarce deserve to be called a silver ore, if the arsenic were not easily dissipated: the quintal contains but from four to six ounces of silver: it is very soft, and easily cut. and when cut has a brilliant metallic appearance; it consists of conchoidal laminæ; it is also found at Quadanal canal. It is reduced by evaporating the arsenic, which then leaves the silver slightly contaminated with iron.

A silver ore of this kind analysed by Klaproth, gave silver 12·75, iron 44·25, arsenic 35, antimony 4.

The red silver ore (rothguldenertz) is a heavy, shining substance, either transparent or opake, mostly of a crimson or reddish colour, though sometimes gray or blackish, but when scraped or powdered always reddish; found either in irregular masses, or crystallized in pyramids or polygons, or dendritical, or plated or radiated incrustations, on or in matrixes of quartz, flint, spar, pyrites, sparry iron ore, lead ore, pyrites, cobalt ore, jasper, gneiss, &c. When radiated or striated, it is called rothgulden bluth. In the fire it crackles and melts after it has acquired a red heat, with an arsenical smell; it detonates with nitre: its specific gravity is from 5·4 to 5·684. Bergman found 100 grains of it to contain 60 of silver, 27 of arsenic, and 12 of sulphur; but sometimes it contains even 70 per cent of silver. The darkest ores are the richest, and these often contain a little iron; the yellowest are the poorest; the most yellow does not belong to this species, being in fact orpiment, containing six or seven per cent of silver.

To analyse this ore in the moist way, Bergman advises to boil it after it is reduced to a very fine powder in dilute nitric acid, and to edulcorate the residuum very carefully which contains the sulphur and arsenic, which may be separated by boiling in a sufficient quantity of aqua regia: if the sulphur still retain any muriat of silver, it may be separated by pure ammonia.

In the dry way it is reduced after torrefaction by a mixture of iron and lead; the iron takes up the sulphur, and the lead the silver, which is afterward separated by cupellation.

Klaproth however denies that it contains arsenic, as not the least vestige of it was to be found in a bright red crystalline ore from the Hartz, or another from Freiberg. The former gave silver 60, antimony 20·3, sulphur 11·7, concrete sulphuric acid 8: the latter, silver 62, antimony 18·5, sulphur 11, concrete sulphuric acid 8·5. The sulphur and its acid he supposes to have been united in the state of an oxide of sulphur in the ore.

Another species of silver ore mineralized by sulphur, and containing a large porportion of lead, is called white silver ore, weissgultigertz. Analysed by Klaproth, 100 parts gave silver 20·4, lead 48·06, antimony 7·88, iron 2·25, sulphur 12·25, alumine 7, silex 0·25. A variety of this dark white silver ore, gave silver 9·25, lead 41, antimony 21·5, iron 1·75, sulphur 22, alumine 1, silex 0·75.

Klaproth distinguishes this from the weissguldenertz of Kremnitz, which has been confounded with it, and which he calls gray silver ore, as it resembles the gray copper ore more than it does the white silver. This gave him silver 14·97, copper 31·36, antimony 34·09, iron 3·3, sulphur 11·5 alumine 0·3. What has frequently been called gray silver ore, fahlertz, is properly an ore of copper, containing accidentally a small portion of silver only.

A bismuthic silver ore was found by Selb, about fifteen years ago, at Schapbach in the Black Forest. It is chiefly disseminated in quartz; and, analysed by Klaproth, 100 parts gave lead 33, bismuth 27, silver 15, iron 4·3, copper 0·9, sulphur 16·3.

In the duchy of Zweybrueeken a native amalgam of silver occurs in various forms. Some pure garnet-like crystals of it, analysed by Klaproth, gave mercury 64, silver 36.

And in Suabia an alloy of silver and antimony occurs, one variety of which, in fine grains, contains ·84 of silver: another, in coarse grains, ·76: the remainder in each being antimony.

The following processes, like the others extracted from Cramer's Art of Assaying, are valuable for the minute accuracy of the instruction as to the management of assays by the furnace.

PROCESS I.

To precipitate silver by means of lead from fusible ores.

Pound the ore in a very clean iron mortar into fine powder: of this weigh one docimastical centner or quintal, and eight of the like centners of granulated lead.

Then have at hand, a docimastical test, that has never yet been used: pour into it about half of the granulated lead, and spread it with your finger through the cavity of it.

Put upon this lead the pounded ore; and then cover it quite with the remainder of the granulated lead.

Put the test, thus loaded, under the muffle of an assay-furnace, and in the hinder part of it: then make your fire, and increase it gradually. If you look through the holes of either of the slides, you will soon see, that the pounded ore will be raised out of the melted lead, and swim upon it. A little afterward, it will grow clammy, melt, and be thrown towards the border of the test: then the surface of the lead will appear in the middle of the test like a bright disk, and you will see it smoke and boil: as soon as you see this, it will be proper to diminish the fire a small matter for a quarter of an hour, so that the boiling of the lead may almost cease. Then again increase the fire to such a degree, that the whole mass may be converted into a thin fluid, and the lead may be seen, as before, smoking and boiling with great violence. The surface will then diminish by degrees, and become covered with a mass of scorias. Finally, have at hand an iron hook ready heated, wherewith the whole mass must be stirred, especially toward the border; that in case any small parcels of the ore, not yet dissolved, should be adherent there, they may be brought down, taking great care not to stir the least particle out of the test.

Now, if what is adherent to the hook during the stirring, when you raise it above the test, melt quickly again, and the extremity of the hook, grown cold, be covered with a thin, smooth, shining crust; it is a sign that the scorification is perfect; and it will be the more so, as the said crust adherent to the hook shall be coloured equally on every side; but in case, while the scorias are stirred, you perceive any considerable clamminess in them, and when they adhere in good quantity to the hook, though red-hot, and are unequally tinged, and seem dusty or rough with grains interspersed here and there; it is a sign that the ore is not entirely vitrified. In this case, you must with a hammer strike off what is adherent to the hook, pulverize it, and with a ladle put it again into the test, without any loss, or mixture of any foreign body, and continue the fire in the same degree, till the scoria has acquired its perfection, and the above-mentioned qualities. This once obtained, take the test with a pair of tongs out of the fire, and pour the lead, together with the scoria swimming upon it, into a cone made hot and rubbed with tallow. Thus will the process of the first operation be performed, which does not commonly, indeed, last above three quarters of an hour.

With a hammer strike the scorias off from the regulus grown cold, and again examine whether they have the characteristics of a perfect scorification: if they have, you may thence conclude that the silver has been precipitated out of the ore turned to scorias, and received by the lead.

When the scorification lasts longer than we mentioned, the lead at last turns to scorias or litharge, and the silver remains at the bottom of the vessel; but the fire must be moderately supplied, and the vessel be extremely good, to produce this effect; for they seldom resist the strength of the scorias long enough; so that the whole scorification may be brought to an end; which has afterward this inconveniency, that the silver is dissipated by grains in the small hollows of the corroded ore, and can hardly be well collected again, when the ore has but little silver in it. Indeed, there is still more time to be consumed to obtain the perfect destruction of the lead, by means of the combined actions of the fire and air, because the scorias swimming at the top retard it considerably.

In this process, the sulphur and the arsenic of the silver ore, when the ore is broken small, and extended widely in a small quantity, are in part easily dissipated by the fire, and in part absorbed by the lead; the lighter part of which, swimming upon the heavier, becomes very clammy by means of the sulphur which is in the ore: but when this is dissipated by the violence of the fire, it turns into glass or scorias: but when arsenic is predominant in the ore, the plumbeous part turns immediately into a very penetrating and very fusible glass, having a dissolving efficacy, unless the arsenic lies hidden in a white pyrite or cobalt. For this reason, the fixed part of the ore, which is no silver, is dissolved by that glass, melts, and assumes the form of scorias. The unmetallic earths and the pure copper of lead-ores, which adhere to it, are of this kind. The silver then remains immutable; and being freed from these heterogeneous bodies, which are partly dissipated and partly melted, it is precipitated and received by the remaining lead. Hence this process is completed by three distinct operations; viz.

1. By roasting.
2. By scorification.
3. By the melting precipitation of the silver, which is the result of the two former operations.

The ore must be pulverized very fine in order to increase the surface, that the dissipation of the volatiles, and the dissolution by litharge, may be sooner effected. This pulverizing must be done before the ore is weighed, because there is always some part of the ore adherent to the mortar or iron plate on which it is made fine; which part being lost, the operation is not exact. Erker was in the right, when he prescribed eight centners of lead for the subduing of fusible ores. Nevertheless it must be owned, that this quantity is superfluous in some cases. However, as the fluxibility of the silver ore depends on the absence of stones, pyrites, &c., it is easy to see, that there are an infinite number of degrees of fluxibility, which it would be needless to determine by the bare sight. Besides, a little more lead does not render the process imperfect; on the contrary, if you use too small a quantity of lead, the scorification is never completely accomplished. Indeed there are a great many ores that destroy a considerable quantity of lead: such are the red silver ore, and that in which there is a great deal of the steel-grained lead ore. If the fire must be sometimes diminished in the middle of the process, it is in order to hinder the too much attenuated litharge, which is continually generated out of the lead, from penetrating the pores of the test, and from corroding it; which is easily done when the fire is over strong; for then the surface of the vessel which is contiguous to the lead contracts cavities, or, being totally consumed by small holes, lets the metal flow out of it. The vessels that are most subject to this inconvenience are those, in the materials of which lime, plaster, and chalk, are mixed. Nay, these bodies, which are naturally refractory, being eroded during their scorification, at the same time communicate a great clamminess to the scoria; so that a great quantity of the mass remains adherent to the test in the form of protuberances, when it is poured out; and by this means a great many grains of the regulus are detained.

Process II.

The button obtained by the preceding process contains all the silver of the ore, and the unscorified part of the lead. The silver may be afterward separated from the lead, and obtained pure, by cupellation.

Process III.

(Art of Assaying, part ii. process 3.)

If the silver ore cannot be washed clean, or if it be rendered refractory by a mixture of unmetallic earths and stones, the scorification of these earthy matters frequently cannot be completed by Process I: Cramer *therefore directs, that such ores shall be treated in the following manner.*

Bruise the ore into an impalpable powder, by grinding in a mortar; to a docimastical centner of it add a like quantity of glass of lead, finely pulverized: for the more exactly these two are mixed together, the more easily the scorification afterward succeeds. Put this mixture, together with twelve centners of lead, into the test, according to Process I; then put the test under the muffle.

Make first under it a strong fire, till the lead boils very well; when this takes place, diminish the violence of the heat, as was directed in Process I, but keep it thus diminished a little longer: then finally again increase the fire to such a degree, till you perceive the signs of a perfect scorification and fusion. Now this process lasts a little longer than the foregoing, and requires a greater fire toward the end.

It sometimes happens, that a very refractory ore cannot be dissolved by litharge, and that a mass, which has the clamminess of pitch, swims upon the metal and upon the scorias themselves, which are already subdued in part: when this takes place, shut the vents of the furnace to diminish the fire; then gently touch this refractory body with a small cold iron hook, to which it will immediately stick; take it off softly, not to lose any thing; pound it into a fine powder, adding a little glass of lead, and put it again into the test; then continue the scorification, till it is brought to its perfection. But you must always examine the scoria of your refractory ore, to see whether there may not be some grains of metal dispersed in it: for sometimes the scorias that grow clammy retain something of the metal: which if you suspect, pound the scoria into a fine dust, and thus the grains of metal will appear, if there be any left, because they can never be pounded fine. The silver is separated by cupelling, as in Process I.

All earths and stones are refractory in the fire; for although some of them melt naturally in the fire, as is the case with those that are vitrifiable; yet all the others, a very few excepted, melt with much greater difficulty than metals, and never become so thin in the fusion as is requisite for the sufficient precipitation of a precious metal. But litharge itself does not conveniently dissolve these refractory matters by the help of fire alone, without mechanical mixture; for the very moment the litharge penetrates through the insterstices of the refractory ore, and begins to dissolve it, a tenacious mass is produced, which hardly admits any farther dilution by the litharge. You may plainly perceive this, when you make coloured glasses with metallic oxides; for, if you pour carelessly upon them an oxide that gives a colour, you will never cause them to be equally tinged throughout, even though you should torture them for whole days together in a strong fire. Indeed, glass already made can never be diluted by only pouring salts and litharge upon it. Hence, you must use the artifice of glass-makers, who, in the making of the most perfect glasses, take great care to mix their ingredients well, either before they put them into the fire, or at least during the fusion itself, which is done here by pounding glass of lead mixed with the ore: but if you think that your glass of lead is not sufficiently fusible, you may add to it litharge, melted first, and then pounded into a fine powder.

As this scorification requires a longer and a greater fire than the foregoing, and as a greater quantify of litharge is beside this requisite to subdue the refractory scoria; it is easy to see, why a much greater quantity of lead must be used here than in Process I; and although less lead is often sufficient, it is nevertheless proper, always to use the greatest quantity that can be requisite; lest, for instance, it should be necessary to try so many times the lead alone, to make it evident how much silver the lead, when alone, leaves in the cupel. Nor is there any occasion to fear lest any thing of the silver be taken away by the lead, provided the cupels be good, and the cupelling duly put in execution: for you can hardly collect a ponderable quantity of silver out of the fumes of the lead, which rise during the cupelling, as well as out of the litharge, that is withdrawn into the cupel.

PROCESS IV.

Art of Assaying, Part ii. process 4.)

If the ore be rendered refractory by pyrites. Cramer *directs, that the silver should be precipitated by lead in the following manner.*

Break your ore into a rough powder, and put a centner of it into the test: put upon this another test in the manner of a tile; put it under the muffle hardly red-hot: increase the fire by degrees. There will always be a crackling; which being ended, take away the upper test; for when the vessels have been red-hot about one minute, the ore ceases to split. Leave the ore under the muffle, till the arsenic and the sulphur are for the most part evaporated; which you will know from the cessation of the visible smoke, of the smell of garlic, or the acid; then take away the test, and leave it in a place not too cold, that it may cool of itself.

Pour out, without any dissipation, the roasted ore, and with a knife take away what is adherent to the vessel; pound it to a very subtile powder, and grind it together with an equal weight of glass of lead; and lastly, scorify the whole collected ore in the same test in which the testing was made, unless it has contracted chinks, as was described in Process III.

Remarks. Yellow pyritous ores contain a very great quantity of sulphur, even greater than is necessary to saturate the metal that lies concealed in them. For which reason this superfluous sulphur dissipates in a middling fire; but if it had been mixed with lead, it would have rendered it refractory, nor could it afterward be dissipated from it without a considerable destruction of the lead. The white arsenical pyrites turn also a great quantity of lead into glass, on account of the abundance of the arsenic they contain. In consequence of this, these ores must be previously roasted, that the sulphur and arsenic may be dissipated. Nor is there any occasion to fear, lest any part of the silver be carried away with the arsenic; for when arsenic is separated from any fixed body, by a certain degree of fire, it carries nothing of that body away with it.

PROCESS V.

(Art of Assaying, Part ii. process 9.)

Silver may be precipitated from its ore by cupellation only, in the following process, given by Cramer.

Pound one centner of ore, roasted in the manner directed in the last process; beat it to a very subtile powder; and if it melt with difficulty on the fire, grind it together with one centner of litharge, which is not necessary when the ore melts easily; then divide the mixture, or the powder of the ore alone, into five or six parts, and wrap up every one of them severally in such bits of paper as can contain no more than this small portion.

Put a very large cupel under the muffle; roast it well first, and then put into it 16 centners of lead; when the lead begins to smoke and boil, put upon it one of these portions with the small paper it was wrapped up in, and diminish the fire immediately, in the same manner as if you would make a scorification in a test, but in a less time The small paper, which turns presently to ashes, goes off of itself, and does not sensibly increase the mass of the scorias. The ore proceeding from this is cast on the border, and very soon turns to scorias Increase the fire again immediately, and at the same time put another portion of the ore into the cupel. The same effects will then be produced. Continue your operations in the same manner, till all the portions are thrown in and consumed in the lead. Lastly, destroy the remaining lead with a stronger fire.

The silver that was in the ore and in the lead will remain in the cupel. If you deduct from it the bead proceeding from the lead, you will have the weight of the silver contained in the ore. If the ore employed were easy to be melted, all the scoria vanishes; but if it were refractory, or not fusible, all the scoria does not always pass away, but there remains something of it occasionally in the form of dust. A great many ores and metals may be tried this way, except such only as split and corrode the cupels. There are likewise some of them, which must be previously prepared, in the same manner as is required to render them fit for going through a scorification. See the preceding Processes.

Remarks. The ore thrown at several times upon lead boiling in a cupel may be dissolved without the foregoing scorification: but this is very far from having an equal success with all kinds of ores; for there are ores and metals, which resist very much their dissolution by litharge; and which being on this account thrown on the border, are not sufficiently dissolved; because the litharge soon steals away into the cupel. Nevertheless there are some others, which vanish entirely by this method, except the silver and gold that were contained in them.—A previous roasting is necessary; first, for the reasons mentioned, and then, because the ore thrown upon boiling lead should not crackle and leap out; for, having once passed the fire, it bears the most sudden heat.

Process VI.

(Cramer, process 15.)

Silver may be precipitated out of the same bodies as were mentioned in the foregoing processes, by scorification in a crucible.

The body out of which you intend to precipitate silver must be previously prepared for a scorification by pounding and roasting, as mentioned in the former processes. Then in the same manner, and with the same quantity of lead, put it into a crucible, which is found on strict examination to be entire, solid, not speckled with black spots, like the scoria of iron, especially at its inferior parts, and capable of containing three times as much. Add besides glass-gall and common salt, both very dry, and in sufficient quantities, that, when the whole is melted, the salts may swim at top at the height of about half an inch.

Put the crucible thus loaded into a wind-furnace; shut it close with a tile; put coals round it, but not higher than the upper border of the crucible. Then light them with burning coals, and increase the fire till the whole melts very thin, which will be done by a middling fire, maintained always equal, and never greater: leave it thus for about one quarter of an hour, that the scorification may be perfectly made. Take off the tile, and stir the mass with an iron wire, and a little after pour it out into the mould. When the metal is cleared from scorias, try it in a test by cupelling it.

Remarks. The scorification of any ore whatever, or of any body fetched out of ores, may indeed be made by this apparatus, as well as in a test under a muffle: but it serves chiefly to the end that a greater quantity of metal may be melted from it with profit. For you may put many common pounds of it at one single time into the crucible; but then you need not observe the proportion of lead prescribed in the foregoing process; indeed, a quantity of lead two or three times less is sufficient, according to the different qualities of the object. But the mass will certainly be spilt, unless you choose a very good crucible; for there is no vessel charged with litharge, that can bear a strong fire having a draught of wind, without giving way through it to the litharge.

You add glass-gall and common salt, that they may forward the scorification, by swimming at top; for the refractory scoria rejected by the litharge, and adhering between this and the salts that swim at top, is soon brought to a flux, and the precipitation of the silver is thereby accelerated. They also hinder a small burning coal fallen into the crucible from setting the litharge a-boiling, which troubles the operation; for the litharge, or glass of lead, especially that which is made without any addition, as soon as the carbon enters into it, rises into a foamy mass, consisting of a multitude of small bubbles very difficult to be confined, unless the carbon be entirely consumed, and the litharge reduced to lead, which sometimes rises above the border of the vessel.

VI. *The following is given by Mr. Sage as the best method of assaying ores of silver.*

Melt a quintal of the roasted ore with as much litharge, and three quintals of common carbonat of potash, in a crucible, the bottom of which is lined with 24 or 30 grains of charcoal, softened with a little oil, so that the paste may be applied to the bottom and half way up the side by the finger. Put on a cover, but without luting it. Place two such crucibles side by side in a common furnace, and cover them with charcoal. The bellows are not necessary. When the mixtures enter into fusion, which will readily be perceived by the ear, push the charcoal aside, so that you may be able to take off the lids, and see what is going on. If the effervescence raise the contents above the middle of the crucible, remove the lids, when the weight of the air will check the swell, and prevent it from running over. As soon as all is quiet, put on the lids again, cover up the crucibles with charcoal, and let them stand till they are cold. If the assays have been well fused, the leads obtained will not differ in weight two grains. Subject them to cupellation, and you will obtain buttons, which ought not to differ a sixteenth of a grain. A sixteenth of a grain represents an ounce in a hundred pounds: but if the ore be so poor as to yield less than an ounce, as is the case with most of the mines at present worked in America, the assay should be made with four hundred grains at least.

Native metallic silver may be separated from the stones and earths with which it is intermixed by amalgamation with mercury, which operation is to be performed in the same manner as in the separation of native gold.

Ores of Tantalium. Of these only two have yet been found, in both of which the metal is in the state of oxide. One of them was mistaken for an ore of tin, till it was analysed by Eckeberg. See Tantalium.

Ores of Tellurium. The ores of this lately discovered metal have yet been found only in the gold mines of Transylvania. In all of them the metal is in the state of an alloy, being combined with gold in every species, though but with a very minute portion in the native tellurium, formerly known by the name of *aurum paradoxicum*, which contains 92·55 of tellurium, and 7·20 of iron, in the hundred parts. In the graphic gold ore, yellow gold ore, and foliated or black ore, it is united with silver likewise. In the second and third of these there is a considerable portion of lead, and some sulphur: and the last contains a little copper also. See Tellurium.

Ores of Tin. The existence of native tin was long a matter of doubt among mineralogists. It has nevertheless been undoubtedly found in various places. Magellan, among other specimens, mentions, 1. Malleable tin in a granular form, and also foliaceous, bedded in a white hard matter resembling quartz, but which, on proper examination, proved to be arsenic; a circumstance that evinces its being native tin, because the arsenic could not have retained this form, if the tin had undergone the fusing heat. It appeared like a thick jagged or scolloped lace or edging, and was found at St. Austel in Cornwall. 2. In the form of crystalline metallic laminæ, or flat crystals, rising side by side out of an edging, which shone like melted tin. They were nearly as thin as the leaves of talc, intersecting each other in various directions, with some cavities between them, within which appeared many specks and granules of tin that could be easily cut with a knife; this also came from Cornwall. 3. In a massy form, more than an inch thick in some places, and enclosed in a stone resembling quartz, which was taken to be a hard crust of crystallized arsenic.

All the ores of tin hitherto found, except the sulphuret from Huel or Wheal Rock, St. Agnes, Cornwall, are in the oxided state. They are remarkable for their great weight, which is between 5·8 and 6·97, according to Klaproth.

The common ore called tin-stone has a vitrified appearance, resembling a garnet of a blackish-brown colour, but much heavier. Its surface is shining, sometimes striated, and its fracture lamellar; soft enough to be cut or scraped with a knife, and affording a pale red powder. Some authors assert, that it contains arsenic, but Kirwan positively denies the existence of arsenic as a mineralizer of tin. The Germans call the irregular compact tin ore by the name of zinnstein; but the crystallized tin-stones are called zinngraupen, if the crystals be distinct and somewhat large. The zinnzwitter ores, in which the crystals are small and not so distinct, resemble small grains, scattered through a compact raw tin-stone, or a stone of any other kind.

The common matrix of tin in the Cornish mines is the killas and the growan. This consists of white clay mixed with mica and quartz, without any particular texture; which, when lamellar and hard, is called gneiss by the Germans, and is nothing else but decayed granite, in which the feltspar has been broken down to clay.

The zinngraupen, brown crystallized tin-stone, from Cornwall, consists of quadrangular prisms, or double quadrangular pyramids, joined by their bases, so that these crystals are octaedral; these are found at Trwaunance and Soil-hole, in the parish of St. Agnes. Similar prismatic crystals, but of as small a size as a hair, are found in tin-stone upon killas, at Polgooth, one of the richest tin mines. which produces sometimes a clear profit from 1000 to 1200*l.* per month.

The stream-tin is collected in the valleys of the tin-mountains in Cornwall, and yields a considerable quantity of this metal. The soil is dug several feet deep, and washed by water going over it, till the heavier particles of the ore remain at the bottom. These are nothing else but the abrasions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The stream-tin from Pensagillis is remarkable on account of the native gold now and then met with in it; and found, though very rarely, in pieces of the value of two or three pounds sterling. It principally consists of round, oval, and somewhat smooth pieces, from the size of a bean to that of a pea, and less, the polished surfaces of which show a variety of reddish, gray, light-brown, and dark-yellow colours.

The wood-tin ore looks like hematites, and is found in the parishes of St. Columb, Roach, and St. Denis. This is without any crystallized form, and has a very inconsiderable quantity of iron with it.

Another wood-like tin ore, described by professor Brunnich, shows various fine fibres converging to different centres, like the radiated zeolyte; but is so compact and hard, as to strike fire with steel. Its specific gravity at 45° of Fahrenheit is 5·80, and even 6·45. It contains some arsenic and a considerable proportion of iron; and gives sometimes 63·5 per cent of tin. It is very scarce, and found only in small pieces.

The tin spar, or white tin ore, is generally of a whitish or gray colour; sometimes it is yellowish, semitransparent, and crystallized, either of a pyramidal form, or irregular. It resembles a calcareous or rather ponderous spar, but is easily known by its great weight, and shining greasy appearance. Its fracture also is vitreous. It was formerly thought to contain arsenic, but Margraaf found it to be the purest of all tin-ores; though it is said to contain sometimes a mixture of calcareous earth. Its specific gravity is = 6·007.

Tin grains are of a spherical polygonal figure, like the garnets; but seem more unctuous on their surface. It is found either in large or small grains.

Bergman received a specimen of native aurum musivum from Nerschinskoi in Siberia. It resembled the artificial aurum musivum externally, or rather the aurum musivum formed a crust environing a nucleus radiated in its fracture, and resembling a white metal. It yielded to the knife, and the place of section exhibited a variable colour. Its powder was black. By the analysis, it proved to consist of tin mineralized by sulphur, with a very small portion of copper. In the Journal de Physique for 1783 it is said, that the specimen was too small to admit of a determination of the quantities in the large way: but in the preface to the Sciagraphia it is said, that the native aurum musivum contained forty parts of sulphur to one of tin: and the other mineral, which resembled antimony, contained one fifth part of sulphur only.

At Huel Rock, in St. Agnes, in Cornwall, there has been found a metallic vein nine feet wide, at twenty yards beneath the surface. Raspe was the first who discovered this to be a sulphuret of tin: it is very compact, of a bluish white colour, approaching to gray steel, and similar to the colour of gray copper-ore: it is lamellar in its texture, and very brittle. It consists of sulphur, tin, copper, and some iron. Raspe proposes to call it bell-metal ore.

According to Klaproth's analysis of this ore, 100 parts contain 25 of pure sulphur, 34 of tin, 36 of copper, two of iron, and three grains of the stony matrix. A faint smell of arsenic was perceptible in roasting it. The darker varieties however are much poorer in tin, and contain more iron.

Bergman's method of assaying tin ores in the humid way is too commonly ineffectual. Klaproth gives the following mode. Mix the ore, in fine powder, with a lixivium containing six times its weight of caustic potash; evaporate to dryness in a silver vessel on a sand heat; and then keep in a state of moderate ignition for half an hour. Dilute the mass, while yet warm, with boiling water, and filter. Let the residuum be again ignited with six times its weight of potash, and dissolve in boiling water as before. Mix the solutions, and add muriatic acid, till the precipitate, which first falls down, is dissolved by its excess. Separate the tin from the acid by carbonat of soda; wash the precipitate; dry it; and redissolve it in muriatic acid by a gentle heat. Into the colourless solution, diluted with two or three parts of water, put a stick of zinc, and in a few days the whole of the tin will gather round it in dendritic laminæ. The residuum left after the second solution is to be treated with muriatic acid, and what tin is in it precipitated by zinc in the same manner. If it contain any iron, this may now be precipitated by prussiat of potash.

The sulphuret requires to be treated somewhat differently. To one part of the powdered ore add four of muriatic and two of nitric acid, and after they have stood together 24 hours digest for some time in a gentle sandheat; then dilute with a little water, and filter. Let the sulphur of the residuum be burned off on a test, and treat what remains with fresh nitromuriatic acid. The part not soluble being ignited with a little wax, the iron will be reduced, and the remainder is silex from the matrix. The solutions are to be precipitated with carbonat of potash; the precipitate redissolved in muriatic acid diluted with three parts of water; and a stick of pure tin immersed in this solution. The copper will be deposited on the tin, and leave the solution colourless. The copper being dissolved by brisk digestion in nitric acid; if any tin were mixed with it, this will fall down in the state of white oxide. The tin may be separated by zinc, as in the preceding instance; and what was dissolved from the stick used in precipitating the copper must be deducted from its weight.

In the dry way, these ores, after pulverization and separation of the stony matter by washing, are to be melted with a mixture of double their weight of a flux, consisting of equal parts of pitch and calcined borax, in a crucible lined with charcoal, and to which a cover is luted; fusion should be speedily procured.

Bergman recommends a mixture of one part of the ore with two of tartar, one of black flux, and half a part of resin: this is to be divided into three parts, and each successively projected into a crucible heated white, and immediately covered after the foregoing portion ceases to flame: the whole operation takes up but seven minutes, or less.

Previous to smelting in the large way, the impure ores of tin must be cleansed as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of tin than of any other metal, because in the smelting of tin ores a less intense heat must be given, than is sufficient for the scorification of earthy matters, lest the tin be oxided. Tin ores previously bruised may be cleansed by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones or ferruginous ores, a slight roasting will render these impure matters more friable, and consequently fitter to be separated from the tin ores. Sometimes these operations, the roasting, contusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleansed from adhering heterogeneous matters, is to be roasted in an oven or reverberatory furnace with a fire rather intense than long continued, during which it must be frequently stirred to prevent its fusion. By this operation the arsenic is expelled, and in some works is collected in chambers built purposely above the oxiding furnace.

Lastly, the ore cleansed and washed is to be fused, and reduced to a metallic state. In this fusion, attention must be given to the following particulars:

1. No more heat is to be applied, than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily oxidable.

2. To prevent this oxidation of the reduced metal, a larger quantity of charcoal is used in this than in the other fusions.

3. The scoria must be frequently removed, lest some of the tin should be involved in it; and the melted ore must be covered with charcoal powder, to prevent the oxidation of its surface.

4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

Ores of Tungsten. See Tungsten.

Ores of Uranium. See Uranium.

Ores of Zinc. This metal has not been found in a native state.

All the ores of zinc tinge plates of copper of a yellow colour, when stratified with that metal and charcoal: but for this purpose the sulphureous ores must be previously roasted. The ores of zinc are either oxides, carbonats, sulphats, or sulphurets.

Mr. Steinhauer, of Fulneck, says, that a native oxide, scarcely inferior to the flowers of zinc of the shops, is found in considerable quantity in the West-riding of Yorkshire. In general it is mixed with iron, silex, and alumine in variable proportions, and is known by the name of calamine.

Its colour is white, gray, yellow, brown or red, and of various degrees of hardness, though scarce ever so hard as to strike fire with steel; its texture equable or cellular, and its form either irregular, crystallized or stalactitical; when calcined it loses no part of its weight, except it be mixed with charcoal, and then flowers of zinc sublime; it is soluble in acids, and with the sulphuric affords sulphat of iron as well as of zinc, which shows the iron it contains is not much oxided. The specific gravity of the best sort, that is, the gray, is 5: 100 parts of this afforded Bergman 84 of oxide of zinc, three of iron, one of alumine, and 12 of silex; but in other specimens these proportions are very different; some ores are so poor as not to contain above 4 per cent of oxide of zinc; a good ore should afford at least 30 per cent, and its specific gravity be about 4·4 or 5.

Sometimes calamines contain a mixture of calcareous earth and lead. Indeed most of the English calamines contain lead.

Bergman gives us two methods of analysing calamine. The first is to oxide it in the nitric acid with the assistance of heat, and boil away the acid to dryness. Repeat this operation twice or thrice, using each time twice as much of the acid as the ore weighs; and lastly, dissolve all that is soluble in a fresh portion of nitric acid: by this means the zinc (and lead if any) with the alumine will be taken up, while the iron, being highly oxided, will with the silex remain undissolved. If the solution contain lead, the muriatic acid will precipitate it; after which the sulphuric may be used to precipitate the lime, if any be contained in the ore, or the lead and other metals may be precipitated by adding a piece of zinc. The zinc may then be precipitated by the prussiat of potash, the weight of which divided by five gives that of zinc in its metallic form contained in the ore. The undissolved residuum should be treated with three times its weight of concentrated sulphuric acid, and evaporated to dryness, and all that is soluble extracted with warm water; the iron should be precipitated by the prussiat of potash, and the alumine by the carbonat of soda, which should also be added to the nitric solution after the zinc is precipitated.

The second method is shorter and more ingenious. He distills the sulphuric acid over calamine to dryness; the residuum he lixiviates in hot water; what remains undissolved is silex; to the solution he adds pure ammonia, which precipitates the iron and alumine, but keeps the zinc in solution, as it is soluble in sulphat of ammonia; the precipitate he redissolves in sulphuric acid, and separates the iron and alumine as before.

In the ore of tutenague the oxide of zinc is mixed with a notable proportion of iron. Engestrom, in the Memoirs of Stockholm for the year 1775, has given us an analysis of an ore of this sort from China; it was of a white colour, interspersed with red streaks of oxide of iron, and so brittle as to be easily broken betwixt the fingers. It was soluble in the mineral acids, particularly with the assistance of heat; and with the sulphuric afforded sulphats both of zinc and iron; the quantity of carbonic acid was so small as to be absorbed by the solution; it contained in various specimens from 60 to 90 per cent of zinc; the remainder was iron and a small proportion of alumine. Bindheim also discovered this variety in Germany, and found it to consist of zinc, a little iron, and silex.

Of a similar nature appears to be a singular mineral lately discovered in the mine of Fahlun, in Sweden, by Mr. Gahn, and thence called Gahnite zinc by Brongniart. It is the *automalite* of Eckeberg; zinciferous corundum of Hissinger. In its properties it approaches the spinel and ceylanite. It is crystallized in very regular octaedra; sufficiently hard to scratch quartz; a non-conductor of electricity; infusible by the blowpipe alone, but with borax melts into a green glass, that becomes colourless on cooling. The crystals are small. Their longitudinal fracture foliated, transverse, uneven and somewhat conchoidal. Their specific gravity, according to Eckeberg, 4·261; according to Haüy, 4·697.

Eckeberg, who first analysed this mineral, gives as its constituent parts, oxide of zinc 0·24, alumine 0·60, silex 0·05, iron 0·09, sulphur and loss 0·02. Vauquelin found in it oxide of zinc 0·28, alumine 0·42, silex 0·04, iron 0·05, sulphur and loss 0·17; beside 0·04 of the stone, that remained unaltered.

The vitreous zinc ore, or zinc spar, is a carbonat of zinc, of a whitish-gray, blueish-gray, or yellowish colour, and of a hardness generally sufficient to strike fire with steel. In its fracture it resembles quartz, irregular, stalactitical or crystallized in groups, and weighty; by calcination it loses one third of its weight, without emitting a sulphureous or arsenical smell, and is infusible in the strongest heat either singly or with soda, but easily fusible with borax or microcosmic salt. In the mineral acids it is soluble with effervescence, and with the sulphuric affords sulphat of zinc. One hundred grains of this ore contain about 65 of the oxide of zinc, 28 of carbonic acid, six of water, and one of iron; and sometimes a little of silex.

Bergman suspects the substance called zinc spar by Baron Born to be a different substance. Bindheim found it insoluble in acids before calcination, and in the dry way infusible with the three usual fluxes; but after calcination it becomes soluble in acids.

Haüy found, that the crystallized native oxide of zinc is rendered electric by heat without friction.

The zeolitiform ore of zinc is a carbonat mixed with a notable proportion of silex. The real contents of this substance were first discovered by Pelletier. It was long taken for a zeolite, being of a pearl colour, crystallized, semitransparent, consisting of laminæ diverging from different centres, and becoming gelatinous with acids. It was commonly called zeolite of Friburgh. He found 100 grains of it to contain from 48 to 52 of quartz, 36 of carbonat of zinc, and eight or 12 of water.

These ores are easily analysed in the moist way, by dissolving them in the dilute sulphuric acid: the silex, if any, will remain undissolved; and the zinc and iron are taken up, and may be separated by adding a piece of zinc previously weighed, and boiling the solution; by which the iron will be precipitated. The solution, which then contains only zinc, should be precipitated by carbonat of soda. One hundred and ninety-three grains of this precipitate are equivalent to 100 of zinc in its metallic form, from which the weight lost by the inserted zinc should be subtracted; the weight of the carbonic acid and water may be collected by comparing the loss of weight which the ore suffers by calcination and solution in acids.

Of the ores of zinc which are mineralized by sulphur, or ore blendes, there are several varieties. They are generally of a lamellar or scaly texture, and frequently of a quadrangular form, resembling galena; they all lose much of their weight when heated, and burn with a blue flame; their specific gravity is inferior to that of galena. Almost all contain a mixture of lead ore; most of them exhale a sulphureous smell when scraped, or at least when sulphuric or muriatic acid is dropped on them. Werner divides them into three species by their colours; the yellow, brown, and black.

The phosphorescent blende is generally greenish, yellowish-green, or red, of different degrees of transparency, or opake. When scraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, when distilled *per se*, a siliceous sublimate rises, which shows it contains the sparry acid, probably united to a metal, since it sublimes. It is almost wholly soluble in the muriatic acid in a boiling heat.

Bergman found 100 parts of that of Scharfenberg to contain 64 of zinc, five of iron, 20 of sulphur, four of fluor acid, six of water, and one of silex.

A sulphuret of zinc was lately met with in one of the Gwennap mines, incrusting a spongy pyrites intermixed with quartz, and so like wood-tin, as to be supposed a variety of it by the miners. According to Dr. Kidd, it consists of 66 oxide of zinc, 33 sulphur, and a very minute portion of iron. The pyrites contains cobalt.

In the dry way zinc is reduced by distilling its ore after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, and a strong heat: but by this method scarce half the zinc it contains is obtained.

The first dressing of calamine for the large works of zinc consists in picking out all the pieces of lead ore, lime, and iron-stone, cauk, and other heterogeneous substances, which are found mixed with it in the mine: it is then roasted in proper furnaces, where it loses about a third or fourth part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible, by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a ton of the crude calamine of Derbyshire is reduced to 12 cwt. only.

Bergman affirms, that a certain Englishman, whose name he does not mention, made, several years ago, a voyage to China, for the purpose of learning the art of smelting zinc, or tutenague; and that he became instructed in the secret, and returned safely home.

It is not improbable, but that a fact of this kind may have served to establish the manufactory of zinc in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed six pots, of about four feet each in height, much resembling large oil-jars in shape; into the bottom of each pot is inserted an iron tube, which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues, downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape; and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which, being remelted, are cast into ingots, and sent to Birmingham under the name of zinc, or spelter; although by this last name of spelter, only a granulated kind of soft brass is understood among the braziers, and others who work in London, used to solder pieces of brass together.

Great part of the zinc volatilized by the force of fire, in large furnaces, as those at Goslar, adheres to their sides in the form of a whitish oxide: this is scraped off when the furnace is cold, and is called by the name of ofenbruch or cadmia, which is employed, as well as zinc, to make brass.

Oriental. Precious stones from the East have been supposed to be harder and more brilliant than those which come from South America. How far this may really be the case is not perhaps easy to be determined. Jewellers use the words oriental and occidental to denote the superior or inferior quality of a gem, without giving themselves any trouble about the place it came from. Thus an oriental topaz is one of the best, whether it come from the East Indies or not; and the inferior stones or coloured quartz are called occidental topazes, though some of them perhaps may come from the East.

Origanum. An essential oil is kept in the shops under the name of the oil of origanum, which is obtained from the leaves of the origanum vulgare Linnæi, or wild marjoram.

Orobithes. See Disolithes, that stone being sometimes so called from its resemblance to vetches.

Orpiment. A combination of arsenic with sulphur, of a yellow colour. See Arsenic, and Realgar.

Orris. The dry roots of the Florence iris or oris (iris alba Florentina, C. B.) are entirely mild, and said to be a medicine of good service in disorders of the breast. They have a pleasant sweet smell resembling that of violets, and hence are employed in sweet-scented powders, for flavouring liqueurs, &c. The distilled water smells a little of the root, but exhibits no appearance of oil: the distilled spirit also has some slight smell. The strongest preparation both in smell and taste is the spirituous extract, this containing nearly all the active parts of the root concentrated into a small volume. An ounce of the root yielded a drachm and 17 grains of spirituous, and afterward a drachm and 40 grains of watery extract: water applied at first extracted from the same quantity three drachms, and spirit afterward only eight grains. The extract made by water at first both tastes and smells of the orris, though not near so strongly as the spirituous.

Osmium. A new metal lately discovered by Mr. Tennant among platina, and thus called by him from the pungent and peculiar smell of its oxide. For the mode in which he extracted it, see Iridium.

Its oxide may likewise be obtained in small quantity by distilling with nitre the black powder left after dissolving platina; when at a low red heat an apparently oily fluid sublimes into the neck of the retort, which on cooling concretes into a solid colourless, semitransparent mass. This being dissolved in water forms a concentrated solution of oxide of osmium. This solution gives a dark stain to the skin, that cannot be effaced. Infusion of galls presently produces a purple colour in it, which soon after becomes of a deep vivid blue. This is the best test of the oxide. With pure ammonia it becomes yellow, and slightly so with carbonat of soda. With lime it forms a bright yellow solution; but it is not affected either by chalk or by pure magnesia. The solution with lime gives a deep red precipitate with galls, which is turned blue by acids. It produces no effect on solution of gold or platina; but precipitates lead of a yellowish brown, mercury of a white, and muriat of tin of a brown colour.

Oxide of osmium becomes of a dark colour with alcohol, and after some time separates in the form of black films, leaving the alcohol without colour. The same effect is produced by ether, and much more quickly.

It parts with its oxigen to all the metals except gold and platina. Silver kept in a solution of it some time acquires a black colour, but does not deprive it entirely of smell. Copper, tin, zinc, and phosphorus, quickly produce a black or gray powder, and deprive the solution of smell, and of the property of turning galls blue. This black powder, which consists of the metallic osmium and the oxide of the metal employed to precipitate it, may be dissolved in nitro-muriatic acid, and then becomes blue with infusion of galls.

If the pure oxide dissolved in water be shaken with mercury, it soon loses its smell, and the metal forms a perfect amalgam. By squeezing the superfluous mercury through leather, and distilling off the rest, a dark gray or blue powder is left, which is the osmium.

Exposed to a strong heat in a cavity in a piece of charcoal, it does not melt; nor is it volatile, if oxidation be carefully prevented. With copper and with gold it forms malleable alloys, which are easily dissolved in nitro-muriatic acid, and afford by distillation the oxide of osmium. The pure metal, previously heated, did not appear to be acted upon by acids. Heated in a silver cup with caustic alkali, it combined with it, and gave a yellow solution, similar to that from which it was procured. From this solution acids separate the oxide of osmium. *Philos. Transact.*

OSMUNDIC EARTH. See EARTH, FULLERS.

OSTEOCOLLA is a substance formed by stony matters filling up the interstices of rotten roots of trees. It has been particularly described by Mr. Gleditsch, and examined chemically by Mr. Margraaf. See Memoirs of the Berlin Academy for the year 1748. The former author relates, that it is dug from grounds containing fine sand and a fine calcareous earth; and that sometimes the roots of living trees had been found converted into this stony substance. From Margraaf's experiments it appears, that the osteocolla examined by him was composed of a fine sand, a fine calcareous earth, and some rotten remains of a root. Neumann says, that he found muriatic acid in osteocolla. But nothing of that or any other acid could be discovered by Margraaf. Neumann also says, that he totally dissolved osteocolla by means of dilute sulphuric acid. Hence the substances examined by these two chemists seem to have been different. Differences must arise from the different qualities of the soil in which osteocolla is found.

OTTA OR ATYR OF ROSES. The essential oil of roses. It comes to us under this name from Bengal, and is of too high price to become an article of commerce in this country. From a variety of accounts we learn, that it is obtained in the usual method, viz. by the distillation of rose leaves with water, and that a prodigious quantity of roses affords but a small proportion of the oil. It is said to be equal in fragrance to a new-blown rose. This may perhaps be true of the oil when newly distilled; but in the few specimens which have come under my observation, the difference in scent appears to be nearly as great as between most other essential oils and the vegetables which afford them.

OXIDATION. The process of converting metals, or other substances, into oxides, by combining with them a certain portion of oxigen. It differs from *acidification* in the addition of oxigen not being sufficient to form an acid with the substance oxided. Some chemists, particularly the French, have been much inclined to banish the word *calcination* from chemical language, and substitute this in its stead: but the significations of the two are very distinct; for, though there are many cases in which they might be used indiscriminately, calcination often takes place without any oxigen being absorbed; and on the other hand oxidation may be performed without the action of heat, as indeed it is most frequently.

OXIDES. Substances combined with oxigen, without being in the state of an acid.

It is maintained by some, that substances, at least of the metallic kind, have an affinity only for given proportions of oxigen, differing in different substances. Thus there is a certain small quantity for each, with which it will unite, and form what is called an oxide at the *minimum*; and another larger dose, with which it is an oxide at a *maximum*. Some indeed unite with a third, which constitutes them acids. If a substance appear to be combined with an intermediate proportion of oxigen, they say, that the oxide is in reality a mixture of the two, with more or less of one of them. Some again assert, that oxigen unites with substances in a considerable number of different proportions, not in any regular gradation, forming with each a distinct compound, though frequently the difference of oxigen is very little: and thus we have oxides perhaps of the same substance, with 12, 15, 20, 28, and 30 per cent of oxigen. But it is more generally supposed, that substances combine with oxigen in variable proportions, from the lowest to the highest of which they are susceptible, and form compounds with distinct properties within certain ranges of oxigenation.

To distinguish these different stages of oxidation, Dr. Thomson employs the terms *protoxide* for the minimum or lowest state of oxidation, *deutoxide* for the second, *tritoxide* for the third, and so on, calling the maximum, or most highly oxided, the *peroxide*.

OXIGEN. See GASSES.

OXIGENATION. This word is often used instead of oxidation, and frequently confounded with it; but it differs in being of more general import, as every union with oxigen, whatever the product may be, is an oxigenation; but oxidation takes place only when an oxide is formed.

OXYMEL. A compound of honey and vinegar. It is frequently combined with other medical ingredients, and then named from them, as oxymel of squills, &c.

P.

PALLADIUM. This is a new metal, first found by Dr. Wollaston associated with platina, among the grains of which he supposes its ore to exist, or an alloy of it with iridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier.

If crude platina be dissolved in nitro-muriatic acid, and precipitated with a solution of muriat of ammonia in hot water; the precipitate washed, and the water added to the remaining solution; and a piece of clean zinc be immersed in this liquid, till no farther action on it takes place: the precipitate now thrown down will be a black powder, commonly consisting of platina, palladium, iridium, rhodium, copper, and lead. The lead and copper may be separated by dilute nitric acid. The remainder being then digested in nitro-muriatic acid, and common salt about half the weight of the precipitate added on the solution, on evaporating this to dryness by a gentle heat, the result will be triple salts of muriat of soda with platina, palladium, and rhodium. Alcohol will dissolve the first and second of these; and the small portion of platina may be precipitated by sal ammoniac. The solution being diluted, and prussiat of potash added, a precipitate will be thrown down, at first of a deep orange, and afterward changing green. This, being dried, and heated with a little sulphur before the blowpipe, fuses into a globule, from which the sulphur may be expelled by exposing it to the extremity of the flame, and the palladium will remain spongy and malleable.

It may likewise be obtained by dissolving an ounce of nitrat of potash in five of muriatic acid, and in this mixture digesting the compound precipitate mentioned above. Or more simply by adding to a solution of crude platina a solution of prussiat of mercury, on which a flocculent precipitate will gradually be formed, of a yellowish white colour. This is prussiat of palladium, from which the acid may be expelled by heat.

Palladium is of a grayish white colour, scarcely distinguishable from platina, and takes a good polish. It is ductile and very malleable: and being reduced into thin slips is flexible, but not very elastic. Its fracture is fibrous, and in diverging striæ, showing a kind of crystalline arrangement. In hardness it is superior to wrought iron. Its spec. grav. from 10·9 to 11·8. It is a less perfect conductor of caloric than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat its surface tarnishes a little, and becomes blue; but an increased heat brightens it again. It is reducible *per se*. Its fusion requires a much higher heat than that of gold; but, if touched while hot with a small bit of sulphur, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle.

Nitric acid soon acquires a fine red colour from palladium, but the quantity it dissolves is small. Nitrous acid acts on it more quickly and powerfully. Sulphuric acid by boiling acquires a similar colour, dissolving a small portion. Muriatic acid acts much in the same manner. Nitro-muriatic acid dissolves it rapidly, and assumes a deep red.

Alkalis and earths throw down a precipitate from its solutions, generally of a fine orange colour; but it is partly redissolved in an excess of alkali. Some of the neutral salts, particularly those of potash, form with it triple compounds, much more soluble in water than those of platina, but insoluble in alcohol.

Alkalis act on palladium even in the metallic state, the contact of air however promotes their action.

A neutralized solution of palladium is precipitated of a dark orange or brown by recent muriat of tin: but if it be in such proportions as to remain transparent, it is changed to a beautiful emerald green. Green sulphat of iron precipitates the palladium in a metallic state. Sulphuretted hidrogen produces a dark brown precipitate; prussiat of potash an olive-coloured; and prussiat of mercury a yellowish white. As the last does not precipitate platina, it is an excellent test of palladium. This precipitate is from a neutral solution in nitric acid, detonates at about 500° of Fahr. in a manner similar to gunpowder. Fluoric, arsenic, phosphoric, oxalic, tartarous, citric, and some other acids, with their salts, precipitate some of the solutions of palladium.

All the metals, except gold, silver, and platina, precipitate it in the metallic state.

With gold Mr. Chenevix found it forms a gray alloy, much harder than gold, less ductile even than the palladium, and of a coarse-grained fracture. With an equal weight of platina, it resembles platina in colour and hardness, but is rather less malleable, and melts at a heat little higher than is requisite to fuse the palladium. Specific gravity 15·141. With an equal weight of silver it is harder than silver, but softer than wrought iron; and its polished surface resembles platina, except being somewhat whiter. Specific gravity 11·29. Equal parts of palladium and copper are a little more yellow, break more easily, assume somewhat of a leaden hue when filed, and are harder than wrought iron. Specific gravity 10·392. Lead increases its fusibility, and forms with it an alloy, of a gray colour, fine-grained fracture, harder than any of the preceding, but very brittle. Its proportions Mr. Chenevix did not know. Specific gravity 12. With an equal part of tin it is gray, less hard than wrought iron, extremely brittle, and of a compact fine-grained fracture. Specific gravity 8·175. With an equal weight of bismuth still more brittle, and nearly as hard as steel; of a gray colour, but much darker when powdered. Specific gravity 12·587. Iron greatly diminishes its specific gravity, and renders it brittle; arsenic renders it extremely brittle, and increases its fusibility.

As this metal was first offered for sale in small quantity, without any information of the manner in which it was procured, or the name of the person who found it, suspicions respecting its being merely an alloy were entertained. Accordingly Mr. Chenevix, having purchased the whole, and carefully examined it, made various experiments with a view to detect its composition. After a great number of fruitless attempts, it appeared to him to be a compound of platina and mercury. His most successful attempt was the following. He dissolved 100 grains of platina in nitro-muriatic acid, and put in 200 grains of red oxide of mercury made by nitric acid. This not saturating the excess of acid, he added more, till it ceased to be dissolved. He likewise prepared some green sulphate of iron and poured it into a long-necked matrass. He then poured the mixed solution of platina and mercury into the solution of green sulphate of iron, and heated the whole on a sandbath. In less than half an hour a copious precipitate was formed, and the inside of the matrass was lined with a thin metallic coat. The liquor was filtered, and the precipitate digested in muriatic acid, washed, and dried, weighed 276 grains, including 12 remaining in the filter. These 276 were reduced by a low red heat to 151 of a fine powder having a metallic lustre. In a charcoal crucible it fused into a button weighing 134 grains, in which there were 92 of platina, and consequently 42 of mercury. This alloy was of the specific gravity of 11·2; wholly soluble in nitric acid; easily fused by sulphur; precipitated by green sulphat of iron; and in a word not to be distinguished from palladium.

Several other chemists have attempted this union of platina with mercury in vain, and Mr. Chenevix succeeded only four times in above a thousand operations. In many instances, however, where mercury and platina were brought into contact under various circumstances, the platina was increased in weight, and much altered in its qualities; and to this mercury was indispensable.—*Phil. Trans.*—*Gehlen's Journ.*—*Murray.*

Palm-Oil is obtained from the kernels of the fruit of a species of palm-tree, which is a native of the coast of Guinea and Cape de Verd Islands, whence it has been transplanted into Jamaica and Barbadoes. The oil as it comes to us is about the consistence of an ointment, and of an orange colour; of a strong though not disagreeable smell, and very little taste. By long keeping it loses its colour and becomes white, when it ought to be rejected. Alcohol dissolves about $\frac{1}{25}$ of its weight, and ether about $\frac{1}{6}$. Its fusibility is nearly similar to that of animal fat; while in its chemical properties it more resembles the resins, though it differs from them in not being soluble in nitric acid. It is used in external applications, and also as a purgative medicine.

Panacea. This name, which signifies universal remedy, has been given to various preparations. The panacea of antimony was formed by detonating in small portions at a time, in a red-hot crucible, a mixture of six parts, by weight, of antimony, two of nitre, one and a half of common salt, and one of charcoal. The mass when fused and poured out consists of antimony at bottom; an hepatic compound in the next place; and at top, a spongy mass. This last, when pulverized, washed, and dried, is of a golden yellow colour, and is the panacea. It was given in pills containing from one tenth to one third of a grain of the powder, and is said to operate gently as a cathartic and emetic.

We had several mercurial panaceas. The red panacea was made by washing the red oxide of mercury; obtained by nitric acid and calcination: then digesting it for many days in alcohol; next burning off from it a portion of tincture of sulphur; and lastly, digesting it again in alcohol for some days.

The white panacea consisted of calomel on which alcohol had been digested, and which was afterward, according to some prescriptions, to be repeatedly sublimed.

Modern chemistry has rejected these inartificial, troublesome, and at best useless processes.

The magnesian earth obtained by precipitation from the mother water of nitre, was called the nitrous panacea.

Panacea Holsatica. An old name for sulphat of potash.

Panchymagogum Minerale. } Old
Panchymagogus Quercetanus. } names
for the mild muriat of mercury, or calomel.

Paper-Marl. See Marl.

Paranthine. This stone, so called by Mr. Haüy because its crystals have frequently a dull appearance as if they had *effloresced*, has not yet been found, that we know of, except at Arendahl in Norway. Its prismatic crystals are variously grouped in the iron ore of Langloë, and accompanied with brown mica, quartz, garnet, strahlstein, carbonat of lime, &c.

It exhibits great variety of colour and appearance. Sometimes it is gray and translucid; at others gray or yellowish, with a pearly lustre; sometimes of a gray colour and almost a metallic brilliancy; sometimes dull, and of a dead red like common sealing-wax; a Mr. Schumacher says he has seen it of a leek green.

When it is translucid and shining it is sufficiently hard to scratch glass; but when otherwise it is soft, and even friable. Before the blowpipe it swells, and fuses into a shining white enamel. It is not electric by heat, and does not form a jelly with acids. Its specific gravity is 3·712. Its primitive form is a rectangular prism with a square base, which is subdivisible very accurately in the direction of its diagonal.

This stone is of the siliceous kind, the silex being united with alumine, lime, and water.—*Brongniart.*

Parget. The plaster stone, or calcareous earth combined with sulphuric acid.

Parian Marble. A fine white Italian marble which is never polished when wrought, but only finely ground down. It has a glittering texture, and is slightly transparent at the edges. Cronstedt considers it as a limestone, that is, lime combined with carbonic acid and water.

Parting is an operation by which gold and silver are separated from each other. As these two metals resist equally well the action of fire and of lead, they must therefore be separated by other methods. This separation could not be effected, if they were not soluble by different menstruums.

Nitric acid, muriatic acid, and sulphur, which cannot dissolve gold, attack silver very easily; and therefore these three agents furnish methods of separating silver from gold, or of the operation called parting.

Parting by nitric acid is the most convenient, and therefore most used, and even almost the only one employed by goldsmiths and coiners. Wherefore it is called simply parting. That with the muriatic acid is only made by cementation, and is known by the name of concentrated parting. Lastly, parting by sulphur is made by fusion, which the chemists call the dry way, and is therefore called dry parting. We shall describe each of these methods.

Parting by Aqua Fortis. Although parting by aqua fortis be easy, as we have said, it cannot succeed, or be very exact, unless we attend to some essential circumstances.

1. The gold and silver must be in a proper proportion; for, if the gold be in too great quantity, the silver would be covered and guarded by it from the action of the acid.

Therefore, when assayers do not know the proportion of these two metals in the mass to be operated on, they discover it by the touch, or assay needles. See Assay.

If this trial shows that in any given mass the silver is not to the gold as three to one, this mass is improper for the operation of parting by aqua fortis. In this case, the quantity of silver necessary to make an alloy of that proportion must be added.

This operation is called quartation, probably because it reduces the gold to a fourth part of the whole mass.

2. That the parting may be exact, the nitric acid or aqua fortis employed must be very pure, and especially free from mixture of sulphuric and muriatic acids. Its purity must therefore be ascertained; and if this be found not sufficient, the acid must be purified by solution of silver,

If the purity of the aqua fortis were not attended to, a quantity of silver proportionable to these two foreign acids would be separated during the solution; and this portion of silver, converted by these acids to sulphat and muriat of silver, would remain mingled with the gold, which consequently would not be entirely purified by the operation.

When the metallic mass is properly alloyed it is to be reduced to plates, rolled up spirally, called cornets; or to grains. These are to be put into a matrass, and upon them a quantity of aqua fortis is to be poured, the weight of which is to that of the silver as three to two: and as the nitric acid employed for this operation is rather weak, the solution is assisted, especially at first, by the heat of a sand-bath, in which the matrass is to be placed. When, notwithstanding the heat, no farther mark of solution appears, the aqua fortis charged with silver is to be decanted. Fresh nitric acid is to be poured into the matrass, stronger than the former, and in less quantity, which must be boiled on the residuous mass, and decanted as the former. Aqua fortis must even be boiled a third time on the remaining gold, that all the silver may be certainly dissolved The gold is then to be washed with boiling water. This gold is very pure, if the operations have been performed with due attention. It is called gold of parting.

No addition of silver is required, if the quantity of silver of the mass is evidently much more considerable than that of the gold: persons who have not proof needles, and other apparatus to determine the proportion of the alloy, may add to the gold an indeterminate quantity of silver, observing that this quantity be rather too great than too small, and so considerable as to render the mass nearly as white as silver; for a large quantity of silver is rather favourable than hurtful to the operation: it has no other inconvenience, than a useless expense, as the larger the quantity is of silver, the more aqua fortis must be employed. We ought to attend to this fact, that the colour of gold is scarcely perceptible in a mass two thirds of which is silver and one third is gold; this colour then must be much less perceptible when the gold is only one fourth part, or less, of the whole mass.

If the quantity of gold exceed that of the silver, the mass may be exposed to the action of aqua regia, which would be a kind of inverse parting, because the gold is dissolved in that menstruum, and the silver is not, but rather reduced to a muriat, which remains in form of a precipitate after the operation. But this method is not much practised, for the following reasons:

First, the gold cannot be easily separated from the aqua regia; for if the parting have been made with an aqua regia prepared with sal ammoniac, or if the gold be precipitated by ammonia, this gold has a fulminating quality, and its reduction requires particular operations. If the aqua regia have been made with muriatic acid, and the precipitation effected by a fixed alkali, the gold will not then be fulminating, but the precipitation will be very slow, and probably not complete. See Gold.

Secondly, in the parting by aqua regia, the silver is indeed precipitated into a muriat, and thus separated; but this separation is not perfect, as a small quantity of muriat of silver will always remain dissolved by the acids, if this solution even could only be effected by the superabundant water of these acids. Accordingly the silver is not so accurately separated from the gold by aqua regia, as the gold is from the silver by aqua fortis. We shall afterward see, at the article Parting (Concentrated), that by this operation silver may be separated from gold in the dry way without the necessity of quartation, although these metals should not be in a proper proportion for the parting of aqua fortis.

The gold after the parting by aqua fortis is much more easily collected when it remains in small masses, than when it is reduced to a powder.

When the mass has been regularly quarted, that is, when it contains three parts of silver and one part of gold, we must employ, particularly for the first solution, an aqua fortis so weakened, that heat is required to assist the solution of the silver: by which means the solution is made gently; and the gold which remains preserves the form of the small masses before the solution. If the aqua fortis employed were stronger, the parts of the gold would be disunited, and reduced to the form of a powder, from the activity with which the solution would be made.

We may indeed part by aqua fortis a mass containing two parts of silver to one part of gold; but then the aqua fortis must be stronger; and if the solution be not too much hastened, the gold will more easily remain in masses after the operation. In both cases, the gold will be found to be tarnished and blackened. Its parts have no adhesion together, because the silver dissolved from it has left many interstices; and the cornets or grains of this gold will be easily broken, unless they be handled very carefully. To give them more solidity, they are generally put into a test under a muffle, and made red-hot, during which operation they contract considerably, and their parts are approximated. These pieces of gold are then found to be rendered much more solid, so that they may be handled without being broken. By this operation also the gold resumes its colour and lustre; and as it generally has the figure of cornets, it is called gold in cornets, or grain gold. Essayers avoid melting it, as they choose to preserve this form, which shows that it has been parted.

The gold and silver thus operated upon ought to have been previously refined by lead, and freed from all alloy of other metallic matters, so that the gold which remains should be as pure as is possible. However, as this is the only metal which resists the action of aqua fortis, it might be purified by parting from all other metallic substances; but this is not generally done for several reasons. First, because the refining by lead is more expeditious and convenient for the separation of the gold from the imperfect metals; and secondly, because the silver, when afterward separated from the aqua fortis, is pure; lastly, because most imperfect metals do not remain completely and entirely dissolved in nitric acid, from the degree of oxidation produced in them by this acid, and the gold would be found, after the parting, mixed with the part of these metals which is precipitated.

The gold remaining after the parting ought to be well washed, to cleanse it from any of the solution of silver which might adhere to it; and for this purpose distilled water ought to be used, or at least water the purity of which has been ascertained by its not forming a precipitate with a solution of silver, because such a precipitate would alter the purity of the gold.

The silver dissolved in the aqua fortis may be separated either by distillation, in which case all the aqua fortis is recovered very pure, and fit for another parting; or it may be precipitated by some substance which has a greater affinity than this metal with nitric acid. Copper is generally employed for this purpose at the mint.

The solution of silver is put into copper vessels. The aqua fortis dissolves the copper, and the silver precipitates. When the silver is all precipitated, the new solution is decanted, which is then a solution of copper. The precipitate is to be well washed, and may be melted into an ingot. It is called parted silver. When this silver has been obtained from a mass which had been refined by lead, and when it has been well washed from the solution of copper, it is very pure.

Cramer justly observes, in his Treatise on Assaying, that however accurately the operation of parting has been performed, a small portion of silver always remains united with the gold, if the parting have been made by aqua fortis; or a small portion of the gold remains united with the silver, if the parting have been made by aqua regia; and he estimates this small alloy to be from a two hundredth to a hundred and fiftieth part, which quantity may be considered as nothing for ordinary purposes, but may become sensible in accurate chemical experiments.

The mass of gold and silver to be quarted ought previously to be granulated, which may be done by melting it in a crucible, and pouring it into a large vessel full of cold water, while at the same time a rapid circular motion is given to the water by quickly stirring it round with a stick or broom.

The vessels generally used for this operation, called parting-glasses, have the form of truncated cones, the bottom being commonly about seven inches wide, the aperture about one or two inches wide, and the height about twelve inches. These glass vessels ought to have been well annealed, and chosen free from flaws; as one of the chief inconveniences attending the operation is, that the glasses are apt to crack, by exposure to cold, and even when touched by the hand. Some operators secure their glasses by a coating. For this purpose, they spread a mixture of quick-lime slaked with beer and whites of eggs upon linen cloth, which they wrap round the lower part of the vessel, leaving the upper part uncovered, that they may see the progress of the operation, and over this cloth they apply a composition of clay and hair. Schlutter advises to put the parting-glasses in copper vessels containing some water, and supported by trevets, with fire under them. When the heat communicated by the water is too great, it may be diminished by adding cold water, which must be done, very carefully, by pouring against the sides of the pan, to prevent too sudden an application of cold to the parting-glass. The intention of this contrivance is, that the contents of the glasses, if these should break, may be received by the copper vessel. Into a glass fifteen inches high, and ten or twelve inches wide at bottom, placed in a copper pan twelve inches wide at bottom, fifteen inches wide at top, and ten inches high, he usually put about eighty ounces of metal, with twice as much aqua fortis.

The aqua fortis ought to be so strong as to be capable of acting sensibly on silver when cold, but not so strong as to act violently.

If the aqua fortis be very strong, however pure, and if the vessels be well closed, a small quantity of the gold will be dissolved along with the silver; which is to be guarded against.

Little heat ought to be applied at the beginning, the liquor being apt to swell, and rise over the vessel; but when the acid is nearly saturated, the heat may be safely increased.

When the solution ceases, which may be known by the discontinuance of the effervescence, or emission of air-bubbles, the liquor is to be poured off. If any grains appear entire, more aqua fortis must be added, that all the silver may be dissolved. If the operation have been performed slowly, the remaining gold would have still the form of distinct masses, which are to receive solidity and colour by fire, as Macquer directs. If the operation have been performed hastily, the gold will have the appearance of a black mud or powder, which after five or six washings with pure water must be melted.

After the gold has been separated by parting, before it is put into the crucible, Darcet collects it into as small a vessel as possible, pours on it as much sulphuric acid at 66° as will cover it, places the vessel on a sandbath, gradually raises the heat to ebullition, keeps it thus about an hour, suffers it to cool, decants the acid, and washes the gold till the washings will yield no precipitate either with muriatic acid or alkali. The gold remaining in the state of powder is then to be melted into an ingot, and will always be of the fineness of 24 carats.

The silver is usually recovered by precipitating it from the aqua fortis by means of copper vessels into which the liquor is poured, or of plates of copper which are thrown along with the liquor into glass vessels. A considerable heat is required to accelerate this precipitation. Dr. Lewis says, he has observed, that when the aqua fortis is perfectly saturated with silver, no precipitation was occasioned by plates of copper, till a drop or two of aqua fortis was added to the liquor, and then the precipitation began and continued as usual.

The precipitated silver must be well washed in boiling water, and fused with some nitre, the use of which is to scorify any cupreous particles which may adhere to the silver.

From the solution of copper in aqua fortis, a blue pigment, called verditer, is obtained by precipitation with whiting. See VERDITER.

PARTING (CONCENTRATED). Concentrated parting is also called parting by cementation, because it is actually performed by cementation. This parting or purification of gold is used when the quantity of it is so great in proportion to the silver, that it cannot be separated by aqua fortis. This operation is performed in the following manner:

A cement is first prepared, composed of four parts of bricks powdered and sifted, of one part of sulphat of iron calcined till it becomes red, and of one part of common salt. The whole is very accurately mixed together, and a firm paste is made of it by moistening it with a little water or urine. This cement is called cement royal, because it is employed to purify gold, which was considered by the old chemists as the king of metals.

The gold to be cemented is to be reduced to plates as thin as small pieces of money. At the bottom of the crucible, or cementing pot, a stratum of cement, of the thickness of a finger, is to be put, which is covered with plates of gold: upon these another stratum of cement is to be laid; and then more plates of gold, till the crucible or pot is filled with these alternate strata of cement and of gold. The whole is then to be covered with a lid, which is to be luted with a mixture of clay and sand. This pot is to be placed in a furnace, or oven, and heated by degrees, till it is moderately red, which heat is to be continued during twenty-four hours. The heat must not be so great as to melt the gold. The pot or crucible is then left to cool, and the gold is to be carefully separated from the cement, and boiled at different times in a large quantity of pure water. This gold is to be essayed upon a touch-stone, or otherwise; and if it be found not sufficiently purified, it is to be cemented a second time in the same manner.

The acid of the common salt is disengaged during this cementation, and dissolves the silver alloyed with the gold, by which means it is separated.

This experiment proves, that, although muriatic acid while it is liquid cannot attack silver, it is nevertheless a powerful solvent of that metal. But for this purpose it must be applied to the silver in the state of vapours extremely concentrated, and assisted with a considerable heat. All these circumstances are united in the concentrated parting.

This experiment proves also, that, notwithstanding all these circumstances, which favour the action of the muriatic acid, it is incapable of dissolving gold.

Lastly, the muriatic acid in this state more effectually dissolves the silver than the nitric acid does in the parting by aqua fortis; since this operation succeeds well when the silver is in so small a proportion, that it would be protected from the action of the nitric acid in the ordinary parting.

Instead of sea salt, nitre may be used with equal success; because the nitric acid is then put into a state to attack the silver, notwithstanding the quantity of gold which covers it.

Several chemists and artists use both nitre and common salt in the cement royal; which shows that the acid of aqua regia, if produced and applied in this manner at the same time to gold and silver, attacks the latter metal preferably to the former. By this method some of the gold would probably be dissolved along with the silver. As no advantages are said to attend it, to give it preference to cementation with nitre or with sea salt singly, Dr. Lewis judiciously disapproves of it.

The gold must be very carefully washed after the operation, to cleanse it from particles of dissolved silver, which otherwise would stick to it.

The silver may be separated from the cement by fusion with a sufficient quantity of lead and litharge, and by cupelling the lead which retains the silver.

Gold is never purified by one operation of this kind. It must therefore be again melted, beaten into plates, and cemented as before. The operation is troublesome, and is now little used, except by artists in the small way, for extracting silver or base metals from the surface of gold, and thus giving to an alloyed metal the colour and appearance of pure gold.

PARTING (DRY). Dry parting, or parting by fusion, is performed by sulphur, which has the property of uniting easily with silver, while it does not attack gold.

This method of separating these two metals would be the cheapest, and the most expeditious and convenient of any, if the sulphur could dissolve the silver, and separate it from the gold as well and as easily as nitric acid does: but, on the contrary, we are obliged to employ particular treatment, and a kind of concentration, to begin the union of the sulphur with the silver alloyed with gold. Then repeated and troublesome fusions must be made, in each of which we are obliged to add different intermediate substances, and particularly the metals which have the strongest affinity with sulphur, to assist the precipitation, which in that case does not give pure gold, but a gold still alloyed with much silver, and even with a part of the precipitating metals: so that, to complete the operation, cupellation is necessary, and also parting by aqua fortis.

Hence Macquer infers, that this operation ought not to be adopted, but when the quantity of silver with which the gold is alloyed is so great, that the quantity of gold which might be obtained by the ordinary parting is not sufficient to pay the expenses, and that it is only proper for concentrating a larger quantity of gold in a smaller quantity of silver. As this dry parting is troublesome, and even expensive, it ought not to be undertaken but on a considerable quantity of silver alloyed with gold. Accordingly, Cramer, Schlutter, Schindler, and all good chemists and artists who have given processes for the dry parting, recommend its use only in the above-mentioned cases: it would be much more advantageous, if it could be done by two or three fusions, and if by these an exact separation could be obtained of a small quantity of gold mixed with a large quantity of silver.

The most advantageous method of separating a small portion of gold from a large one of silver appears to be by means of sulphur, which unites with and scorifies the silver without affecting the gold: but as sulphuretted silver does not flow thin enough to suffer the small particles of gold diffused through it to reunite and settle at the bottom, some addition is necessary for collecting and carrying them down.

In order to the commixture with the sulphur, fifty or sixty pounds of the mixed metal, or as much as a large crucible will receive, are melted at once, and reduced into grains by lading out the fluid matter, with a small crucible made red-hot, and pouring it into cold water stirred with a rapid circular motion. From an eighth to a fifth of the granulated metal, accordingly as it is richer or poorer in gold, is reserved; and the rest well mingled with an eighth of powdered sulphur. The grains enveloped with the sulphur are again put into the crucible, and the fire kept gentle for some time, that the silver, before it melts, may be thoroughly penetrated by the sulphur: if the fire were hastily urged, great part of the sulphur would be dissipated without acting upon the metal.

If to sulphuret of silver in fusion pure silver be added, the latter falls to the bottom, and forms there a distinct fluid, not miscible with the other. The particles of gold, having no affinity with the sulphuretted silver, join themselves to the pure silver, wherever they come in contact with it, and are thus transferred from the former into the latter, more or less perfectly according as the pure silver was more or less thoroughly diffused through the mixed. It is for this use that a part of the granulated metal was reserved. The sulphuretted mass being brought into perfect fusion, and kept melted for near an hour in a close covered crucible, one third of the reserved grains is thrown in; and as soon as this is melted, the whole is well stirred, that the fresh silver may be distributed through the mixed, to collect the gold from it. The stirring is performed with a wooden rod; an iron one would be corroded by the sulphur, so as to deprive the mixture of its due quantity of sulphur, and likewise render the subsequent purification of the silver more troublesome. The fusion being continued an hour longer, another third of the unsulphuretted grains is added, and an hour after this the remainder; after which the fusion is farther continued for some time, the matter being stirred at least every half hour from the beginning to the end, and the crucible kept closely covered in the intervals.

The sulphuret of silver appears in fusion of a dark brown colour: after it has been kept melted for a certain time, a part of the sulphur having escaped from the top, the surface becomes white, and some bright drops of silver, about the size of peas, are perceived on it. When this happens, which is commonly in about three hours after the last addition of the reserved grains, sooner or later according as the crucible has been more or less closely covered, and the matter more or less stirred, the fire must be immediately discontinued; for otherwise more and more of the silver, thus losing its sulphur, would subside and mingle with the part at the bottom in which the gold is collected. The whole is poured out into an iron mortar greased and duly heated; or if the quantity be too large to be safely lifted at once, a part is first laded out from the top with a small crucible, and the rest poured into the mortar. The gold, diffused at first through the whole mass, is now found collected into a part of it at the bottom, amounting only to about as much as was reserved unsulphuretted. This part may be separated from the sulphuretted silver above it by a chisel and hammer; or more perfectly, the surface of the lower mass being generally rugged and unequal, by placing the whole mass with its bottom upwards in a crucible: the sulphuretted part quickly melts, leaving unmelted that which contains the gold, which may thus be completely separated from the other. The sulphuretted silver is essayed, by keeping a portion of it in fusion in an open crucible, till the sulphur is dissipated; and then dissolving it in aqua fortis. If it should still be found to contain any gold, it is to be melted again; as much more unsulphuretted silver is to be added as was employed in each of the former injections, and the fusion continued about an hour and a half.

The gold thus collected into a part of the silver may be farther concentrated into a smaller part, by granulating the mass and repeating the whole process. The operation may be again and again repeated, till so much of the silver is separated, that the remainder may be parted by aqua fortis, without too much expense.

The foregoing process, according to Mr. Schlutter, is practised at Rammelsberg, in the lower Hartz. The prevailing metal in the ore of Rammelsberg is lead; the quantity of lead is at most forty pounds in a quintal, or one hundred pounds of the ore

The lead worked off on a test or concave hearth yields about a hundred and ten grains of silver, and the silver contains only a three hundred and eighty-fourth part of gold; yet this little quantity of gold, amounting scarcely to a third of a grain in a hundred weight of the ore, is thus collected with profit. The author above mentioned confines this method of separation to such silver as is poor in gold, and reckons parting with aqua fortis more advantageous where the gold amounts to above a sixty-fourth of the silver: he advises also not to attempt concentrating the gold too far, as a portion of it will always be taken up again by the silver. Mr. Scheffer, however, relates (in the Swedish Memoirs for the year 1752), that he has by this method brought the gold to perfect fineness; and that he has likewise collected all the gold which the silver contained: the silver of the last operations, which had taken up a portion of the gold, being reserved to be worked over again with a fresh quantity of gold holding silver. The sulphuretted silver is purified by continuing it in fusion for some time with a large surface exposed to the air; the sulphur gradually exhales, and leaves the silver entire.

PARTING BY KEIR'S COMPOUND ACID. See SILVER.

PEARL ASH. An impure alkali obtained by lixiviation from the ashes of plants. Mr. Kirwan examined the Dantzic pearl ash. It is exceedingly white, and if not exposed to the air very hard. Its taste is alkaline. The contents of various specimens were different, but at a medium he found the pound troy to consist of

Carbonic acid	1290	grains
Moisture	414	
Sulphat of potash	505	
Muriat of potash	36	
Earth	38	
Potash	3477	
	5760	

As the examination of the alkalies of commerce must be of great utility to the manufacturer, but is very tedious in the way of solution and evaporation, Mr. Kirwan proposes a test by the precipitation of the earth from alum by solutions of these salts.

To discover whether any quantity of fixed alkali worth attention exist in any saline compound, dissolve one ounce of it in boiling water, and into this solution let fall a drop of the solution of corrosive sublimate. This will be converted into a brick colour if an alkali be present, or into a brick colour mixed with yellow if the substance contained lime.

But the substances used by bleachers being always impregnated by an alkali, the above trial is in general superfluous, except for the purpose of detecting lime. The quantity of alkali is therefore what they should chiefly be solicitous to determine: and for this purpose,

1. Procure a quantity of alum, suppose one pound, reduce it to powder, wash it in cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

2. Weigh an ounce of the ash or alkaline substance to be tried, powder it, and put it into a Florence flask with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will answer) if the saline substance to be examined be of the nature of barilla or potashes, or half a pound of water if it contain but little earthy matter or pearl-ash. Let them boil for a quarter of an hour; when cool, let the solution be filtered into another Florence flask.

3. This being done, gradually pour this solution of alum hot into the alkaline solution also heated. A precipitation will immediately appear. Shake them well together, and let the effervescence, if any, cease before more of the aluminous solution be added. Continue the addition of the alum until the mixed liquor, when clear, turns sirup of violets, or paper tinged blue by radishes, or by litmus, red. Then pour the liquor and precipitate on a paper filter placed in a glass funnel, and the precipitated earth will remain on the filter. Pour on this a pound or more of hot water gradually, until it becomes tasteless. Take up the filter, and let the earth dry in it until they separate easily. Then put the earth into a cup of Staffordshire ware, place it on hot sand, and dry the earth until it no longer adheres either to glass or iron; then reduce it to powder in the cup with the glass pestle, and keep it a quarter of an hour in a heat from 470° to 500°.

4. The earth being thus dried, throw it into a Florence flask, and weigh it; then put about an ounce of muriatic acid into another flask, and place this in the same scale as the earth, and counterbalance both in the opposite scale: this being done, pour the acid gradually into the flask that contains the earth; and when all effervescence is over (if there be any) blow into the flask, and observe what weight must be added to the scale containing the flasks to restore the equilibrium; subtract this weight from that of the earth, the remainder is a weight exactly proportioned to the weight of mere alkali of that particular species which is contained in one ounce of the substance examined; all besides is superfluous matter.

Kirwan remarks, that alkalies of the same species may thus be directly compared, because alkalies of different species cannot but require the intervention of another proportion; and the reason he gives is, because equal quantities of alkalies of different species precipitate unequal quantities of earth of alum. Thus 100 parts by weight of mere potash precipitate 78 of earth of alum;

but 100 parts of soda precipitate 170·8 parts of that earth. Therefore the precipitation of 78 parts of earth of alum by potash, denotes as much of this as the precipitation of 170·8 of that earth by the soda denotes of the soda. Hence the quantities of alkali in all the different species of pot-ashes, pearl-ashes, weed- or wood-ashes, may be immediately compared by the above test, as they all contain the potash; and the different kinds of kelp or kelps manufactured in different places, and the different sorts of barilla, may be thus compared, because they all contain the soda; but kelps and pot-ashes, as they contain different sorts of alkali, can only be compared together by means of the proportion above indicated.

The application of this test is founded on the following principles:

1. That a hot solution of a free alkali, or of an alkali combined only with carbonic acid or sulphur, can hold no terrene or metallico-neutral salt in solution; though it may alkalino-neutral salt or quick-lime, if the alkali be free from carbonic acid.

2. That earth of alum cannot be precipitated either totally or partially by the hot solutions of any alkalino-neutral salt, and therefore that its precipitation is always due to the presence of a free alkali, or at least of an alkali combined only with carbonic acid or sulphur, to the quantity of which it is always proportional. It is true, quick-lime will also decompose alum; but the presence of quick-lime is easily discovered by the addition of a few drops of any mild alkaline solution, and by the same means as easily separated.

3. That if the earth of alum take up carbonic acid (which would increase its weight), this air will be separated by the heat employed in drying it, or at least by the muriatic acid poured upon it.

Kirwan says, he can see but one inaccuracy attending this test, and that of little moment; it is this, if the alkali contain sulphur, this will also be precipitated with the earth of alum, and increase its weight. The limits of this inaccuracy, at least in common cases, scarcely reach two or three grains.

Sulphur is easily detected in any alkaline solution, by saturating it with an acid; sulphuretted hidrogen is generally developed, and the liquor becomes troubled.

Not only the proportion, but also the absolute weight of alkali in different alkaline substances or ashes, may be found by this test. Attention must be paid to the nature of the alkali, and the quantity of earth a determinate portion will throw down; which must be ascertained as to the first by experiment, and as to the latter by fundamental trials.

Pearls. From the beauty, lustre and scarcity of this animal product, it has obtained a place among precious stones, though it possesses none of their hardness. It is a calculus or morbid concretion produced in a certain shell-fish of the oyster kind, and sometimes in common oysters and muscles. It is sometimes found upon the inside of the shell, and sometimes in the body of the animal.

The mother-of-pearl fish, or pearl oyster, is an inhabitant of the bottom of the sea, where it remains fixed, and is not to be had but by diving. A number of small ships are generally engaged together in this dangerous business, on such particular spots as have been found to be rich in the pearl fish, and at certain seasons of the year. The divers, according to Neumann, are let down by ropes, and immediately drawn up again upon their pulling a bell as a signal for that purpose. Machines have been contrived for enabling divers to remain some time at the bottom, with a supply of air, beneath a large vessel called the diving-bell, or by means of tubes; but it does not appear that they have been received into use in the pearl fishery. Suffocation is not, however, the only danger to which the divers are exposed. They are subject to ruptures of some of the vessels, from the vast pressure of the water at great depths, and to be wounded or devoured by fishes of prey, which some of the rich beds of pearl fish are so much infested with, that scarcely any one can venture down at all.

After the pearl oysters are thus got up, there still remains a process not a little prejudicial to the health, and extremely offensive. If the shells were opened directly by any violent means, the pearl, said to be at this time in a somewhat soft state, would be liable to be injured, and become of little value. The whole are therefore laid in heaps till the shells open spontaneously, and the fish putrefies: after which, the corrupted cadaverous matter is searched diligently for the pearls, which are often too few to pay the expense of the proprietor, much less to make any recompense to the workmen for a service so loathsome and so hazardous.

Pearls are generally divided into oriental and occidental, more from their qualities than the place of produce, the oriental being reckoned the best, as for the most part they are. The principal oriental pearl fisheries are in the Persian Gulf, and on the coasts of Persia and Arabia; near the islands of Ceylon, Manaar, Sumatra, Java, and Borneo; on some of the coasts of Japan; between Banana and Cochin; off Cape Comorin, and in other parts along the Malabar coast, as particularly at Tutticorin, where there is an excellent pearl bank in possession of the Dutch. The most remarkable pearl fisheries of America are in the Gulf of Mexico, along the coast of New Spain; off St. Margarite or the Pearl Island; in the Rio de la Hacha, at the islands of St. Martha, Quibo, Gorgonia, &c. In Europe, pearls are occasionally found on the coasts of Scotland, Livonia, Courland, in the river Ilts in Bohemia, in the Regen in Bavaria, in certain lakes near Augsberg, and in various other places.

There are pearls of various colours, figures and magnitudes, of an exquisite silver-like brightness, semitransparent, opake, opal-coloured, yellow, greenish, blueish, grayish, reddish, brownish, blackish, rainbow-coloured; round, oval, conical, cylindrical, angular; from the size of a millet-seed or less, to that of a hazel-nut or more. It is observable, that the larger ones approach generally to the figure of a pear. One of the largest pearls hitherto known is described by Tavernier; in the possession of the king of Persia. It was bought by him at the fishery of Catifa in Arabia, for the sum of 32,000 tomans, or above 110,000*l.* It is in the shape of a pear, very regular, and without fault. The diameter, measured on the engraving in Tavernier's Travels, is 0·63 English inch at the largest part, and the length 1·3 inch. Another pearl, belonging to the Great Mogul, and perfectly round, mentioned by the same author as the largest in the world of that figure, measures 0·62 English inch in diameter. Neumann mentions a pearl he saw in the English crown, said to be worth 10,000*l.* sterling. A pearl, called from its figure the sleeping lion, that weighed 578 carats, was offered for sale at Petersburg in 1779 by a Dutchman. On one side, which was flattish, it was beautifully striped. It was bought in India for 4500*l.*

Pearls are valued for their roundness, their size, and their water, that is, their lustre and purity. Their weight is estimated in Europe by carats, in Persia by abases, and in Golconda and Visapour by ratis, each abas and rati being one eighth part less than a carat. The weight of small pearls is expeditiously ascertained, by a brass instrument with holes of different sizes; so that the weight of a pearl is known from the hole it fits. Small irregular pearls are valued from the number that make up an ounce. Neumann gives the following rates: If a hundred make an ounce, they are valued at one hundred rix-dollars; if the number be less, the price is greater; if the number be greater, the price is less. Two hundred to the ounce cost but seventy rix-dollars; three hundred, fifty; nine hundred, ten; two thousand, three; four thousand, two and a half. Of the very small sort, called seed pearls, an ounce usually contains eight or ten thousand, and costs, if the pearls be of the oriental kind, two rix-dollars; if occidental, one rix-dollar and twelve gros. The rix-dollar is four shillings and sixpence, and the gros about twopence.

Attempts have been made to take out stains from pearls, and to render the foul opake-coloured pearls equal in beauty to the oriental. Abundance of processes not to be depended on are found in books of receipts and travels. Pearls may be cleaned from external foulness by washing with a little Venice soap and warm water, or ground rice and salt, with starch and powder blue, with plaster of Paris, with white coral, with sulphat of zinc and tartar, with cuttle bone, pumice stone, and other similar substances. But it is not practicable to take out a stain, which reaches deep into the substance of the pearl. Nor can a number of small pearls be united, as some pretend, into a mass similar to an entire natural one.

Successful attempts have nevertheless been made to form artificial compositions, so greatly resembling natural pearls, as not to be distinguished from natural pearls, except in their magnitude and apparent perfection. Reaumur has given a paper on this subject in the Memoirs of the French Academy for 1716. The ingredient for giving the colour is a fine silver-like substance found upon the underside of the scales of the blay or bleak fish. The scales, taken off in the usual manner, are washed and rubbed with fresh parcels of clean water, and the several liquors allowed to settle. The water being then poured off, the pearly matter remains at the bottom of the consistence of oil, called by the French *essence d'orient*. A little of this is dropped into a hollow bead of blueish glass, and shaken about so as to line the internal surface; after which, the cavity is filled with wax to give solidity and weight.

It is said, and I believe is known to the dealers in this article, that their appearance changes in time.

According to the analysis of Mr. Hatchett, pearls consist of alternate concentric strata of a very thin membranaceous substance and carbonat of lime.

Peastone. See **Pisolithes.**

Peat. Geanthrax. Kirwan remarks, that there are two substances called by this name. The first is of a brown, yellowish-brown, or black colour, found in moorish grounds in Scotland, Holland, Germany, and elsewhere. When newly cut it has a viscid consistence, but hardens by exposure to the air. It consists of clay mixed with calcareous earth and pyrites, and sometimes contains common salt. While soft it is formed into oblong pieces for fuel, after separation of the pyrites and stones. By distillation it affords water and oil, and ammoniac, and a small proportion of fixed alkali is found in its ashes, which are either white or red according as they contain more or less ochre or pyrites.

The second kind is found near Newbury in Berkshire. It contains but little earth, but chiefly consists of wood, branches, twigs, roots of trees, with leaves, grass, straw, and weeds.

The substance called stone turf in England appears to be of the nature of peat. It is soft in the earth, but soon afterwards hardens. From long exposure to the air, it becomes pulverulent. Magellan informs us, that this pit turf is advantageously used by Mr. Wilkinson, in his large smelting furnace for iron in Lancashire.

Dr. Pearson has lately examined peat, in consequence of its ashes, or the salt of peat as they are called, having been strongly recommended as a manure. He observes, that peat is a dense mass of vegetable matter, partly in a dead partly in a living state, with which is mixed more or less earth; and in burning it affords so much empyreumatic oil, as to give a disagreeable taste to roasted meat. It likewise gives out a large quantity of liquid acid, so as to be very destructive to grates; and appears to contain a considerable quantity of iron, frequently, if not always, in the state of sulphat. To this ingredient perhaps the benefit of the ashes as a manure is owing.

Thillaye-Platel has given an ingenious thermolampic apparatus for charring peat, to render it less offensive as fuel, and to turn to account its oily acid, and inflammable gasses.—*See Ann. Chim. vol.* 58, *or my Journal, vol.* 17.

Pech Blende, *or* **Pitch Blende**. The celebrated professor Klaproth has detected a new metallic substance in the mineral usually distinguished by the name of pechblende, or pitch-blende, and ranged among the ores of zinc.

The pitch-blende, or sulphuret of uranium, is found in masses, or else stratified with other earths or minerals, in the Swedish and Saxon mines. It consists of two varieties: the first in masses of a blackish colour, inclining to a deep steel gray, of little brilliancy; its fracture is unequal, and concave in the smallest parts. It is perfectly opake, considerably hard, and becomes convertible into a black powder by trituration. Its mean specific gravity is about 7·5. The second variety is usually found in strata, and is distinguished from the former by a deeper black colour intermixed with spots of red; its colour is more shining, and approaches that of coal; it is less hard, and, when pulverized, it has a greenish tinge.

This mineral suffers no change before the blowpipe. With soda it affords a spongy, semiopake, gray globule. With microcosmic salt it melts, and affords a green transparent globule; and in both there are sometimes seen small globules of reduced lead. When the mineral is treated alone, in a proper vessel, it gives out sulphurous acid and sulphur, with loss of weight; but if it be afterward kept ignited for a considerable time beneath a muffle, it gains some weight by oxidation.

Pelican. A pelican is a glass alembic consisting of one piece. It has a tubulated capital, from which two opposite and crooked beaks pass out, and enter again at the belly of the cucurbit. This vessel has been contrived for a continued distillation and cohobation, which chemists call circulation. The volatile parts of substances put into this vessel rise into the capital, and are obliged to return through the crooked beaks into the cucurbit; and this without interruption, or luting or unluting the vessels.

Although the pelican seems to be a very convenient instrument, it is nevertheless little used, and even much neglected at present, either because the modern chemists have not so much patience as the ancient chemists had, for making long experiments; or because they find that two matrasses, the mouth of one of which is inserted into the mouth of the other, produce the same effect.

Pellicle. A thin skin. By this word chemists generally mean a very thin saline crust, which is formed upon the surfaces of solutions of salts when they are evaporated to a certain degree. This pellicle is nothing else than a number of saline particles crystallized by evaporation at the surface of the liquor, rather than any where else, because the evaporation is made there. These small crystals of salt at first cover the surface of the liquor, and give it a dusky appearance, as if it were covered with dust, or with a very thin skin; from which appearance the name of pellicle has been given.

As all crystallizable salts may be crystallized by evaporation alone, in the solution, therefore, of any of these salts a pellicle may be formed; and also, as all solutions of salts, evaporated till a pellicle is formed, furnish crystals by exposing the liquor to cold, chemists have established a general rule for crystallization, to evaporate solutions of salts till a pellicle is formed, and then to leave them to crystallize by exposure to cold.

This rule is applicable to many salts, but is not general; for some salts, as common salt, do not crystallize by exposure to cold, although the solution of them has been previously evaporated till a pellicle has been formed: while other salts, as nitre and sulphat of soda, may be crystallized in great quantities, although their solutions have not been evaporated so much as that a pellicle has been formed. Hence to crystallize such salts as common salt, the evaporation must be continued after the pellicle has been formed; and to obtain fine crystals of nitre, sulphat of soda, and others which crystallize in a similar manner, the evaporation must not be continued till a pellicle is formed, but their solutions must be left to cool slowly, before it has been so much evaporated. See Crystallization.

Penny-Weights are fictitious parts, into which we suppose any mass of silver to be divided, to specify its degree of purity.

Any mass of silver, the purity of which is to be examined, is supposed to consist of twelve equal parts called penny-weights; and if the silver be perfectly fine, and contain no alloy, then the twelve parts of the mass are all of pure silver, and this silver is said to be silver of twelve penny-weights. If the mass of silver contain a twelfth part of alloy, it will then contain only eleven parts of pure silver, and it will be called silver of eleven penny-weights.

To express more precisely the value of silver, each penny-weight is subdivided into twenty-four grains.

A penny-weight in England is also a real weight used in the weighing of metals. It is equal to twenty-four real grains, and is the twentieth part of an ounce troy.

Pepper. The black pepper of the East Indies contains an essential oil, which has a strong and durable smell, and a taste the mildest of all essential oils. This oil is partly elevated in distillation by alcohol, which thereby acquires the flavour but none of the pungency of the pepper. The spirituous extract is excessively fiery. The watery extract is also very hot and biting. Neither this menstruum nor the spirit can, singly, extract all the hot matter of the pepper.

On distilling the tincture, the alcohol comes over colourless; but toward the end the liquor in the retort becomes muddy, and deposits a greenish matter, which may be observed likewise trickling down the sides of the receiver like oil. This is the substance to which pepper is indebted for its taste and smell, and in its properties it is analogous to the volatile oils.

Pepper likewise contains a peculiar extractive matter, which seems to reside in the outer coat; and a species of starch. The outer coat has the flavour, but little of the heat, of pepper.—*Neumann.*—*Thomson.*

Pepper (Guinea). The red pod of the capsicum annuum. A species of it, called in the West Indies bird-pepper, is the basis of the powder used by the name of Cayenne pepper.

Pepper (Jamaica), Pimento, or All-Spice. The fruit of the myrtus pimenta, L.; the amomum verum of some. The pimento trees grow spontaneously, and in great abundance, in many parts of Jamaica, but more particularly on hilly situations near the sea, on the northern side of that island.

This tree is so entirely the child of nature, that not one attempt in fifty to propagate the young plants, or to raise them from the seeds, in parts of the country where it is not found growing spontaneously, has succeeded. The usual method of forming a new pimento plantation, which in Jamaica is called a walk, consists in appropriating a piece of wood land, in the neighbourhood of a plantation already existing, or in a country where the scattered trees are found in a native state, the woods of which being fallen, the trees are suffered to remain on the ground till they become rotten and perish. In about a year after the first season, abundance of young pimento plants will be found growing vigorously in all parts of the land, which are doubtless produced from ripe berries scattered there by the birds. At the end of two years it will be proper to cleanse the land thoroughly, leaving such only of the pimento trees as have a good appearance. These will then soon form groves, which perhaps do not require much attention after the first four or five years.

It does not appear, that in all the vegetable creation there is a tree of greater beauty than a young pimento. The trunk, which is of a gray colour, smooth and shining, and entirely free from bark, rises to the height of fifteen or twenty feet. It then branches out on all sides, richly clothed with leaves of a deep green, which, in the months of July and August, are beautifully relieved by an exuberance of white flowers. These leaves are equally fragrant with the fruit; and, in distillation, yield an odoriferous oil, which, Edwards informs us, is very commonly used in the medicinal dispensaries in Europe for oil of cloves.

The berries become fit for gathering soon after the trees are in blossom; for the fruit is not suffered to ripen on the tree, because the pulp in that state is difficult to cure. It is, however, impossible to prevent some of the ripe berries from mixing with the rest; but if the proportion of them be great, the price of the commodity is considerably injured.

It is gathered by the hand; and one labourer, on the tree, employed in gathering the small branches, will give employment to three below (who are generally women and children) in picking the berries. An industrious picker likewise will fill a bag of 70lbs. in the day. It is then spread on a terrace, and exposed to the sun for about seven days; in the course of which it loses its green colour, and becomes of a reddish brown, and when perfectly dry it is fit for market.

In a favourable season, a single pimento tree has been known to yield 150lbs. of the raw fruit, or one cwt. of the dried spice: for there is generally a loss of one third in curing. A plenteous crop, however, occurs perhaps but once in five years; and the price in the British market fluctuates accordingly.

Neumann says, that pimento appears from a chemical examination to contain: 1. An indissoluble earth, exceeding in quantity all the other principles taken together, and amounting to five drachms and a scruple in an ounce. 2. Gummy or mucilaginous matter, which is the ingredient next in quantity. An ounce treated with water at first gave two drachms and two grains of gummy extract; and another ounce, freed by alcohol from all that the menstruum could dissolve, yielded still with water five scruples of mucilage. 3. A resinous substance in smaller quantity. The resinous extract obtained by applying alcohol at first, amounted to only one drachm and six grains from an ounce; an ounce, freed from its mucilaginous matter by coction in water, yielded of pure resin no more than one scruple. 4. An essential oil in still smaller quantity: of this principle an ounce of pimento contains scarcely half a drachm.

Upon examining the qualities of the several products, it appeared that the oil is the principal and characteristic part, containing all the smell and the aromatic flavour, though not the pungency of the berry. As the prevailing flavour of pimento approaches that of cloves, the oil also greatly resembles the genuine oil of cloves. It has the same kind of smell and taste, discovers no great heat or pungency, and is so heavy as to sink in water; to which may be added, that the oil of pimento, like that of cloves, resides chiefly in the shell, or cortical part, the internal substance yielding little or none. 2. That the heat and pungency are lodged in the resin. In this respect also pimento agrees with cloves; but as pimento in substance is far less hot and fiery than cloves, its resin is also more mild. 3. That the gummy parts have very little activity.

Alcohol elevates nothing from this spice in distillation, the oil of pimento being too ponderous to rise with so light a fluid. The only way of making a spirit from it is to dissolve some of the oil in pure alcohol. An agreeable spirituous water may be made with proof spirit, the watery phlegm in that liquor carrrying up a part of the oil.

Pericardium (Liquor of the). The fluid contained in the pericardium, or membranous envelope of the heart, and serving to lubricate the surface and facilitate the motion of that important organ, has lately been analysed by Dr. Bostock. It was obtained by opening the body of a boy who had died suddenly, in order to ascertain the cause of his death. The whole quantity collected was about half an ounce: it was nearly of the colour and appearance of the serum of the blood.

1. A quantity of it was slowly evaporated, and a residuum was left, amounting to $\frac{1}{11}$ of the whole.

2. A quantity of the fluid was kept for some time at the heat of boiling water: it became considerably opake and gelatinous.

3. A copious precipitate was produced by the oximuriat of mercury.

4. After the fluid was saturated with the oximuriat of mercury, it produced no precipitate with the infusion of galls.

5. The nitrat of silver produced a precipitate which indicated both animal matter and the muriat of soda.

6. A quantity of the coagulated fluid No. 2, being dried in the temperature of boiling water, was afterward washed with boiling distilled water.

7. The water from No. 6 gave no precipitate with the oximuriat of mercury, nor with galls, but a pretty copious one with the aqua lithargyri acetati.

The small quantity of the fluid which Dr. Bostock was able to obtain prevented him from prosecuting the analysis with more minuteness: from these experiments, however, we may form some idea of its composition. From the first we learn, that it contains 0·92 of water; from No. 2 and 3, that it contains a considerable quantity of albumen, which he estimates at somewhat more than $\frac{1}{20}$ of its weight; from No. 4 and 7, that it contains no jelly; from No. 7, that it contains mucus; and from No. 5, that it contains common salt, but the proportion of this appeared not very considerable. The constituents of the liquor pericardii will therefore be:

Water	92·0	
Albumen	5·5	
Mucus	2·0	The proportion of these substances is somewhat conjectural.
Muriat of soda	0·5	
	100·0	

Philosophical Journal.

Peridot. The Chrysolite; which see.

Perigord Stone. An ore of manganese, black, heavy, of a glittering appearance when broken, and in the whole resembling a slag from a smith's forge.

Perlate Salt and Acid. See Acid (Phosphoric).

Peroxide. This term is used by Dr. Thomson to denote a metal combined with the greatest dose of oxigen it can take up. It is synonymous therefore with oxide at a maximum.

Perspiration. See Sweat.

Peru (Balsam of). This substance is obtained from the myroxylon peruiferum, which grows in the warm parts of South America. The tree is full of resin, and the balsam is obtained by boiling the twigs in water. It has the consistency of honey, a brown colour, an agreeable smell, and a hot acrid taste.

When boiled with water for some time, the liquid separated by the filter reddens vegetable blues, and deposits crystals of benzoic acid on cooling. The water contains no other substance. When distilled with water, it yields a very small quantity of reddish limpid oil. Hoffmann obtained only one part of oil from 16 of balsam.

Lichtenberg mixed two ounces of balsam with eight of water, and distilled. The first two ounces of water came over colourless, and had only a slight smell of the balsam. The next three were milky, smelt strongly of the balsam, and at the bottom of the receiver were some drops of colourless oil. The next ounce and half were similar, but contained more oil. Between 50 and 60 grains of benzoic acid had sublimed into the neck of the retort. By increasing the heat, 3½ drachms of yellow oil came over, and a quantity of benzoic acid. A black shining coal remained in the retort.

When this balsam is exposed to the heat of a water bath, only a drop or two of water and a few drops of oil can be obtained. When placed in a sand bath, and exposed to a temperature gradually raised, nothing more comes over till the balsam is heated to 300°, when a portion of benzoic acid sublimes; and at 324° drops of water and of oil begin to come over. At 550° the balsam begins to boil, and some gas is disengaged. At 594° the oil comes over pretty fast, mixed with a little water. At 617° it comes over still more rapidly. Lichtenberg, to whom we owe these experiments, kept some ounces of balsam at this temperature for two hours, and obtained two ounces of a yellowish oil, and a crystallized mass of benzoic acid, which, together with the water, weighed 6½ drachms. The gas obtained amounted to 58 ounce measures: of these, 38 were carbonic acid. The rest burnt like olefiant gas. By increasing the heat a brownish oil came over, and at last a black oil of the consistence of pitch, and 49 ounce measures of gas were extricated. Of these, six were carbonic acid; the residue burnt with a blueish white flame.

A saturated solution of carbonat of soda forms with this balsam a thick mass. When diluted with water and heated, a portion is dissolved. The solution, when saturated with sulphuric acid, deposits crystals of benzoic acid. One part of the balsam, treated with one part of potash dissolved in four parts of water, formed an opake solution, which gradually separated into two portions; the uppermost, a clear oil with some gray flakes at its lower surface; the undermost, a dark brownish opake solution. This last solution, when saturated with sulphuric acid, let fall a resiniform substance, which had been dissolved by boiling, while benzoic acid crystallized.

Nitric acid acts upon balsam of Peru with energy, and gives it an orange yellow colour when assisted by heat. When distilled with a sufficient quantity of this acid diluted, the liquid in the receiver smells of bitter almonds. When supersaturated with carbonat of potash, and mixed with a solution of iron, a precipitate falls, which, when treated with muriatic acid, leaves Prussian blue, and indicates the presence of prussic acid. During the distillation benzoic acid sublimes. The residue in the retort has a crystalline appearance, is light yellow, dissolves sparingly in boiling water, and precipitates on cooling in the state of a yellow powder. Such was the result of Lichtenberg's trials.

Mr. Hatchett observed that the residue possessed the properties of artificial tannin. When this balsam is treated with sulphuric acid artificial tannin is also form
and the residual charcoal amounts to no l
than 0·64 of the original weight of the b
sam.

The smell of this balsam is agreeably a
matic, and its taste pungent. It is ind
one of the hottest of the natural bals
and is prescribed in medicine as a warm
imulant.. It is likewise used externally w
similar intentions, either alone or in
form of a tincture. The simple tincture
this balsam, directed by the London C
lege, is made by dissolving four ounces t
weight in a pint of rectified spirit of wi

There is a white balsam of Peru, or wh
storax, as it is sometimes called, brou
over in gourd-shells, of a pale yellowish
lour, thick and tenacious, and becoming
age solid and brittle. This is supposed
be the produce of the same tree that affo
the common or black balsam, and to ex
from incisions made in the trunk.

This balsam is much less hot and pung
in its taste, but more fragrant and agreea
in its smell, which approaches that of s
rax. It readily dissolves in alcohol, a
unites with oils both expressed and distill
as well as with animal fats. If it be dr
ped in its fluid state into warm water
spreads totally upon the surface, and for
a pellicle sufficiently cohesive to be tak
off entire, which has been held one of t
principal criteria for distinguishing the t
balm of Gilead. It is very rarely met w
in the shops.—*Thomson's Chemistry.*—*Le*

Peruvian Bark. See Cinchona.
much more full and elaborate analysis
this important article of the Materia M
dica having been published by Vauque
in the Annales de Chimie, since that part
our Dictionary was printed off, we sh
here insert an abridgment of his accou
premising, that he was in part forestalled
Dr. A. Duncan jun., as will be seen on
reference to Cinchona.

Several different kinds of cinchona a
met with in the shops, but the chief a
most in use are the following three. Fir
that formerly called by the vague name
Peruvian bark, and which appears to
taken from the cinchona officinalis, L. Th
is externally of a gray colour, and interna
ly of a pale red; thin, and convoluted fro
the contraction of the inner surface; smoo
and as it were resinous in its fracture, b
sometimes slightly fibrous; and of a
astringent and bitter taste. Its powder
fawn-coloured, mingled with a tinge
gray.

The second, known by the name of re
bark, and sometimes erroneously called i
France quinquina piton, is of a much dee
er colour; commonly very thick; little
at all convoluted; fibrous, and not at all re
sinous in its fracture; with an astringe
and very slightly bitter taste.

The third, or yellow bark, which is

most recent date, is of a pale yellow colour; of a more bitter but less astringent taste than either of the preceding; partly woody, partly resinous in its fracture; and a little convoluted, according as it is more or less thick.

It would be of important service to the physician, as well as to the merchant, if there were any sure and simple methods of distinguishing the good kinds of cinchona from such as are bad or damaged: but hitherto we have nothing to guide us except their appearance, which may be fallacious, and our judgment from which must depend on our individual skill and practice. Mr. Seguin indeed has said, that the aqueous infusion of the good kinds possesses exclusively the property of precipitating infusion of tan, and that of the bad of precipitating animal gelatine; but this is an error, for there are several species of true cinchona that do not precipitate tannin, and yet cure fever.

I have compared the physical and chemical properties of the infusions of every kind of cinchona to be found in the shops, to which I have added that of some other vegetable substances, apparently analogous with cinchona, and which are said to have cured fever. The infusions were prepared with the same quantity of water, the same quantity of bark, at an equal temperature, and for an equal time; so that no difference could arise from the mode of preparation.

I began with the yellow bark. Of this bark,—122 grammes, or near 4 oz. troy, infused for twenty-four hours in two litres (a little more than two wine quarts) of water at 12° (54·6° F.) imparted to it a yellow colour, and a very bitter and slightly astringent taste.

This infusion occasioned a very copious flocculent precipitate in a solution of isinglass.

In a solution of sulphate of iron it produced a green colour resembling that of bile, and some time after a precipitate of the same colour fell down.

The solution of antimoniated tartrite of potash was precipitated by it of a yellowish white.

The oxalate of ammonia threw down from it a precipitate, which was oxalate of lime.

Lastly, it very evidently reddened tincture of litmus.

This infusion when completely precipitated by a solution of isinglass, and filtered, was deprived of colour, and scarcely at all astringent, but it retained its bitterness. In this state mixed with a solution of sulphate of iron, it turned it green as before, except that the colour inclined more to a yellow. It still precipitated the solution of emetic tartar, with this difference, that the precipitate was whiter. This cannot be ascribed to an excess of the isinglass, for a solution of isinglass occasions no change in that of emetic tartar.

Another portion of the infusion, being completely precipitated by emetic tartar and filtered, still rendered the solutions of isinglass and sulphate of iron turbid, but much less than before. The precipitate formed by the emetic tartar was turned slightly green by the addition of a few drops of sulphate of iron.

It would appear from these experiments, that the principle which precipitates emetic tartar, isinglass, and sulphate of iron, is the same; and that, if the liquor still retain the property of precipitating isinglass and sulphate of iron, it is because it retains some portions of the combination of this principle with antimony. This supposition, however, is not reconcileable with the very copious precipitation of isinglass by certain kinds of cinchona, that do not precipitate emetic tartar. The principle that precipitates isinglass therefore must be different from that which decomposes tartarised antimony.

The bark left after this infusion being boiled in water, the decoction had almost exactly the same effects on the reagents above enumerated: the only difference between them was, that the decoction became turbid on cooling, furnished a smaller quantity of precipitate, and this separated from the liquor more speedily.

I have to add, that both of them threw down from the solution of sulphate of copper a reddish yellow precipitate, and from that of acetate of lead a yellowish white.

A species of cinchona lately introduced from Santa Fe has been found to possess the febrifuge power by able physicians. It is gray on the outside, red within, thick, little convoluted, with an astringent and slightly bitter taste. Its infusion is much redder than that of the yellow bark. Tried in the same manner it produced the following effects:

With the solution of isinglass it gives a very copious reddish flocculent precipitate. This effect, which has never yet been mentioned by any person to my knowledge, is worthy of remark.

It occasioned no change in solution of emetic tartar, in which it differs from the yellow bark.

It throws down a fine deep green precipitate from solution of sulphate of iron; perceptibly reddens tincture of litmus; is precipitated by oxalate of ammonia, but the oxalate of lime it thus yields is much less than that from the yellow bark.

It precipitates acetate of lead and sulphate of copper of a reddish brown.

The principle which precipitates emetic tartar appears to be wanting in this bark; and a farther proof of its differing in some respects from the yellow bark is, that their infusions on mixture become turbid.

The decoction of this species produced

the same effects with reagents as its infusion: but it is observable, that it does not grow turbid on cooling.

The infusion of red bark has a light orange red colour, and an astringent bitter taste.

It forms a copious reddish precipitate with isinglass, yellowish white with emetic tartar, brown with the infusion of the cinnamon gray bark, green with sulphate of iron. On the other metallic solutions it acts like other species of cinchona.

A hundred grammes of the white bark, cinchona pubescens of Vahl, in fine powder macerated four-and-twenty hours in distilled water afforded a transparent liquor of a golden yellow colour, very bitter, and frothing when shaken. With reagents it exhibited the following appearances:

Tincture of galls formed in it a copious precipitate, which an excess of the tincture redissolved, and the addition of water again threw down. This shows, that the matter separated by the tannin is not purely animal.

From the solutions of tartarised antimony and nitrate of mercury it threw down a yellowish white precipitate. To that of sulphate of iron it gave a decided green colour, but nothing fell down. Solution of isinglass produced no change in it. It did not redden infusion of litmus.

During evaporation this infusion deposited a rose-coloured substance on the sides of the dish; and being reduced to the consistence of a sirup, it deposited farther on cooling a fresh quantity of a chesnut-brown substance. The filtered liquor was still coloured, and contained the salt peculiar to cinchonas, which will be noticed hereafter.

The brown substance, washed with a small quantity of cold water, is soluble in warm water and in alcohol; but very sparingly in cold water. Its taste is very bitter.

In the aqueous solution of this sediment nut-galls form a copious precipitate. Tartarised antimony and nitrate of mercury produce the same effects in this solution as in the infusion of the bark itself. Sulphate of iron is turned green by it. Oxigenized muriatic acid loses its smell when poured into the solution, and presently forms a flocculent precipitate. Isinglass has no effect on it: it is not changed by sulphuric or acetic acid: and when diluted with caustic potash it gives out no smell of ammonia.

Two hundred and twenty-five grammes (3475 grains) of this substance, weighed when dry, afforded on distillation a great deal of water, a perceptible quantity of ammonia, and a purple oil, which loses this colour on being dissolved in alcohol, but resumes it as the menstruum evaporates by being left exposed to the air.

They left in the retort eleven decigrammes (17 grains) of coal, which yielded by incineration one decigramme (1·54 grain) of ashes soluble with effervescence in muriatic acid, and the solution of which yielded lime and iron.

It is evident from what has been seen, that it is this coloured, bitter substance, which, in the maceration of the cinchona in question, produces with reagents all the phænomena mentioned above. This substance seems to be a medium, in its nature and properties, between vegetable and animal substances. Probably it is the efficacious principle in the cure of intermittent fevers. The liquor separated from this substance was treated with alcohol, which took up the colouring matter; and this proved to be nothing but a portion of the same substance that the water had retained. The portion insoluble in alcohol was of the consistence of a thick mucilage, and had scarcely any taste or colour. It dissolved in large quantity in water; and the solution yielded by spontaneous evaporation slightly coloured and lamellated crystals of a salt, which will be farther noticed in the sequel.

The same portion of cinchona, when it had been macerated for the seventh time, still giving a precipitate with galls, I conceived that the cold water had been incapable of dissolving the whole of the principle by which this effect was produced. In consequence I boiled the residuum of the cinchona, and the liquor thus obtained exhibited the same phænomena as the infusion, except that it did not precipitate the solution of tartarised antimony, probably because it was too much diluted with water.

Eighty-four grammes (1297 grains) of the common bark of the shops, cinchona officinalis, treated like the preceding, afforded a paler-coloured liquor, and more mucilaginous, though equally bitter. This infusion slightly reddened that of litmus. With other reagents it exhibited similar phænomena to the cinchona pubescens.

All the liquors obtained by maceration when evaporated afforded a sediment, the properties of which so much resembled those of the same substance from the cinchona pubescens, that I conceived they might be mixed together: but the supernatant liquor, containing the salt essential to cinchona, was evaporated separately, and set to crystallize by spontaneous evaporation, after the colouring matter had been separated by alcohol, and in a few days crystals were produced from it.

Thus we have two species of cinchona, which do not precipitate isinglass, and which are consequently destitute of the principle that produces this effect in other species. According to Mr. Seguin, they are to be classed among the best sorts.

After several washings with cold water, as galls still occasioned a precipitate, the residuum was treated with hot water, which acquired a pretty deep colour. This was less bitter than the liquor obtained by maceration, and still more mucilaginous than the decoction of the cinchona pubescens. It formed a precipitate with galls and nitrate of mercury, and turned green with sulphate of iron; but neither tartarised antimony nor isinglass occasioned any change in it.

Mr. Vauquelin had likewise an opportunity of examining several different kinds of cinchona brought over from America by Von Humboldt and Bonpland. These were the following:

Bark of Loxa, taken from branches of the second year, and used by the apothecary to the king of Spain.

This is externally gray, internally yellow, thin, convoluted, and bitter and astringent to the taste.

Eight grammes of this bark, infused for twenty-four hours in 150 grammes of water at 15° (59° F.), yielded a reddish yellow liquor not very deeply coloured, having a slightly mouldy smell, and a bitter taste. It precipitated galls, tartarised antimony, and acetate of lead of a yellowish white, iron of a bluish green, oxalate of ammonia white, and isinglass in large, white, glutinous flocks. The precipitates formed by tartarised antimony and isinglass redissolved in an excess of the hot infusion.

From these properties this cinchona must have great febrifuge virtue.

White bark of Santa Fe.

This bark has a rusty yellow colour externally, which is deeper within. It is flat and thick. Its fracture is granulated nearly like that of beech bark. Its taste is neither bitter nor astringent like that of the other barks.

Eight grammes macerated for twenty-four hours in 150 grammes of water imparted to it a deeper yellow colour than the Loxa barks. This infusion precipitated neither galls, tartarised antimony, nor isinglass; it turned solution of iron green; and precipitated acetat of lead of a brownish yellow.

From these properties this bark appears not to be a true cinchona.

Orange-coloured bark of Santa Fe.

This bark is of a cinnamon yellow colour, without any epidermis, thick, and very fibrous in its fracture. The thinnest pieces are convoluted, the thickest flat. It is not at all astringent.

Its infusion, made as above, is scarcely coloured; has a decidedly bitter taste; forms a copious white precipitate with tartarised antimony; precipitates tannin, but not isinglass; turns iron slightly green; and does not render the infusion of Loxa bark turbid. This species of cinchona differs from that of Loxa, and cannot have very striking febrifuge properties.

Common Peruvian bark.

This bark is gray externally, and of an ochre red within: its surface is wrinkled; it is convoluted, and of various thicknesses according to the difference of the pieces; its taste is bitter and astringent.

Eight grammes, macerated for twenty-four hours in 150 grammes of water, gave it a light yellow colour, and a bitter and astringent taste. This infusion precipitated tartarised antimony, isinglass, and tannin of a yellowish white, and sulphate of iron green. It reddened litmus paper.

Red bark of Santa Fe.

This does not appear to differ in any sensible degree from that mentioned above by the name of Santa Fe bark.

Eight grammes, macerated as above, gave an infusion of the red colour of Malaga wine, with an astringent taste, and but little bitterness. It precipitated isinglass brown; gave no precipitate with tannin or tartarised antimony; turned sulphate of iron green; and slightly reddened litmus paper. These chemical properties are equally apparent in the Santa Fe bark described above.

Yellow bark of Cuenca, from branches of four or six years old.

This bark is gray exteriorly, covered with a white lichen, of a brown yellow interiorly, having a fibrous fracture, and scarcely any taste. Its infusion is neither bitter nor astringent. It precipitates neither tartarised antimony, isinglass, nor tannin: merely turns sulphate of iron green; but precipitates acetate of lead.

It can have no febrifuge virtue.

TABLE

Of the Effects produced by the Species of Cinchona brought from America by Messrs. Von Humboldt and Bonpland, with the Reagents mentioned.

Species.	*Isinglass.*	*Tannin.*	*Iron.*	*Tart. Antim.*	*Observations.*
1. Common gray Peruvian bark	Copious precipitate.	The same.	A green colour.	Copious precipitate.	A bitter, astringent taste. Reddens litmus.
2. Red bark of Santa Fe.	Copious precipitate.	None.	A green colour.	None.	Red colour of Malaga wine. Little bitterness, but astringent to the taste.
3. Yellow bark of Cuença.	None.	None.	Greened.	None.	Neither bitter nor astringent. Precipitates acetate of lead.
4. The king of Spain's Loxa bark.	Copious precipitate.	The same.	Green.	Copious precipitate.	Reddish colour, not deep. Mouldy smell. Bitter.
5. White bark of Santa Fe.	None.	None.	Greened.	None.	Pretty deep yellow colour. Neither bitter nor astringent. Precipitates acetate of lead.
6. Yellow bark of Santa Fe.	None.	Copious precipitate.	Greened.	Copious precipitate.	Taste decidedly bitter, slightly astringent. Infusion light-coloured.

To gain some additional light respecting the nature of the principles contained in cinchona, I instituted a comparative examination of several other vegetable substances, that appear to have some analogy with it, and the composition of which is a little better known: such as galls, oak bark, Angustura bark, and some others.

Nut-galls.

The infusion of this substance copiously precipitated isinglass white; iron, blue; tartarised antimony, yellowish white; infusion of yellow bark, in dirty white flocks; copper, brown yellow; and lead, yellowish white.

It did not precipitate infusion of Santa Fe bark, or of tan.

The infusion of nut-galls therefore, like that of yellow bark, contains the principle that precipitates isinglass with that which precipitates tartarised antimony; and in this respect they resemble each other. But they differ with regard to the principle that acts on tan and on iron, since this metal is precipitated green by cinchona, and blue by galls. They differ too in another point, since they mutually precipitate each other.

Tan.

The infusion of this substance, made wit the same care and in the same proportion as those of the cinchona bark, precipitate solution of isinglass yellowish; iron, blue copper, brown: but it occasioned no chang in infusion of Santa Fe bark, or solution o tartarised antimony. It reddened infusio of litmus, and was precipitated by oxalat of ammonia.

Hence we see, that oak bark does no contain the substance that precipitates tartarised antimony, as nut-galls, yellow bark and some other barks do; and in this respect it differs from them, though they agre in precipitating isinglass.

Cherry-tree bark.

This bark, which has sometimes bee fraudulently substituted for that of cinchona, has nothing in common with it excep the property of forming a green precipitat with solution of sulphate of iron. It occasions no change in isinglass, tartarised antimony, or decoction of oak bark. Its po sessing any febrifuge property therefore i very questionable.

Centaury and germander.

These two plants afforded me the same results as cherry-tree bark: their efficacy in fever therefore is equally doubtful.

White willow bark.

This bark, to which febrifuge virtues have formerly been ascribed, possesses in fact some of the chemical properties of certain species of cinchona; namely, those of precipitating isinglass, and throwing down sulphate of iron green, and acetate of copper brownish. The white willow bark, therefore, as it unites the bitter and astringent tastes, may possibly be a febrifuge.

Angustura bark.

The infusion of this bark does not precipitate isinglass: but it forms a copious precipitate with infusion of nut-galls, and with that of a yellow bark, though it merely renders infusion of Santa Fe bark slightly turbid.

It precipitates iron, tartarised antimony, copper, lead, and infusion of tan all yellow.

This bark, we see, differs from several of the species of cinchona, and from the other substances submitted to the comparative examination, in not precipitating animal gelatine. It wants too the astringent taste, but on the other hand is extremely bitter. There is reason to believe too, that the principle, which in this precipitates the metallic solutions, is not altogether the same with that in the cinchonas; at least the colour of the precipitates it gives is very different. From these properties, however, the Angustura bark may possibly be a febrifuge.

Mr. Vauquelin next proceeded to a more minute examination of the infusions and decoctions of those species of cinchona, that precipitate neither tannin nor the antimoniated tartrit of potash.

These sorts of bark impart to cold water a red colour, frequently a yellowish red, sometimes a brown red. Water thus larded with the soluble part of these barks froths on agitation like wort. Its taste is bitter, and more or less astringent, this differing in the different sorts.

Left to stand in an open vessel, or in a close one if not full, it soon grows mouldy, and is covered with a greenish pellicle.

Some of them are perceptibly reddened by infusion of litmus, which announces the presence of a free acid.

Alcohol mixed with these infusions in the proportion of two parts to one, precipitates a grayish substance, which grows black on desiccation. The fluid is left more clear, and of a purer red. This indicates the presence of mucous matter.

In those infusions which contain a free acid a small quantity of caustic alkali forms a red precipitate inclining to violet: but a larger quantity of the reagent redissolves this precipitate, and renders the colour of the infusion more intense.

Subjected to evaporation they become higher coloured; and, after being thus boiled down, they let fall on cooling a very bitter brown substance, which dissolves readily in alcohol, particularly with the assistance of heat, and is precipitated from it by water, if the solution be sufficiently saturated. Water itself redissolves this substance, though it has been separated from it by evaporation; but it requires a larger quantity, than when it is accompanied with the other principles of cinchona, which seems to show, that these principles promote the solution in water.

If the infusions of bark be allowed to cool several times before they are evaporated to dryness, at each cooling they let fall a matter similar to that just mentioned. It was formerly supposed, that this substance was rendered insoluble by combining with oxigen, but the effect appears rather to be owing to the insufficiency of the water.

It is this sort of resinous matter, that gives to bark and its infusions their bitter taste: for if these sediments be separated as they form, and the infusion thus boiled down be afterward made up to its former quantity by the addition of water, it will no longer possess the same degree of bitterness. The whole of this matter, however, cannot thus be separated from water; for the other principles of the cinchona always retain a pretty large quantity in solution.

But if, after having proceeded as I have just mentioned, the infusions of cinchona reduced to the state of soft extract be treated with alcohol, the greater part of the *resiniform* matter will be separated; nothing will remain but a brown viscous substance, that has scarcely any bitterness, is perfectly soluble in water, and does not precipitate from it on cooling.

These experiments teach us, that in the infusions of these species of cinchona there are at least two very distinct substances: one bitter and astringent, soluble in alcohol, and but little soluble in water; the other, on the contrary, wholly insoluble in alcohol, very soluble in water, and having a sweet and mucilaginous taste.

These substances being unquestionably those which operate most efficaciously in the diseases in which cinchona is employed, I conceive it will not be superfluous to give an account of their properties somewhat more at large. I shall begin with that which is soluble in alcohol. 1. This substance, in the dry state, has a brown red colour, and a very bitter taste. 2. Cold water dissolves only one portion of it, another remaining in a flocculent form and of a reddish colour; but if the mixture be heated, this dissolves too, and the result is a clear liquor, of a very deep red, which grows turbid on cooling, but lets fall very little sediment.

What is remarkable in the manner in which this substance comports itself with water is, that, if we employ but a small quantity of this fluid, it dissolves entirely, and produces a ~~clear liquor: if after this~~ more water be added, it grows turbid; and again it becomes clear on the addition of a still greater quantity of this fluid.

It would seem from this, that there is some other substance present with it, which promotes its solution when concentrated, and loses this property by being diluted in water.

This is the matter that renders the decoction or infusion of cinchona turbid, by separating as it cools; as it does the water in which it is macerated, if this be evaporated to a certain point. It is the same as has been called in pharmacy resin of bark: but its solution in water grows mouldy in a few days, and produces fungi, like a solution of gum; which proves it not to be a true resin, for it is well known that resins never grow mouldy.

The aqueous solution of this substance, recently prepared, and in a somewhat concentrated state, produced the following effects with the different reagents I shall mention.

1. With ammonia it coagulated into a whitish, thick matter, which grew brown in the open air, and hardened considerably a little while after: but it softens by heat, and assumes the ductility and silky lustre of turpentine when kneaded between the hands.

2. It produced nearly the same appearances with the alkaline carbonats.

3. The common acids produced no sensible change in it. Oxigenized muriatic acid turned it yellow, without producing any precipitation; but, if ammonia be then added, a light, flocculent, grayish-white precipitate is formed.

4. The solution of animal gelatine does not precipitate it, yet the infusion of these species of cinchona precipitates the solution of animal glue: the principle that produces this effect, therefore, must be altered during the evaporation.

5. The muriat of iron, or any other ferruginous salt, produces in it a deep green colour, and soon after a precipitate of the same tint.

6. The antimoniated tartrit of potash occasions no precipitation in it. This substance, therefore, is not the same as that which in the infusions of certain species of cinchona precipitates this metallic salt.

7. Lastly, it very perceptibly reddens infusion of litmus.

The acidity of this substance, and the precipitation occasioned by alkalis in its concentrated solution, led me to suspect, that its solubility was in part owing to the presence of the free acid that accompanies it: and this appeared to me to be confirmed by the circumstance, that, when once separated by an alkali, washed, and dried, it was no longer soluble in water but in an infinitely small proportion.

To acquire a greater degree of certainty ~~on this subject,~~ I put some into water acidulated with various acids; ~~and I found, in~~ fact, that it dissolved in them readily, and that its solutions resumed a bitter taste, similar to that it had before it was precipitated by an alkali.

I remarked, that this substance, when precipitated, retained a part of the alkali employed to throw it down: at least the following experiment seemed to prove this. After its solution had been precipitated by ammonia, and washed in a large quantity of water, I mixed with it caustic potash; which immediately produced a very evident smell of ammonia; and this was not the case, before it had been precipitated by that alkali.

It is evident, therefore, that this substance combines with a portion of the ammonia, which is employed to precipitate it from its solution; unless the acid, which naturally accompanies it, forms with this alkali an insoluble salt, that mixes with the resinous matter, a circumstance that appears not very probable.

It seems from these properties, that this substance acts the part sometimes of an acid, at others of an alkali, since it combines with both these, and in part neutralizes their properties.

If, after having precipitated this matter by alkalis, an excess of these reagents be added, it is redissolved, and the solution has a brown red colour.

The solubility of this substance in alcohol is singularly increased by heat. When the menstruum is saturated with it, it has a red colour, and an extremely bitter taste. Water throws down from it a copious precipitate of a fine red slightly inclining to rose colour. The alcoholic solution exposed to the air in an open vessel crystallizes in a needly form like a salt.

The alcoholic solution precipitated by water still retains a portion of this substance, which continues to give it a rose-colour inclining to deep orange [*nacarat*], and a perceptibly bitter taste. It deposits this in scales of a brown red by spontaneous evaporation.

That principle of the cinchona which is insoluble in alcohol, being dissolved in water, filtered, and left to spontaneous evaporation in a warm place, thickens like a kind of sirup, and crystallizes in laminæ, sometimes hexaëdral, at others rhomboidal, at others square, and slightly tinged with a reddish brown. A portion of a thick fluid always remains, which never crystallizes completely, and which must be separated by decantation.

By repeated solution and crystallization this salt may be obtained white and pure. Of its properties I shall speak hereafter

As to the matter that does not crystallize, but remains in the form of a mother-water, it exhibited all the characters of a mucilaginous matter, still retaining a small portion of the salt I have just mentioned, which it is impossible to separate from it entirely by crystallization.

The barks in question, after being exhausted by water, and even by alcohol, still yield something to acids. They all act nearly in the same manner: that is to say, their effect is confined to simple solution, without occasioning any perceptible change in the nature of the principles of the cinchona.

I must observe, however, that, if the bark have been reduced to fine powder, and subjected to the repeated action of a large quantity of alcohol assisted by heat, little is left to be done by acids. The matter taken from the bark by acids is according to all appearance the same as that which dissolves in alcohol, as I shall show farther on.

Nitric acid acquires from it a red, inclining to rose-colour, and sometimes to a deep orange [*nacarat*]: but these tints vary greatly in their intensity according to the strength of the acid; the stronger this is, the more they incline to yellow. The nitric acid loses much of its acidity by this combination, at least as far as we can judge from the taste: it is true it dissolves at the same time a certain quantity of lime, which is detected by oxalat of ammonia, and this contributes to its neutralization.

If saturated carbonat of potash be poured into this nitric solution, a fine red precipitate is formed: but if the common carbonat be employed, and added in excess, the colour of the precipitate becomes violet, purple, or blue. Thus alkalis have the property of blueing that colour of these barks which is naturally red.

Metallic solutions likewise form in it precipitates of various colours, and more or less abundant, according as the nitric acid contains more or less vegetable matter: but if the excess of acid be saturated, the metallic salts then produce in it very copious precipitates, and the liquor is deprived of colour.

1. Solution of muriat of tin produces in it a rose-coloured or carnation precipitate.

2. That of sulphat of iron, a grayish precipitate.

3. That of copper, a chesnut brown.

4. Sulphat of titanium, assisted with a little carbonat of soda, formed with the nitric solution of cinchona an orange-red precipitate, pretty analogous in colour to that produced by solutions of this metal with galls.

5. Alum occasioned no change in the acid solution of cinchona; but aided by a little alkali it carries down with it the colouring part, and the liquor is rendered colourless.

In the countries where these cinchonas grow, a very fine and permanent chesnut red for wool and cotton might be obtained from their bark. Soap turns it to a rose colour.

The sulphuric and muriatic acids, diluted with water, and poured on the residuums of these cinchonas, dissolve the resiniform substance, and saturate themselves with it like the nitric acid. The colour they thus acquire inclines less to yellow than that of the nitric acid: it is always of a more decided red.

The precipitates formed in these solutions by alkaline carbonats are likewise of a purer red; and an excess of these alkaline salts gives the precipitate a more evident blue.

The residuums of the cinchonas appear to contain a large quantity of lime: at least a great deal of sulphat of lime is produced by spontaneous evaporation in the sulphuric acid in which they have been macerated.

From the action of acids on the resiniform matter of these species of cinchona, if it should at any future time be demonstrated that this substance is the only febrifuge principle in them, it is evident, that the art of physic may derive from these barks much more advantage in the cure of intermittent and low fevers, by adding to them acids or wine. In fact, as has been seen above, water extracts from cinchona, particularly when it is merely bruised, but a very small quantity of resiniform matter, and even the greater part of this is precipitated by cooling. Now by this means it is certain, that from a large quantity of cinchona we extract but a very small part of the febrifuge principle; which too, being diffused through a large body of water, unquestionably cannot produce all the effect of which it would be capable in a more concentrated state.

It has long been known, that the effect of the essential salt of cinchona in fever is by no means proportional to that of the quantity of bark from which it has been extracted; which proves, that something useful in the cure of this disease is left in the magma.

According to my way of thinking, the method hitherto pursued for preparing the essential salt of bark is the reverse of what it ought to be. When an infusion of cinchona is made, it is evaporated to a certain point, left to grow cool that it may deposit a sediment, this resiniform sediment is separated from the liquor, and the evaporation and refrigeration are repeated, till the liquor no longer becomes turbid, and has only a pale yellow colour. It is then dried on plates by the heat of a stove. By operating thus, a very small quantity of resiniform matter only remains in the water, with a gum, and a salt with a calcareous basis, the efficacy of which in the cure of fever is very questionable.

Comparative examination of the resin of these cinchonas with other known vegetable substances.

Is there in the vegetable kingdom any immediate principle, with which this can be classed? Is it to be placed among the resins, as has hitherto been done? It is true that chemists and apothecaries formerly arranged together so many substances under this genus, that, if we looked to some of its properties only, we might also rank this among them: but if we apply the name of resin only to those substances which are absolutely entitled to it, those of cinchona and many other vegetables must be separated from the resins properly so called.

If the resiniform matter of these cinchonas resemble resins by its solubility in alcohol, it differs from them by its solubility in water, acids, and alkalis, and particularly by its property of precipitating metallic salts, and fixing in cloth. I believe then it may be considered as a peculiar vegetable principle, the properties of which have not hitherto been well understood by chemists. This principle is not the same in every species of cinchona: it differs in those that precipitate infusion of tan and tartarised antimony, and in those that precipitate isinglass only.

It is probably a principle extremely analogous to it, that most commonly imparts a bitter taste to vegetables.

The following is a recapitulation of the properties of cinchonas:

1. The different species of bark may be divided into three classes with regard to their chemical properties.

In the first may be comprised those that precipitate tannin, and do not precipitate animal glue.

In the second, those that precipitate animal glue, and do not precipitate tannin.

In the third, those that precipitate both tannin and animal glue, and also tartarised antimony.

2. We may conjecture with sufficient probability, that every vegetable substance, which does not possess at least one of the properties above mentioned, will not be a febrifuge; and it is probable too, that the more these properties unite in a cinchona, or in any other substance, the more striking will be its febrifuge effects.

3. The property of precipitating tannin not being common to all the cinchonas, it is not from this exclusively that they derive their febrifuge virtue; for there are several that do not precipitate it, and yet cure intermittent fever.

4. It appears, however, that the principle which precipitates infusion of oak bark and nut-galls is febrifuge, for the species that produce this effect are generally allowed to be the best for medicinal use.

5. On the other hand, since cinchonas which precipitate neither infusion of tan nor nut-galls are febrifuge, we must conclude, that the principle by which these precipitations are produced is not the only one in cinchona that cures fever.

6. The principle that precipitates infusion of tan and nut-galls has a brown colour and a bitter taste: it is less soluble in water than in alcohol; it precipitates, likewise, tartarised antimony, but not isinglass. It has some analogy with resinous substances, though it affords ammonia by distillation.

7. It is apparently with the tannin of oak bark and nut-galls, that this principle combines to form the precipitates it occasions in the infusions of those substances: yet, as this principle exists in some species of cinchona that precipitate isinglass at the same time, it remains questionable, whether it actually combine with the tannin of the infusion of oak bark, or whether the principle, that in other species of cinchona precipitates isinglass, be real tannin.

8. But one or the other of these suppositions must necessarily be true, since the infusions of these two sorts of cinchona mutually precipitate each other.

9. The principle, which in some species of cinchona precipitates isinglass, has a bitter and astringent taste: it is more soluble in water than that which in other species precipitates infusion of tan: it is likewise soluble in alcohol, and it does not precipitate tartarised antimony.

10. It appears, that the substance which precipitates infusion of tan is the same as that which decomposes antimoniated tartrit of potash.

We see from all these doubts, that much remains yet to be done, before we shall attain an accurate knowledge of the principle or principles in cinchona, from which it derives its efficacy in the cure of fevers. It is to be hoped, that time and assiduity will accomplish the solution of this important question.

Analysis of the salt of cinchona.

Mr. Deschamps, jun., a druggist at Lyons, is the first who appears to have announced the presence of a peculiar salt in cinchona, which must not be confounded with the essential salt of la Garaye, for this contains at the same time both resin and mucilage; but as Mr Deschamps has described only some of the physical properties of this salt, I thought it necessary to analyse it, in order to discover the nature and proportions of its principles. I have already said how this salt may be obtained and purified: here, therefore, I shall confine myself to an account of its properties.

1. This salt is white; crystallizes in square laminæ, which are sometimes rhomboidical, or truncated at their solid angles; and these laminæ frequently unite in clusters.

2. It has scarcely any taste, and is flexible between the teeth.

3. It requires about five parts of water at 50° Fahr. for its solution.

4. On burning coals it swells up like tartar, and emits a similar smell; and leaves a grayish substance, which dissolves in acids with effervescence, and is nothing but a mixture of carbonat of lime and charcoal.

5. Its solution does not alter the colour of litmus. In alcohol it is completely insoluble.

6. The fixed alkalis, whether caustic or carbonated, decompose it, and precipitate lime from it, either pure or in the state of carbonat.

7. It is not decomposed by ammonia; which proves, that its acid has a stronger affinity for lime.

8. Both sulphuric and oxalic acids form a precipitate in its solution, if it be in a tolerably concentrated state; the result being sulphat or oxalat of lime.

9. It produces no apparent alteration in solution of acetat of lead, or of nitrat of silver.

10. Concentrated sulphuric acid poured on this salt reduced to powder, blackens it slightly; but it does not emit any of the pungent vapour evolved from acetats.

11. A remarkable circumstance is, that the infusion of tan, and of some species of cinchona, that of Santa Fe for instance, occasion a yellow flocculent precipitate in the solution of this salt.

The various phænomena produced by these experiments indicating that this salt consisted of a vegetable acid and lime, in order to decompose it, and obtain the acid separate, I employed oxalic acid, which is well known to render lime most insoluble by combining with it. With this view I proceeded in the following manner:

I dissolved 100 parts of this salt in as much water as was requisite. Into this solution I poured a solution of oxalic acid from a quantity of a known weight, at different times, till no more precipitate was formed. About twenty-two parts were necessary to precipitate the whole of the lime, yet I obtained but twenty-seven parts of dry precipitate.

This proves, that the oxalic acid employed retained about half its weight of water of crystallization; and that the salt of cinchona contained but a small quantity of lime, for in twenty-seven parts of oxalat of lime there are but fifteen of this earth at most.

After having thus separated the lime from this salt by means of oxalic acid, I allowed the supernatant liquor to evaporate spontaneously; and it was thus reduced to the state of a very thick sirup, without affording any sign of crystallization, after it had stood above a week. Having stirred it, however, with a piece of glass, in order to take out a portion which I intended for another experiment, I was surprised to find the fluid crystallized a few instants after into a hard mass, formed of a great quantity of laminæ, diverging from several very distinct centres of crystallization.

It was slightly tinged of a brown colour: its taste was extremely acid and a little bitter, because the salt of cinchona I had employed had not been perfectly purified.

I shall now proceed to the properties I observed in this acid, on which however I cannot enlarge very minutely, as I had but a moderate quantity of the salt at my disposal. I believe, however, that I have examined it sufficiently to be convinced of its being a peculiar acid hitherto unknown.

In its state of crystallization it has a very acid taste, and is a little bitter*, as I have said above.

It keeps perfectly well in the open air, being neither deliquescent nor efflorescent.

On burning coals it melts very quickly, boils, grows black, emits pungent white vapours, and leaves but a very light coally residuum.

With the earths and alkalis it forms soluble and crystallizable salts.

It does not precipitate nitrat of silver, mercury, or lead, as most other vegetable acids do.

There appears no doubt, that this acid is new to us; for on reviewing the characters of all the other vegetable acids known, neither of them unites in it all the properties of this.

In fact oxalic acid forms an insoluble salt with lime, and besides decomposes the compound formed of this earth and acid of cinchona.

The citric and tartarous acids form likewise insoluble salts with lime, and decompose acetat of lead.

The malic acid does not crystallize, and precipitates acetat of lead.

The benzoic acid is but little soluble in cold water, and is volatilized without being decomposed.

The gallic acid too is but little soluble in cold water, and blackens solution of iron.

It is analogous to the acetous acid in the solubility of its combinations; but the acetous acid does not crystallize, and is volatilized without alteration.

I say nothing of the camphoric, suberic, or succinic acids, for they bear no analogy to it.

Let us thence conclude, that this acid is really different from all those hitherto known, and give it the name of *kinic* acid, from the word *quinquina*, till, becoming more intimately acquainted with its nature and combinations, we can frame a better.

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* Mr. Vauquelin has just been ascribing this bitterness to the impurity of the salt he employed, consequently it is not a character of the acid.—C.

It is to this acid united with lime, according to the report of Mr. Deschamps, that the physicians of Lyons ascribe the febrifuge virtue of cinchona. They assert, that no intermittent fever can resist two doses of this salt of thirty-six grains each.

If this assertion were proved, we might pretty easily conceive how a drachm of this salt cures an intermittent fever; for this quantity is as much as can be obtained from at least five or six ounces of common gray bark.

I cannot directly contradict this result, announced by persons of credibility and well informed; yet I think I have sufficient reason to entertain some doubts of its accuracy. In the first place, before it can deserve complete confidence, it must have been tried a great number of times, and with uniform success: for it too often happens, that effects are ascribed to medicines, which in fact are owing entirely to nature. In the art of physic, more than in any other branch of natural philosophy, causes are so complicated, that it is difficult to trace with certainty what belongs properly to each.

On the other hand physicians have learned by long experience, that the infusions and extract of bark prepared after the manner of La Garaye are far from producing equal effects in fever with the quantity of bark from which they are prepared, if this were administered in its natural state: yet these preparations contain the salt in question.

It is known too, that spirituous tinctures of bark, in which the salt of Mr. Deschamps does not exist, since it is insoluble in such menstruums, cure intermittent fevers.

Besides, there are cinchonas, which contain but extremely small quantities of this salt, and vegetables in which none of it is found, that likewise cure fevers. It is not then without reason, as is obvious, that I express my doubts on this head: if it have sometimes happened, that this salt has cured fever, we may suspect, that it had not been perfectly freed from the bitter principle, which it strongly retains.

It is desirable, however, that this question should be resolved by experiment as soon as possible: for, if the results of experience be conformable to those of the physicians of Lyons, it would certainly be a very useful discovery for mankind.—*Annales de Chimie.*

Petalite. This mineral, which is mentioned by Dandrada, is but little known. It is of a reddish colour; of a laminated fracture; fragile, but sufficiently hard to scratch glass; insusible by the blowpipe; and of the specific gravity of 2·62.

It is found at Uton, Salha, and Fingrufan, near Niakoparberg in Sweden.—*Brongniart.*

Petrifactions. Stony matters deposited either in the way of incrustation, or within the cavities of organized substances, are called petrifactions. Calcareous earth being universally diffused and capable of solution in water, either alone, or by the medium of carbonic acid or sulphuric acid, which are likewise very abundant, is deposited whenever the water or the acid becomes dissipated. In this way we have incrustations of limestone or of selenite in the form of stalactites or dropstones from the roofs of caverns and in various other situations. This simple principle of chemical deposition, operating under different circumstances, will account for a great number of striking appearances observed in the bowels of the earth. In our small and hasty experiments, a speedy and copious solution of matter is required, and we do not scruple to declare that substance insoluble, which requires one or two thousand times its weight of a fluid to dissolve and suspend it. But in the extensive and long continued operations of nature, a much less solubility will be sufficient to produce very marked effects. Hence, we may without difficulty account for the siliceous stalactites, mentioned by Chaptal, as well as the crystallized depositions of metallic bodies by us taken to be insoluble.

Systematical writers more particularly confine the term petrifaction to such organic substances as have been converted into stone, or have assumed the nature of a fossil. Much labour and erudition have been employed in giving denominations from the Greek to these, according to their apparent origin. It is perhaps difficult to show the utility of such extended catalogues. At all events less will suffice the chemist.

The most remarkable observations relative to petrifactions are thus given by Kirwan:

1st. That those of shells are found on or near the surface of the earth; those of fish deeper; and those of wood deepest. Shells in specie are found in immense quantities at considerable depths.

2dly. That those organic substances that resist putrefaction most, are frequently found petrified; such as shells and the harder species of woods: on the contrary, those that are aptest to putrefy are rarely found petrified; as fish, and the softer parts of animals, &c.

3dly. That they are most commonly found in strata of marl, chalk, lime stone, or clay, seldom in sand-stone, still more rarely in gypsum; but never in gneiss, granite, basaltes, or shoerl; but they sometimes occur among pyrites, and ores of iron, copper, and silver, and almost always consist of that species of earth, stone, or other mineral that surrounds them, sometimes of silex, agate, or carnelian.

4thly. That they are found in climates where their originals could not have existed.

5thly. That those found in slate or clay are compressed and flattened.

The arrangement of petrifactions by

Cronstedt is made under four heads; earthy, saline, inflammable, and metallic.

Calcareous petrifactions are: 1. Chalk in the form of vegetables or animals, either loose or friable: or 2. Filled with solid limestone.

Siliceous petrifactions are of the nature of flint or agate. Carnelians have been found in the form of shells, at the river Tomm in Siberia; agate in the form of wood; coralloids (millepora) of white flint; and wood of yellow flint.

This last is the produce of Italy, Adrianople, and Loughneagh, a lake in Ireland. It is the hone used to sharpen razors.

Argillaceous petrifactions have been observed in the form of the roots of trees. The osteocolla is of this kind.

Saline petrifactions are extraneous bodies penetrated by mineral salts. Human bodies have been twice found in the mine at Falun in Dalarne. The last was kept several years in a glass case, but began at length to moulder and fall to pieces. The turf and roots of trees, which are found in water strongly impregnated with sulphat of iron, are considerably changed in their nature. They do not burn with a flame, but only like a coal in a strong fire, neither do they decay in the air.

Extraneous bodies penetrated by mineral inflammable matter appear to be of the nature of pit-coal. Of this kind is jet. See that article. Vegetables are found penetrated with asphaltum in a state of less preservation than jet. The compound of sulphur and iron, or martial pyrites, is likewise the agent of petrifactions. Of these Cronstedt mentions human, bivalves, and insects, but gives no particulars of their history.

Metallic petrifactions are; 1. Of silver, either native on the surfaces of shells in England, or mineralized with copper and sulphur in the fahlertz or gray silver ore, in form of ears of corn, &c. and supposed to be vegetables. These are found in argillaceous slate at Frankenburg, and Tahlitteran in Hesse. 2. Of copper, which is either in the form of oxide, or mineralized. The oxide of copper is deposited in the parts of animals. Mineralized copper, or the cupreous pyrites, penetrates shells, and is also found in the form of fish in various parts of Germany.

The ferruginous petrifactions likewise consist of iron, either in the form of an oxide, which has assumed the place or shape of extraneous bodies (this consists chiefly of vegetables in the form of ochre or hemitites); or else the martial pyrites, which has operated as the agent of petrifaction.

PETROLEUM. Petrol, Bergoel, Steinoel. A species of BITUMEN, which see.

PETROSILEX. The same with chert, the hornstein of the Germans.

PETUNTSE. See PORCELAIN, also KAOLIN.

PEWTER, which is commonly called étain in France, and generally confounded there with true tin, is a compound metal, the basis of which is tin. The best sort consists of tin alloyed with about a twentieth, or less, of copper or other metallic bodies, as the experience of the workmen has shown to be the most conducive to the improvement of its hardness and colour, such as lead, zinc, bismuth, and antimony. There are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley pewter wine measures and large vessels.

The best sort of pewter consists of 17 parts of antimony to 100 parts of tin; but the French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, eight of antimony, one of bismuth, and four of copper. On the contrary, the ley-pewter, by comparing its specific gravity with those of the mixtures of tin and lead, must contain more than a fifth part of its weight of lead. This quantity of lead is far too much, considering some of the uses this sort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are measured, into acetat of lead; which, being taken internally, is productive of various chronic diseases, as the colica pictonum, palsies, stupors in the limbs, &c.

Foreigners generally assert, that English tin is always a mixed metal when exported abroad: and the French encyclopedists in particular (Article ETAIN) inform us, on the authority of Mr. Rouelle, that the English tin, when cast into moulds of six inches in thickness, and cooled, if it be divided into three layers, the uppermost has three pounds of copper in the 100 of tin: the second layer has five pounds of lead in the same quantity of tin; and the lowest layer has nine of lead in the 100 of tin. Geoffroy had formerly given a similar account of the English tin, with some variety in the doses. But there never was any other foundation for such an assertion, than that pewter has been mistaken for tin abroad: and in fact, all pewter dishes, and all other pewter pieces, are called by the name of tin ware all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in a greater abundance than any where else. Beside the above, neither Borlase, nor Pryce, who wrote so minutely on the method of preparing tin in Cornwall, mentions any operation or mixtures this metal undergoes or receives, before or after it is cast in the slabs, blocks, or pieces of tin, in which size and form it is sold, and sent to every market in Europe; so that the whole must be a mistake in terms, as already mentioned, by taking pewter simply for tin.

Pharmacolite. This mineral is a native arseniat of lime. Exposed to the flame of the blowpipe it diffuses a garlic smell, but is not completely volatilized, the lime remaining pure. It dissolves in nitric acid without effervescence. What has hitherto been met with is in acicular crystals, united in fibrous, radiated masses, and of a milk white colour when pure. These masses are light and friable. Their specific gravity is 2·64. According to Klaproth it consists of 0·50 arsenic acid, 0·25 lime, and 0·24 water.

This arseniat of lime is by no means common. It was first discovered by Selb, near Wittichen, in Furstemberg, disseminated in small mamillary or silky masses on a granite. As the same vein contained cobalt, its surface was tinged of a violet colour. Barytes and sulphat of lime likewise occurred in the vein. It has been found in France too, at St. Marie-aux-Mines in the Vosges, in perfectly white, fibrous, mamillary masses.—*Brongniart.*

Phlegm. Chemists have given the name phlegm to the most watery part obtained from bodies by distillation or otherwise. It is now little used.

Phlegm is frequently water mixed superabundantly, and not combined in the bobies from which it is obtained. Such are the phlegms obtained by distillation with the heat of a water-bath, from all those vegetable and animal matters which contain no principle so volatile as to rise with a less heat than that of boiling water. These phlegms, which are produced merely by drying, are nothing but water almost pure, that is, the water of vegetation: but a phlegm consisting of water which had been combined in any body, as for instance, the phlegm obtained in the distillation of oils, is far from being pure water. It is still mixed and even united with a sensible quantity of the principles of the body, and requires further operations, and chiefly the assistance of intermediate substances, to separate it perfectly.

Neither is that phlegm pure water, which, though it is superabundant, yet adheres to certain substances, especially to those that are volatile. Such are liquid volatile alkalis, and most alkalis. By distillation we may separate a considerable quantity of their phlegm or superabundant water, which operation is called dephlegmation: but this phlegm contains always a certain quantity of the saline matters with which it was originally mixed.

Hence we may see that the word phlegm signifies in general the most watery part separated from several bodies, but that is rarely pure water; and that phlegms differ from each other according to the nature of the substances from which they are obtained.

Phlogisticated Air. See Gas, Nitrogen.

Phlogisticated Alkali. Prussiat of potash. See Acid, Prussic.

Phlogiston. The whole of physical science consists in the arrangement or classification of facts. Investigation or analysis in chemistry is employed merely in discovering general results under which particular facts may be arranged, or to which they may be referred, notwithstanding the obscurity or disguise produced by individual circumstances, not essential to the phænomenon under investigation. Thus we may remark in the considerably simple motions of the heavenly bodies, that the moon revolves round the earth; but the situation of our planet renders the revolutions of the other planets round the sun less obvious. Investigation from optical principles, however proved this to be the case; and it became a considerable advance in astronomy, that the motions of all the planets could be arranged under the fact of the moon's revolution considered as a general result. In this state of knowledge it became an object of research to ascertain what general fact these motions might be referred to. Des Cartes referred them to the motion of a floating body carried round by a vortex or whirling current of water. It was afterwards ascertained from the more general facts of bodies in motion, that the revolutions of the planets and those of floating bodies are by no means of the same kind. Newton was accidentally led to consider the path of bodies projected near the surface of the earth; and he found by accurate examination, that the moon is a projectile kept from falling by a force impressed on it, in the same manner as a stone is made to describe a curve through the air, which last only wants a sufficient impulse to carry it round the earth in an orbit. Here then we see a genera fact of another and more remote kind. Copernicus generalized the celestial motions by merely referring them to the moon's motion. Newton generalized them still more by referring this last to the motion of a stone through the air. And yet farther this motion of the stone was shown to be referable to two simple facts, namely, the uniform motion of a body acted on by a past impulse, and the accelerated motion of a body constantly acted upon by gravitation or the cause of weight. Thus far astronomers have proceeded in this department of science, and at this point they are at a stand; because no facts more simple have yet been remarked, under which the communication of motion either by impulse or gravitation can be classed.

From this familiar elucidation of the progress of astronomical science, which is very simple, it may easily be seen how great the probability is, that errour may arise from classing facts under others of a different nature; and that, when a combination of truth and falsehood is exhibited, as the means of explaining natural phænomena, the former may be made to support and maintain the latter, as was the case with the system of Copernicus united with the vortices of des Cartes. It may also be remarked, that the false results, which from time to time are incorporated with the materials of any branch of philosophy, owe their establishment to superficial views, and the apparent or partial resemblance, which seduces the cultivators of infant science: and that they generally maintain their ground until some very considerable addition is made to the general mass of information.

Without pretending to enter the wide field of chemical history, we may in a few words observe, that from the nature of things, the first chemical operations must have consisted in the effects of heat applied to bodies in the operations of cookery, of pottery, and of mine works, which accordingly have existed, at least, as early as history itself. The operations in the humid way with saline substances appear to have been of much later date. And those upon bodies in the aëriform state are still more modern. These three classes of operations comprehend the whole of chemistry, and would naturally lead us to consider the subject of phlogiston, as it is supposed to exhibit itself in the dry, the humid, and the aëriform processes: but these processes are so frequently combined together, that it is scarcely possible to treat of them separately.

When bodies are heated to such a degree as to emit light, there are some which if left to themselves in the open air become cold again without any perceptible change in their properties; and there are others which retain their ignition, and even become hotter, until an entire decomposition of the whole substance has taken place. This process is well known by the name of combustion or burning, and the distinction of bodies into combustible and incombustible is one of the most striking and distinct of any we are acquainted with. That a combustible body must have something in its properties or component parts not to be found in an incombustible body is evident. But it is not always easy to distinguish the existence of a property from that of a component part. For any thing we know on this obscure subject, two bodies may agree in certain properties and differ in others; whence it may follow, that bodies may agree in the property of combustibility, and yet possess no common principle or component part. It was nevertheless a habit of reasoning much indulged in the middle ages, to refer effects rather to distinct substances than to habitudes or properties.

The ancient chemists did not therefore so much endeavour to explain combustibility as a property, as to ascertain what might be the principle of combustibility in bodies. They looked round for general facts. Their attention became fixed on such bodies as are the most eminently combustible. They supposed these bodies to exist in various proportions in other bodies capable of being burned. In this way the science of chemistry came to be filled with accounts of the oils and sulphurs of bodies. But as it was not found practicable to exhibit these oils or sulphurs, a distinction was consequently made between the gross oils and sulphurs, and the more subtle or philosophical matters of the same denomination, which were supposed to give inflammability to bodies.

As this refinement was carried farther, the denominations themselves were dismissed; and by the perspicuous modifications of Becher and Stahl, a common principle of inflammability, identical, and always similar to itself, capable of being extricated from bodies, and transferrable from one body to another in certain circumstances, was universally admitted by chemists under the denomination of phlogiston. The nature of the phlogiston was to be investigated from the facts. The most striking fact is, that the temperature of bodies becomes raised in those circumstances where the phlogiston is said to be extricated. The phlogiston was therefore considered to be elementary fire, existing as one of the principles of combustible bodies, deprived of its most eminent property while in this state of combination, but exhibiting all its distinctive attributes at the instant of disengagement.

The doctrine of heat, though of such extensive importance in almost every natural change, continued long in an unimproved state, because the facts are in general simple, and not easily analysed and referred to facts still simpler. Yet the moderns in their reflections on this subject could not but perceive, that the temperature of bodies, and consequently the matter of heat, if such a thing exist, distributes itself with a sort of equality, as well through incombustible as combustible bodies. While the various capacities of bodies were unknown, the disposition of heat to enter into all bodies must have appeared to be absolutely equal. It was not easy to reconcile this with Stahl's doctrine of phlogiston or fixed fire. Again, this doctrine overlooks the necessity of respirable air in the process of combustion.

The more modern chemists were obliged to make considerable alterations, and those who maintained the phlogiston found themselves obliged to return to the old doctrine of sulphur and oils, though in more general terms. With them the phlogiston was not fixed fire, but some identical substance, the property of which is to be combustible, viz. to unite with respirable air, when at a certain temperature, and to produce, extricate, or develop heat. But what this substance might be was indetermined. For a time it was supposed, according to the hypothesis of Kirwan, to be hidrogen in a combined state. But it has not been possible to extricate hidrogen from the metals, excepting when water was present, of which this air is found to be a component part. This doctrine is at length abandoned, as all the phænomena are more readily explained by the simple absorption of oxigen, which incontrovertibly takes place.

It must not be disguised, however, that in all the processes formerly explained by the doctrine of phlogiston, very remarkable changes are also seen in the development and disappearance of heat and light and in the capacities of the bodies affected; and that many of the modern chemists take as great liberties in the use of a supposed caloric, or matter of heat, in their explanations, as the earlier chemists did with their phlogiston.

Since the doctrine of phlogiston was tacitly established upon the position, that a common principle of combustibility is necessary for the explanation of the facts; and as this position is assumed but not proved, we shall gain a different view of the subject by rejecting it, and substituting the property of rapidly combining with oxigen. This is simply the doctrine of the modern, or antiphlogistian chemists. There is no inconsistency in affirming that bodies may be strongly disposed to inflammability, and yet differ in every other property. Let us then, say they, reject as mere supposition, the notion that they do agree in any other respect than such as may be indicated by positive facts. The facts of combustion are simply, that oxigen gas is absorbed and enters into combination, while heat is given out. Elastic fluids are known to contain more heat in that state than when condensed. Much heat must therefore arise from the condensation of the oxigen gas. It does not necessarily follow, that any heat came from an equal change of circumstances from an incombustible body, or at least not more than might have been extricated under an equal change of circumstances from an incombustible body. Whence it follows, that the simple explanation of combustion from the facts is, that the combustible body has a strong attraction for oxigen, at a certain temperature, that it has attracted this fluid with the production of heat during the combination, and that its properties are changed. See CALORIC.

In two theories, which differ so widely as that the one subtracts where the other adds, it must be a material, though not a decisive point, to ascertain whether the body under consideration becomes heavier or lighter by being burned. In this respect the antiphlogistian theory has the advantage; for, in all experiments which have been accurately made, bodies gain weight by being burned. If the residues of combustion were in all cases fixed, it would be easy to ascertain this general fact. But in all organized substances, and many among those of the mineral kingdom, most of the products assume the vapourous or elastic state. When the vapour is condensible, it is easier to ascertain its weight, than when it continues elastic. There are many difficulties, however, which attend the accurate accomplishment of experiments, wherein a known supply of oxigen is required to be given to the combustible matter, and the products are to be received, condensed, measured, or weighed. A notion of these difficulties may be had by consulting the writings of Lavoisier. This chemist found, by burning alcohol in a lamp with a serpentine chimney kept cool upon the principle of the worm of a still, nearly seventeen ounces of water were collected from sixteen of the spirit; and it is known that a considerable product of carbonic acid must also have been lost.

The metals, which are truly combustible bodies, though few of them will burn in the common air of the atmosphere without the assistance of foreign heat, exhibit this increase of weight in a remarkable manner. The general facts are, 1. There is no elastic fluid which is capable of calcining, burning, or oxiding the metals but oxigen gas. 2. They are not oxided by atmospheric air, but in proportion to the quantity of oxigen it contains. 3. In proportion as they burn, they absorb, condense, and fix this oxigen; whence it is inferred, that the latter abandons that which held it fused, or divided in a state of an elastic fluid. 4. Hence it is only the solid part of oxigen which unites to metals. 5. And for this reason it is, that rapid combustion is attended with a disengagement of heat and light. 6. But as the heat and light are bodies of such levity that their weight cannot be appreciated by our instruments, the loss and disengagement of these, which Lavoisier supposes to be principles, make no change in the weights of our experiments. 7. Metals therefore increase in weight by the quantity of oxigen they fix during their combustion. 8. All the semimetals, and imperfect metals, present absolutely the same phænomena, and are therefore facts of the same kind. 9. In all the various processes by which metals are oxided, otherwise than by means of the air, they undergo absolutely the same modification, their weight increases, and they lose their metallic state in the same manner as by the simultaneous action of heat and the air. Mr. Fourcroy calls these positive and simple facts, though indeed they include the consideration of the materiality of heat, which may perhaps be no more a separate matter than phlogiston.

He afterward adds the following observations: 1. That the metals differ in the several quantities of oxigen they require for their saturation. 2. That some lose this principle by the simple contact of heat and light, sometimes even by the action of the latter only assisted by very little heat.

3. That the greater number do not admit of this, and are not therefore reducible by these agents. 4. That no induction can be made from this difference in the metallic oxides, any more than it could be fairly concluded that neutral sulphuric salts do not contain the same acid as the metallic vitriols, because the latter are decomposable by mere heat, and the former not. 5. That not only the oxigen is absorbed in different doses, but that it is likewise combined in them, after privation of a greater or less quantity of the matter of heat, and of light; and that the capacities of the residues or oxides for heat will differ accordingly. 6. That each metallic oxide may exist in different states of oxidation from the absorption of the smallest quantity possible of oxigen to that which is necessary for saturating the metal: so that the oxidation of each metal stops, as it were, at different degrees. Thus it is that lead becomes oxided, first of a gray, and then of a yellow and red colour, and iron is black and brown. 7. That the periods of oxidation in each metal depend on circumstances, which are more or less favourable to the attraction of the metals for oxigen; the principal of which circumstances is a certain temperature, neither too high nor too low. Thus a certain metal will absorb and fix only a very small quantity of the oxigen of the atmosphere, and never becomes any thing but an oxide of a certain nature, at the usual temperature, whereas it will fix a much greater quantity, and its calcination will become complete, if it be strongly heated; such as zinc, iron, &c. 8. That the different metallic substances differ in their attractions for the basis of oxigen, part of which attractions have been already ascertained as to their order, by Bergman; who, according to the system of phlogiston, remarked, that the precipitation of metals in acids by each other follows the same order in all acids, and must therefore depend much more on their disposition to become calcined or oxided, than on their respective attractions for the acid solvent. 9. Lastly, the metallic oxides are decomposed and reduced to the metallic state by the laws of attraction followed by the oxigen. Thus heat separates it from some, one metal takes it from another, hidrogen takes it from most metals, and carbon, or pure charcoal, perhaps from all.

Among the few metals which are capable of calcination and reduction by mere heat, there is no one which sets the theory of that process, and the doctrine of the antiphlogistians, in so clear a point of view as mercury. Lavoisier gives a very perspicuous account of the experiment*, which can be performed only on a small scale.

He took a mattrass of about 36 cubical inches capacity, having a long neck of six or seven lines internal diameter, which was bended first sideways like that of a retort, and then in a reverse direction upward, so as conveniently to be inserted beneath an inverted jar of mercury for pneumatic experiments. Into this mattrass was introduced four ounces of mercury, and a portion of the air was then drawn out of the receiver by means of a siphon, and the station of the mercury noted in this vessel by pasting a slip of paper on its external surface. Having accurately noted the height of the thermometer and barometer, he lighted a fire in a furnace, which he kept up almost continually for twelve days, so as to keep the quicksilver always very near its boiling point. Nothing remarkable took place during the first day; the mercury, though not boiling, was continually evaporating, and covered the interior surface of the vessel with small drops, at first very minute, which, gradually augmenting to a sufficient size, fell back into the mass at the bottom of the vessel. On the second day small red particles began to appear on the surface of the mercury: these, during the four or five following days, gradually increased in size and number, after which they ceased to increase in either respect. At the end of twelve days, seeing that the oxidation of the mercury did not at all increase, he extinguished the fire, and allowed the vessels to cool. The bulk of air in the body and neck of the mattrass, and in the bell-glass, reduced to a medium of 28 inches of the barometer, and 54·5° of the thermometer, at the commencement of the experiment was about fifty cubical inches. At the end of the experiment the remaining air, reduced to the same medium, pressure and temperature, was only between forty-two and forty-three cubical inches; consequently it had lost about one sixth of its bulk. Afterward, having collected all the red particles, formed during the experiment, from the running mercury in which they floated, he found these to amount to forty-five grains.

Mr. Lavoisier was obliged to repeat this experiment several times, as it is difficult in one experiment both to preserve the whole air upon which we operate, and to collect the whole of the red particles or oxide of mercury which is formed during the oxidation.

The air which remained after the oxidation of the mercury in this experiment, and which was reduced to five sixths of its former bulk, was no longer fit either for respiration or for combustion; animals being introduced into it were suffocated in a few seconds, and when a taper was plunged into

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[*] Elements of Chemistry. The remarks as well as the account of the experiment, are Lavoisier's.

it, it was extinguished as if it had been immersed in water.

In the next place, he took forty-five grains of the red matter formed during this experiment, which he put into a small glass retort, having a proper apparatus for receiving such liquid, or gaseous product, as might be extracted. having applied a fire to the retort in the furnace, he observed, that, in proportion as the red matter became heated, the intensity of its colour augmented. When the retort was almost red-hot, the red matter began gradually to decrease in bulk, and in a few minutes after it disappeared altogether; at the same time forty-one grains and a half of running mercury were collected in the recipient, and seven or eight cubical inches of elastic fluid, greatly more capable of supporting both respiration and combustion than atmospherical air, were collected in the pneumatic apparatus.

A part of this air, being put into a glass tube of about an inch diameter, showed the following properties:—A taper burned in it with dazzling splendour; and charcoal, instead of consuming quietly, as it does in common air, burnt with a flame, and attended with a decrepitating noise, like phosphorus, and threw out such a brilliant light, that the eyes could hardly endure it. This is the air to which Dr. Priestley gave the name of dephlogisticated. See AIR, ATMOSPHERICAL, and GAS, OXIGEN.

In reflecting upon the circumstances of this experiment, we readily perceive that the mercury, during its oxidation, absorbs the salubrious and respirable part of the air, or, to speak more strictly, the base of this respirable part; that the remaining part is a species of gas, incapable of supporting combustion or respiration; and consequently that atmospheric air is composed of two elastic fluids of different and opposite qualities. As a proof of this important truth, if we recombine these two elastic fluids, which we have separately obtained in the above experiment, viz. the forty-two cubical inches of nonrespirable air, with the eight cubical inches of respirable air, we reproduce an air precisely similar to that of the atmosphere, and possessing nearly the same power of supporting combustion and respiration, and of contributing to the oxidation of metals.

Although this experiment furnishes us with a very simple means of obtaining the two principal elastic fluids, which compose our atmosphere, separate from each other, yet it does not give us an exact idea of the proportion in which these two enter into its composition: for the attraction of mercury to the respirable part of the air, or rather to its base, is not sufficiently strong to overcome all the circumstances which oppose this union. These obstacles are the mutual adhesion of the two constituent parts of the atmosphere tor each other, and the elective attraction which unites the base of oxigen with caloric: in consequence of these, when the oxidation ends, or is at least carried as far as is possible, in a determinate quantity of atmospheric air, there still remains a portion of respirable air united to the mephitis, which the mercury cannot separate. It is ascertained from other experiments, that, at least in our climate, the atmospheric air is composed of respirable and mephitic airs, in the proportion of twenty-one and half of the former, and seventy-eight and half of the latter, by measure.

Since, during the oxidation of mercury, air is decomposed, and the base of its respirable part is fixed and combined with the mercury, it follows from tho general facts relating to combustion, that heat and light must be disengaged during the process. But the two following causes prevent us from being sensible of this taking place: as the oxidation lasts during several days, the disengagement of heat and light, spread out in a considerable space of time, becomes extremely small for each particular moment of the time, so as not to be perceptible; and the operation being carried on by means of fire in a furnace, the heat produced by the oxidation itself becomes confounded with that proceeding from the furnace. To this might be added, that the respirable part of the air, or rather its base, in entering into combination with the mercury, does not part with all the heat which it contained, but still retains a part of it in the new compound; but the discussion of this point, and its proofs from experiment, do not belong to this part of our subject.

The disengagement of heat and light is rendered apparent to the senses, when the decomposition of air takes place in a more rapid manner; for this purpose iron is excellently adapted, as it possesses a much stronger affinity for the base of respirable air than mercury. The following elegant experiment of Dr. Ingenhousz, upon the combustion of iron, is well known. Take a piece of fine iron wire, twisted into a spiral, fix one of its extremities into a cork, adapted to the neck of a bottle, and fix to the other extremity of the wire a small morsel of tinder. Matters being thus prepared, fill the bottle with oxigen gas, then light the tinder, and introduce it quickly with the wire upon which it is fixed into the bottle, which stop up with the cork. The instant the lighted tinder comes into contact with the oxigen, it begins to burn with great intensity; and, communicating the inflammation to the iron wire, it too takes fire, and burns rapidly, throwing out brilliant sparks: these fall to the bottom of the vessel in rounded globules, which become black in cooling, but retain a degree of metallic splendour. The iron thus burnt is more brittle even than glass, is easily reduced into powder, and is still attractable by the magnet, though not so powerfully as it was before combustion.

Lavoisier repeated this experiment with a view to ascertain the products. Having filled a bell-glass of about six pints measure with oxigen gas, he transported this jar by means of a very flat vessel into a quicksilver bath, taking care to render the surface of the mercury perfectly dry, both within and without the jar, with blotting paper. He then provided a small cup of china-ware, very flat and open, in which he placed some small pieces of iron, turned spirally, and arranged in such a way as seemed most favourable for the combustion being communicated to every part. To the end of one of these pieces of iron was fixed a small piece of tinder, to which was added about the sixteenth part of a grain of phosphorus; and, by raising the bell-glass a little, the china-cup with its contents was introduced into the pure air. It is true that by this means some common air must mix with the pure air in the glass; but this, when it is done dexterously, says Mr. Lavoisier, is so very trifling, as not to injure the success of the experiment. This being done, a part of the air was sucked out from the bell-glass, by means of a siphon, so as to raise the mercury within the glass; and to prevent the mercury from getting into the siphon, a small piece of paper was twisted round its extremity. In sucking out the air, if the motion of the lungs only be used, we cannot make the mercury rise above an inch or an inch and a half: but, by properly using the muscles of the mouth, we can, without difficulty, cause it to rise six or seven inches.

He then took an iron wire, properly bent for the purpose, and making it red-hot in the fire, pressed it through the mercury into the receiver, and brought it into contact with the small piece of phosphorus attached to the tinder. The phosphorus instantly took fire, which communicated to the tinder, and from that to the iron. When the pieces have been properly arranged, the whole iron burns, even to the last particle, throwing out a white brilliant light, similar to that of Chinese fire-works. The great heat produced by this combustion melts the iron into round globules of different sizes, most of which fall into the china-cup; but some are thrown out of it, and swim on the surface of the mercury. At the beginning of the combustion, there is a slight augmentation in the volume of the air in the bell-glass, from the dilatation caused by the heat; but presently afterward a rapid diminution of the air takes place, and the mercury rises in the glass; insomuch that when the quantity of iron is sufficient, and the air operated upon is very pure, almost the whole air employed is absorbed.

It is proper to remark in this place, that, unless in making experiments for the purpose of discovery, it is better to be contented with burning a moderate quantity of iron; for when this experiment is pushed too far, so as to absorb much of the air, the cup which floats upon the quicksilver, approaches too near the upper part of the bell-glass; and the great heat produced, which is followed by a very sudden cooling, occasioned by the contact of the cold mercury, is apt to break the glass; in which case the sudden fall of the column of mercury, which happens the moment the least flaw is produced in the glass, causes such a wave, as throws a great part of the quicksilver from the basin. To avoid this inconvenience, and to insure success to the experiment, one drachm and a half of iron is sufficient to burn in a bell-glass, which holds about eight pints of air. The glass ought likewise to be strong, that it may be able to bear the weight of the column of mercury which it has to support.

By this experiment it is not possible to determine at one time, both the additional weight acquired by the iron, and the changes which have taken place in the air. If it be the wish of the operator to ascertain what additional weight has been gained by the iron, and the proportion between that and the air absorbed, we must carefully mark upon the bell-glass, with a diamond, the height of the mercury, both before and after the experiment. After this, the siphon, guarded as before with a bit of paper to prevent its filling with mercury, is to be introduced under the bell-glass, having the thumb placed upon the extremity of the siphon, to regulate the passage of the air, and by this means the air is gradually admitted, so as to let the mercury fall to its level. This being done, the bell-glass is to be carefully removed, the globules of melted iron contained in the cup, and those which have been scattered about, and swim upon the mercury, are to be accurately collected, and the whole is to be weighed. The iron will be found in that state called martial ethiops by the old chemists, possessing a degree of metallic brilliancy, very friable, and readily reducible into powder under the hammer, or with a pestle and mortar. If the experiment have succeeded well, from a hundred grains of iron will be obtained a hundred and thirty-five or a hundred and thirty-six grains of ethiops, which is an augmentation of thirty-five per cent.

If all the attention have been paid to this experiment which it deserves, the air will be found diminished in weight exactly equal to what the iron has gained. Having therefore burnt one hundred grains of iron, which has acquired an additional weight of thirty-five grains, the diminution of air will be found exactly seventy cubical inches; and as it is known that the weight of oxigen is very near half a grain for each cubical inch, the augmentation of weight in the one exactly coincides with the loss of it in the other.

If it be required to examine the nature of the air, which remains after this experiment, we must operate in a somewhat different manner. After the combustion is finished, and the vessels have cooled, we first take out the cup, and the burnt iron, by introducing the hand through the quicksilver, under the bell-glass; we next introduce some solution of potash, or pure alkali, or of the sulphuret of potash, or such other substances as are judged proper for examining their action upon the residuum of the air. After this examination, so much water must be let into the glass as will displace the quicksilver; and then, by means of a shallow dish placed below the bell-glass, it is to be removed into the common water pneumato-chemical apparatus, where the air remaining may be examined at large, and with great facility.

When very soft and very pure iron has been employed in this experiment, and when the combustion has been performed in the purest respirable or oxigen gas, free from admixture of the noxious or mephitic part, the air which remains after the combustion will be found as pure as it was before; but it is difficult to find iron entirely free from a small portion of charry matter, which is chiefly abundant in steel; and it is likewise exceedingly difficult to procure pure air perfectly free from some admixture of nitrogen, with which it is almost always contaminated: this air, as Mr. Lavoisier affirms, does not in the smallest degree disturb the result of the experiment, as it is always found at the end exactly in the same quantity as at the beginning.

The oxidation of metallic substances by the action of acids is evidently an operation of the same nature as that which is effected by heat and oxigen gas. Numberless experiments have shown, that oxigen is a component part of acids. But this being a modern discovery, the theory of phlogiston was applied to the acids, which were supposed to be capable of attracting or expelling that principle from metallic bodies as well as other substances. On this head the several articles relating to the acids and metals may be consulted. It must nevertheless be admitted, that as oxigen is known to be a component part of acids, as they lose a portion of it whenever they are employed to oxide any metal, as the oxide is found to have gained this very principle, it appears unnecessary or redundant to admit phlogiston in explaining these effects. The general facts of metallic solution are,

1. The metals cannot unite with acids unless previously oxided, or united with the base of oxigen gas. This therefore appears to be the medium of the union.

2. The degree of oxidation for this purpose is definite. If too near the metallic state, they are difficultly taken up; and if too much oxided, they cease to be suspended.

3. This degree differs in the several metals.

4. In every metallic solution by an acid, the metal attracts and combines with oxigen, either from the acid which is decomposed, or from the atmosphere which is rendered less salubrious, or else from the water which is decomposed. See Water. In the first case, one of the principles of the acid, or its base, is set at liberty, and usually flies off, as sulphur in the decomposition of sulphuric acid, in the composition of sulphurous gas, or either nitrogen or nitrous gas when nitric solutions are made. In the second case, as in the acetous solution of copper, which only takes place when atmospheric or oxigen gas is present, this last fluid is absorbed. And in the third there is a disengagement of hidrogen. It is deduced, that the hidrogen is afforded by the decomposition of the water, because the acid is found, when disengaged from the metal*, to be capable of forming as much neutral salt with an alkali as a like quantity of the same acid would do.

5. The muriatic acid, and such vegetable acids as are composed of bases which have a stronger attraction for oxigen than the metals have, are not decomposed by the metals, and accordingly they are not dissolved unless water or oxigen be present in sufficient abundance. And these solutions either emit hidrogen, or do not effervesce at all.

6. The disposition of these acids to unite with the oxide, or combination of metal and oxigen, greatly favours the attraction of that fluid. So that metals which would long remain exposed to the air without oxidation will attract oxigen when in contact with an acid: and other metals, copper for instance, which is not capable of decomposing water alone at any obtainable temperature, will effect it by the help of an acid.

There are some cases, in which the water and the acid are at the same time decomposed by the metal, as in the solution of tin by the nitric acid. Tin is so strongly attractive of oxigen, and requires so large a quantity for its saturation, that after having absorbed that of the nitric acid, and reduced it to the state of nitrogen gas, it decomposes the water, and disengages hidrogen. These two principles, being thus separated from their first compounds, unite together, and form ammonia. See Gas, Ammoniacal. Hence there is no perceptible disengagement of elastic fluid. In this case it appears, that the formation of ammonia in the solution of tin by the nitric acid always takes

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* This experiment was well performed by Dr. G. Fordyce with zinc and sulphuric acid. See Phil. Trans. or the article Zinc.

place; for by throwing quicklime or pure fixed alkali into this solution, there is always a disengagement of ammonia.

7. It follows from all that has hitherto been said, that in every metallic solution, in which the acid is decomposed, two doses of this salt are required, of which the mind conceives the necessity. 1. That, the decomposition of which supplies the metal with oxigen. 2. That which dissolves the oxided metal.

8. Hence, if no greater quantity of acid be added to a metal, than is necessary for its oxidation, it will be oxided, and not dissolved. Thus it is, that a few drops of concentrated nitric acid being thrown upon tin, antimony, bismuth, and even zinc, quickly reduce the metals into white, dry, and pulverulent oxides.

9. From this accurate distinction of the two doses of acid, we see why a metal, though very greedy of oxigen, does not decompose this acid sufficiently, nor deprive it of enough of oxigen, to saturate itself; for if too highly charged with this principle, it would not unite to the undecomposed portion of the acid, and there would be no solution; but instead of saturating itself in this manner, in proportion as the metal arrives at the determinate point of oxidation, the acid dissolves it, and the metal does not decompose it beyond that point, because its affinity with the acid is then stronger than with a greater dose of oxigen.

10. Various circumstances, and especially an elevated temperature, change these attractions; they increase that of the metal for oxigen, and by favouring its saturation with that principle, they either prevent its uniting with the acid, or effect its separation: the former event takes place in the mixtures of acids and metals, the mutual action of which is increased by a strong temperature, and the latter takes place in most metallic solutions, when they are too strongly heated.

11. Most metallic solutions, which are left exposed to the air, absorb oxigen with more or less facility; and the metals which they contain, becoming more oxided than before, separate and fall down; so that there is not one of these solutions which remains in the same state if exposed to air, or which can be considered as absolutely permanent.

12. Since the metals cannot remain united to the acids, but in the state of oxides of a determinate degree, it is easily conceived, that, by plunging into a metallic solution a metal, which has a stronger affinity with oxigen than that which is dissolved, the former must deprive the latter of its oxigen, take its place in the acid, and cause the second to subside in a form more or less metallic, accordingly as it has deprived it of more or less oxigen. This is the reason of the precipitation of silver by copper, copper by iron, &c.

It may easily be perceived, that the great questions relating to phlogiston in the oxidation, solution, and precipitation of metallic substances are intimately connected with the composition and decomposition of water. On this subject see WATER.

PHOSPHORUS (ENGLISH), *or* KUNCKEL'S PHOSPHORUS. The name phosphorus is applied to all substances capable of giving light in the dark; such as glow-worms, rotten wood, diamonds after having been exposed to the sun or light; the Bolognian stone, and certain spars after calcination. The effects of these phosphoric matters may proceed from electricity, or some property of light. We shall mention these in the following article. The phosphorus we now treat of is of a very different nature. It is a substance not only luminous in the dark, but also inflammable and burning; and it is the basis of a peculiar acid.

The knowledge of this phosphorus is not very ancient: it was discovered by a citizen of Hamburgh, called Brandt, in his researches for the philosopher's stone. Kunckel was desirous to acquire this secret, and for this purpose associated himself with one of his friends, called Kraaft; who, thinking by means of it to make a fortune, resolved, after having procured it, not to reveal it, and even obtained a promise from the inventor, not to communicate it to Kunckel. Kunckel, vexed by this treachery, resolved to search for the phosphorus: and although he knew no more of the process, than that urine was the substance employed, he prosecuted this inquiry with such zeal, that at length he made phosphorus. This chemist took to himself very justly the honour of having discovered it, and was accordingly considered as one of the discoverers of it, with so much more reason, as he did not find it by chance, and without searching for it, as Brandt had done, but after a rational inquiry undertaken for this purpose. Accordingly Kunckel's name is affixed to this phosphorus, which is commonly called the phosphorus of Kunckel.

The celebrated Mr. Boyle has also had the reputation of having made this discovery. Those who give him the credit of this say, that Boyle, having seen a piece of phosphorus in England in 1679, which Kraaft had carried thither to show to the king and queen of England; and having been informed only, that this phosphorus was produced from some matter belonging to the human body, attempted, like Kunckel, to discover the method of preparing it; and in the following year actually made a small quantity, which he lodged with the secretary of the Royal Society, who gave him a receipt for it. But Stahl, in a small work called the Three Hundred Experiments, says, that Kraaft told him, that he communicated the process to Mr. Boyle. If this be true, Boyle has claimed the honour of a discovery to which he had no right; an unputation injurious to the reputation of a man so justly famous. But it must be acknowledged, that the truth of this imputation is very questionable. For Kraaft, who, as Stahl relates, was ignorant of chemistry, and who had been treacherous to Kunckel, was nothing in all this affair of phosphorus but a trader in secrets. For having purchased the secret of preparing phosphorus, he sold it again every where; and therefore no credit is to be given to the testimony of such a man.

It is not indeed probable, that a man of such undoubted integrity as Boyle would have communicated the process to the Royal Society as his own, if this had been the case. Neither does the invention appear to be of such magnitude, as not to be easily hit upon by those who were determined to spare no pains or attention in the pursuit of discovery, as was the case with the chemists of that day, most of whom indulged extravagant hopes. The process of Boyle consisted in nothing more than distilling urine, till the last volatile product came over, which is the phosphorus; and he used no other artifice to facilitate the operation, than that of first evaporating the fluid part of the urine, until it became of the consistence of sirup. He then mixed this liquid with thrice its weight of fine sand, and exposed the whole to distillation for twelve hours, the fire being made as intense as possible for the last six hours.

Boyle communicated the process for making phosphorus to a German chemist called Godfrey Hantkwitz, who accordingly prepared it in London. Kunckel and he were then the only persons, who made any considerable quantity of it, and the latter made a lucrative trade of it. Stahl says, that he knew also this Mr. Hantkwitz, and considered him as a good practical chemist, and that he had an excellent laboratory in London. A descendant of his still keeps a respectable chemist's shop in Southampton-street, Covent-Garden, which has always been famous for the extreme purity of the articles sold. The date 1680 is over the door.

Processes for making phosphorus were frequently published about that time. Mr. Hellot, in his Memoir on the subject, enumerates all that were then known, namely, the process published by Boyle in 1680, in the Philosophical Transactions, No. 196; that of Kraaft; for, after selling the secret to many persons, he afterward published it in a treatise concerning phosphorus, written by the Abbé de Commieres, published in the Mercure Galant, for June 1683; that of Brandt, in a collection of Experiments and Observations of Dr. Hook, published by Mr. Derham in 1726; that of Mr. Homberg, in the Ancient Memoirs of the Academy, in 1692, who says, that he had seen Kunckel make phosphorus; and lastly, the processes found in the works of several chemists, particularly of Theikmeyer, Hof man and Neewentuit.

But notwithstanding all these process whether they were not sufficiently co plete, or too laborious and expensive, chemist, excepting Hantkwitz, made pho phorus, and the operation still continued secret till the year 1737, when a strang came into France, who offered to ma phosphorus. The ministry granted him reward for his process, which he accordin ly communicated. Messrs. Hellot, Duf Geoffroy, and Duhamel, all experimen philosophers and chemists of the Acade of Sciences, executed this process succe fully. Mr. Hellot wrote a distinct accou of it, and published it amongst the Memo of the Academy of Sciences for the y 1737; a large extract of which may found in the Elements of Practical Chemist

Since the publication of the memoir Mr. Hellot, the process of phosphorus no longer a secret. But as this operati has hitherto been rather curious than u ful, and is also expensive and troubleso Macquer says, he does not know that French chemist repeated it at that time, cepting Mr. Rouelle, who soon afterwa began a course of chemistry, in which undertook to make phosphorus in the p sence of his pupils. Macquer was t present as one of these, and Hellot atten during the whole operation. The pu continued there the whole night; but fr a fault in the retort this first operat failed. However, in the year followi Mr. Rouelle succeeded many times.

To make phosphorus by Mr. Margra process, a kind of muriat of lead is previo ly prepared, by distilling a mixture of f pounds of minium with two pounds of p dered sal ammoniac, from which all the a monia is by this operation obtained. residuum after the distillation, that is, muriat of lead, is to be mixed with nine ten pounds of extract of urine boiled the consistence of honey. Margraaf quires, that this urine should be putref which is unnecessary according to B mé's observation. This mixture is to made slowly in an iron caldron set upon fire, and by frequently stirring the matt Half a pound of powdered charcoal is t to be added, and evaporation is to be co nued till the whole is reduced into a bl powder. This powder is to be put in retort, to extract from it, by a mode and graduated heat, all the volatile p ducts of urine; that is, ammonia, fetid and an ammoniacal matter which adh to the neck of the retort. In this dist tion the heat is to be only raised so a make the matter red-hot. After the di lation, a black and friable residuum mains, from which the phosphorus is to extracted by a second distillation, an stronger heat. Before it is exposed to other distillation, it may be tried, by thr ing some of it upon hot coals. If the matter have been well prepared, a smell of garlic exhales from it, and a blue phosphorical flame is seen, undulating along the surface of the hot coals.

This matter is to be put into a good earthen retort capable of sustaining a violent fire. Margraaf recommends retorts of Waldenburgh, or those which are made near Kirchan in Saxony; but in France they use Hessian retorts, although they have the inconvenience of allowing a large quantity of phosphorus to transpire during the operation. Baumé secures his retorts with a covering of clay and hair. Our Staffordshire potters make good earthen retorts for this purpose. They may be previously washed over with a strong solution of two parts of borax and one of lime, which by a strong heat forms an impervious glaze; and may be farther coated with clay and sand.

Three quarters of the retort are to be filled with the matter which is to yield the phosphorus. It is to be placed in the common furnace for distillation with a retort; excepting that, instead of being terminated by an ordinary reverberatory or dome, this ought to be terminated by the upper piece of an air-furnace, to which a tube is to be applied, the diameter of which ought to be from four to six inches, according to the size of the furnace, and the height from eight to nine feet. This apparatus, which Baumé uses, is necessary for raising a sufficient heat, and for the convenience of throwing in a sufficient quantity of fuel through the door of the upper piece of the furnace. The retort ought to be well luted to a receiver of moderate size, pierced with a small hole, and half full of water. For this purpose ordinary fat lute may be bound on with strips of linen, dipped in a lute prepared with lime and whites of eggs. The hole in the furnace through which the neck of the retort passes ought to be well stopped with furnace earth. Lastly, a small wall of bricks is raised betwixt the furnace and receiver, to guard this vessel against heat as much as is possible.

All these preparations being made the evening before the distillation is to be performed, we are then capable of proceeding to this operation, which is very easy. The retort is to be heated by slow degrees during an hour and a half; and then the heat is to be increased till the retort is red-hot, and the phosphorus begins to pass in luminous vapours: when the retort is almost of a white heat, the phosphorus passes in drops, which fall and congeal in the water at the bottom of the receiver. This degree of heat is continued till no more passes into the receiver. When a retort contains 8 pints or more, this operation continues about five hours.

Margraaf's apparatus is somewhat different from that above described. He divides the whole quantity of matter from which the phosphorus is to be obtained into six small retorts, which he places in a furnace that he describes. The advantage of this division is, that, if any accident happen to one retort, the whole matter is not lost; and as the retorts are smaller, a less heat is required. If indeed much phosphorus were to be made, this practice would be safe and excellent; but Macquer affirms, that the method above described of Baumé is very convenient, when a large quantity of phosphorus is not wanted, and that he has never seen it fail.

Phosphorus does not pass pure in this distillation, but is blackened by soot or coal, which it carries along with it: it may easily be purified and rendered white and fine by a second distillation or rectification. This rectification is made in a small glass retort, to which is adjusted a small receiver half full of water. A very gentle heat is sufficient, because phosphorus once formed is very volatile: and as the fuliginous matter with which it is soiled was raised merely by the violence of the heat, it remains at the bottom of the retort in this distillation, and the phosphorus passes very pure.

The process published by Hellot for the preparation of phosphorus is only different from this in two respects; first, that his is only one operation, and not divided into two, as Margraaf's is; and, secondly, that he does not use muriat of lead. The operation is certainly much facilitated by Margraaf's method of separating the volatile matters of the urine by a previous distillation; because, after that, nothing more is requisite but to apply heat sufficient to raise the phosphorus; which may be done in four or five hours, whereas without this previous operation the distillation lasts twenty-four hours. The advantage of the muriat of lead was long a matter of doubt; but since it has been ascertained that the acid of phosphorus exists in urine in two combinations, the explanation has become easy. This acid is combined with ammonia and with soda. The former salt is decomposed by charcoal, and gives over phosphorus with heat; which the latter does not. But when the muriat of lead is added, the muriatic acid seizes the soda, and forms common salt; part of the coal is employed in reducing the lead, and another part in reducing the disengaged phosphoric acid, which then comes over in the form of phosphorus.

The process for disengaging phosphorus from bones has already been described under the article Acid (Phosphoric), which see. The phosphoric glass obtained in the first instance from bones is not sufficiently deprived of calcareous earth to be used in any other process than that of making phosphorus. For this purpose, however, it is not necessary to bring it to the consistence of glass. The evaporation may be conveniently performed in a copper vessel; and when the fluid has acquired the consistence of sirup, it may be mixed with its own weight of charcoal in powder, and submitted to distillation in a good earthen retort. Instead of applying a receiver, the neck of the retort may be immersed in a basin of water to a small depth; and the phosphorus, as it comes over, will fall in drops to the bottom. It is true, that in the process thus managed there will be apparently much phosphorus burned by the admission of the common air, which now and then passes into the neck of the retort, whenever the absorption of the water causes its surface to fall below the aperture; but this quantity is really inconsiderable, and is compensated by the simplicity and facility of the process. The operator must be careful, that the neck of the retort be not plunged to too great a depth; because in this case the water would pass into the body of the retort at the time of absorption, before the surface of the water in the basin had fallen sufficiently to admit the air. The phosphorus comes over as soon as the retort is red-hot; and when the drops cease, the whole apparatus must be suffered to cool. It has the form of reddish wax or tallow; and may be pressed together under the water while it is yet warm. If this be done with the naked hand, great care must be taken, that no particle shall remain sticking to the hands, and particularly under the nails; as such a particle, by taking fire when brought into the air, might produce very painful and disagreeable consequences. It may be moulded into sticks, by putting the pieces into small conical tubes of glass, closed at one end, and fixed upright in a piece of wood, the whole being immersed under water: on heating the water, the phosphorus will melt, and take the desired form. The impurities that rise to the upper ends of the tubes may be cut off when taken out, which must not be done till all is cool.

Phosphorus may be had exceedingly pure by straining it through a leather bag immersed in hot water; or, which is still better, by distilling it a second time with a very gentle heat, as already mentioned. The blackish colour of phosphorus is ascribed to a portion of carbonaceous matter, which is mixed with it. This disappears almost entirely by boiling with a small quantity of ammonia; and if the phosphorus be boiled two or three successive times in alcohol, it becomes perfectly transparent, and of a beautiful opal colour, with very little loss of weight.

Phosphorus must be kept in a bottle of water, to prevent its gradual combustion. In winter care must be taken, that the bottle is not stopped so closely as to burst by the expansion of the water if it should freeze, as dangerous accidents have happened from this.

The method of procuring phosphorus by distillation from urine was superseded by the easier method of Scheele, by which it is obtained from bones. This method is accordingly used by most chemists; but Mr. Giobert of Turin has since improved the process with urine so much as to exceed in simplicity and cheapness that of Scheele; insomuch that the phosphorus may, without any offensive operation, be procured with convenience and certainty in the course of a day, or even a few hours, if the quantity be small.

From the consideration of what happens by the addition of muriat of lead in the distillation of phosphorus, this chemist inferred that the muriatic acid seized the ammonia and soda of the urine, while the disengaged phosphoric acid combined with the lead, and formed a compound consisting of two parts, both reducible by charcoal, but not both volatile, and therefore separable by heat. It might, however, be questioned, as far as could be deduced from experiment in the dry way, whether the charcoal were not originally concerned in the decomposition, and whether the affinities were not different in a lower temperature, as is seen in other chemical facts. Hence it remained to be tried, whether the combination would equally take place in the humid way, or with pure urine, without any previous concentration by the disgusting process of evaporation. For if the decomposition of the phosphoric salts could be had by the intermedium of the muriat of lead, or any other metallic salt, and the metal were to fall down in the form of an insoluble compound with the phosphoric acid; this compound might be edulcorated and exposed to distillation with charcoal.

Mr. Giobert had observed, that the phosphoric acid, by simple elective attraction, i capable of decomposing the acetats and even the nitrats of lead. He had, therefore, every reason to expect success by double affinity with urine. The success was equal to his expectation. Acetat of lead wa added to urine. A precipitate fell down, on which he poured sulphuric acid. The supernatant liquor being decanted, and saturated with ammonia, proved to be a phosphoric salt, and the nearly insoluble residue was sulphat of lead. From these fact it was clear, that the first precipitate wa phosphat of lead, that the sulphuric aci seized the lead, and disengaged the phosphoric, and that this last formed a neutra salt by the addition of ammonia.

This is a ready method of procurin phosphat of ammonia for essays by th blow-pipe, and may be more cheaply performed by the addition of sulphat of ammonia, which is the product of various operations, less expensive than those by which th acid and alkali are obtained separate. Carbonat of ammonia will also decompose th phosphat of lead; but in this case a tripl compound of phosphoric acid, ammonia and oxide of lead is obtained. No such ef fect happens with the sulphat of ammonia.

When phosphorus is exposed to the atmosphere, it emits fumes of a somewhat fetid smell; and if it be in the dark, it appears luminous. This combustion is so slow, that it is not visible by day-light, and the phosphorus can be held in the hand. At 160° it burns with a bright flame, and emits much caloric, with a copious white vapour. Minute division, or slight friction, is likewise sufficient to inflame it. It is singular, that in pure oxigen gas it must be heated much more to take fire than in atmospheric air. In nitrogen gas it appears faintly luminous for a short time; and on the admission of a little oxigen, the whole of the gas appears luminous. If a little nitrogen be added to oxigen gas, in which there is phosphorus, a coruscation of blue light immediately occurs. It is remarkable, that phosphorus dissolves in oxigen gas, without exhibiting the usual phænomena of combustion; yet, if either nitrogen or hidrogen be introduced, a luminous appearance takes place. If introduced into nitric oxide gas while in a state of combustion, it continues to burn. It melts in oxigenized muriatic acid, and at a temperature above 70° or 80° burns with brilliant sparks, emitting copious white fumes. If a few small pieces be put into nitrous acid, the phosphorus soon decomposes it by attracting oxigen, and very dense red vapours are disengaged. If the violence of the effervescence throw up any bits of phosphorus into the vapour, a flash of light is immediately perceived. Van Marum kindled phosphorus wrapped in cotton powdered with resin, in the vacuum of an airpump. He did the same with it wrapped in cotton only, but more difficultly: with the phosphorus alone, or merely powdered with resin, he could not succeed. Dr. van Bemmelen, on the contrary, found the experiment succeed with cotton and resin, or with resin alone, but not with cotton alone.

From the affinity of phosphorus for oxigen some have employed it for eudiometrical purposes.

Phosphorus combines with the pure fixed alkalis in a boiling heat, and forms a phosphuret; during which a peculiar elastic fluid is given out, which possesses the remarkable property of taking fire as soon as it communicates with the air of the atmosphere. This air has evidently the same relation to phosphorus as the sulphuretted hidrogen has to sulphur; and, like that, it consists of a solution of the phosphorus in hidrogen. See GAS (PHOSPHORIC).

Sulphur and phosphorus unite by fusion, and form a solid compound of a fetid smell, which burns with a yellow flame, and swells in water; at the same time communicating acidity to that fluid, and emitting a smell of sulphuretted hidrogen. The phosphuret of sulphur must be made with a very gentle heat, at most not exceeding 200° F. or a violent explosion will ensue. It dissolves readily in expressed oils, and forms a fine liquid phosphorus. It dissolves too in volatile oils. Dr. Briggs observes, that the explosion is owing to the decomposition of water, and therefore a phial, or tube, filled with sulphur and phosphorus only, and closely stopped, may be put into hot water, and thus gradually made to boil, so as to fuse the contents together, with perfect safety.

All kinds of oils dissolve phosphorus, and are rendered luminous by it; several essential oils form a solution, which takes fire by exposure to the air, probably in consequence of the emission of phosphuretted hidrogen. The butter of wax, which consists of wax deprived of part of its acid by distillation, is said to be the properest material for producing this effect.

The combustible property of phosphorus has been lately applied in various ways to procure fire; but the danger of spontaneous accension in improper situations, and the expense, have prevented its coming at all in competition with the ordinary method of flint and steel. The phosphoric contrivances are a phosphuric taper or match, and a bottle, the method of making which is as follows:

1. The most simple process for making the phosphoric matches consists in taking a glass tube, four inches long, and one line in diameter, closed at one end. A small quantity of phosphorus is introduced into the tube, and pushed to its farther end; after which a taper covered with a small quantity of wax is introduced into the same tube. The open end is then hermetically sealed, and the other end is plunged into boiling water. The phosphorus melts, and fixes itself upon the match.

A line is drawn at one third of the length of the tube, with a flint, that it may be broken as occasion may require.

The match is to be drawn out quickly, to inflame the phosphorus.

The process of Mr. Lewis Peyla, to make the inflammable bougies, consists in taking a glass tube, five inches long and two lines wide, one end of which is sealed with the blowpipe. Small tapers of wax are prepared with three double threads of cotton twisted together. The extremity of the match or taper is half an inch long, and must not be covered with wax.

A piece of lead is laid in a saucer filled with water; and upon this the phosphorus is cut, beneath the water, into fragments of the size of a grain of millet. One of these grains is to be dried, and introduced into the tube of glass; after which the fortieth part of a grain of very dry sulphur is to be added, that is to say, half the weight of the phosphorus. One of the bougies is then aken, and its extremity dipped in very clear oil of wax. If too large a quantity rises, it must be dried with a cloth.

The match is introduced into the tube, with a turning or twisting motion between the fingers.

The bottom of the tube must then be plunged into boiling water to soften the phosphorus, observing to keep it no longer than three or four seconds in the water.

The other extremity of the tube is afterward sealed.

These bougies must be kept in a tin tube, to avoid the danger of inflammation.

2. To form the phosphoric bottles, a glass bottle is heated by fixing it in a ladle full of sand, and two or three small pieces of phosphorus are then introduced into it. A small red-hot iron wire is used to stir the phosphorus about, and cause it to adhere to the internal surface of the bottle, where it forms a reddish coating. The heated wire is introduced repeatedly; and when all the phosphorus is thus distributed within the bottle, it is left open for a quarter of an hour, and afterward corked. When this is used, a common match tipped with sulphur is introduced into the bottle, turned round, and quickly drawn out. The phosphorus which sticks to the sulphur takes fire, and lights the match.

The theory of this phænomenon depends on the circumstance, that the phosphorus is strongly dried or half oxided, and needs only the contact of air to set it on fire.

Very strong alcohol dissolves a portion of phosphorus when cold, and more when heated, which is again separated by cooling. Metals do not readily combine with this substance when simply heated with it; but when the phosphoric acid, together with charcoal, is exposed to a strong heat, a considerable number of the metals may be made to unite with it, probably in consequence of their being previously oxided by the acid. See the several metals.

Chaptal conjectures, that the luminous matter of the glow-worm, lampyris splendidula Linnæi, and other lucid animals, is a combination of phosphorus and oil. Forster of Gottingen observes, that the shining matter of the glow-worm is liquid. If the glow-worm be crushed between the fingers, the phosphorescence remains on the finger. Henckel reports, in the eighth dissertation of his Pyritologia, that one of his friends, of a sanguine temperament, after having danced too much, perspired to such a degree, that he thought his life in danger. While he undressed, traces of phosphoric flame were seen on his shirt, which left yellow-red spots behind them, resembling the residue of burnt phosphorus: this light was long visible.

Phosphoric Stones, or Earthy Phosphori. These stones when properly calcined have the property of shining in the dark. The most celebrated and most anciently known phosphorus of this kind is
that called the Bolognian stone, from Bologna, a city of Italy, near which this stone
is found. It is the ponderous spar, or sulphat of barytes.

The muriat of lime is easily fused, and,
being poured into a clean iron mortar, appears when cold of a yellowish white colour, and semitransparent like horn. It is
luminous when struck in the dark, and
thence was called a phosphorus by Homberg. The experiment does not always
succeed, probably for want of combustible
matter, which is usually present when thi
compound is obtained from the residue o
ammonia distilled from impure sal ammo
niac and lime. Solution of chalk in the ni
tric acid forms on evaporation a tenaciou
mass like turpentine, which, dried and cal
cined a little, proves luminous in the dark
This phosphorus is usually distinguished b
the name of its first discoverer, Baldwin:
is called also phosphorus hermeticus, fron
its being kept in hermetically sealed glasse
to secure it from the air. It differs from
some other natural phosphori, in appearin
in some degree luminous after exposure t
the light of a taper, as well as of the sun.

The effect of the earthy phosphori seem
to depend on a degree of slow combustion
not yet well explained. These substanc
seem to resume oxigen and moisture fro
the atmosphere, and emit light either on th
principle of common combustion, or fro
previous absorption. According to th
last opinion, the shining of phosphori, aft
exposure to light, is not a mere combustio
produced by the action of the lumino
body, but an absorption and emission of th
matter of light.

The late Mr. Canton gave a receipt f
making an artificial phosphorus, greatly s
perior to any single natural substance, wi
the additional advantage of being very ea
ly and cheaply prepared. His receipt is
follows:—Calcine some common oyst
shells, by keeping them in a good coal f
for half an hour, and let the purest part
the calx be pulverized and sifted. M
with three parts of this powder one part
the flowers of sulphur; let this mixture
rammed into a crucible of about an in
and a half in depth, till it is almost fu
and let it be placed in the middle of the fi
where it must be kept red-hot for one ho
at least, and then set by to cool. When
is cold, turn it out of the crucible, and, c
ting or breaking it to pieces, scrape
upon trial, the brightest parts; which,
good phosphorus, will be a white powd
and may be preserved by keeping it i
dry phial with a ground stopple.

The quantity of light, which a little
this phosphorus gives, when first broug
into a dark room, after it has been expo
for a few seconds on the outside of a w

dow to the common light of the day, is sufficient to discover the time by a watch, if the eyes have been shut, or in the dark, for two or three minutes before.

By this phosphorus celestial objects may be very well represented, as Saturn and his ring, the phases of the Moon, &c., if the figures of them made of wood be wetted with the white of an egg, and then covered with the phosphorus. And these figures appear to be as strongly illuminated in the night, by a flash from a near discharge of an electrified bottle, as by the light of the day.

John Baptist Beccaria discovered that the sulphureo-calcareous phosphorus imbibed the peculiar coloured rays to which it had been exposed. Thus, having exposed different phosphoric pieces to rays of the sun, transmitted through green, yellow, and red glasses, he observed that each of them, when afterwards viewed in the dark, exhibited that colour to which it had been exposed.

PHOSPHURET. A compound of phosphorus with any other substance.

PIMELITE. A greenish earth, containing oxide of nickel, and serving as a gangue to the chrysoprase, has been thus called by Karsten.

PIMENTO. See PEPPER (JAMAICA).

PINIT. This stone, the *micarelle* of Kirwan, has hitherto been found only in brown or reddish crystals, opake and lamellar, and forming regular hexaedral prisms. These prisms are easily broken, and irregular in their fracture; but natural junctures, parallel to the faces of a regular hexaedral prism, may be discerned in their texture.

It is infusible by the blowpipe; adheres to the tongue; and is soft enough to be scratched by a knife. Its powder has a greasy feel; and, when breathed upon, emits a very strong smell of alumine. Its specific gravity is 2·92.

The pinit has some analogy to the steatites, and to mica; but it differs from the latter, particularly in its primitive form and infusibility. That of France differs considerably in its component parts, according to the analysis of Mr. Drappier, from that of Saxony analysed by Klaproth, as will appear by the following comparison:

	French.	*Saxon.*
Silex - - -	46 -	29·5
Alumine - -	42 -	63·75
Oxide of iron -	2·5 -	6·75
Loss in water and gas	7	
Actual loss - -	2·5	–
	100	100

The crystals of pinit vary in colour from a metallic reddish brown to a blackish brown. The brownest are a little translucid.

It was found in the mine of Pini, near Schneeberg in Saxony, and makes part of a large-grained granite, composed of quartz, feldtspar, and mica. It has since been found by Mr. Coq, on the road from Menat, about thirty-four miles from Clermont, in the department of Purg-de-Dôme. This variety, which is disseminated in a gray porphyry with feldtspar for its base, and containing quartz crystals, does not adhere to the tongue.—*Brongniart.*

PIPE CLAY. The difference between the porcelain clay and those of more moderate purity, called pipe clays, of which we have plenty in Devonshire, is commonly, that the former remains white when burned in an open fire; but the latter, containing a portion of mineral oil, becomes of a blueish-gray in a moderate heat, by the coal produced by this combustion. A stronger heat, however, will perfectly consume this coal, and restore the whiteness. On the whole, however, it appears rather as if this distinction between the clays used in pottery were grounded on the nature of the product they afford, than on any very evident property ascertainable before they are wrought and baked.

PISASPHALTUM. A species of bitumen, which in cold weather is solid, but at other times has a sort of semifluidity. It differs from petroleum only in possessing a greater degree of consistency.

PISOLITHES. A stalactitical calcareous stones of a gray colour, arising from oxide of iron. They are so named from resembling pease in size and figure, being spheroidal concretions, formed of very distinct concentric strata, for the most part surrounding a grain of sand, or some other foreign body, as a nucleus. The most known are those of the baths of San Filippo, in Tuscany, vulgarly called Tivoli comfits. They are found in those parts of the stream where there are eddies. There is a bank of them likewise in the middle of the warm springs at Carlsbad, in Bohemia, all of which have a grain of sand as a nucleus.

PISTACITE. The stone thus called by Werner, which must not be confounded with the *pistazite*, has received various names. It is the *epidote* of Haüy, *green schoerl of Dauphiny* of Romé de l'Isle, *delphinite* of Saussure, *acanticone* and *acanticonite* of Dandrada, *arendalite* and *glassy strahlstein* of some.

Though it has been known but a few years, it has been found in several places, in very different situations, and under various forms, so that it is not very easy to give its general characters; particularly as they are not very distinct, or well marked, except in the crystallized varieties.

The fracture of the pistacite is lamellar in one direction, the laminæ being parallel to the faces of a rhomboidal prism, of which the angles are 114½° and 65½°. In the opposite direction its fracture is irregular.

It is sufficiently hard to strike fire with steel; is fusible into a brown scoria; and has always a greenish tint, which varies from a yellowish green to a bottle-green. Its specific gravity is 3·45.

By attending closely to these characters, we may distinguish the pistacite from other stones. Those which it most resembles are the actinote, greenish amphibole, and greenish asbestus. But the actinote melts into a grayish enamel, and divides into rhomboidal prisms, the angles of which are 124½° and 55½°, a difference sufficient to be perceived by the eye, without the assistance of any instrument. The amphibole is more difficult to distinguish from the pistacite when it is in mass; but it is not so hard, and its fracture is generally less vitreous. The common greenish asbestus is not so liable to be confounded with it; and its powder, which is soft to the touch, differs sufficiently from the harsh powder of the pistacite.

The analyses that have been made of the pistacite differ less than those of many stones. The following are the greatest and least quantities of the substances that appear to be essential to its composition. Silex from 0·37 to 0·45; alumine from 0·21 to 0·28; lime from 0·14 to 0·21; oxide of iron from 0·11 to 0·24. These results are taken from the analyses of Descotils, Vauquelin, Chenevix, and Laugier.

The most common form of the crystals of the pistacite is a prism of six or eight sides, four of which, that are larger than the rest, belong to the primitive form, the prism with a rhomboidal base. These prisms are terminated by several oblique facets, and frequently by a horizontal face. The faces are well defined, sharp, and a very fine natural polish.

In some of the varieties of the pistacite the oxide of manganese occurs.—*Brongniart.*

Pistazite. Some German writers have given this name to a species of smaragdite.

Pitch. Tar boiled down to dryness is the common black pitch: this part of the process is commonly performed in a still, in order to save an essential oil, which arises in the boiling, and which is called, from the name of the tree which tar is principally prepared from, oleum pini, and oleum tædæ. This oil is greatly valued by painters, varnishers, &c., on account of its drying quality: it soon thickens of itself almost to the consistence of a balsam. Along with the oil there comes over a watery liquor, which the workmen injudiciously throw away; though it is a good acid, capable of being applied to sundry useful purposes. Neumann knew a person in France, who saved by it several thousand dollars.

Pitch is not a pure and perfect resin; it has not only suffered a notable change from the heat employed in its preparation, but likewise participates of the other principles
of the wood of a gummy and saline nature
and of a burnt earth. Hence its dispositio
to separate, and precipitate, when melte
with oils, fats, and resins, into plasters an
ointments; and hence it is gradually co
roded by air and moisture, when employe
as a cement or defence for wood or oth
substances, in ships, carriages, cisterns, cas
shingle coverings for houses, &c. Shi
builders endeavour to improve their tar a
pitch, so as to render them more durab
by various additions.

Two ounces of dry pitch treated by Ne
mann with alcohol gave but one ounce a
half a scruple of resinous extract: half
ounce of empyreumatic oil separated
ring the digestion, and there remained
dissolved half an ounce of earthy matt
from which water would extract nothi
The same quantity of the same pit
boiled at first in water, yielded two drac
and half a scruple of gummy extract; f
the remainder, nevertheless, were obta
ten drachms of spirituous extract, tha
near two drachms more than when s
was applied at first, the indissoluble
amounting as before to half an ounce.
distilled water smelled and tasted al
like red herrings: the spirit had no rem
able impregnation. Eight ounces of p
distilled in an open fire, yielded two ou
one drachm and a half of an acid, and
ounces five drachms of a fetid oil, t
ounces of a shining black coal remainin
the retort.

The soot which arises in the burni
pitch is the substance commonly sold u
the name of lamp-black: in France,
pitch is burnt for this purpose in a ki
furnace made of tiles, so disposed as to
vent the escape of the smoke.

Lewis informs us, that what is c
lamp-black (originally the soot coll
from lamps) is obtained, in different
of Germany, Sweden, &c., not from
resin or pitch, but from the dregs
pieces of bark of the tree separated in
preparation. For making common
the impure juice collected from incisi
pines and fir-trees is boiled down w
little water, and strained while hot th
a sack: on cooling, the resin congeals
the surface of the water, and is then p
up in barrels; it is distinguished acc
to its colour, into white, yellow, and b
The dross left on straining is bur
lamp-black, in a low oven, from whi
smoke is conveyed by a long passage
square chamber, having an aperture
top, upon which a large sack is fas
the soot concretes partly in the sack,
is occasionally removed, and partly i
chamber and passage, from which
swept out.

Lamp-black is more oily or resinou
the common wood-soot: it gives out
to alcohol and less to water by infusio

yields a larger quantity of oil on distillation. Mixed with boiled oil, and a little boiled turpentine, it forms the black composition used as ink in printing. See **Ink**, also **Pyrophorus**.

Pitch-Blende. See **Pech-Blende.**

Pitch (Jews). See **Asphaltum.**

Pit-Coal. See **Coal.**

Plants. See **Vegetable Kingdom.**

Plaster of Paris. Sulphat of lime. See **Acid (Sulphuric).**

Plastic Stone, *or* **Agalmatolite.** This stone, which has come to us from China cut into images of different kinds, had been commonly considered as a steatites; but Klaproth has found, that it does not belong to the magnesian genus. There are two kinds, the transparent and the opake.

The transparent is of an olive or asparagus green, verging to a greenish blue. It consists of silex 54, alumine 36, oxide of iron 0·75, and water 5·5, in 100 parts.

The opake is reddish white, with variously coloured veins. It contains in 100 parts, silex 62, alumine 24, lime 1, oxide of iron 0·5, water 10.—*Klaproth's Analyses.*

Platina is one of the metals for the discovery of which we are indebted to our contemporaries. Ulloa appears to have first mentioned it in 1735; and our countryman Wood brought a quantity from Jamaica in 1741. It was supposed to be found only in Spanish America, among the gold mines there. Mr. Vauquelin, however, has lately discovered it in Spain, in the mines of Guadalcanal, which have been reopened: and there are said to be two ancient candlesticks in a cathedral in Germany apparently made of it before America was discovered.

We receive it in the form of small particles, from the minutest size up to that of a pea; though the last are very seldom met with: and some pieces as large even as a pigeon's egg have been found. Its particles or grains are smooth, irregularly figured, with round edges, and are flattened, probably by hammering in the mills in which the gold is amalgamated. These grains are of a whiter colour than iron, and are considerably malleable. In the state in which we receive them, they are often mixed with ferruginous sand, which may be separated by the magnet; and also with grains of quartz or crystal. When it is separated from heterogeneous particles, the crude platina itself is slightly magnetic, and is between sixteen and eighteen times as heavy as water. The most violent fires are insufficient to melt it, though its parts may be made to cohere together into a solid button by the strong heat of a wind furnace. Burning lenses of the most powerful kind fuse it, and convert it into a malleable metal; and small portions of crude platina may be easily melted upon charcoal, by flame urged by a stream of oxigen gas. This ore has recently been found to contain, likewise, four new metals, palladium, iridium, osmium, and rhodium; which see; beside iron and chrome.

From the great infusibility of platina, its grains cannot be united by fusion, so as to obtain it in a solid compact mass, so that different indirect processes have been resorted to for this purpose.

De l'Isle appears to have been the first who succeeded in this. He dissolved the crude platina in nitro-muriatic acid, precipitated by muriat of ammonia, and exposed the precipitate to a very violent heat. Then the acid and alkali were expelled, and the metal reduced in an agglutinated state, which was rendered more compact by pressure while red-hot.

Margraaf found, that arsenic rendered platina more fusible; and Guyton availed himself of this property, to render platina capable of being wrought. Jeannety adopted this method, and employed it to some extent. His process, as reported by Pelletier, was as follows:

Pure or refined platina is by much the heaviest body in nature. It is very malleable, though considerably harder than either gold or silver; and it hardens much under the hammer. Its colour on the touch-stone is not distinguishable from that of silver. When in the highest degree of purity, it is not magnetical; but when its specific gravity is as low as 21·36 it contains iron sufficient to render it magnetical. Pure platina requires a very strong heat to melt it; but when urged by a white heat, its parts will adhere together by hammering. This property, which is distinguished by the name of welding, is peculiar to platina and iron, which resemble each other likewise in their infusibility.

Platina is not altered by exposure to air; neither is it acted upon by the most concentrated simple acids, even when boiling, or distilled from it. Oxigenized muriatic acid dissolves it, as does likewise aqua regia. In this particular of solubility platina resembles gold.

The aqua regia best adapted to the solution of platina is composed of one part of the nitric and three of the muriatic acid. The solution does not take place with rapidity. A small quantity of nitric oxide is disengaged, the colour of the fluid becoming first yellow, and afterward of a deep reddish brown, which, upon dilution with water, is found to be an intense yellow. This solution is very corrosive, and tinges animal matters of a blackish-brown colour: it affords crystals by evaporation.

The crude platina is triturated with water, to remove any particles of iron, or other impurities mixed with it. One pound and a half of it are mixed with three pounds of white arsenic, and one pound of purified potash, (the subcarbonat of potash;) a crucible capable of containing twenty pounds is placed in a furnace, so as to be well heated; and a third part of the above mixture is thrown into it; after applying to this a strong heat, a second portion is thrown in, and afterward the remaining part: care being taken to mix the whole by stirring with a rod of platina. The heat is raised, and when the whole is thoroughly melted, the crucible is withdrawn, and allowed to cool.

The metallic mass thus obtained is magnetic: it is broken, and melted a second time in the same manner: and if this second fusion do not free it sufficiently from iron, it is fused a third time, though in general two fusions are sufficient.

This first stage of the operation being finished, crucibles are taken, the bottom of which is flat, and the circumference such as to give a mass of metal three inches and a quarter in diameter; they are raised to a red heat, and into each is thrown a pound and a half of the metallic substance obtained in the former part of the process, with an equal weight of arsenic, and half a pound of potash; and the heat is raised so as to melt this completely. The crucible is then withdrawn, and allowed to cool, placing it horizontally, so that the button of metal shall be of equal thickness.

The buttons thus obtained are placed in a furnace under a muffler, which ought not to be higher than the circumference of the buttons placed on edge, and inclined a little toward the sides of the muffle; three buttons are placed on each side of it; the fire is raised until the muffle is equally heated throughout its circumference; and whenever the metallic buttons begin to emit vapour, the doors of the furnace are closed, to preserve the heat at the same degree; it being necessary, that it should be kept so to the end, as, if suddenly raised high, the whole operation would be defeated.

The buttons are exposed to this heat for six hours, their places being changed occasionally, that they may be heated as equally as possible. They are then put into common oil, are exposed for the same length of time to a heat sufficient to dissipate the oil in vapour. This operation is continued as long as any vapour arises from the bar: and when this has ceased, the heat is pushed as far as it can by the medium of the oil;—a step of the process without which the platina is not obtained perfectly malleable.

Lastly, when these operations have been finished, which, when they have been properly executed, require about a week, the buttons are cleansed with nitrous acid, and are boiled in distilled water; to remove any adhering acid: they are then placed one above another in a crucible, and exposed to the strongest possible heat, after which they are subjected to the pressure of the coining engine. The heat is at first applied to them in a crucible, that no foreign matter may be introduced into the spongy substance of the buttons. They are lastly heated in the naked fire, and formed into a square bar, which is hammered for a longer or shorter time according to its size.

Count Moussin Poushkin has given the following more simple method of preparing malleable platina:

Precipitate the platina from its solution by muriat of ammonia, and wash the precipitate with a little cold water. Reduce it in a convenient crucible to the well known spongy metallic texture, which wash two or three times with boiling water, to carry off any portion of saline matter that may have escaped the action of the fire. Boil it for about half an hour, in as much water mixed with one tenth part of muriatic acid as will cover the mass to the depth of about half an inch, in a convenient glass vessel. This will carry off any quantity of iron that might still exist in the metal. Decant the acid water, and edulcorate, or strongly ignite the platina.

To one part of this metal take two parts of mercury, and amalgamate in a glass or porphyry mortar. This amalgamation takes place very readily. The proper method of conducting it is to take about two drachms of mercury to three drachms of platina, and amalgamate them together; and to this amalgam may be added alternate small quantities of platina and mercury, till the whole of the two metals is combined. Several pounds may be thus amalgamated in a few hours, and in the large way a proper mill might shorten the operation.

As soon as the amalgam of mercury is made, compress it in tubes of wood, by the pressure of an iron screw upon a cylinder of wood adapted to the bore of the tube. This forces the superabundant mercury from the amalgam, and renders it solid. After two or three hours burn upon the coals, or in a crucible lined with charcoal, the sheath in which the amalgam is contained, and urge the fire to a white heat; after which the platina may be taken out in a very solid state fit to be forged.

As it is but lately that the four new metals mentioned above were discovered mixed with platina, most of our chemical experiments have been made, not on the pure metal, but on platina more or less alloyed with some or all of these; whence many seeming anomalies in them may be explained. To these is owing the black powder deposited on dissolving platina in nitro-muriatic acid, which is in part redissolved, if it be not removed as it falls down.

The solution when concentrated is of a deep reddish brown colour, and affords crystals of the same colour, but of various shades by evaporation. The dark colour is owing to iridium, which likewise colours the precipitates by alkalis. If potash be added to the solution, small, red, octaedral crystals are deposited; and on continuing to add more alkali a yellow powder falls down, which is insoluble in water. Ammonia acts in a similar manner. Soda, if added in sufficient quantity, occasions a spongy yellow precipitate. In all these precipitations the oxide forms triple salts, by uniting with a portion of the alkali, as well as the acid. The triple muriats with potash and ammonia are sparingly soluble in water; that with soda is more soluble, and forms prismatic or tabular crystals. They are all reducible by heat alone.

From this tendency to form ternary combinations several of the neutral salts equally precipitate platina from its solutions. Of these the muriat of ammonia acts upon it in the most trifling manner. The precipitate first thrown down by it is yellow, and ultimately dark red. This was supposed to be owing to different stages of oxidation merely; but it appears that the yellow only is the triple salt of platina, and that the redness of the subsequent portions is owing to the presence of more or less oxide of iridium.

The muriat of platina and ammonia decomposed by potash affords a slightly fulminating precipitate. Count Moussin Poushkin has formed triple salts of muriat of platina with barytes and magnesia; and likewise with soda. The latter (made by digesting two parts of muriat of soda, and one of platina, in nitric acid, in a retort, and distilling over four fifths of the liquor,) afforded fine prismatic crystals, some four or five inches long, of an amber, brown red, or poppy colour, according to the purity of the platina.

Several of the metallic salts decompose the solution of muriat of platina. Muriat of tin is so delicate a test of it, that a single drop of the recent solution of tin in muriatic acid gives a bright red colour to a solution of muriat of platina scarcely distinguishable from water.

If the muriatic solution of platina be agitated with ether, the ether will become impregnated with the metal. This ethereal solution is of a fine pale yellow, does not stain the skin, and is precipitable by ammonia.

If the nitro-muriatic solution of platina be precipitated by lime, and the precipitate digested in sulphuric acid, a sulphat of platina will be formed. A subnitrat may be formed in the same manner. According to Mr. Chenevix the insoluble sulphat contains 54·5 oxide of platina, and 45·5 acid and water: the insoluble muriat, 70 of oxide; and the subnitrat, 89 of oxide: but the purity of the oxide of platina in these is uncertain.

Platina does not combine with sulphur directly, but is soluble by the alkaline sulphurets, and precipitated from its nitro-muriatic solution by sulphuretted hidrogen.

Pelletier united it with phosphorus, by projecting small bits of phosphorus on the metal heated to redness in a crucible; or exposing to a strong heat four parts each of platina and concrete phosphoric acid with one of charcoal powder. The phosphuret of platina is of a silvery white, very brittle, and hard enough to strike fire with steel. It is more fusible than the metal itself, and a strong heat expels the phosphorus, whence Pelletier attempted to obtain pure platina in this way. He found however, that the last portions of phosphorus were expelled with too much difficulty.

Platina unites with most other metals. Added in the proportion of one twelfth to gold, it forms a yellowish white metal, highly ductile, and tolerably elastic, so that Mr. Hatchett supposed it might be used with advantage for watch-springs, and other purposes. Its specific gravity was 19·013.

From a supposition that it might be employed to adulterate gold, the Spaniards prohibited its importation into Europe; but it appears from Guyton, that so little as 0·155 of platina debases the colour below that of the palest gold. Yet according to Lewis, one part of platina with four of gold forms an alloy not paler than gold made standard with silver, and sufficiently ductile to be extended into thin plates.

Platina renders silver more hard, but its colour more dull.

It has been supposed, that platina would not combine with mercury; and it does not easily in a compact state. Guyton however found, that a plate of platina was increased in weight, and rendered brittle by boiling in quicksilver; and count Moussin Poushkin, as has been seen, formed an amalgam of it in its spongy state without difficulty.

Copper is much improved by alloying with platina. From $\frac{1}{6}$ to $\frac{1}{25}$ or even less render it of a golden colour, harder, susceptible of a finer polish, smooth grained, and much less liable to rust.

Alloys of platina with tin and lead are very apt to tarnish.

From its hardness, infusibility, and difficulty of being acted upon by most agents, platina is of great value for making various chemical vessels. These have, it is true, the inconvenience of being liable to erosion from the caustic alkalis and some of the neutral salts. It has been recommended instead of tin as a superior coating for copper vessels, to which it may be applied by rubbing it on the copper in the state of soft amalgam, and heating the copper to ignition; then mixing a little of the amalgam with chalk, sprinkling the mixture with water, coating the copper afresh with this, and igniting it a second time. This will give a very perfect coat, assuming a shining silver colour under the burnishes. Polished iron, steel, or brass, as we learn from Mr. Stodart, may likewise be coated by immersion in an ethereal solution of platina. Platina alloyed with copper and arsenic has been used for mirrors for reflecting telescopes, for which it is well adapted, as it is susceptible of a very high polish, reflects a single image, and does not tarnish by exposure to the air. From its infusibility Guyton has employed it as a pyrometer, Klaproth has applied it on china, silver being unfit for this.—*Phil. Trans.*—*Manch. Memoirs.*—*Journ. de Phys.*—*An. de Chim.*—*Scherer's Journ.*—*Nich. Journ.*—*Bergman.*—*Murray.*

Pleolast. See Ruby.

Plumbago, or black lead, is a well known substance, of a black colour, and shining appearance when cut. Its texture is rather scaly, but its fracture exhibits a granular and dull appearance. None of the specimens have any considerable hardness.

This mineral is found in England, Germany, France, Spain, and Africa; but the sort best adapted for making pencils comes chiefly from Borrodale in Cumberland. For this purpose, it is carefully sawed into narrow slips, or pieces, not more than one tenth of an inch thick; which are glued between two half cylinders of cedar wood. An inferior kind of pencils is made by the Jews, by mixing the powder of sawdust with gum arabic, or fusing it with resin or sulphur; and pressing or pouring it into the cavities of reeds. The powder of plumbago, with three times its weight of clay, and some hair, makes an excellent coating for retorts; and the black lead or Hessian crucibles are composed of the same materials. See Iron, of which it is a carburet.

Plumbum Corneum. The old name of muriat of lead.

Pneumatic Apparatus. See Laboratory.

Polarity. In the experiments of magnetism it has been found, that the attractive and repulsive forces exerted between pieces of iron or steel, which have undergone the touch (see Magnetism), are governed by the position of certain parts of the iron or magnet called its poles.

Bodies attracted or repelled by the power of electricity are also observed to turn one side, if at liberty, toward the body which acts upon them. From analogy it is concluded, that a similar modification obtains in the effect of the chemical affinities, and is in a great measure the cause of the symmetrical figures of minerals. See Attraction, also Crystallization.

Polierschiefer. The polishing slate of Werner is of a dull yellowish gray colour, slaty texture, and earthy fracture when broken transversely. It is soft, adheres to the tongue, is fine but meagre to the touch, and sometimes so light as to float on water. It does not effervesce with nitric acid; and is hardened a little by a violent fire, without melting. Brongniart considers it as a variety of that species of tripoli commonly called rotten stone. It comes from Billin, in Bohemia.

Pollen. The fecundating powder of the stamina of vegetables. The prolific matter in the male part of plants is elaborated by the anthera; and as the organs of the plant do not admit of an actual intromission of the male into the female, because vegetables do not possess locomotion, the fecundating seed is produced in the character of a po
der, which the agitation of the air and ot
causes may carry off, and precipitate u
the female organs. This fecundating p
der has a smell resembling that of the s
matic fluid of animals. It is usually of a
sinous nature; that is to say, it is inflam
ble, and soluble in alkalis and ardent sp

The wax of bees was supposed to co
of the pollen very little altered; but
Haber has shown, that the bees employ
pollen merely to prepare from it food
their young.

Pompholix. The white oxide w
sublimes during the combustion of zinc
been called by this name. It is better kn
by the name of flowers of zinc. See Z

Ponderous Earth. See Earths,
rytes.

Pont Marle. See Marle.

Porcelain. Is the most beautiful
the finest of all earthen wares. All ear
wares which are white and semitranspa
are generally called porcelains; but am
these so great differences may be obser
when they are examined chemically,
notwithstanding the similarity of thei
ternal appearance, they cannot be
sidered as matters of the same kind. T
differences are so evident, that even per
who are not connoisseurs in this way p
much the porcelain of some countrie
that of others.

As the several kinds of porcelain diff
much from each other, no general pro
can be given for making it. We ough
confine ourselves to describe and cons
the manufacture of some particular po
lain, remarkable for its excellence
beauty. But this also is almost impra
cable, because in all the manufact
where it is made, both in France and o
countries, the ingredients and metho
preparation employed are carefully conc
ed. The exhibition of a general statemer
the principal operations will neverthele
of value, not only to artists, who very o
have no general views of the subjects
pursue, but to philosophical men,
most frequently are the best improve
manufactories.

The art of making porcelain is on
those in which Europe has been exce
by oriental nations. The first porce
that was seen in Europe was brought f
Japan and China. The whiteness, tr
parency, fineness, neatness, elegance,
even the magnificence of this pott
which soon became the ornament of su
tuous tables, did not fail to excite the
miration and industry of Europeans.
would perhaps be a fruitless underta
to inquire into the history of the severa
tempts made in Europe to imitate the
ginal porcelain, as most of these are
known and would lead us too far from
subject. Macquer is of opinion, that
first European porcelains were made in
ony and in France; and afterward in

land, Germany, and Italy. But as all these were different from the Japanese, so each of them had its peculiar character.

The illustrious Reaumur first attended to this object among the moderns, and communicated his researches in two memoirs to the Academy of Sciences in 1727 and 1729. This great experimental philosopher took the best method of arriving at a thorough knowledge of the subject; and although he was mistaken in some points, and neglected to consider some of the essential qualities requisite to constitute good porcelain, he is nevertheless the first person who published any distinct notions upon the subject. He did not satisfy himself with considering the external appearance, the painting and gilding, which are only ornaments not essential to the porcelain, but he endeavoured to examine it internally: and having broken pieces of the Japanese, Saxon, and French porcelains, he examined the difference of their grains (which name is given to their internal structure). The grain of the Japanese porcelain appeared to him to be fine, close, compact, moderately smooth, and somewhat shining. The grain of the Saxon or Dresden porcelain was found to be still more compact, not granulous, smooth, shining like enamel. Lastly, the porcelain of St. Cloud had a grain much less close and fine than that of Japan, not or but little shining, and resembling the grain of sugar.

From these first observations he perceived, that porcelains differed considerably. That he might examine them farther, he exposed them to a violent heat. More essential differences than those of the grain appeared upon this trial; for the Japanese porcelain was unaltered by the fire, and all the European were melted, as Reaumur says.

This essential difference betwixt the Japanese and European porcelains suggested to Reaumur a very ingenious thought, and in many respects true, concerning the nature of porcelain in general. As all porcelains somewhat resemble glass in consistence and transparency, though they are less compact and much less transparent, this philosopher considered them as semivitrifications. Now every substance may appear, and may actually be in a semivitrified state in two ways; for, first it may be entirely composed of vitrifiable or fusible matters; and in this case, by exposing it to the action of fire, it will be actually melted or vitrified, if the heat be sufficiently strong and long continued. But as this change is not made instantly, especially when the heat is not very violent, and as it passes through different stages or degrees, which may be more easily observed as the heat is better managed; hence, by stopping in proper time the application of heat to porcelain made in this manner, we may obtain it in an intermediate state betwixt those of crude earths and of completely vitrified substances; and also possessed of the semitransparency and of the other sensible qualities of porcelain. We know also, that, if such porcelain be exposed to a stronger degree of fire, it will then be completely fused and entirely vitrified. But most of the European porcelains have this fusibility; from which Reaumur concludes, that their composition is founded upon the above-mentioned principle.

In the second place, a paste of porcelain may be composed of fusible and vitrifiable matter, mixed with a certain proportion of another matter, which is absolutely infusible in the fires of our furnaces. We may easily perceive, that, if such a mixture be exposed to a heat sufficient to melt entirely the vitrifiable ingredient, this matter will actually melt; but as it is intermixed with another matter which does not melt, and which consequently preserves its consistency and opacity, the whole must form a compound partly opake and partly transparent; or rather a semitransparent mass; that is, a semivitrified substance, or porcelain, but of a kind very different from the former; for, as the fusible part of this latter has produced all its effect, and as it has been as much fused as it can be during the baking of the porcelain, the compound may be exposed a second time to a more violent fire, without approaching nearer to a complete vitrification, or without departing from its state of porcelain. But as oriental porcelain has precisely these appearances and properties, Reamur concludes with reason, that it is composed upon this principle; and he afterward confirmed his opinion by undeniable facts.

Father Entrecolles, missionary at China, had sent home a summary description of the process by which the inhabitants of that country make their porcelain, and also a small quantity of the materials which they employ in its composition. He said, that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them petuntse, which they carefully grind to a very fine powder; and the other, called by them kaolin, is a white earthy substance, which they mix intimately with the ground petuntse.

Reaumur examined both these matters; and having exposed them separately to a violent fire, he discovered, that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He afterward mixed these matters, and formed cakes of them, which by baking were converted into porcelain similar to that of China. Reaumur easily found, that the petuntse of the Chinese was a hard stone of the kind called vitrifiable, but much more fusible than any of these which were known in Europe; and that the kaolin was a talky matter reduced to very fine powder. From that time he hoped to make a porcelain, of the same kind as the Chinese, with materials found in France. Whether he could not find any materials equal to those of China, particularly that material analogous to the petuntse of the Chinese, or whether other occupations prevented the continuance of his researches, we do not know; but we find from his second Memoir upon porcelain, that he afterward attempted to make an artificial petuntse, by mixing our vitrifiable stones with salts capable of rendering them fusible, or even by substituting for it glass ready formed, and by adding to these such substances as he thought might be substituted for kaolin. But he probably found, that he could not execute these intentions; for he did not resume this subject from the year 1729 to 1739, when he gave a process for converting common glass to a singular kind of porcelain, to which he has given his name, and of which we shall treat in the following article.

Although Reaumur has not entirely exhausted this subject, he has surmounted many difficulties, and has given just notions concerning it: in a word, he has opened the road for all those who afterward engaged in this pursuit, and has therefore a right to share the honour of the important discoveries which have been since made by others.

But as a person, who first unravels so intricate and hidden a matter as the manufacture of porcelain, can scarcely discover every thing concerning his subject, Macquer supposes Reaumur has been mistaken, or rather misled, in two important particulars. His first errour concerns the Saxon porcelain, which he confounds with the other fusible porcelains made in Europe. Macquer expresses his doubts, whether formerly a porcelain were made in Saxony composed entirely of fusible or vitrifiable materials, the vitrification of which was stopped in proper time. Possibly this was the first kind of porcelain made in that country, and which Reaumur had examined. He is however certain, that he has never seen any such Saxon porcelain; and that all of that country, which he had examined, was capable of resisting the most violent fires without fusion, as well at least as those of China and Japan. Reaumur might have been misled by the appearance of the internal texture of this porcelain. For when a piece of it is broken, its internal surface does not appear granulous, but compact, uniform, smooth, shining, and much resembling white enamel. But this appearance, so far from showing that Saxon porcelain is a fused or vitrified substance, proves that it is not entirely composed of fusible matters.

All who have considered attentively this subject, know, that the internal surface of the most fusible porcelains is also the least dense and least compact; the reason of which is, that no vitreous matter can be smooth and dense internally, unless it has been completely fused. But if the density and shining appearance of the internal surface of the Saxon porcelain were only the effects of the fusion of a vitreous matter, how could we conceive, that vessels formed of that matter should have sustained the necessary fusion for giving this density and shining appearance, without having entirely lost their shape? The impossibility of this is evident to every one who has been conversant in these matters, and in the fusion of glass.

This quality of the Saxon porcelain must therefore proceed from another cause. It does indeed contain, as every porcelain does, particularly those of China and Japan, a fusible substance, which has been even completely fused during the baking. Its density also and its internal lustre proceed chiefly from this fused matter; but we are also certain that it contains a large quantity of a substance absolutely infusible, from which it receives its admirable whiteness, and its firmness and solidity during the baking; in a word, which supplies the place of the oriental kaolin, and which has the property of contracting its dimensions considerably while it incordorates with the fusible substance. If it be subjected to the most decisive trial, namely, the action of a violent fire, capable of melting every porcelain composed of fusible matters alone, Macquer affirms, after many experiments, that it cannot be fused, unless by a fire capable of melting the best Japanese porcelain. The Saxon porcelain is therefore not to be confounded with those which are vitreous and fusible, but is in its kind as excellent as that of Japan, and perhaps superior, as we shall see when we enumerate the qualities which constitute the excellence of porcelain.

The subject of Reaumur's second errour, or, at least, that which he has not sufficiently explained, is the kaolin of China. According to him, this matter is a fine talky powder, from the mixture of which with petuntse the oriental porcelain is formed. Possibly a very finely ground talky substance mixed with petuntse might form a porcelain similar to the oriental; but persons acquainted with the manufacture of any porcelain, according to Macquer, must perceive the impossibility of forming vessels, unless the paste of which they are made be so ductile and tenacious, that it may be worked upon a potter's lathe, or at least that it may be moulded. But talks or any kinds of stones, however finely ground, cannot acquire the requisite tenacity, which clays only, of all known earthy substances, possess. The Chinese porcelain vessels evidently appear to be turned upon the lathe, since they retain the marks of it: hence they must have been formed of a very tenacious paste, and consequently the kaolin is not a purely talky matter, but is mixed with clay; or else the petuntse and kaolin are not, as Reaumur supposes, the only ingredients of the paste of which Chinese porcelain is formed, but a sufficient quantity of some binding matter, unknown to father d'Entrecolles and Reaumur, must be also added.

In this point, however, Macquer is very probably mistaken, as it has lately been found, that some magnesian earths are capable of forming pottery, as well as alumine. The porcelain of Baudiffero was pronounced both by Macquer and Baumé to be a clay of superior quality to that used at Sévres; Mr. Giobert, however, attempting to manufacture alum with it, produced to his great surprise nothing but very pure and beautiful crystals of sulphat of magnesia. In fact, on a careful analysis he found it consist of magnesia 68, carbonic acid 12, silex 15·6, sulphur of lime 1·6, water 3. Prof. Proust too informs us, that a beautiful porcelain, much harder than that of Sévres, is manufactured near Madrid; in which a siliceous magnesian stone, with only a few particles of alumine and lime, and a portion of potash, which he supposes contributes much to its superiority, is used instead of kaolin. Further, the Chinese are said to have discovered lately a new substance, which they prefer to kaolin, called hoa-che. This is described as a species of chalk, having a great resemblance to soap, of an exceeding fine grain, and glutinous: and it is added, that their physicians prepare a detersive, aperient, and cooling medicine with it; qualities much more indicative of a magnesian than an aluminous salt. The china made with it too is peculiarly light.

Although, since Reaumur, no scientific person has written expressly concerning porcelain, many have attempted to make it. Manufactures have been established in almost all the states of Europe. Beside that of Saxony, which has been long established, porcelain is also made at Vienna, at Frankenthal, and lately in the neighbourhood of Berlin. All these German porcelains are similar to the Saxon, and are made of materials of the same kind, although they differ somewhat from each other. England and Italy also have their porcelains, the chief of which were those of Chelsea and of Naples. But porcelain is now made of excellent quality in Staffordshire, Worcestershire, and many other parts of England. Mr. de la Condamine, in a journey into Italy, visited a manufacture of porcelain established at Florence by the Marquis de Ginori, then governor of Leghorn. Mr. de la Condamine observed particularly the large size of some pieces of this ware. He says he saw statues and groups half as large as nature, modelled from some of the finest antiques. The furnaces in which the porcelain was baked were constructed with much art, and lined with bricks made of the porcelain materials. The paste of this porcelain is very beautiful; and from the grain of broken pieces of it, it appears to have all the qualities of the best Chinese porcelain. A whiter glazing would be desirable, which they might probably attain, if the Marquis Ginori had not determined to use those materials only which were found in that country.

But in no state of Europe have more effectual attempts been made to discover porcelain, or an earlier establishment of manufactures, than in France. Before even Reaumur had published on this subject, porcelain was made at St. Cloud, and in the suburb of St Antoine at Paris, which was of the vitreous and fusible kind, but considerably beautiful. Since that time, considerable manufactures of it have been established at Chantilly, at Villeroi, and at Orleans; the porcelains of which have a distinguished merit. But certainly the admirable works produced in the royal manufacture at Sévres do most honour to France. This porcelain holds at present a distinguished rank, from its shining white, its beautiful glazing, and coloured grounds, in which, according to Macquer, no porcelain has equalled it. The magnificence of the gilding, the regularity and elegance of its forms, surpass every thing of the kind. In the painting and sculpture much genius and talents are displayed. Lastly, as all the operations of this great establishment were directed by men of known capacity, assisted by philosophical and chemical researches, this manufacture in Macquer's time was upon the point of producing porcelain capable of emulating or equalling the most perfect and most solid works of this kind.

We must carefully distinguish the qualities which only contribute to beauty and external appearance, from the intrinsic and essential properties, in which the goodness and solidity of porcelain consist. All persons who have made experiments in this way have soon discovered the possibility of making compounds very white, beautifully semitransparent, and covered with a shining glaze; but which cannot be worked for want of tenacity, are not sufficiently compact, are essentially fusible, are subject to break by sudden application of heat and cold; and lastly, the glazing of which cracks, becomes rough, and consequently loses its lustre by use, because it is too soft.

On the other side, we shall also find it not difficult to compose very tenacious pastes, which shall be capable of being easily worked and well baked, which in the baking shall acquire the desirable hardness and density, which are infusible, and capable of sustaining very well the sudden change of heat and cold; and in a word, which shall have the qualities of the most excellent porcelain, excepting whiteness and beauty. We shall soon see, that the materials fit for the composition of such porcelains may be found abundantly in every country. The only difficulty then in this inquiry concerning porcelain is, to unite beauty and goodness in one composition.

Macquer first remarked, that, before we had any knowledge of oriental porcelain, and from time immemorial, porcelain was made in Europe equal to it in goodness and in essential qualities, and was universally used, and even sold very cheap. For those potteries called stone-ware are not of modern invention, and have all the essential qualities of the best Japanese. If we except whiteness, on which alone the semitransparency depends, and compare all the properties of Japanese porcelain with those of our stone-ware, no difference can be found betwixt them. The same grain appears internally in both; the same sound is produced by striking them when properly suspended; the same density, the same hardness, by which they strike fire with steel; the same faculty of sustaining the heat of boiling liquors without breaking, and the same infusibility in fire, are observable. Lastly, if the earths of which stone-ware is made were free from heterogeneous colouring matters, which prevent their whiteness and semitransparency; if vessels were carefully formed; if all the proper attentions were given; and if these vessels were covered over with a fine glazing; they would be as perfect porcelain as that of Japan. The most perfect porcelain, therefore, is nothing else than a fine white stone-ware.

The French stone-ware, or poterie de gre, is formed of a whitish clay, in which a good deal of fine white sandy particles is intermixed. The English stone-ware is composed of tobacco-pipe clay and ground flints. This ware, when sufficiently burnt, has, as well as the French, those qualities of porcelain which Macquer calls essential, namely strength, hardness, the property of sustaining the heat of boiling water, and infusibility. See POTTERY.

Earths of this kind were thought to be more rare in Europe than in Japan and China. And probably also the want of a knowledge where to find these earths was the cause, that the first makers of porcelain confined themselves to an external imitation, by employing nothing but vitrifiable matters with fusible salts and a small quantity of white earth, from which fusible and vitreous porcelains were composed, which might be called false porcelains. But things are much changed since these first attempts. Beside the discoveries of the Count de Lauraguais and of Mr. Guettard, genuine white porcelains were made a long time ago in Germany, especially in Saxony and at Frankenthal.

These porcelains are not inferior in any respect to the oriental; they are even much superior in beauty and whiteness to the modern oriental porcelain, which has much degenerated in these respects: they seem even to excel the oriental in the most valuable quality of porcelain, namely, the property of sustaining the sudden change o heat and cold. We cannot judge of th quality of porcelain by a slight trial; fo so many circumstances concur to make piece of porcelain capable or incapable o sustaining the sudden application of he and cold, that if at the same time boilin water be poured into two vessels, one which is good porcelain and the other ba the former may possibly break, and th latter remain entire: the only true metho of discovering good porcelain in this r spect is, to examine several pieces of which are daily used—for instance a set tea-cups. But Macquer says, he has o served, that in many such pieces of orie tal porcelain, which have been long a daily used, cracks in the direction of th height may be always perceived, whic are never seen in the good European po celains.

Every one talks of porcelain, and y few are connoisseurs in it. None can considered as such, but those who ha long made it an object of their inquiri That the antient Japanese porcelain is t most perfect, is a general opinion. Th porcelain is indeed very beautiful, and w must also acknowledge, that its quality is e cellent. It has been our model, and h long been the object of our admiration a emulation; but we have never been a to equal it, and many persons believe never can be equalled. Some persons ev decry the Saxon porcelain for a quali which really gives it a superiority to t Japanese, namely, the greater smoothne lustre, and less granulous appearance of internal surface than the oriental. The semblance of this surface to that of gl has evidently suggested this notion; and would be well founded, if the density a lustre of this porcelain proceeded only fr a fusible and vitreous quality: but as th do not, and as this porcelain is as fixed a as infusible as the Japanese, its density, far from being a fault, is a valuable qual For we must allow, that of porcelains eq in other respects, those are best which most firm and compact. Hence, the in rior substance of the Japanese porcelai esteemed for its greater density, compa ness, and lustre, beyond our vitreous or f porcelains; because these qualities indic greater cohesion, and more intimate inc poration of its parts. For the same rea also, the superior density of the Saxon p celain ought to give it the preference to Japanese. Besides, nothing would be sier than to give the Saxon porcelain granulous texture of the Japanese, by m ing with the paste a certain quantity of sa But the persons who perfected that ma facture were certainly sensible, that suc conformity to the Japanese porcelain wo lessen the merit of theirs. For we kno that, in general, porcelains are better proportion as they contain a larger proportion of clay or earth, and less of sand, flints, or other matters of that kind.

The basis of the porcelains, which Macquer calls fusible, vitreous, or false porcelains, is called by artists a fritt. It is nothing else than a mixture of sand or of powdered flints, with salts capable of disposing them to fusion, and of giving them a great whiteness by means of a sufficient heat. This fritt is to be then mixed with as much of a white tenacious earth, of an argillaceous or marly nature, as is sufficient to make it capable of being worked upon the wheel, and no more. The whole mixture is to be well ground together in a mill, and made into a paste, which is to be formed, either upon the wheel or in moulds, into pieces of such forms as are required.

Each of these pieces, when dry, is to be put into a case made of earthen ware. These cases are called by English potters *seggars*, which is a corruption of the words *safe guard.* They are generally formed of coarser clays, but which must also be capable of sustaining the heat required without fusion. By means of these cases, the contained porcelain is preserved from the smoke of the burning fuel. The whiteness of the porcelain depends much on their compactness of texture, by which the smoke is excluded, and on the purity of the clay of which they are made. These cases are to be ranged in piles one upon another, in a furnace or kiln, which is to be filled with them to the roof. The furnaces are chambers or cavities of various forms and sizes, and are so disposed, that their fireplace is on the outside, opposite to one or more openings which communicate within the furnace. The flame of the fuel is drawn within the furnace, the air of which rarefying determines a current of air from without inwards, as in all furnaces. At first a very little fire is made, that the furnace may be heated gradually; and is to be increased more and more, till the porcelain is baked; that is, till it has acquired its proper hardness and transparency; which is known by taking out of the furnace from time to time small pieces of porcelain placed for that purpose in cases which have lateral openings, and examining them. When these pieces show that the porcelain is sufficiently baked, the fire is no longer to be supplied with fuel, the furnace is to be cooled, and the porcelain taken out, which in this state resembles white marble not having a shining surface. This is afterward to be given by covering them with a vitreous composition, called the glazing.

The porcelain when baked and not glazed is called biscuit, and is more or less beautiful according to the nature of its composition.

As no imitation of sculpture in porcelain can preserve all the delicacy of its workmanship when covered with a glazing; and as sculptors avoid polishing their marble figures, because the lustre of the polish is disadvantageous; therefore in superior manufactures, all figures, or little statues, and even some ornamental vases, are left in the state of biscuit. The other pieces of porcelain are to be glazed in the following manner:

A glass is first to be composed suited to the nature of the porcelain to which it is to be applied, for every glass is not fit for this purpose. We frequently find, that a glass, which makes a fine glazing for one porcelain, shall make a very bad glazing for another porcelain, shall crack in many places, shall have no lustre, or shall contain bubbles. The glazing then must be appropriated to each porcelain, that is, to the hardness and density of the ware, and to the ingredients of its composition, &c. Much appears to depend on the glaze and the body of the ware possessing the property of equally expanding by increase of temperature: if they differ in this respect, the glaze must infallibly crack during the cooling from the furnace.

These glazings are prepared by previously fusing together all the substances, of which they consist, so as to form vitreous masses. These masses are to be ground very finely in a mill. This vitreous powder is to be mixed with a sufficient quantity of water, or other proper liquor, so that the mixture shall have the consistence of cream. The pieces of porcelain are to be covered with a thin stratum of this matter, and when very dry they are to be again put into the furnace in the same manner as before, and to be continued there till the glazing is well fused. The necessary degree of fire for fusing the glazing is much less than for baking the paste.

The pieces of porcelain which are intended to remain white are now finished; but those which are to be painted and gilded must undergo farther operations. The colours to be applied are for the most part the same as those used for enamel painting. They all consist of metallic oxides bruised and incorporated with a very fusible glass. The purple precipitate of gold, that bears the name of cassius, affords a crimson; but it requires nice management, as a little too much heat, or carbonaceous vapours, easily spoil it. If the flux contain a great quantity of lead, it will produce a violet. The crimson for soft porcelain is made with fulminating gold gently decomposed and muriat of silver. Red oxide of iron prepared with nitic acid, and afterward calcined by fire, produces a red, or rose colour; but too much heat changes it brown. Yellows are composed of the oxides of lead and antimony, with sand; to which oxide of tin is sometimes added. By adding a little red oxide of iron, the fine lively colour of the marigold is produced. Blues are derived from oxide of cobalt: greens from oxide of copper, and sometimes from a mixture of yellow and blue. When a strong heat is required, the oxides of cobalt and nickel are mixed, but they afford only a brownish green. Brown reds are obtained by mixing in different proportions manganese, brown oxide of copper, and amber. Oxide of manganese, brown oxide of copper, and a little oxide of cobalt, give a beautiful black, but it is liable to scale and become dull. At Sévres a fine black is made by mixing blue with the oxides of iron and manganese. In melting copper with two parts of glacial acid of phosphorus, and a twelfth part of powdered charcoal, a fine red enamel is found covering the phosphuret of copper, which would make a good colour on porcelain. These colours being ground with gum water, or with oil of spike, are to be employed for the painting of the porcelain with designs of flowers and other figures. For gilding, a powder or oxide of gold is to be applied in the same manner as the coloured enamels. The painted and gilded porcelains are to be then exposed to a fire capable of fusing the glass with which the metallic colours are mixed. Thus the colours are made to adhere, and at the same time acquire a gloss equal to that of the glazing. The gold alone has not then a shining appearance, which must be afterward given to it by burnishing with a blood-stone. Silver applied in the same manner as gold would be very liable to tarnish; but platina, precipitated from its solution by muriat of ammonia, and the muriat expelled by heat so as to leave the platina in the form of a light gray powder, may be applied in the same manner as gold, and when burnished will resemble silver with a slight steel cast.

The operations for the infusible porcelains, and also for such as are of the nature of stone-ware, are somewhat more simple. The sands and stones which enter into their composition are to be ground in a mill: the earths or clays are to be washed: the materials are to be well mixed, and formed into a paste: the pieces are first rudely formed upon a potter's wheel; and when dry, or half dry, they are turned again upon the wheel, or in a lathe or other engine, and their form is made more perfect: they are then placed in the furnace, not to bake them, but only to apply a sufficient heat to give them such a solidity, that they may be handled without breaking, and may receive the glazing. As the pieces of porcelain after this slight heat are very dry, they imbibe water readily. This disposition assists the application of the glazing. The vitrifiable or vitrified matter of this glazing, which has been previously ground in a mill, is to be mixed with such a quantity of water, that the liquor shall have the consistence of milk. The pieces of porcelain are hastily dipped in this liquor, the water of which they imbibe, and thus on their surface is left an uniform covering of the glazing materials. This covering, which ought to be very thin, will very soon become so dry, that it cannot stick to the fingers when the pieces are handled.

The pieces of the porcelain are then put into the furnace to be perfectly baked. The heat is to be raised to such a height, that all within the furnace shall be white, and the cases shall be undistinguishable from the flame. When, by taking out small pieces, the porcelain is known to be sufficiently baked, the fire is discontinued, and the furnace cooled. If the baking have been well performed, the pieces of porcelain will be found by this single operation to be rendered compact, sonorous, close-grained, moderately glossy, and covered externally with a fine glazing. The painting and gilding of this porcelain are to be executed in a manner similar to that already described. For the various compositions of glazes and enamels, see POTTERY.

PORCELAIN OF REAUMUR. Reaumur having made many experiments to discover the nature of the materials which enter into the composition of the oriental porcelain, and having ascertained, that all porcelain is an intermediate substance betwixt an earth and glass, very ingeniously thought of reducing glass ready made to the state of porcelain, by reversing the effect of the vitrification, or partly unvitrifying it: hence this kind of ware has been called porcelain unvitrified. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky colour, semitransparent, so hard as to strike fire with steel, infusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine bottles are made, succeeds best. The glass vessel which is to be converted into porcelain is to be inclosed in a baked earthen case or seggar. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster; and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthen ware; after which the glass vessel will be found transformed into such a matter as has been described.

This kind of porcelain has not a very white colour, particularly on its surface; but for some purposes it may be useful, especially for chemical vessels. Reaumur has not explained how this transformation is effected. Macquer imagined, that the sulphuric acid of the gypsum quits its basis of calcareous earth, and unites with the alkaline salt and saline earth of the glass, with which it forms a kind of salt, different from the sulphat of lime, by the interposition of which matter the glass acquires the qualities of porcelain.

Reaumur says, that glass thus rendered

opake, white, infusible, and hard, is inferior in beauty to the oriental porcelain; but that in utility and every essential quality of porcelain it is equal to any, and even superior in the property of sustaining alternations of heat and cold.

The character given by Reaumur of this porcelain induced Dr. Lewis (who had also observed the changes produced upon glass retorts exposed to violent heat in a sand-bath) to make farther experiments on this matter, an account of which he has published in the Philosophical Commerce of Arts.

From Dr. Lewis's experiments we find the following results:

1. Green glass cemented with white sand received no change in a heat below ignition. In a low red-heat the change proceeded exceeding slowly; and in a strong red-heat, approaching to whiteness, the thickest pieces of glass bottles were thoroughly converted in the space of three hours.

2. The glass suffered the following progression of changes by continued heat: First, its surface became blue, its transparency was diminished, and a yellowish hue was observable when it was held between the eye and the light. Afterward it was changed a little way on both sides into a white substance, externally still blueish; and as this change advanced still farther and farther within the glass, the colour of the vitreous part in the middle approached nearer to yellow: the white coat was of a fine fibrous texture, and the fibres were disposed nearly parallel to one another, and transverse to the thickness of the piece: by degrees the glass became throughout white and fibrous, the external blueishness at the same time going off, and being succeeded by a dull whitish or dun colour: by a still longer continuance in the fire, the fibres were changed gradually from the external to the internal part, and converted into grains; and the texture then was not unlike that of common porcelain. The grains, at first fine, and somewhat glossy, appeared afterward larger and duller, and at length the substance of the glass became porous and friable, like a mass of white sand slightly coherent.

3. Concerning the qualities of the converted glass Dr. Lewis observes, that the whiteness of the internal part was not inferior to that of porcelain, but that its surface was the least beautiful; that the thick pieces were quite opake, and that several thin pieces were semitransparent: that while it remained in a fibrous state its hardness became greater than that of glass, or of the common kinds of porcelain; it was capable of sustaining sudden changes of heat and cold better than any porcelain; and in a moderate white heat, it was fusible into a substance not fibrous, but vitreous and smooth, like white enamel: that when its texture had become coarsely granulated, it was now much softer and infusible: and lastly, that when some coarsely granulated infusible pieces, which with the combination of a moderate heat would have become porous and friable, were suddenly exposed to an intense fire, they were rendered remarkably more compact than before; the solidity of some of them being superior to that of any other ware.

4. No difference appeared in the internal colour, hardness, texture, or the regular succession of changes, from the use of different cementing substances; though in external appearances the differences were considerable. All the pieces, which had been surrounded with charcoal or with soot, were externally of a deep black colour, which did not disappear by exposure to a strong fire during an hour, with free access of air. Coloured clays and sands communicated different shades of a brown colour; and white earths gave whitish, grayish, or brownish tinges. White sand, calcined flints, and gypsum, gave in general the greatest whiteness, and tobacco-pipe clay the greatest glossiness and brightness.

5. Glasses composed of earths without alkaline salt, glass of lead, flint glass, crown-glass, looking-glass plates, a glass prepared with calcined flints and a fixed alkaline salt, and even green glass which had been fused with a ninth part of alkaline salt, suffered none of the above alterations by cementation. Green bottle-glass and common window-glass were most susceptible of these alterations.

6. The changes produced by cementation could not proceed from any absorption of matter from the cementing substance; because no increase of weight was given, and because the same changes were produced upon a piece of glass merely by heat, without any cementing substance.

Dr. Lewis in his reflections on this subject refers the change to a loss of part of the alkali of the glass. The weight of the fibrous porcelain is not perceptibly different from that of the glass itself; but he observes, that the alkali which may exude is attached to the outer surface; and in the latter stages of the process, it evidently causes an agglutination of the sand in which the glass may be bedded. Mr. Delaval, who has made many experiments on this object, showed me a mass of sand concreted in the form of the neck of a bottle, out of which he had poured the sand of the glass itself reduced to perfect grains by the heat. It seems probable in this instance, that the sand of cementation had a greater affinity to the alkali than that of the glass itself.

Porphyry. Any stone which in a siliceous or argillaceous ground contains scattered specks, grains, or dots of feldtspar, visible to the naked eye, is commonly denominated a porphyry. Quartz, hornblende, and mica, and other crystals as well as those of feldtspar, are usually found with the latter: and Mr. Kirwan would not exclude such stones with a magnesian or calcareous ground.

Many of the porphyries are very beautiful, and were wrought for ornamental purposes by the ancients, but are not at present on account of their extreme hardness.

A kind of porphyry called sonorous is found in the mountains of Bohemia, and Upper Lusatia, and in the county of Fulda, of a gray colour sometimes approaching to green, and a foliaceous fracture. It has a sound almost metallic when broken.

Portland Stone. A compact sandstone from the isle of Portland. The cement is calcareous.

Potash. By this name is now commonly distinguished that alkali which was formerly called fixed, to distinguish it from ammonia, and vegetable, as it was supposed to be peculiar to that kingdom: though it has been found of late in various stones, and in small quantities even in animal substances, and at a red-heat it is volatilized. From the article known in commerce by the name of potashes, which consist chiefly of this alkali, though in a very impure state, the French neologists termed the alkali *potasse*, whence our potash is derived; though this has the inconvenience of rendering the pure alkali liable to be confounded with the heterogeneous compound from which it is extracted. The names of lixivia, given it by Dr. Black, tartarin, by Kirwan, vegalkali, by Dr. Pearson, and kali, by the London college, are not open to this objection; but neither of them has been adopted by other chemists. Some have retained the French word without alteration, others have altered its termination merely; and perhaps potassa is the preferable term, though we have followed the current of the more general usage.

The composition of potash remains at present in obscurity; though Chaptal supposed, from some phænomena in the manufacture of nitre, that it was a compound of lime and nitrogen; and Desormes and Guyton have since imagined, that they had reason to conclude it to be a compound of lime and hidrogen; an opinion favoured by the observation of Berthollet, that hidrogen appears more entitled to be considered as the alkaline principle than nitrogen: but no facts at all conclusive have been adduced on this subject.

It is universally known that the vegetable fixed alkali may be extracted in greater or less quantity from the roots of almost all vegetables, and it is now well established, that it preexists in vegetables before combustion; not indeed in a separate uncombined state, but united partly with the sulphuric and muriatic acids, and sometimes the nitric; but generally, and for the greater part, with a vegetable acid and oil, with which it forms essential salts, as they ar termed. These vegetable acids and oils ar decomposed during combustion, and thu the alkaline part is set free. But the su phuric acid by contact with inflamed ma ter is converted into sulphur, part of whi unites to the disengaged alkali, which pr tects it from combustion, and forms what called an alkaline sulphuret; a produ formed in most ashes, especially when t air has not had free access to them duri combustion.

As alkaline salts are of great importan in the several arts, the proportion of asl afforded by different vegetables, and that alkali by each vegetable, has of late been curately attended to. Kirwan has the fore presented the best authenticated res of the experiments made with this view.

One thousand lbs.	*lbs. of ashes.*	*lbs. of salt.*	
Stalks of Turkey wheat or mais	88·6	17·5	
Sun-flowers .	57·2	20·	
Vine-branches .	34·	5·5	
Box . .	29·	2·26	
Sallow . .	28·	2·85	
Elm . . .	23·5	3·9	
Oak . .	13·5	1·5	
Aspen . .	12·2	0·74	
Beech . .	5·8	1·27	
Fir . . .	3·4	0·45	
Fern in August .	36–46	4·25	Hom
Wormwood .	97–44	73·	Wieg
Fumitory . .	219·	79·	Iden

Table of the saline product of one thousand of ashes of the following vegetables:

	Saline products.	
Stalks of Turkey wheat or mais	198 lbs.	
Stalks of sun-flower	349	
Vine-branches	162·6	
Elm . .	166	
Box . .	78	
Sallow . .	102	
Oak . .	111	
Aspen . .	61	
Beech . .	219	
Fir . .	132	
Fern cut in August . .	116	or 125 accordin Wildenheim
Wormwood .	748	
Fumitory .	360	
Heath . .	115	Wildenheim.

On these tables Kirwan makes the lowing remarks:

1. That in general weeds yield ashes, and their ashes much more salt, woods; and that consequently, as to sal the vegetable alkali kind, as potash, p ash, cashup, &c., neither America, Tr nor the northern countries have any ad tage over Ireland.

2. That of all weeds fumitory prod

most salt, and next to it wormwood. But if we attend only to the quantity of salt in a given weight of ashes, the ashes of wormwood contain most. Trifolium fibrinum also produces more ashes and salt than fern.

Most of the experiments on woods were made in France by order of government, under the inspection of the overseers of the salt-petre works; yet are to be read with caution by those who attend to the quantity of alkali with respect to bleachers. For as sulphat of potash, a salt useless to bleachers, is as serviceable to the makers of saltpetre as alkaline salts*, they have constantly confounded one with the other; but the experiments made on weeds were instituted by persons who carefully discriminated these salts. One hundred grains of the salt of wormwood contain but six of the sulphat of potash, and one hundred grains of the salt of fumitory contain fifteen. All alkaline salts, unless mixed with lime, contain also one fifth at least of carbonic acid, which produces no other effect in bleaching than that of restraining their activity.

The process for obtaining pot- and pearl-ash is given by Kirwan, as follows:

1. The weeds should be cut just before they seed, then spread, well dried, and gathered clean.
2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be found. A close smothered fire, which has been recommended by some, is very prejudicial.
3. They should be lixiviated with twelve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately discover when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.
4. The lie thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the lie, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak lies evaporate more quickly than the stronger. The salt thus procured is of a dark colour, and contains much extractive matter, and being formed in iron pots is called pot-ash.
5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed, and the alkali would form such a union with the earthy parts as could not easily be dissolved. Kirwan adds this caution, because Dr. Lewis and Mr. Dossie have inadvertently directed the contrary. This salt thus refined is called pearl-ash, and must be the same as the Dantzic pearl-ash.

The French call the refined ash *potasse*, and the unrefined *salin*. Kirwan remarks, that the alkali manufactured in the above-mentioned manner may not be sufficiently pure for the earlier operations of bleaching; but by the addition of half a pound of quicklime to every hundred of the salt, or ten pounds for every ton, it will be rendered sufficiently sharp. There is no danger, that any of the lime will remain in the lie; but if any should, it will immediately be discovered and deposited by the addition of a little of the unmixed lie.

For the most œconomical construction of a laboratory and furnaces for the above operations, Kirwan refers to the description given in a French tract called *L'Art de fabriquer le Salin et la Potasse;* which I have not seen. And he adds, that it would be no inconsiderable advantage to perform the evaporation by a fire made of vegetables, the ashes of which might afterward be employed. Pearl-ash, as he also remarks, is frequently tinged green or blue from manganese, which Scheele has shown to exist in the ashes of most vegetables. When the alkali is calcined without melting, it proves perfectly white, like the Dantzic pearl-ash. See PEARL-ASH.

To obtain this alkali pure, two parts of quicklime in powder are added to one of pearl-ash; as much water as will slake the lime is then poured on; and afterward more water is added, so as to reduce the whole to a thin consistence. After this has stood two or three days, stirring it occasionally, the liquor is filtered through a large glass funnel, the tube of which is obstructed by a piece of linen; and the residuum is elutriated on the filter with more water, till eight or ten times the weight of the pearl-ash have passed through. In this process, however, the whole of the carbonic acid is not extracted by the lime, other saline matters will be held in solution, and a portion of silex may be dissolved by means of the alkali. Barytes, however, will abstract the greater part of the carbonic acid, and likewise the sulphuric, as its attraction for these is more powerful than that of lime.

If it be required in a state of extreme purity, Berthollet recommends, to evaporate this solution till it becomes of a thickish consistence, add about an equal weight of

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* Much of the nitre obtained by elixation of the nitre-beds has a calcareous basis. Sulphat of potash will change this into nitre by double affinity. For the alkali unites with the nitric acid, which gives its calcareous base to the sulphuric.

alcohol, and let the mixture stand some time in a close vessel. Some solid matter, partly crystallized, will collect at the bottom; above this will be a small quantity of a dark coloured fluid; and on the top another lighter. The latter, separated by decantation, is to be evaporated quickly in a silver basin in a sand heat. Glass, or almost any other metal, would be corroded by the potash. Before the evaporation has been carried far, the solution is to be removed from the fire, and suffered to stand at rest: when it will again separate into two fluids. The lighter, being poured off, is again to be evaporated with a quick heat; and on standing a day or two in a close vessel it will deposit transparent crystals of pure potash. If the liquor be evaporated to a pellicle, the potash will concrete without regular crystallization. In both cases a high-coloured liquor is separated, which is to be poured off; and the potash must be kept carefully secluded from air.

Mr. Henry observes, that a perfectly pure solution of potash will remain transparent on the addition of barytic water, show no effervescence with dilute sulphuric acid, and not give any precipitate on blowing air from the lungs through it by means of a tube.

Since the preceding was sent to press, Mr. Davy has made an extraordinary discovery by subjecting potash and soda to the action of a powerful galvanic pile. Moistened potash, exposed on a plate of platina to the action of the galvanic circle, was decomposed into oxigen and a base, that in some of its properties resembles the metals. This detrudes oxigen from its rank as the generator of acidity, since it appears to be a constituent part of both the fixed alkalis and the volatile alkalis likewise, and consequently to be no less essential to alkalis than to acids; if not more essential to them, since we know of some substances possessing acid properties, the existence of oxigen in which is at least very doubtful, if not disproved. We may add, that oxigen has been educed by Mr. Davy from both strontia and barytes.

The base of potash thus obtained is highly inflammable, and forms an amalgam with mercury: but it is so far from having the specific gravity of metals, that it is lighter than most fluids, its gravity being to that of distilled water only as six to ten.

At the freezing point it is hard, brittle, and when broken exhibits facets, as if crystallized, when examined by the microscope. At 40° it is scarcely distinguishable from a small globule of quicksilver; at 60° it is quite fluid; and at a heat a little below redness it is volatile.

It is extremely greedy of oxigen, absorbing it rapidly from the atmosphere, and resuming the alkaline state. It amalgamated with twice its bulk of quicksilver, and applied to iron, silver, gold, or platina, these metals are immediately dissolved, and converted into oxides, while the alkali is regenerated. Glass is decomposed by it, the basis of potash combining with its alkali, and forming a red oxide, in which the base is less oxigenated than in potash. This red oxide was likewise procured by other means.

From a considerable number of experiments, potash appeared to consist of 85 parts base and 15 of oxigen.

A globule of the base, placed on a piece of ice, burnt with a bright flame and intense heat, and potash was found in the water from the melted ice. In this case, as well as when a globule was thrown into water, a considerable quantity of hidrogen was rapidly evolved. When a globule was placed on a piece of moist turmeric paper, it appeared instantly to acquire intense heat, but moved so rapidly in quest of the moisture, that the paper was no where burned; but a deep red stain, that marked its course, proved the regeneration of the alkali.

From the avidity of the metalloid, as it has been called, for oxigen, it is not easy to keep it: but in distilled naphtha a film forms round it, which excludes oxigen so that it may be preserved four or five days.

Mr. Charles Sylvester, and some other gentlemen, have repeated Mr. Davy's experiments with similar results. Mr. Sylvester, however, always found a small portion of black matter formed at the wire coming from the copper end of the battery, which was not a suboxide of the base, for it remained permanent in water several weeks; and it did not appear to be charcoal. In one of this gentleman's experiments, the metalloid exploded, and burst the glass tube in which it was enclosed; and in one by a gentleman at Tunbridge it deflagrated suddenly, and was thrown about so as to injure his eyes: it should not be attempted, therefore, without caution.

This is the whole that has yet been made known on the subject; if any thing farther occur, it shall be noticed at the end of the article Soda, which see.—*Irish Trans.*—*Mem. of the Ac. of Sciences, and Nat. Instit.*—*Nich. Journ.*—*Chaptal.*—*Henry.*—*Murray.*

Potato. This is the bulb of a species of solanum, the tuberosum, an American plant, first brought to this country by Sir Walter Raleigh, now cultivated in every part of Europe, and in Britain constituting one of the most important articles of food. The plant and the bulb are too well known to require description.

Potatoes have been repeatedly subjected to chemical examination. Parmentier published an elaborate dissertation on their culture, uses, and properties, about the year 1776, which contributed considerably to promote the cultivation of them on the continent. Dr. Pearson communicated to the Board of Agriculture a valuable essay on potatoes, containing a set of chemical experiments on them, performed with his usual skill and ingenuity; and very lately Einhof has published an elaborate analysis of the root, in the fourth volume of Gehlen's Journal.

The variety of potato which chiefly occupied the attention of Einhof was that which has a red skin and flesh-coloured juice. When dried by a moderate heat, till they ceased to lose any weight, the potatoes were reduced to one fourth of their original weight.

The analysis of this root was conducted by Einhof pretty much in the same manner as his analysis of barley and rye. A determinate quantity of potatoes was reduced with water to a pulp, and then washed on a searce, till the liquid ceased to come off milky, or to hold any thing in solution. What remained on the cloth was the fibrous matter of the potato; but it differed essentially from the fibrous matter of most plants. With boiling water it formed a paste similar to that made by means of starch, and when dry it assumed a semitransparent appearance. This matter, when triturated in a mortar, and again washed with water, yielded a considerable portion of starch. The residue, which was of a light gray colour, being triturated a second time, formed a powder that bore a considerable resemblance to starch both in its appearances and properties.

The liquid with which the potato was washed was at first milky, but deposited on standing a heavy white powder, which was starch. When filtered it had a carmine red colour, and reddened vegetable blues. When boiled, a flaky precipitate separated, partly white and partly red. This precipitate possessed the properties of albumen. The residue, evaporated to the consistence of an extract, had a brownish colour, was insoluble in alcohol and ether, soluble in water, and, according to Einhof, was a mucilaginous matter. The following were the proportions of these various substances obtained from 7680 parts of potatoes:

Starch . . .	1153
Fibrous starchy matter .	540
Albumen . . .	107
Mucilage, in the state of a thick sirup .	312
	2112

To ascertain the nature of the acid that exists in potatoes, Einhof separated the juice of potatoes by a gentle pressure. He had first frozen and then thawed them, to facilitate the separation. Lime-water was added in excess to this liquid, and the precipitate was digested in diluted sulphuric acid, to separate the lime from the acid. Thus obtained, it was found to be a mixture of tartarous and phosphoric acids*. The sap, thus deprived of its acid, contained an excess of lime in combination with the mucilage. Einhof found, that this lime became gradually saturated with carbonic acid, even though the sap was kept in close vessels; and that in process of time, if a sufficient quantity of lime were present, the mucilage acquired a sweet taste; and when treated with alcohol, a portion dissolved, which yielded crystals of sugar. This he considered as a conversion of the mucilage into sugar.

From 1820 parts of dried potatoes, Einhof obtained 96 parts of grayish white ashes. Of these, 64 parts were soluble in water. They consisted chiefly of carbonat of potash; but contained likewise 10¼ parts of phosphoric acid, 3½ of sulphuric acid, and 2 of muriatic. The insoluble 35 parts consisted of earths and oxides. From 20 parts of it he obtained

2·5	Silex,
6·0	Lime,
4·0	Alumine,
7·0	Magnesia, with some manganese and oxide of iron.
19·5	

Einhof examined different kinds of potatoes. He found the same ingredients in all, but the proportions varied considerably. It is not necessary to state the results of his experiments, because similar variations doubtless occur even in the same kind of potato.

When potatoes are exposed to the action of frost, it is well known that they become soft, and acquire a sweet taste. This is succeeded by a sour taste, owing to the rapid evolution of acetic acid, and the root soon passes to a state of putrefaction. From the experiment of Einhof we learn, that the sugar is formed at the expense of the mucilage; for the other ingredients were found, in potatoes sweetened by frost, in the usual proportions. He considers this sweetening process as connected with the vegetative powers of the root.

When potatoes are boiled, they lose from one to one and a half per cent of their weight. The juice, which may be separated from them, is sweet-tasted. The meal is insoluble even in boiling water, though potato starch forms a transparent solution with hot water. Thus it appears, that by

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* Though Einhof obtained phosphoric acid by the method described in the text, it does not follow that it existed in the potatoes in an uncombined state. It might have been in combination with lime, and held in solution in the potato-juice by means of the tartarous acid.

boiling, the albumen, fibrous matter, and starch, combine together, and form an insoluble compound.

From the experiments, it appears that potatoes differ essentially from wheat and barley by containing no gluten. They approach, in some measure, to the nature of rye.—*Thomson's Chemistry.*

Potential Cautery. This name was formerly employed for the strong common caustic, the *calx cum kali puro* of the present London Pharmacopœia. It is made by boiling down a solution of caustic potash, and adding lime reduced to powder by affusion of water, so as to form a paste.

Pot Stone. See Lapis Ollaris.

Potter's Lead Ore. The common galena, or combination of lead and sulphur. See Lead and Ores.

Pottery. The art of making pottery is intimately connected with chemistry, not only from the great use made of earthen vessels by chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. We must however acknowledge, that, although chemists have the greatest interest to procure good crucibles and other earthen vessels, this art has been left almost entirely to the potter. Mr. Pott is the first who attended to this object. Beside many experiments stated in his Lithogeognosia, from which much instruction may be received relating to the perfection of chemical vessels, he has written a treatise expressly on this subject, in which he gives many compositions for crucibles, the chief of which shall be mentioned in this article.

All kinds of pottery are in general made of clays or argillaceous earths, because these earths are capable of being kneaded, and easily receiving any form, and of acquiring much solidity and hardness by exposure to fire. But clays differ much in the effects produced upon them by fire. Some clays which are of the purest kind resist the most violent fire without receiving any other change than a considerable hardness; but still they are not rendered so hard and compact as other clays. A second kind of clays by exposure to violent heat acquires a hardness equal to that of flints, and a texture compact and glossy, like that of good porcelain; but they are nevertheless infusible by the most violent heat. These qualities are occasioned by some fusible materials being mixed with them, as sand, chalk, gypsum, or ferruginous earth, which are in too small a quantity to effect a complete, but only a beginning or partial fusion. Lastly, a third kind of clays is first hardened by fire, and afterward completely fused. This last kind of clays evidently contains the largest quantity of the fusible matters above mentioned.

From the properties of these three principal clays it may be concluded, that from clays alone three principal kinds of pottery may be produced. With the first kind of clay, pots or crucibles may be formed capable of sustaining the most violent fire without fusion, of containing melted metals, and even hard glasses not too fluid; but which, from want of sufficient compactness, are incapable of containing during a long time in fusion very fusible substances, such as nitre, glass of lead, glasses containing much arsenic, &c., by which substances their pores are pervaded. These clays are employed advantageously for the formation of large pots or crucibles used in glass-houses for containing hard glass, as bottle-glass.

With clays of the second kind may be made crucibles and other potteries, commonly called stone ware. Potteries made with these earths, when sufficiently baked, are very sonorous, so hard as to strike fire with steel, capable of containing all liquids, of which the former kind, from their porosity, are incapable, and even resist the action of nitre, glass of lead, and other fluxes, when the earth of which they are formed is of good quality: but their hardness and density, which prevent their sudden expansion and contraction, by the hasty application of heat and cold, make them liable to break in all operations where they are suddenly exposed to heat or to cold, as for instance, in a furnace through which a strong current of air passes. If this kind of pottery had not this inconvenience, it would be the best and most perfect for the purposes of ordinary life and chemistry. Notwithstanding this inconvenience, it is the only pottery that is applicable on many occasions; but then all possible care must be taken to prevent its breaking, by a very gradual application of heat and cold, and by protecting it from currents of cold air.

With the fusible clays may be made many kinds of vessels, which are cheap, as they require little fire to bake them; for all this kind of pottery is but slightly baked; whence its texture is coarse and porous. Some utensils are made of this pottery without glazing; but in general they are covered with a glazing, without which, water or other liquids would pass through their pores. Some of this pottery, which is finished with more care, is covered with a white enamel, which makes it very neat and like porcelain. This is called Delft Ware, which see. Other coarser potteries of this kind are glazed with glass of lead mixed with metallic oxides, or fusible coloured earths; from which they receive various colours. This is the ordinary pottery.

A fine kind of pottery is made of white clays, or of such as whiten in the fire, the surface of which is vitrified by throwing into the furnace, when the ware is sufficiently baked, some common salt and saltpetre. This pottery is called English ware on the continent, because the first and best was made in England. It is white, fine, well baked, and has some small degree of transparency when thin; so that it is intermediate betwixt porcelain and common stone-ware, and may therefore be called a semiporcelain.

Keir affirms, that he has never seen any English stone-ware that had the semitransparency and whiteness mentioned by Macquer. As the English stone-ware is composed of tobacco-pipe clay and ground flints, both which substances are perfectly infusible, singly or jointly, it cannot possess any degree of transparency. The use of the flints is to give strength to the ware, so that it shall preserve its form during the baking: whereas vessels made of clay alone, though infusible by fire, and capable of acquiring, by having been exposed to an intense heat, the hardness of the best porcelain; yet while they are hot and soft they sink by their own weight, so as to lose the form given them. The process of manufacturing this stone-ware, according to Dr. Watson, is as follows:

Tobacco-pipe clay from Dorsetshire is beaten much in water: by this process, the finer parts of the clay remain suspended in the water, while the coarser sand and other impurities fall to the bottom. The thick liquid, consisting of water and the finer parts of the clay, is farther purified by passing it through hair and lawn sieves of different degrees of fineness. After this, the liquid is mixed (in various proportions for various wares) with another liquor, of as nearly as may be the same density, and consisting of flints calcined, ground, and suspended in water. The mixture is then dried in a kiln; and being afterward beaten to a proper temper, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When this ware is to be put into the furnace to be baked, the several pieces of it are placed in the cases made of clay, called seggars, which are piled one upon another, in the dome of the furnace: a fire is then lighted; and when the ware is brought to a proper temper, which happens in about forty-eight hours, it is glazed by common salt. The salt is thrown into the furnace, through holes in the upper part of it, by the heat of which it is instantly converted into a thick vapour; which, circulating through the furnace, enters the seggar through holes made in its side (the top being covered to prevent the salt from falling on the ware), and attaching itself to the surface of the ware, it forms that vitreous coat upon the surface which is called its glaze.

This curious method of glazing earthen ware by the vapour of common salt was introduced into England by two Dutchmen, near a century ago. It appears to be produced by a combination of the alkali with the siliceous earth or sand of the clay.

The yellow or Queen's ware is made of the same materials as the flint-ware; but the proportion in which the materials are mixed is not the same, nor is the ware glazed in the same way. The flint-ware is generally made of four measures of liquid flint, and of eighteen of liquid clay; the yellow ware has a greater proportion of clay in it; in some manufactories they mix twenty, and in others twenty-four measures of clay with four of flint. These proportions, if estimated by the weight of the materials, would probably give for the flint-ware about three cwt. of clay to one cwt. of flint, and for the yellow ware somewhat more clay. The proportion, however, for both sorts of ware depends very much upon the nature of the clay, which is very variable even in the same pit. Hence a previous trial must be made of the quality of the clay, by burning a kiln of the ware. If there be too much flint mixed with the clay, the ware, when exposed to the air after burning, is apt to crack; and if there be too little, the ware will not receive the proper glaze from the circulation of the salt vapour.

This glaze, even when it is most perfect, is in appearance less beautiful than the glaze on the yellow ware.

The yellow glaze is made by mixing together in water, till it becomes as thick as cream, 112 lb. of white lead, 24 lb. of ground flint, and 6 lb. of ground flint glass. Some manufactories leave out the glass, and mix only 80 lb. of white lead with 20 lb. of ground flint: and others doubtless observe different rules, of which it is very difficult to obtain an account.

The ware before it is glazed is baked in the fire: by this means it acquires the property of strongly imbibing moisture; it is therefore dipped in the liquid glaze, and suddenly taken out; the glaze is imbibed into its pores, and the ware presently becomes dry. It is then exposed a second time to the fire, by which means the glaze it has imbibed is melted, and a thin glassy coat is formed upon its surface: the colour of this coat is more or less yellow, according as a greater or less proportion of lead has been used. The lead is principally instrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the substances hitherto known, has the greatest power of promoting the vitrification of the substances with which it is mixed. The flint serves to give a consistence to the lead during the time of its vitrification, and to hinder it from becoming too fluid, and running down the sides of the ware, and thereby leaving them unglazed.

The yellowish colour which lead gives when vitrified with flints may be wholly changed by very small additions of other mineral substances. Thus, to give one instance: the beautiful black glaze, which is fixed on one sort of the ware made at Nottingham, is composed of twenty-one parts, by weight, of white lead, of five of powdered flints, and of three of manganese. The Queen's ware at present made is much whiter than formerly.

The coarse stone-ware made at Bristol consists of tobacco-pipe clay and sand, and is glazed by the vapour of salt, like Staffordshire flint-ware; but it is far inferior to it in beauty.

Chaptal tried various methods to glaze pottery without lead, and two among them succeeded well enough in his opinion to justify his publishing them. The first consists in mixing the earth of Murviel, which appears to be a fusible or compound clay, in water, and dipping the pottery therein: this done, it is suffered to dry; after which it is plunged into a second water, in which levigated green glass is mixed. This covering of vitreous powder fuses with the clay of Murviel, and the result is a very smooth, very white, and very cheap glazing.

The second method consists in immersing the dried pottery into a strong solution of sea-salt, and afterward baking it. The trial which Chaptal made in his furnaces gave him reason to expect, that this method might be used in large works.

He likewise obtained a very black glazing by exposing pottery strongly heated to the fumes of sea-coal. He coated several vessels in this manner by throwing a large quantity of coal in powder into a furnace, wherein the pottery was ignited to whiteness. The effect, he informs us, is still more complete, when the chimneys or tubes of aspiration of the furnace are at that moment closed, and kept so for some minutes.

The residuum left after distilling oxigenized muriatic acid, ground with sand, would make a good dark-bronze-coloured glaze, free from the noxious qualities imp.. able to lead.

Mr. Jousselin, a French potter, says, that he employs a glaze composed entirely of earthy materials, which does not cost more than one fifteenth of the price of what is commonly used. And the pumice-stone affords a glaze, that contains nothing in the least noxious, and on which no menstruum known has the least effect.

A writer in Sonnini's Bibliothèque Physico économique observes, that it is of some importance in domestic economy, to be able to judge of the goodness of an article in such extensive use as earthen ware, with regard to the goodness and innoxiousness of its coating.

The glaze of earthen ware may have several defects: it may be scratched more or less readily by a hard body; weak acids, such as vinegar, lemon-juice, verjuice, &c., may attack and dissolve the lead it contains; or oily substances standing long on it may produce the same effect, stain it, and render it dull.

To determine its power of resisting friction, it may be rubbed with sand; and if this scratch it more readily than it does a glaze known to be good, we may be assured it is
soft.

If vinegar be boiled for some hours in a
vessel coated with a soft glaze, it will attac
the glaze, and dissolve a portion of its lead
which will be precipitated from the vinega
on the addition of a few drops of sulphuri
acid, commonly called oil of vitriol.

But a method more within every one'
reach, and therefore deserving to be known
is. to let fall a drop of strong ink on a piec
of earthen ware, dry it before the fire, an
then wash it. If the glaze be too soft, th
ink will leave on it a slight spot.

Some potteries can sustain a sudden ap
plication of heat and cold sufficiently we
for the uses of the kitchen, and are there
fore called fire-ware; but these are alwa
the coarsest, least baked, and the glazing
which is the softest. They also do not la
long when much used; for it is absurd
suppose, as some persons do, that potte
may be made capable of sustaining fire li
a metal vessel. We are certain, that th
best of this kind, which are employed f
this purpose, break as soon as they are p
upon the fire. They do not indeed brea
so as to separate in pieces, or even to let
quors pass through them; but many sma
cracks are formed, which we may be assur
of by the crackling heard upon their bein
first set on the fire, by the many crac
which may be perceived in their glazin
and by their ceasing to ring when struc
after they have been once heated. Ea
time that these vessels are set on the fi
many small imperceptible cracks are form
in them, which by frequent use become
numerous, that the vessel may be broken
the least force. Thus all the difference b
twixt the potteries which are intended
be used on the fire, and the good ston
ware which is not intended for that pu
pose, is, that the latter kind may be brok
at once, when heated and cooled carelessl
whereas the former is broken by degree
Nevertheless the fire-ware is useful, as it c
serve for a short time.

Tobacco-pipes require a very fine, ten
cious, and refractory clay, which is eith
naturally of a perfectly white colour, or, i
have somewhat of a gray cast, will neces
rily burn white. A clay of this kind mu
absolutely contain no calcareous or ferr
ginous earth, and must likewise be carefu
deprived of any sand it may contain.
washing. It ought to possess, besides,
capital property of shrinking but little
the fire. If it should not prove sufficien
ductile, it may be meliorated, by the adm
ture of another sort. Last of all, it
beaten, kneaded, ground, washed, and s
ed, till it acquires the requisite degree
fineness and ductility.

When after this preparation the clay h
obtained a due degree of ductility, it
rolled out in small portions to the us
length of a pipe, perforated with a wi

and put, together with the wire, into a brass mould rubbed over with oil, to give it its external form; after which it is fixed in a vice, and the hollow part of the head formed with a stopper. The pipes thus brought into form are cleared of the redundant clay that adheres to the seams, they are then marked with an iron stamp upon the heel, and their surfaces smoothed and polished. When they are well dried, they are put into boxes and baked in a furnace.

In the Dutch manufactories, these boxes consist of conical pots made of clay, with conical lids, with a tube passing through the middle of them, by which the pipes are supported; or else they are long clay boxes, in which the pipes are laid horizontally, and stratified with fragments of pipes pounded small.

Lastly, the pipes, when baked, should be covered with a glazing or varnish, and afterward rubbed with a cloth. This glazing consists of a quarter of a pound of soap, two ounces of white wax, and one ounce of gum arabic or tragacanth, which are all boiled together in five pints of water for the space of a few minutes.

All the operations where great heat is employed require vessels of baked earth; because these alone can sustain at once the action of violent fire and of chemical solvents. Vessels made of good baked clay eminently possess these two qualities, and are the best which can be employed in chemistry; but as they have the inconvenience of breaking by sudden application of heat and cold, and as many operations do not require vessels so dense, mixtures of earth have been used, of which crucibles are made, capable of being rendered suddenly red-hot, and suddenly cooled without breaking, and sufficiently dense to contain metals and other matters in fusion during a long time. The best crucibles of this kind are brought from Hesse in Germany. These crucibles are made with a good refractory clay, mixed, according to Pott, with two parts of sand of a middling fineness, from which the finest part has been sifted. The mixture of sand with clay produces two good effects; the first, to make the clay leaner, as it is called, and thus to prevent the clay from cracking by the contraction it sustains during its drying; and, secondly, to prevent its acquiring too great closeness and compactness of texture by being baked. Thus we obtain crucibles moderately dense, capable of containing metals and other things in fusion, and infinitely less subject to break by heat and cold than those made of pure clay.

The particles of the sand mixed with clay in this composition for crucibles ought to be rather of a moderate size than very fine; because, as Pott remarks, the former renders the crucibles much less apt to crack than the latter. In the second place, that chemist forbids the use of sand, flints, or other earths of that kind, in the composition of crucibles intended to contain glasses or vitrifying matters a long time in fusion; because these vitreous matters act upon sand, flints, and all those called vitrifiable earths; by which means these crucibles are soon penetrated and melted.

This inconvenience is prevented, and all the advantages obtained from a mixture of sand are procured, by substituting to the sand a good baked clay in gross powder. In this manner are made the pots which contain the vitrifiable materials in glass-house furnaces, some of which resist the continued fires employed there during three weeks or a month. The pots indeed used in glass-houses frequently sustain a constant fire during several months, and sometimes even a year. They become gradually more and more thin, the glass or flux contained probably dissolving them thus slowly.

The quantity of burnt clay in the composition for crucibles varies in proportion to the nature of the crude clay from 1, 2, 2½, or even three parts of the former, to one of the latter. In general, the stronger, more tenacious and compact the crude clay is, the larger quantity of burnt clay ought to be mixed with it.

The crucibles made in France are composed on the same principles. They are made of clay mixed with broken butter-pots, which are a stone-ware made in Normandy and Picardy. These crucibles resist admirably well sudden heat and cold, and they would be excellent if the crude clay which enters into their composition was capable of resisting a violent fire: but this clay being mixed with martial and pyritous matters swells in the fire, and begins to melt. Besides, these crucibles owe their good quality of not breaking by sudden application of heat and cold to their little density, which is attended with this inconvenience, that they are penetrable by very fluid matters.

We may from what has been said perceive the difficulty, perhaps the impossibility, of making perfect crucibles. Pott has made so many experiments on this subject, that he seems to have exhausted it. The basis of all his compositions was clay; but this he mixed in different proportions with metallic oxides, burnt bones, calcareous stones, talcs, amianthus, asbestus, pumice-stones, tripoli, and many others, from none of which did he obtain a perfect composition, as may be seen from his Dissertation: hence it may be concluded, that we must have in our laboratories crucibles of different kinds suitable to the several operations.

Crucibles may possibly be made better than any hitherto known, and of more extensive use. The essential point is, to obtain a very refractory clay free from pyritous matter and ferruginous earth, from which the sand must be washed. This must be mixed with two or three parts of the same clay baked and pounded grossly;

and of this mixture or paste crucibles must be formed in moulds, and baked in a very strong fire. As retorts and cucurbits are designed for the distillation of liquors generally very corrosive and penetrating, they ought to be made of stone-ware. To this the following observations may be added:

1. Crucibles made of fat clays are more apt to crack, when suddenly exposed to heat, than those made of lean or meagre clays. Meagre clays are those in which a considerable quantity of sand is mixed with the pure argillaceous earth, and fat clays are those which contain but a small proportion of sand.

2. Some crucibles become porous by long exposure to fire, and imbibe part of the contained metals. This inconvenience is prevented by glazing the internal and external surfaces, which may be done by moistening these with oil of tartar, or by strewing upon them, when wetted with water, powdered glass of borax. These glazings are not capable of containing glass of lead.

3. Crucibles made of burnt clay grossly powdered, together with unburnt clay, were much less liable to crack by heat than crucibles made of the same materials, but in which the burnt clay was finely powdered, or than crucibles made entirely of unburnt clay.

4. If the quantity of unburnt clay be too great, the crucible will be apt to crack in the fire. Crucibles made of ten ounces of unburnt clay, ten ounces of grossly powdered burnt clay, and three drachms of calcined sulphat of iron, are capable of retaining melted metals, but are pervaded by glass of lead. The following composition is as good or better than the preceding:— Seven ounces of unburnt clay, fourteen ounces of grossly powdered burnt clay, and one drachm of calcined sulphat of iron. These crucibles may be rendered more capable of containing glass of lead, by lining their internal surfaces, before they are baked, with burnt clay diluted with water. They may be farther strengthened by making them thicker than is usually done, or by covering their external surfaces with some unburnt clay, which is called arming them.

5. The composition, of which crucibles the most capable of containing glass of lead were made, was eighteen parts of grossly powdered burnt clay, as much unburnt clay, and one part of fusible spar. These crucibles must not, however, be exposed too suddenly to a violent heat.

6. Crucibles capable of containing very well glass of lead, were made of twenty-four parts of unburnt clay, four parts of burnt clay, and one part of chalk. These required to be armed.

7. Plume-alum powdered, and mixed with whites of eggs and water, being applied to the internal surface of a Hessian crucible, rendered it capable of containing glass of lead during a long time.

8. One part of clay and two parts of Spanish chalk made good crucibles. The substance called Spanish chalk is not a calcareous earth, but appears to be a steatites.

9. Two parts of Spanish chalk and one part of powdered tobacco-pipes made a good composition for lining common crucibles.

10. Eight parts of Spanish chalk, as much burnt clay, and one part of litharge, made solid crucibles.

11. Crucibles made of black lead are fitter than Hessian crucibles for the melting of metals; but they are so porous, that fused salts pass entirely through them. They are more tenacious than Hessian crucibles, are not so apt to burst in pieces, and are more durable.

12. Crucibles placed with their bottoms upwards are less apt to be cracked during the baking than when placed differently.

13. The paste of which crucibles are made ought not to be too moist, else when dried and baked they will not be sufficiently compact: hence they ought not to be so moist as to be capable of being worked on a potter's lathe, but they must be formed in brass or wooden moulds. See Pott's Dissertation on Chemical Vessels.

Scheffer says, that the best crucibles cannot easily contain metals dissolved by sulphur, in the operation of parting by means of sulphur. See Parting. He says, that they may be made much more durable and solid, by steeping them a few days in linseed oil, and strewing powdered borax upon them before they are dried.—*Mem. Sued.* xiv. 1752.

Potstone. See Lapis Ollaris.

Powder. This word signifies precisely the same thing in chemistry as it does in common life. Any solid matter divided into small particles not adherent to each other forms a powder. When any substance is pulverised, the number of surfaces or quantity of surface in the whole will obviously be greater the finer the powder. Various contrivances are in daily use to pulverise different bodies. The pestle and mortar are used in the operations of pounding and trituration. The circulation of two mill-stones against each other, with grooves cut in the face of each to admit the subject of action, is used in the operation of grinding. By a hard smooth stone rubbed on the face of another, also smooth, levigation is effected; for which purpose water or some other fluid is added to the substance to be levigated. And lastly, washing is used to separate the smaller particles of powder from the larger or heavier; whether the latter be chiefly wanted, as in mine-works, or the former, as in washing emery and other fretting powders.

Several chemical and a still greater number of medical preparations are known by the name of powders.

Powder of Algaroth. This preparation, which was also called emetic powder, or mercurius vitæ, is a submuriat of antimony. See Antimony.

Powder (Fulminating). A compound of nitrat of potash three parts, subcarbonat of potash two parts, flowers of sulphur one part, which detonates on exposure to heat. See Fulmination.

Powder (Gun). See Gunpowder. This powder is well made when it explodes with a bright clear flame, and does not soil the plane on which it is burned. It is also reckoned a good criterion, when a number of small separate heaps of powder are laid at a small distance from each other, and one being fired does not set fire to the rest; because this can only be done by small grains of powder or coal being thrown at a distance before they are completely burned. Such powder must therefore be slow and weak in its action. But the real force is best ascertained from the mechanical effect. This is measured by filling a small instrument or pistol called the powder-proof, and firing it. The explosion drives the index of a wheel through a greater or less number of divisions, as the powder is stronger or weaker. Other instruments more easily compared with each other have been made, in which the explosion from a gun drives upwards a plug or piston loaded with a heavy weight, to heights which vary with the force. But the description of these is in some measure foreign to the general objects of chemical science.

The analysis of the chemist cannot show whether the parts of gunpowder be intimately mixed as they ought to be to give it all its force, nor whether the saline matter has been partly separated, or the coal rendered less inflammable by damp in the keeping. But it is nevertheless on many accounts desirable and necessary to know the component parts of particular parcels of this substance. For this purpose the nitre may be extracted by boiling in water, and its quantity ascertained by evaporation and crystallization, or otherwise by drying and weighing the residue, which is the charcoal and sulphur. From this residue the sulphur may be burned off on a metallic plate by a gentle heat sufficient only to make it smoke by day-light. The remainder will be the charcoal.

Robins, in his Principles of Gunnery, has shown, that the force of the hot elastic fluid extricated by the explosion of gunpowder is nearly equal to a thousand times the pressure of the atmosphere.

This force is seldom applied to any of the arts of peace, on account of the expense, except in blasting rocks as it is called; either for the purpose of working the stone in quarries, or removing such as are in the way of roads, or obstruct the course of navigation, and in mining. For this purpose a hole, proportionate to the size of the rock which is intended to be split by the force of the explosion, is bored in it, and a sufficient charge of gunpowder put in. A wire, or iron rod, being then introduced, to preserve a communication from the fuse to the powder, loose stones are commonly thrown into the hole, and rammed down hard. In this way, however, it sometimes happens, that both powder and labour are lost, in consequence of this touchhole filling up in striking out the wire with a hammer: but what is worse, it is attended with considerable danger, as every now and then it happens, that the powder is set on fire by the collision of the iron and stone, and the workmen are killed or wounded by the explosion.

A very safe, effectual, and commodious method, however, was made known in the Philosophical Journal, about three years ago, by W. Jessop, Esq., that cannot be too generally known by all who are concerned in mining, or blasting rocks with gunpowder. This consists in the simple mode of introducing a straw filled with fine powder, after the hole is bored and charged, and then filling the rest of the hole with loose sand. As an instance of its efficacy he mentions, that by way of trial he bored a hole an inch and half in diameter, and twelve inches deep, in a knotty piece of oak twenty inches in diameter, and charged it with three inches of powder, over which he put four inches of sand, intending, as he supposed this would be blown out, to enlarge the quantity of sand an inch at a time, till he found what was sufficient. This charge, however, split the piece into six pieces with great violence.

He then repeated the experiment on a similar log of oak, with a charge of two inches of powder, and three inches of sand. This split the piece in two, and blew half of it into the air, and to the distance of forty yards.

This practice has since been adopted with success, not only in different parts of this country, but on the continent.

Mr. Jessop suggests, that this might be very usefully applied to destroy cannon, instead of employing the common ineffectual mode of spiking them; and it is extremely probable, that it might be adopted with advantage in many instances, but I have not yet heard of its having been tried.

Powder (Purple) of Cassius. See Precipitate of Gold by Tin.

Prase. This name, derived from the Greek πρασον, a leek, has been given to different stones, that are now distinguished by mineralogists. One of these, the quartz prase, has all the characters of quartz, of which it is a species. It is of a dark olive or leek green, and its aspect is sometimes a little greasy. Its colour is uniformly diffused through the mass and dissolved in it, which is sufficient to enable us to distinguish it from the quartz coloured by chlorite, which too is of a more lively though opake green. Haüy has observed, that it is coloured by the green schorl, or strahlstein, needly crystals of which it frequently contains.

It has been found at Mummelgrund in Bohemia; near lake Onega in Finland; at Breitenbrunn, near Schwartzenberg in Saxony, in a metallic vein, and accompanied with strahlstein; and in Siberia.

The silex prase appears to be a variety of the silex pyromachus, or gun-flint, of which it has the conchoidal and dull fracture, and all the other characters, being distinguishable only by its dirty or leek green colour. Its conchoidal and not waxy fracture, and its deep colour, distinguish it from the chrysoprase.—*Brongniart.*

Precious Stones. These have been already enumerated under the head Gems, and each is particularly described under its proper name.

Precipitate, *and* **Precipitation.**—When a body dissolved in a fluid is either in whole or in part made to separate and fall down in the concrete state, this falling down is called precipitation, and the matter thus separated is called a precipitate. The form of precipitates is usually pulverulent. We see from this explanation, that the terms precipitate and precipitation relate merely to the manner in which any product is obtained, and not at all to its component parts or properties. But as the effects denoted by these expressions continually occur in chemical operations, the words are much and usefully applied.

The most usual effect of precipitation is seen when, a compound substance being suspended in a solvent, another substance is added, which unites with one of the principles of the compound, and separates the other: and this being insoluble in the fluid, falls down. See Attraction. As precipitations require the presence of a fluid, and as most substances may be rendered fluid by fire, it naturally follows, that two kinds might be distinguished, namely, in the dry and in the humid ways. Of precipitations in the dry way some instances may be seen in the schemes of Elective Attraction of Bergman, see Attraction, and under the article Blowpipe. But the terms are seldom applied to dry operations; and all the products properly called precipitates are produced in humid processes.

Since the insolubility of the matter which falls down is a condition without which precipitation does not ensue, and is the only condition required to effect it, we might call the separation of salts and other bodies from their solvents by evaporation, by this name. But this is not usual, as the word implies a speedy separation. Chemists are accordingly habituated so to apply it. When a precipitation takes place slowly, they frequently use the word deposition. Thus the matter which falls quickly is said to be precipitated: but they generally say a deposition takes place, when the change is not effected but in the course of many hours or days.

From the numberless cases in which precipitation takes place, it embraces the greater part of the leading phænomena of chemistry; for the particular instances of it, therefore, the reader must consult the various articles under which they occur.

There are different methods by which dissolved metals may be separated from their solvents; and the appearance and nature of these precipitates are occasionally varied in a very singular manner. Some of the most remarkable are the following:

In almost all cases metals may be precipitated by alkaline salts, which by their superior power of attraction for acids separate them from their solvents: but the difference of the alkalis, with respect to their nature and preparation, produces different characters in the precipitates.

With the pure fixed alkalis the oxides are commonly thrown down pure.

If the alkali be in the state of carbonat, the carbonic acid unites with many of the oxides. Carbonat of potash, in the neutral state, precipitates a white oxide from muriat of mercury: but carbonat of soda does not, as the quantity of acid it contains is insufficient for this effect.

Ammonia sometimes in part reduces the precipitates, its hidrogen combining with a portion of their oxigen. It throws down a black or white precipitate of mercury; and renders its orange-coloured oxide white. Gold is thrown down by it in the fulminating state, and it is likewise employed in preparing a fulminating silver. See Fulminating.

The acids frequently occasion precipitations from various causes.

By stronger elective attraction silver, mercury, and lead are taken from the nitric acid by the addition of the sulphuric or muriatic. These acids form with the metals new compounds, which are difficult of solution in water: they are therefore precipitated in greater or less quantity, according to circumstances.

The nitric acid decomposes the muriatic solutions of tin and antimony, by oxiding the metals beyond the point at which they are soluble in acids.

The alkalis saturated by acids, or neutral salts, sometimes disturb metallic solutions: either by means of a double elective attraction—thus all those which contain sulphuric or muriatic acid decompose solutions of silver, mercury, or lead, in nitric acid; the alkalis forming nitrats, and the metals being precipitated in the state of sulphats or muriats—or by forming a triple compound. Thus potash, or ammonia, though saturated with sulphuric, nitric, or muriatic acid, precipitates platina from aqua regia. A neutral salt with base of soda does not produce this effect.

Some metallic salts can decompose others, and precipitate their bases. This may happen when the acid is different in the two salts, or, what is more singular, even though it be the same.

Solution of gold gives us an example of each of these two cases. This, as is well known, is precipitated by sulphat of iron, the reason of which was first explained by Bergman. Upon examining the precipitate carefully it will be easily understood: for this, when washed and dried, not only shows many resplendent, gold-coloured particles, but also unites with mercury by trituration, dissolves in aqua regia, but not in muriatic acid alone, together with other circumstances which evince a complete reduction of the gold. Crystallized sulphat of iron contains iron not much oxided, so that the oxide of the gold may very easily be reduced on the same principles as if metallic iron were present. That this is the true foundation of the process, appears also from this, that the weight of the dissolved gold is precisely recovered: it is also proved from this circumstance, that pale sulphat containing iron more perfectly oxided, will not precipitate gold. It may reasonably be inquired why the surrounding aqua regia leaves such a precipitate untouched. The reason is, that the menstruum is diluted and weakened by the quantity of water; for upon boiling it gently, so as to expel the water, the menstruum recovers its solvent power, and takes up the precipitate. Bergman in the next place inquires into the origin of the purple precipitate.

That a solution of gold in aqua regia should be precipitated by a solution of tin in the same menstruum, is of more difficult explanation:—in this case it is the same menstrum, that holds the two metals dissolved: What then is the cause of the change? At first Bergman imagined, that the tin had attracted a superabundance of the acid, and taken it from the gold, which, being therefore destitute of the proper quantity, must necessarily fall to the bottom: but upon employing a solution containing superabundant aqua regia the same precipitate was occasioned. The cause was not therefore to be sought in the menstruum: he therefore examined the précipitate itself. Its external appearance shows nothing like the metallic splendour, but altogether resembles an oxide. It is easily found by its weight, that it cannot consist entirely of gold; and in fact chemical examination discovers a considerable quantity of tin. It cannot be dissolved by the muriatic acid alone, but, upon the addition of a little nitric acid, is easily taken up: triturated with mercury, it scarcely unites with it. These properties seem to indicate, that the gold is so far reduced as to resist the muriatic acid, unless aided by the nitric; but its earthy appearance, and its habits with respect to mercury, evince that it is not in its complete metallic form. Bergman therefore offers the following conjectural explanation: The solution of tin necessary for this operation must contain the metal as slightly oxided as possible, consistent with solubility. This is dropped into a solution of gold very much diluted, by which means the tin is more readily disposed to become oxided in a greater degree by taking oxigen from the oxide of gold, which at the same time is thus made to approach nearer the metallic state. Neither metal can then be retained by the acid; for the one is too much oxided and the other too far reduced: they must both therefore of consequence fall to the bottom, mixed intimately together. It is probable that, in this case, it is the oxide of tin which prevents the union with mercury.

Besides, the metals precipitate one another after a certain order. This order is found to be the same in all acid menstrua, as we have frequently had occasion to mention.

But many irregular circumstances occur in this matter, depending no doubt upon accidental circumstances. The order is indeed constant, and never inverted; zinc prevails over iron; iron over lead; lead over tin; tin over copper; copper over silver; silver over mercury; &c.: yet it sometimes happens, that a metal, which according to the general rule precipitates another, in its metallic state, from one solvent, precipitates it from another in the form of an oxide; and from a third not at all. Some examples will illustrate this:—zinc precipitates iron from muriatic acid in its metallic state, but from the nitric only in the form of an oxide. Perhaps the oxidation which ensues in the zinc may not be sufficient to reduce the iron, which in the latter case has been much more oxided; or perhaps, though less probably, the iron, though separated in the metallic form, may have been afterward oxided by the nitric acid. Tin precipitated from muriatic acid by lead appears in the metallic form, but is not thrown down from nitric acid; and from vinegar is precipitated in form of an oxide, even by iron and zinc: lead lets fall nothing from vinegar upon the addition of iron. These and other anomalies are expressly examined in Bergman's Treatise on Elective Attractions; but in this place he only remarks, that a small excess of acid is necessary; and that without it no precipitation begins*: but a great superabundance prevents this operation, by again dissolving the precipitate; besides, the weights of the precipitates and the dissolved precipitants do not correspond.

The colours of the metallic precipitates are of considerable utility to be known and attended to. Bergman employed soda, because the degree of saturation of it with carbonic acid is most constant. When he

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* This was first observed by the celebrated Gahn.

had occasion for a pure alkali, he prepared it by a small quantity of burned lime, in a close bottle; the goodness of it was proved by its occasioning no precipitation in lime water. For the preparation of Prussian alkali, at is was formerly called, or prussiat of potash, see Acid (Prussic).

Gold dissolved in aqua regia is precipitated by pure soda, almost black; by the carbonat yellow; as also by the prussiat of potash, unless some iron be present, which frequently happens. As the whole of the gold is scarcely ever precipitated, Bergman does not pretend to ascertain the weights.

Neither the pure nor carbonated soda precipitates one half of the platina dissolved in aqua regia; the precipitate is of an orange colour, which on drying changes to a brown. An over proportion of alkali redissolves the precipitate with a more obscure tinge; indeed the precipitation is so imperfect, that alkali saturated with acid seems to dissolve it. The prussiat of potash does not precipitate the depurated solution, nor even make it turbid; but heightens the colour in the same manner as the excess of alkali does.

Silver dissolved in nitric acid is precipitated white by carbonat of soda; by pure soda, brown; and by prussiat of potash, of an obscure yellow; by the sulphuric as well as the muriatic acid, white; but the former precipitate consists of more distinct particles, which grow black more slightly in the light of the sun.

Muriat of mercury is precipitated red, or rather of a rust colour, by carbonat of soda; by the pure, more yellowish, or orange. Nitrat of mercury, prepared without heat, yields a rust-coloured precipitate with carbonat of soda; a black with pure soda: when prepared with heat, it yields to pure alkali an orange, or reddish yellow precipitate: by prussiat of potash it is precipitated from all acids white; which, when dried, becomes of a brownish yellow. Muriat of mercury is very sparingly precipitated by this alkali. The precipitate occasioned by prussiat of potash is again dissolved, if too much alkali be used.

It has been shown already, that a white precipitate may be obtained by carbonat of potash, and the cause of this has been explained.

Corrosive muriat of mercury must be very cautiously precipitated by pure as well as by carbonated fixed alkali; for the part separated may again be dissolved by a large quantity of water. If too much alkali be used, a new compound arises of a peculiar nature.

Nitrat of lead is thrown down white by pure soda, carbonat of soda, or prussiat of potash. If too much alkali be used, the last precipitate is dissolved with a brownish yellow colour. Sulphat and muriat of lead are precipitated white.

Nitrat of copper, which in solution is blue, is precipitated of a bright green by carbonat of soda; and by pure soda, of a grayish brown, which grows reddish by age. By prussiat of potash, copper is precipitated of a greenish colour, which afterward grows of a brownish red, and upon exsiccation almost black. The carbonic acid readily takes up a small portion of copper during the precipitation, which is again deposited by the heat of boiling.

Iron is precipitated green by the carbonat of soda, from sulphuric or muriatic acid: this precipitate becomes of a brownish yellow, especially on drying; with the pure alkali it approaches more to black. In the precipitation some part is held in solution by the carbonic acid, if the carbonated alkali be used. Prussiat of potash yields a dark blue precipitate.

Tin is precipitated white by every alkaline salt, even by the prussiat of potash; but at length some blue particles which are mixed appear, so that the whole, when collected and dried, is of a light blue colour. That these blue particles depend upon iron is easily seen upon oxidation, for they become ferruginous and obey the magnet. Bergman always found an admixture of iron in tin.

Bismuth is precipitated white by water and alkalis, particularly the former. Prussiat of potash throws down a yellow powder, which being mixed with blue particles, occasioned by iron, at length appears green. This yellow sediment easily dissolves in nitric acid.

Nickel is precipitated of a whitish green by fixed alkalis; by the prussiat of potash, of a yellow; and by exsiccation it is condensed into a dark brown mass.

Arsenic dissolved in acids, which prevent too great oxidation, may, to a certain degree, be precipitated white by the fixed alkali, even when combined with prussic acid, but the sediment is found soluble in water; yet nitric acid, either alone or joined with the muriatic, generally oxides the arsenic to such a degree, that it becomes unfit for solution. Arsenic dissolved in muriatic acid, with the addition of a little nitric acid, deposited a white sediment; upon the addition of a large quantity of prussiat of potash, the sediment was mixed with Prussian blue; this was dissolved in water, and freed by frequent filtration from the blue particles, and at length, on evaporating to dryness, yielded a semipellucid mass.

Cobalt dissolved in acids is thrown down by fixed alkali, whether carbonated or pure, of a reddish blue, which colour on drying grows darker, especially when the former alkali has been used. Prussiat of potash throws down a powder of almost the same colour, which upon drying becomes of a reddish brown.

Zinc is precipitated white by carbonated and pure fixed alkali, as also by the prussiat of potash; but this last, on drying, becomes of a lemon colour. A small portion of carbonic acid may easily escape during the precipitation.

Antimony is precipitated white by alkalis. When the prussiat of potash is used, there are almost always some blue particles precipitated, though the metal had been prepared without any iron. The operation must be cautiously conducted, otherwise some part may be taken up by the alkaline salt.

Manganese generally renders solvents brown, and with carbonated alkali yields a yellowish brown sediment; with the pure one still darker; with the prussiat of potash a powder is separated, at first blue, then white, the mixture of which renders the mass a darkish, or rather a black-green. In order that the oxide of the manganese may be obtained pure and white, the precipitate afforded by pure alkali must be dissolved in pure vinegar; for there still remains a quantity of undissolved iron, which would be taken up by the carbonic acid if present. This acetous solution contains scarcely any iron. This metal may also at first be separated by a small quantity of ammonia.

The common solution of manganese is not perfectly precipitated by carbonated alkali: and if the remaining fluid be left to evaporate spontaneously to dryness, grains of a metallic splendour are deposited on the glass, which are not unlike copper. These are readily, though but partially, dissolved in nitric acid; but upon the addition of zinc, nothing falls but the manganese, though at first it is a little reddish. With prussiat of potash, a yellow precipitate, resembling pure manganese, falls, provided the solution has first deposited the iron by standing; but the recent solution yields a precipitate nearly the same as is obtained from the common regulus. The yellow sediment is soluble in water.

A considerable difficulty always attends the description of colours, because the several varieties, which are almost innumerable, have no particular names. Colours are indeed subject to changes, but the smallest never occurs without some determined cause; they should therefore be carefully observed, for we may always learn something, provided we consider every thing with due attention.

A due consideration of the metallic precipitates will explain many obscurities in the science of chemistry

The first inquiry of Bergman relates to their weight. He examined only those precipitates which are occasioned by carbonat of soda, pure soda, and prussiat of potash. The results of many experiments were rejected, as too vague and indeterminate; but he expresses his hope, that the rest were better founded. However, upon reflecting how difficult it is to depurate and wash completely the metallic sediment, so that neither the alkali, the carbonic acid, the water, nor any other extraneous matter shall adhere, he considers them only as collections of the first terms of infinite series, which converge very quickly. In order to obtain the nearest possible approximation, he frequently repeated the experiments in the most accurate manner. In the following table 100 parts of the metal are always supposed to be dissolved.

					Dry Precip.
100 parts of	Gold,	precipitated by	carbonat of soda	yielded	106
....	....	....	pure soda - -	....	110
....	....	....	prussiat of potash -	....	
....	....	....	sulphat of iron -	....	100
....	Platina,	....	carbonat of soda -	....	84
....	....	....	pure soda - -	....	86
....	....	....	prussiat of potash -	....	
....	Silver,	....	carbonat of soda -	....	129
....	....	....	pure soda - -	....	112
....	....	....	prussiat of potash -	....	145
....	....	....	muriat of potash -	....	133
....	....	....	sulphat of potash -	....	134
....	Mercury,	....	carbonat of soda -	....	110
....	....	....	pure soda - -	....	104
....	....	....	prussiat of potash -	....	
....	....	....	sulphat of potash -	....	119
....	Lead,	....	carbonat of soda -	....	132
....	....	....	pure soda - -	....	116
....	....	....	prussiat of potash -	....	
....	....	....	sulphat of potash -	....	143
....	Copper,	....	carbonat of soda -	....	194
....	....	....	pure soda - -	....	158
....	....	....	prussiat of soda -	....	530
....	Iron,	....	carbonat of soda -	....	225
....	....	....	pure soda - -	....	170
....	....	....	prussiat of potash -	....	590
....	Tin,	....	carbonat of soda -	....	131
....	....	....	pure soda - -	....	130
....	....	....	prussiat of potash -	....	250

					Dry Preci
100 parts of	Bismuth,	precipitated by	carbonat of soda	yielded	130
....	....	....	pure soda - -	....	125
....	....	....	prussiat of potash -	....	180
....	....	....	pure water - -	....	113
....	Nickel,	....	carbonat of soda -	....	135
....	....	....	pure soda - -	....	128
....	....	....	prussiat of potash -	....	250
....	Arsenic,	....	carbonat of soda -	....	
....	....	....	pure soda - -	....	
....	....	....	prussiat of potash -	....	180
....	Cobalt,	....	carbonat of soda -	....	160
....	....	....	pure soda - -	....	140
....	....	....	prussiat of potash -	....	142
....	Zinc,	....	carbonat of soda -	....	193
....	....	....	pure soda - -	....	161
....	....	....	prussiat of potash -	....	495
....	Antimony,	....	carbonat of soda -	....	140
....	....	....	pure soda - -	....	138
....	....	....	prussiat of potash -	....	138
....	Manganese,	....	carbonat of soda -	....	180
....	....	....	pure soda - -	....	168
....	....	....	prussiat of potash -	....	150

Upon comparing these weights, a question at first occurs concerning the cause of such enormous differences; and it is plain, that this cause must be sought for in the precipitates themselves. The fixed alkali. saturated with carbonic acid, when added to the solution, is taken up by the more powerful menstruum, and the weaker is of course expelled. and is absorbed by the oxide, as it falls in greater or less quantity according to circumstances. That this is actually the case is easily demonstrated:—let a bottle, containing a sufficient quantity of nitric acid, be accurately weighed: let there be put into it by degrees, *e. g.* a hundred and thirty-two parts of lead precipitated by carbonated alkali, and not only an effervescence will be observed, which continues until the very last particle is dissolved; but when the solution is finished a deficiency of weight is discovered, which amounts nearly to twenty-one, and which is indubitably owing to the extrication of carbonic acid. But 132−21=111, a weight which still considerably exceeds that of the metal. Upon distillation nearly eight of water are discovered; there yet remain therefore three, which by violent heat are increased by seven; for 132 of the precipitate, well calcined, yield 110. The whole increment of weight then does not depend upon the water and carbonic acid. The same thing is evinced from the consideration of the precipitate of lead by the pure alkali; as it is evident, that in this case there is no carbonic acid; besides, no effervescence accompanies the solution. If we suppose the quantity of water equal in both cases, yet even this supposition, the whole excess is accounted for, for 116−8=108. Berg thought it probable, therefore, that matter of heat was attached to the o and reasoned as follows:—This matte heat is always present in pure alkali when it is dissolved in the simple a heat is always generated. And again The increment of weight can scarc conceived, without supposing an incre of matter. 2d. When the pure alka employed, no other matter can be suspe 3d. The same cause is also present, the weight is increased by dry calcina 4th. Let the heat occasioned by the mi of determinate portions of any acid pure alkali be marked upon a thermom let then an equal quantity of the menstruum be saturated with a metal terward, upon the addition of an quantity of pure alkali, it will be either that no heat is generated, or a d very much less than before. Some o matter of heat therefore is taken up fixed*, which also generally make colours of the precipitates more ob and in distillation with muriat of a nia communicates to the volatile alka quantity that had been taken away. has been said of lead is also true o other metals, a few excepted, which to take up little or no carbonic these are tin, antimony, gold, and tina.

But some precipitates retain also a tity of the menstruum. Thus, cor

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* The increase of weight acquired by metals from the absorption of oxygen in ca tion was less known and attended to at the time the great Bergman composed his tise on Metallic Precipitates than since; otherwise this fact would have afforded an solution of the present difficulty, than the violent supposition of material and ponde heat.

muriat of mercury, precipitated by an alkaline carbonat, retains a portion of muriatic acid, which cannot be washed off by water; but by pure alkali the precipitate may be obtained, either free of the acid altogether, or in a great measure. In this case, as in many others, the carbonic acid seems to generate a triple salt, which is scarcely soluble. The presence of the muriatic acid is easily discovered by nitrat of silver, if the precipitate be previously dissolved in pure nitric acid. Hence we observe another difference in mercury precipitated from muriatic acid, according as carbonated or pure alkali has been employed: the latter precipitate, well washed and put into ammonia, is scarcely changed in colour; but the former instantly grows white, generating a species of sal alembroth, but containing so little muriatic acid as not to be easily soluble in water.

The oxides which retain any of their former menstruum generally give over on distillation a small portion of sublimate. The mercurial oxide, just mentioned, exposed to a sufficient degree of heat, is partly reduced to crude mercury partly to mild muriat of mercury, by means of its remaining muriatic acid. This mild muriat of mercury did not exist in the precipitate; for in that case it would be easily discovered by acids, in which it is not soluble, and would grow black with pure alkali; neither of which things takes place; it is therefore generated during the distillation.

The excellent treatise of Bergman concludes with pointing out some of the advantages resulting from the examination of metallic precipitates.

It is evident, that, by a more intimate acquaintance with these precipitates, the chemical theory of the operation will be better understood.

Hence we may discover their more useful and remarkable properties. Every one knows, that aurum fulminans, the mineral purple, and other encaustic pigments, by which the colours of gems may be imitated, have been derived from this source.

A foundation is by this means established for the art of assaying by the humid way, from the bare knowledge of the weights. It may be objected, that the doctrine of the weights is very fallacious; that they vary in the different precipitates; that by imperfect precipitation something remains in the liquor; and that extraneous matters sometimes are mixed with them. All this is true; yet if the mode of operation be always the same, the results of the experiments must be constant. Let us suppose, that a quantity of metal, precipitated in a certain manner, makes a weight; if that same manner be exactly employed, we may fairly conclude, that a quantity of precipitate, occurring in any case, is correspondent to a quantity of perfect metal; although in the fundamental experiment either the precipitation is incomplete, or some extraneous matter is present. If all the circumstances which occasion increase or deficiency be carefully attended to, the conclusion will remain unimpeached: let the method therefore be accurately determined, and there will be no danger of fallacy.

Hence the nature of metals is illustrated. Platina, nickel, cobalt, and manganese, are suspected by some persons to derive their origin from a mixture of other metals. But if iron necessarily enters into the composition of platina, when this is dissolved in aqua regia it should produce a blue upon the addition of prussiat of potash: and this is the case in fact when common platina is employed, but not when it is rightly depurated. See Platina.

If iron, adhering very obstinately to nickel, formed a great part of it, the precipitates obtained from it by alkalis could not differ from martial precipitates so much as they do, in colour, weight, and other properties.

The same is true of cobalt and manganese. The regulus obtained from black manganese contains about 0.08 of iron: let us see how this affects the mixture

One hundred parts dissolved in an acid menstruum yield to prussiat of potash a powder, consisting partly of blue, partly of brownish-yellow particles, which is equal in weight to 150lbs.; but 8lbs. of iron yield 48 of Prussian blue, nearly ⅓ of the whole mass: hence it follows, that 100 parts of pure manganese yield to prussiat of potash scarcely 111, i. e. nearly six times less than an equal weight of iron.

The general facts relating to the quantities of metals precipitated by metals are given by Bergman in the form of equations. It may perhaps be more convenient to readers in general to see them in words at length.

There are six things to be considered when this effect is intended to happen. 1. The metal already in solution. 2. The quantity of solvent which sustains it. 3. The quantity of oxigen lost or acquired by the metal: and 4. by the metal presented, or the precipitant. 5. The quantity of solvent required to take up a portion of this metal equal to that held in solution. 6. The oxigen it would acquire by solution. Then,

1. If the weights of solvent (2 and 5) be equal;

And also the quantities of oxigen (3 and 6), there will be no difficulty in the precipitation. For the solvent is capable of dissolving as much of the one metal as of the other, and the precipitate can give as much oxigen to the precipitant as its own reduction demands.

Again: if the quantity of oxigen demanded by the precipitant exceed that to be subtracted for its reduction from the precipitate, there will be no obstacle to the effect.

But if the oxigen required to dissolve

the whole precipitant be less than the precipitate has to impart, a part only of this last will fall down; unless the precipitation be aided by some cause of a different nature from those here attended to.

2. If the weight of solvent required to sustain the precipitant be less than would sustain an equal portion of the metal intended to be thrown down, the effect with regard to oxigen will be the same as in No. 1, but the obstacles will be less.

3. If the weight of solvent, required as in the last case, be greater than would sustain the metal intended to be thrown down, the whole of the precipitant will not be dissolved, and the precipitate will not be entirely separated, unless the oxigen required by the precipitant so much exceed that of the precipitate, as that the portion of the precipitant dissolved may absorb the whole requisite quantity of that principle.

This excellent chemist then proceeded to apply these general principles to the test of experiment. Among the several processes, he chose to institute two sets. In the first, silver was taken as the term of comparison, because it is precipitated from nitric acid by all the metals but gold and platina; and in the second set he made use of zinc, which is a precipitant to them all.

One hundred docimastic pounds of silver were dissolved in nitric acid with as little excess of acid as possible. For all metallic salts redden the tincture of turnsole, and cannot be deprived of this small excess without decomposing the salts. To the solution was added twice the quantity of distilled water, and then mercury was added at several times. Various crystallizations of the arbor Dianæ were afforded, as the proportions of the mercury varied. In fact, where the mercury was most abundant in proportion to the silver to be precipitated, the vegetations were more slowly produced: but were more beautiful, more brilliant, stronger, and sometimes crystallized in prisms. The mercury when thrown into the solution of silver hardens; its surface becomes irregular, and at last it puts forth branches which increase by slow degrees. These branches, collected, washed and dried, weighed 455 pounds. The whole of the mercury added was 490 lbs. Consequently there were 455 — 100 = 355 pounds of mercury amalgamated with the silver, and 490 — 355 = 135 pounds of mercury dissolved in the acid.

Two hundred and thirty-four pounds of lead were required to precipitate one hundred of silver. The plate of lead soon becomes black on immersion, and is quickly covered with small crystalline needles of silver. The last portions are thrown down very slowly, if recourse be not had to heat. The precipitate being collected always weighs eight or ten pounds more than the quintal, evidently from some of the lead which falls in the state of oxide.

A plate of very clean copper, weighing 375 pounds, was very quickly covered with a crystalline crust of silver, after it had been plunged into the solution. When all the silver had fallen down, the plate of copper well washed was found to have lost thirty-two pounds. The precipitate of silver proved to be exactly the quintal.

With the intention of ascertaining the different force of solvents, Bergman added copper to a solution of silver in sulphuric acid. Thirty pounds were sufficient to precipitate the quintal of silver. Whence we may remark that the nitrous acid is more easily decomposed, and made to afford oxigen to the metal, than the other.

Iron exhibited a very peculiar character. In general no precipitation took place by adding iron to the nitric solution, and the facts are highly interesting and remarkable.

Silver dissolved in the sulphuric acid is precipitated very speedily and well by iron. The iron plate lost thirty-nine pounds in precipitating one hundred pounds of silver.

Those metals which the sulphuric acid dissolves readily are more easily precipitated, than from a similar nitric solution. This fact ought to be kept in mind in the humid method of analysis.

Tin in leaves precipitates silver very speedily from the nitric acid. It has even the crystalline form; but the fluid speedily becomes black, and frequently continues so for four-and-twenty hours. Eighty-eight pounds of tin precipitated the quintal of silver at a moderate heat; but the precipitate well washed amounted to two hundred and fifteen pounds. This increase of weight arose from the oxide of tin which fell down with the precipitate of silver. It was contaminated by a blackish matter, probably an impurity.

Bismuth at the first instant precipitates silver very well; but towards the end it is very difficult to ascertain the necessary quantity. A solution of bismuth perfectly saturated cannot support either heat or dilution with water, without depositing a white powder, which mixes with the precipitate, and cannot be separated but with extreme difficulty. The precipitate of silver is so spongy, that it absorbs the whole of the fluid; so that towards the end there is not enough to dissolve the bismuth, and no distinct observation of the effect can be made. When this difficulty began to present itself, Bergman endeavoured [illegible] express the fluid from the sediment between two plates of glass. Out of this fluid he precipitated the bismuth by the addition of water; and after decantation, the silver was separated by muriatic acid. Hence, from the weight of silver in the saline state, he acquired a knowledge of the quantity which had been precipitated by the known weight of bismuth. By this expedient he found, that the thermometer being at 15° (of Celsius, which answers to 59° of Fahrenheit) one hundred and seventy-four pounds were required. When the precipitate was washed, the water was rendered turbid, and seemed to carry off some portions of bismuth. The whole sediment weighed one hundred and eighty pounds. The first parcels of bismuth, instead of becoming black upon immersion, became white, and were covered with small brilliant crystallizations of silver. Toward the middle it is dissolved without losing its lamellated structure, and assumes a whitish, earthy aspect, seldom of a metallic appearance; but toward the end, the pieces which are continued to be added become immediately black.

Nickel, as soon as it is put into the solution of silver, turns the fluid green, and some precipitation seems to take place; for metallic and brilliant spots, though few and slowly produced, are seen upon the surface. The operation was not hastened by excess of acid, and a digesting heat. It is absolutely necessary to reduce the semimetal to a fine powder; a step which is unnecessary for all the other metals, arsenic excepted. It is very difficult to make an experiment with accuracy, when a precipitate is to be thrown down by the gradual addition of a pulverulent matter. Sixty-four pounds of nickel are required to throw down one quintal of silver. The precipitate is full of small crystals, and contaminated by a brown powder. It weighed in the whole one hundred and sixteen pounds.

Of all the metals arsenic precipitates silver with the greatest difficulty. It must be pulverized; for, if it be in fragments, its surface becomes white, and the interior part is not attacked, and it would be to no purpose to employ either an excess of acid or evaporation to dry this. Ninety-two pounds precipitate the quintal of silver. The precipitate washed and dried amounted to one hundred and forty pounds; the increase being owing to the oxide of arsenic.

The quintal of silver is precipitated by thirty-nine pounds of cobalt, in the crystalline form, without the assistance either of heat or pulverizing. The solution immediately becomes red.

Zinc is blackened as soon as it is immersed in the solution of silver. It becomes covered with an ash-coloured moss, which in a few moments acquires the brilliancy of silver. Fifty-five pounds are sufficient for the precipitation. The introduction of this precipitant produces heat.

The precipitation is equally well effected by antimony. The precipitate has even a peculiar appearance. The revived metal resembles twisted fragments of silver leaf. The solution will bear diluting, but not heat, which prevents the last portions of silver from easily separating. About eighty-three pounds of the precipitant are required, and the precipitate weighed two hundred pounds, viz. double the weight of the silver employed. This increase arose from the oxide of antimony, which was almost totally precipitated; for the fluid scarcely contained a few pounds.

Manganese becomes immediately covered with a pellicle of silver. A powder was produced during this operation, partly black, and partly greenish, which weighed eleven pounds. Forty-four pounds of the precipitant were required, and the precipitate was more solid than with the other metals; it was yellowish.

From the preceding experiments, the several metals are comparable with each other, in the character of precipitants of a common substance, namely, silver. In the following experiments, they are comparable in another way, viz. as precipitates by the common substance, zinc.

A quintal of pure gold dissolved in aqua regia, with the least possible excess of acid, required two hundred and seventeen pounds of zinc for its precipitation.

A like quantity of gold was precipitated by three hundred and one pounds of English tin. Sixty-six pounds of gold were completely revived, and one hundred and sixty pounds of a black purple were obtained. The rest of the liquid had still a purple tinge; but it was not decomposed at a moderate heat, by the addition of a new quantity of tin. One hundred and fifty-eight pounds of zinc precipitated a powder inclining to purple, which when washed and dried weighed two hundred and twelve pounds.

A quintal of crude platina was dissolved in aqua regia, until the menstruum would take up no more at a boiling heat. It required, however, four hundred and sixteen pounds of zinc to bring the solution to a complete saturation. The fluid acquires a blood colour, and is filled with black particles, which separate with a lively effervescence. After this intestine commotion has subsided, a black powder falls, which, when washed and dried, weighs seventy-seven pounds. The remaining liquor is yellowish, and affords small crystalline grains by evaporation, especially if a minute portion of potash be added. The black powder urged by the flame, before the blow-pipe, on charcoal, first emits white fumes, and then resumes the metallic brilliancy, not perfectly white, but grayish. It is not magnetical, either before or after this application of heat.

The phænomena of zinc and silver have already been described.

One hundred pounds of mercury require forty-four pounds of zinc, to precipitate them from the nitric acid.

The quintal of lead, dissolved in the same acid, is precipitated by twenty-six pounds of zinc. That which falls at a moderate heat possesses the metallic aspect at first, and is even crystallized; but soon afterward it becomes converted into a white powder. By the heat of ebullition, an oxide only is obtained, which, when washed and dried, weighs one hundred and twenty-four pounds.

One hundred and sixty-four pounds of zinc precipitate one hundred of copper dissolved in the nitric acid. The solution, which is at first blue, becomes afterward green. Beside the copper in the metallic state, a powder is precipitated, partly white and partly greenish. The whole precipitate weighs two hundred and eleven pounds.

Thirty-eight pounds of zinc precipitate twenty-six of copper from a quintal of sulphat of copper.

Iron dissolved in the nitric acid affords, upon the addition of zinc, nothing but a mere oxide, the same as would have separated spontaneously; so that it is impossible to ascertain any decided proportion.

One quintal of sulphat of iron put into a closed matrass, and without any heat, to prevent the oxidation of the precipitate, let fall nothing but a small quantity of ochreous sediment, and the zinc was not diminished at the end of eight days.

Sixty-eight pounds of zinc are required to precipitate one quintal of tin dissolved in aqua regia. The precipitate has not the metallic aspect. It is a white oxide, and weighs one hundred and forty-nine pounds. Forty-nine pounds of zinc precipitate one hundred of bismuth dissolved in the nitric acid. At a moderate heat it has the metallic form; but at a superior temperature, an oxide only is obtained, which weighs one hundred and thirty-three pounds.

A quintal of nickel dissolved in nitric acid let fall eighty pounds of a black matter, which was almost entirely arsenic in the metallic state Fifty-four pounds of zinc are required for this purpose. By a longer digestion with this semimetal, nothing more is separated but a powder of a greenish white, which is a mixture of the oxides of zinc and nickel. The rest of the solution remains as perfectly green as before. It appears, therefore, that the arsenic which still remains in the first regulus of nickel may be separated better in this way than by repeated calcinations.

Zinc immersed in a solution of a quintal of arsenic in aqua regia precipitated at first nothing but some blackish particles, which became white during digestion, and increased in quantity by the addition of more white powder. The weight of the precipitate was one hundred and twenty-three pounds, and the loss of the precipitant one hundred and twenty-six.

Cobalt lets fall by the addition of zinc, assisted by a digesting heat, a powder, which weighs thirty-one pounds. The colour of the solution remains unchanged, and the weight of the zinc is very little altered, though the evaporation be carried repeatedly to dryness.

The solution of a quintal of antimony in aqua regia is precipitated by seventy pounds of zinc. The antimony is recovered in the form of a white powder, and the solution cannot be had very clear, but by means of excess of acid. The precipitate is more or less charged with oxide of zinc, according to the intenseness of the heat.

Manganese lets fall the foreign substances, which may be united with it, more or less readily than iron, nickel, and cobalt. The piece of zinc becomes red, if copper be present, though in small proportion, and this foreign metal may be better precipitated in this than in any other way. A green and white powder is deposited, which phænomenon has already been noticed in copper alone.

The important consequences deduced by Bergman from the preceding experiments are as follow:

The metals adhere to the different acids in different degrees of oxidation. For example, one hundred pounds of silver dissolved in the nitric acid require thirty-two of copper for their reduction, whereas in the sulphuric we have seen that no more than thirty of copper are necessary. Again, one hundred pounds of copper in the sulphuric acid require no more than one hundred and forty-six of zinc, but in the nitric acid one hundred and sixty-four. Again, twenty-three pounds of copper precipitate the quintal of mercury from nitric acid; but in the muriatic acid sixteen pounds are sufficient. Whence it may be concluded, that the nitric acid oxides the metals to a high degree, the sulphuric acid not so much, and the muriatic still less.

Since the solutions were made with the least possible excess of acid, it must follow, from the weights of the precipitant and the precipitate, that the respective quantities of oxigen gained by equal weights of the metals during solution, will be proportioned to those weights.

By the application of the principles established at the beginning of this extract, relative to the silver considered as a precipitate, it is observable, that the weight of solvent required to dissolve one hundred parts of the precipitant does in no instance prove accurately equal to that, which has suspended the same quantity of the metal which affords the precipitate. The quantity of solvent for equal portions of lead and of mercury is greater than for silver; but for copper, iron, tin, (bismuth,) nickel, arsenic, cobalt, zinc, and manganese, it is less. Zinc, considered as a precipitant, likewise affords no examples wherein these quantities are equal. For platina, iron, and antimony, the quantity of solvent for the precipitant is greater than for an equal portion of the precipitate; but in all the other instances it is less.

Bergman suspects, not without motives, that the quantity of solvent required for the precipitate being greater, and the quantity of oxigen required to be imparted to the precipitant, being either equal to or greater than that required by the precipitate, will be the consequence of a more abundant solution of the precipitant than is necessary to reduce the metal which is precipitated. If this suspicion be real in all similar cases, it will affect the ground of these calculations. A scrupulous attention to the phænomena may probably explain this difficulty. Every solution of metal is accompanied with the development of an aëriform fluid, which escapes with effervescence; but its precipitation, when the solution is saturated, does not exhibit this phænomenon; or at least the bubbles of air which appear are very small, and seldom observed. Iron, which is easily attacked by all solvents, remains unaltered for many weeks in the nitric solutions of lead and silver. Bergman has few doubts with regard to the precipitations of silver, because they were well made, and all the silver is preserved in the metallic state; but those in which zinc is the agent are not entitled to the same confidence. For in some, the point of saturation is difficultly observed; in others, effervescence appears; and lastly, in others the precipitate and precipitant unite. The next paragraph but one shows how it happens, when the menstruum which has dissolved the first metal is not sufficient to dissolve the requisite quantity of the second, or when the oxigen required by the precipitant is insufficient, that the reduction is not completely made.

Most of the precipitated metals possess the metallic aspect. In this case they are always crystallized. But it sometimes happens, that their affinity for oxigen is such, as to occasion them readily to absorb it without any remarkable heat. Such are lead, bismuth, arsenic, and antimony; and what is more remarkable, they sometimes combine with it, before the metal has arrived at the bottom of the vessel. Tin in particular exhibits this remarkable fact.

The comparison of the weights shows in the most positive manner, that it is not seldom that a portion of the precipitant falls down likewise in the state of oxide.

In other cases the two metallic oxides unite, and fall down in the most intimate state of union; such are those of copper and zinc, tin and gold.

Most of the precipitants become first black, then are bristled over with small ash-coloured needles, which speedily assume the metallic aspect. These are the different degrees of revivification.

From the preceding series of experiments by Bergman, we may deduce the affinity of the metals with oxigen to be in the following order: lead, bismuth, mercury, silver, arsenic, tin, antimony, nickel, zinc, manganese, iron, cobalt, copper, gold, and platina. It may here be remarked, that this is not the order of chemical attraction, but an order relative to the quantities of this principle, which each metal gains as the precipitant of zinc, or loses when precipitated by silver. That the chemical attractions have not yet been shown to bear any direct relation to the quantities of two principles united to a certain point of saturation, is explained under the article ATTRACTION. If mature reflection be made on the different stages of oxidation of metals, it will be seen, that, though this great work of Bergman has furnished us with many admirable conclusions, and the subject has been pursued with considerable success by many subsequent chemists, much yet remains to be done, both in the way of experiment and the explanation of facts, before this subject will be nearly exhausted.

Mr. Lavoisier, from the result of Bergman's experiments, computed the following table of the quantity of oxigen acquired by one hundred grains of each of the metals:

	Metals.	*Oxigenous principle.* Grs.	For solution merely.
100 grs. of	Platina	81·690	
	Gold	43·612	
	Iron	27 37	
	Copper	36·000	15·85
	Cobalt	29·190	
	Manganese	21·176	
	Zinc	19·637	
	Nickel	14·721	
	Reg. of ant.	13·746	22·383
	Tin	14	23·555
	Reg. of ars.	11·739	24·743
	Silver	10·800	
	Bismuth	9·622	
	Mercury	8·000	
	Lead	4·470	14·190

We shall conclude this article with the following tables and observations from Dr. Thomson's Chemistry, being the latest publication in which the subject is considered:

I. OXIGEN AND ACID SOLUTIONS.

Zinc
Iron
Tin
Antimony
Arsenic
Lead
Bismuth
Copper
Platina
Mercury
Palladium, Rhodium }
Iridium, Osmium }
Silver
Gold

This table exhibits the order in which the metals precipitate each other in the metallic state from acid and alkaline solutions. Zinc and iron throw down all the metals below them, either in the metallic state, or in the state of a black powder, as happens to antimony, arsenic, bismuth, and the four new metals discovered in crude platina. Ritter has announced, that these black powders are combinations of the metals with hidrogen. This assertion deserves to be verified. It would be of considerable importance in explaining the nature of the precipitation if it were to prove true. I am not certain whether antimony and arsenic precipitate the metals below them, but they are acted on more speedily by tin than either lead or copper. Lead precipitates copper. Bismuth and platina are inserted only from analogy. Copper throws down mercury, and mercury silver and gold.

Mr. Sylvester has lately rendered it very probable, that these precipitations are occasioned by the galvanic action of metals on each other. It has been shown by Volta, that metals differ in the avidity with which they absorb electricity; and that when two metals are placed in contact and separated, the one becomes *plus* and the other *minus* electrified. In this respect they may be arranged in a regular series, zinc being at the one extremity and gold at the other; all the metals which precede having the property of changing to minus the electricity of all the metals below them. Now, when metals are in different states of electricity, it has been shown, that when placed properly they decompose water, and produce all the other phænomena of galvanism. Mr. Sylvester has rendered it extremely probable, that it is the hidrogen evolved that produces the reduction of the metal. If this opinion be correct, the order in which the metals precipitate each other ought to be precisely that of their tendency to take electricity from each other.

Were we to endeavour to unite this table with the order of affinities of oxigen for simple substances, which, according to Dr. Thomson, is

Hidrogen,
Carbon,
Phosphorus,
Sulphur,
Nitrogen,
Muriatic acid,

these observations would indicate, that hidrogen ought to be placed immediately after tin. Yet from the experiments of Priestley, we know that hidrogen is capable of reducing oxide of iron to the metallic state. Charcoal likewise decomposes the oxides of all metals; but, on the other hand, the oxides of zinc, iron, tin, and some others, have the property of decomposing carbonic acid. Phosphorus precipitates all the metals below lead, and perhaps even some above it. Even sulphur reduces most metallic oxides; but many of them in return decompose sulphuric acid when assisted by heat. Hence the relative places the simple combustibles and incombustibl cannot well be ascertained. Probably w shall not err far if we place hidrogen aft tin, carbon after antimony, phosphorus a ter lead, sulphur after copper, and azo and muriatic acid after mercury. Were w to complete the table from analogy, the r fractory metals and manganese would b placed before zinc, and nickel just befo platina: but such analogies are very apt t mislead.

II. ACID SOLUTIONS.

Protoxide of iron
Peroxide of silver
Red oxide of mercury
Peroxide of zinc
Oxide of manganese
Oxide of lead
Peroxide of copper
Peroxide of iron.

This table exhibits the order in whic the metallic oxides precipitate each oth from those acid solutions in which they a respectively soluble. It was drawn u from the experiments of Gay Lussac. Th relative order of several of the oxides is n quite certain, but they all precipitate pe oxide of iron, and most of them peroxide copper; while this last throws down peroxide of iron.

III. ACID SOLUTIONS.

Fixed alkalis
Barytes
Strontian
Lime
Ammonia
Magnesia
Yttria }
Glucina }
Zirconia
Alumine
Metallic oxides.

This table represents the general order i which the bases precipitate each other fro saline solutions; but there are many excep tions. Berthollet has even made it proba ble, that the order of precipitation varie with the proportion of the ingredients use He has demonstrated, that the precipitatio is rarely or never complete; that the base divide the acid solvent between them i proportion to their relative quantities, an to the quantity of each necessary to neutralize the acid. It is obvious that all thos cases must be excepted, in which the aci and base or precipitant form an insolubl compound, because then they precipitate i combination. I place the fixed alkalis first because, when muriate of barytes is drop into potash so pure that it occasions no muddiness in barytes or lime-water, a flaky precipitate constantly appears. No difference can be perceived in the action of potash and soda in this respect. These alkali do not precipitate one another. Potash is placed first in the tables of Bergman, merely because it forms with acids less soluble salts than soda; and therefore, as Berthollet has shown, when a saline solution containing the two alkalis is evaporated, the salts of potash crystallize first. It has not been proved that barytes precipitates strontian and lime; even if it did, it could never, with propriety, be used as a precipitant of them. It is known that ammonia never occasions a precipitate in the solutions of the three alkaline earths that precede it in the table; but it precipitates all the bodies that follow it, if we except those metallic oxides which it is capable of holding in solution.

How far magnesia is capable of precipitating the earths placed below it in the table, has not been examined; but it is probable that it is, as it is capable of forming neutral salts with acids, which is not the case with them. The marked attraction which magnesia shows for alumine would perhaps prevent it from taking the place of alumine; it would probably combine and form with it a substance insoluble nearly in potash. Zirconia is placed merely from analogy. Alumine is probably thrown down, at least partially, by glucine, as it forms with acids a salt approaching more nearly to neutralization. Several of the metallic oxides precipitate ammonia; but the relative power of the substances placed in the table below ammonia is not of much importance, as they cannot well be employed, except indirectly as precipitants.

The acids do not precipitate each other from bases; therefore no table can be given of them. Many of them have the property of forming with bases insoluble compounds. Such acids separate bases from other acids, and precipitate with them. It was from this circumstance that Bergman arranged the acids in his tables; but Berthollet has shown, that the order is in many cases hypothetical, and that the nature of the precipitates varies with the proportion.

I shall now give a table of those substances which have the property of separating bodies either partially or completely from solutions, and which therefore are employed by chemists to ascertain the presence of the respective bodies, or to determine their quantity. Such a table can comprehend only the alkalis, earths, metallic oxides, acids, and a few other compound bodies. The simple substances are in general too intimately combined to admit of separation by such means.

IV. GENERAL TABLE OF PRECIPITANTS.

1. *Alkalis.*	*Precipitants.*
Potash	Tartaric acid
Soda	None
Ammonia	Fixed alkalis.

There are no substances known capable of precipitating the fixed alkalis. They are detected by separating other substances from them, combining them with acids, and ascertaining the properties of the salts formed. Tartaric acid detects potash in many cases, when dropped slowly into solutions containing it. Tartar is formed, which being nearly insoluble, falls to the bottom in small crystals. Phosphoric acid forms with potash a salt nearly insoluble in cold water, but yet it cannot be used as a precipitant. We know of no substance capable of precipitating soda in this way. All the known salts of soda, except the fluate, oxalate, and camphorate, are very soluble. Though ammonia does not precipitate, yet it becomes perceptible by its odour, when solutions containing it are mixed with a fixed alkali.

2. *Alkaline Earths.*	*Precipitants.*
Barytes	Sulphuric acid
Strontian	Sulphuric acid
Lime	Oxalic acid
Magnesia	Phosphoric acid.

All the alkaline earths are precipitated completely by the alkaline carbonats, and they are commonly used for the purpose. The acids indicated in the table likewise precipitate completely, provided they be combined with an alkaline base, and the proper precautions be taken to remove bodies that might impede the action. Sulphat of soda may be said to precipitate barytes completely from all solutions; but it does not act so powerfully upon strontian. Oxalate of ammonia acts with nearly the same energy on lime, provided there be no excess of acid present. But the oxalat of lime is soluble in most acids. We have no good precipitant of magnesia; it is usually detected by separating the other bodies, and then throwing it down by means of an alkali. Phosphoric acid has been proposed by Dr. Wollaston. His method is ingenious. He pours *carbonat of ammonia* (as nearly neutral as possible) into the magnesian solution. No precipitate appears, because the carbonic acid is sufficient to keep it in solution; but, on adding phosphat of soda, it falls down in an insoluble state combined with the phosphoric acid.

3. *Earths proper.*	*Precipitants.*
Yttria	Ammonia, prussiat of potash
Glucine	Ditto, ditto
Zircon	Ditto, hydrosulphuret of potash
Alumine	Ditto, ditto.

All these earths are precipitated by the alkaline carbonats. None of them has an appropriate precipitate by means of which it is detected and separated. The separation is accomplished by more complicated means. If the solution be in sulphuric acid, indeed, alumine may be detected by means of potash, crystals of alum gradually separating.

4. *Metallic oxides.*	*Precipitants.*
Gold	Sulphat of iron Nitrat of mercury
Platina	Sal ammoniac
Silver	Muriat of soda
Mercury	Muriat of soda
Palladium	Prussiat of mercury
Rhodium	None } Zinc
Iridium	None
Osmium	None, mercury
Copper	None, iron
Iron	Succinate of soda
Nickel	None, sulphat of potash
Tin	Oxymuriat of mercury
Lead	Sulphat of soda
Zinc	None, alkaline carbonats
Bismuth	Water, muriat of soda
Antimony	Water, hydrosulphuret of potash
Tellurium	Water
Arsenic	Nitrat of lead
Cobalt	None, alkaline carbonats
Manganese	Tartrat of potash
Chromium	Nitrat of lead
Molybdena	None
Uranium	Prussiat of potash, alkalis
Tungsten	None, muriat of lime
Titanium	Infusion of galls
Columbium	Zinc, infusion of galls
Cerium	Oxalate of ammonia.

Almost all the metallic oxides may be thrown down either completely or partially by means of the alkalis, alkaline carbonats, or alkaline earths. Hydrosulphuret of potash likewise throws them almost all down; but many of them have, besides, particular precipitants, by means of which they may be separated from solutions. The precipitants usually employed are inserted in the preceding table.

The sulphat of iron throws down gold in the metallic state, and is commonly employed to separate that metal, except when the solution contains iron, and we wish to ascertain its quantity; in that case nitrat of mercury may be used.

Platina is precipitated from nitro-muriatic acid in the state of a yellow powder by sal ammoniac. This is the precipitant commonly employed, because the ammonio-muriat of platina is easily decomposed by heat.

Silver is completely precipitated from almost all solutions by common salt; the muriat of silver being insoluble in most liquids. It is one of the best precipitants with which we are acquainted.

Mercury is usually detected and separated by sublimation. There is no good precipitant of it except when in the state of protoxide; then muriat of soda throws it down almost completely.

Dr. Wollaston has shown, that palladium may be separated from nitro-muriatic solutions by means of prussiate of mercury. No good precipitant of rhodium is known. Dr. Wollaston obtained it in a separate state by means of common salt. Neither do we know any good precipitant of iridium or osmium: Mr. Tennant separated the first by means of zinc, and the second by means of mercury.

No saline precipitant of copper sufficiently accurate for use is known; the metal is usually thrown down by means of a plate of iron, or by sulphuretted hidrogen.

Succinat of soda or ammonia has lately been used with much advantage as a precipitant of iron.

No precipitant of nickel is known. Proust used sulphat of potash to separate it from cobalt by means of repeated crystallizations.

There is no good precipitant of tin; it may be thrown down, however, pretty completely, by means of oximuriat of mercury. Zinc is commonly employed to separate it from solutions.

Lead is thrown down very completely from its solutions by sulphat of soda.

There is no good precipitant of zinc known. The method employed by chemists when they wish to obtain it from solutions is to separate, in the first place, all the earths and other metallic oxides that may be present, and then to throw down the zinc by means of an alkaline carbonat.

Bismuth is thrown down from its solution by water and by muriat of soda. The white precipitate does not blacken when exposed to the sun; neither is it soluble in nitric acid; which sufficiently distinguishes it from muriat of silver.

Antimony is precipitated by water. Hydrosulphuret of potash or ammonia may be necessary in order to detect the metal by the orange-coloured precipitate thrown down.

Tellurium, as appears from Klaproth's experiments, is thrown down by water. We know but little of its precipitants.

Arsenic in the state of white oxide is imperfectly precipitated by evaporation. Hydrosulphuret of potash throws it down yellow: but the best method of ascertaining its quantity is to convert it into an acid and then throw it down by means of nitra of lead.

We have no good precipitant of cobal When tartrat of potash is put into a solutio containing it, and set aside, red rhomboida crystals form in it spontaneously, consistin of cobaltic tartrat of potash. This is not bad way of obtaining the metal nearly pure but it does not separate all the cobalt.

Neither have we any good precipitant o manganese. Richter has recommended tartrat of potash, which succeeds to a certai extent, especially if the solution does no contain an excess of acid.

Chromium, when in the state of an aci is thrown down by nitrat of lead.

We have no good precipitant of molybdena. By evaporation, it falls down spontaneously from acids in the state of an oxid

Uranium is well characterized by th

brown colour of the precipitate by prussiat of potash. The fixed alkalis throw it down completely from its solutions in the state of a brown powder.

We have no good precipitant of tungsten. It is usually obtained separate by combining its oxide with ammonia, evaporating to dryness, and then calcining.

Titanium is thrown down like coagulated blood by nut-galls; columbium in the state of a white powder by a plate of zinc; and cerium by oxalate of ammonia.

5. *Acids.*		*Precipitants.*
Sulphuric		Muriat of barytes
Sulphurous		Nitrat of lead
Phosphoric		Muriat of lime
Carbonic		Muriat of an alkaline earth
Fluoric	-	Muriate of lime
Boracic	-	Sulphuric acid
Nitric	-	None
Acetic	-	None
Benzoic	-	Muriatic acid
Succinic	-	Sulphat of iron
Moroxylic		Acetat of lead
Camphoric		None
Oxalic	-	Muriat of lime
Mellitic	-	Acetat of barytes
Tartaric	-	Potash
Citric	-	Acetat of lime
Saclactic	-	Ditto
Malic	-	None
Suberic	-	Muriatic acid.

This part of the table requires scarcely any explanation. When an alkali or neutral salt is indicated as a precipitant, the acid falls down in the state of an insoluble salt; when an acid is used, then the acid is precipitated in the state of small crystals. When no precipitant is indicated, in that case the acid forms no known insoluble salt, and is itself soluble in water.

When an acid forms an insoluble salt with any base, that acid, or its salts, almost always has the property of separating the base from the solutions which contain it. The base and its salt act in the same way when mixed with solutions containing the acid. Hence it is of importance to know the insoluble salts which the acids form with all the bases, because then we can always foretel the effect of mixing saline solutions together. If any acid and base be present, capable of forming an insoluble salt, they usually combine and precipitate. I shall, for that reason, insert the following table; it exhibits the solubility of most of the salts hitherto examined. The letter S indicates that the salt possesses a considerable degree of solubility; the letter I, that it is not sensibly soluble; and the letter L, that it is but little soluble, or possessed of a degree of solubility not exceeding one or two *per cent.*

Acids.	Potash.	Soda.	Ammonia.	Barytes.	Strontian.	Lime.	Magnesia.	Yttria.	Glucine.	Alumine.	Zircon.	Peroxide of gold.	Peroxide of platina.	Peroxide of silver.	Mercury.	Palladium.	Peroxide of copper.	Iron.	Tin.	Yellow oxide of lead.	Nickel.	Zinc.	Bismuth.	Antimony.	Tellurium.	Arsenic.	Cobalt.	Manganese.	Molybdena.	Uranium.	Titanium.	Cerium.
Sulphuric	S	S	S	I	I	L	S	S	S	S	I	S	S	L	L	S	S	S	S	I	S	S	L	L	S	L	S	S	S	S	S	S
Sulphurous	S	S	S	I	I	L	S			I				L	—		S	S	S	I	S	S	I	I								S
Phosphoric	L	S	S	I	I	I	S	I	I	I				I	I		I	I	I	I	L	S	S	S		L	S	L	S		I	I
Phosphorous	S	S	S	L		I	L			S				I																L		
Carbonic .	S	S	S	I	I	I	I	I	I	I				I	I		I	I	—	I	I	I	I					I			I	I
Fluoric .	S	S	S	L		I	I			S				I	I		S	S	S	I	S	S	L			L	S	L	S	S		
Boracic .	S	S	S	I	L	L	L			I				I	I		L	I	I	I	L	I	I	I		L	L	L	I			
Nitric . .	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	—	S	S	S	S	S	S	S	S
Muriatic .	S	S	S	S	S	S	S	S	S	S	S	S	S	I	I | S	S	S	S	S	L	S	S	S	S	S	S	S	S	S	S	S	S
Hyperoxym.	S	S	S	S	S	S	S			S				S			S	S														—
Arsenic .	S	S	S	I	I	I		I		I				I	I		S	I	I	I	S	I	I	I		I	S	L		I	I	I
Tungstic	S	S	S	I		I	S			I					I		I	I		I		I								I		
Molybdic	S	S	S			I	S							I	L		I	I		I	I	I	I	I				I		L		I
Chromic	S	S		I		S								I	I		I			I		I										

Acids.	Potash.	Soda.	Ammonia.	Barytes	Strontian	Lime.	Magnesia.	Yttria.	Glucine.	Alumine.	Zircon.	Peroxide of gold.	Peroxide of platina.	Peroxide of silver.	Mercury.	Palladium.	Peroxide of copper.	Iron.	Tin.	Yellow oxide of lead.	Nickel.	Zinc.	Bismuth.	Antimony.	Tellurium.	Arsenic.	Cobalt.	Manganese.	Molybdenum.	Uranium.	Titanium.	Cerium.
Acetic . .	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S		S	S	S	S	S		S
Benzoic .	S	S	S	S		S	S			S			L	S	I		S	S		S		S	S	S		S		S				I
Succinic .	S	S	S	L		L	S	L	I					S	S			I	S	L		S	S	S				S	S			L
Moroxylic	S	S	S			S																										
Camphoric	L	L	L	L		L	L			L																						
Oxalic . .	S	S	S	I	I	I	I	I		S			S	L	L		L	S	S	L			L	L		S		I	S		L	I
Mellitic .	S	S	S	I		I	I			I				S	I		L	L		L												
Tartaric .	S	S	S	L	L	I	I	S		S				S	I		S	S	S	I		L	I	S		S	S	S	S	L	L	I
Citric . .	S	S	S	L	L	L								I	L		S	S		L		L										S
Sebacic .	S	S	S	S	S	S											S															
Saclactic .	S	S	S	I		I	I			I				I	I		S	S		I												
Malic . .	S	S	S	L	S	L	S			L				L	I		S	S		I		S										
Suberic .	S	S	S	L		L	S			S							S	S		I												
Formic .	S	S	S			S											S															

Several of these salts, however, although insoluble in water, are still soluble in several saline or acid solutions. This prevents the precipitation from appearing in all cases of mixture as it otherwise would.

Precipitate (Black *and* **Rose-coloured).** Lemeri, who mentions many precipitates of mercury of different colours, says, if a solution of mercury in acid of nitre be precipitated by urine, instead of a solution of common salt, a rose-coloured precipitate of mercury will be formed; and if afterward some fixed alkali or ammonia be added to the liquor from which the rose-coloured precipitate has been formed, another precipitate, which is black, will be obtained.

The rose-coloured precipitate consists of mercury united with the phosphoric acid, and the black appears to be mercury nearly reduced. This last must be most abundant, where the mercurial solution has been made by heat. See Mercury.

Precipitate (Green), *and* **Precipitate (Black),** *or* **(Violet-coloured), of Mercury.** Some authors, particularly Lemeri, give processes for other preparations of mercury, which have been employed as medicines, and which are improperly called precipitates. Such is the green precipitate, which is a mixture of four parts of mercury and one part of copper, dissolved separately in the nitric acid, and treated as in the process for making red precipitate; afterward partly dissolved a second time by being digested with vinegar; and lastly reduced by evaporation to a dry consistence. Such also is the preparation called by Lemeri violet mercury, or black mercurial panacea, or black precipitate, which is an artificial cinnabar overcharged with sulphur, mixed with sal ammoniac, and prepared by a very long and laborious process: but as these preparations have been made only for the use of medicine, and have fallen into disrepute, we shall not say any more of them, excepting, that they are singular mixtures, accompanied with many unforeseen appearances, which could not be explained without farther examination and particular dissertations.

Precipitate of Gold by Tin, *or* **Purple Powder of Cassius.** This precipitate of gold may be made by several methods: but which of these is the best, has not yet been decided. The cause of this uncertainty is, that the preparation requires delicate management, and is uncertain in its result; the beauty of the colour seeming to depend on some small circumstances not yet discovered; for we find that the colour of the powder obtained frequently varies, notwithstanding the processes seem to have been the same. Macquer tried several methods. Under the article Gold will be found that which best succeeded with him, and it is nearly the same as that described by Mr. Gellert in his Metallurgic Chemistry.

In the Novi Commentarii of the Royal Society of Göttingen for the year 1774, there is an account of experiments made to investigate the causes of the uncertainty of success in preparing the purple precipitate of Cassius, by Joan. Christ. Polyc. Erxleben. According to this author, a principal requisite for the success of this operation is, that the solution of tin should not be turbid: and as the nitric acid in dissolving tin converts a great deal of this metal into a white oxide, care must be taken, that the proportion of nitric acid in the aqua regia employed for the solution of the two metals be not too great. A too great proportion also of muriatic acid is to be avoided; as this acid, when in too great quantity, blackens the surface of the tin, and thereby impedes its solution in the aqua regia. He recommends, therefore, to prepare the aqua regia by adding to aqua fortis one quarter of its weight of muriatic acid; and if, upon adding a small piece of tin, a perfect solution take place without exposure to heat, the acids are in due proportion; but if a black oxide remains undissolved, he advises to add more nitric acid, and if a whitish oxide, more muriatic acid: the solution is to be performed slowly and without heat, by adding small portions of tin only at a time, till all is dissolved. He does not find it necessary, that the solutions of gold and tin should be saturated, as Baumé asserts. He says, that, unless the solution of tin be recently prepared, it is not fit for the precipitation of the purple precipitate; that by standing a longer or shorter time, according to the vessel being well or ill stopped, it loses its dark colour, and its power of producing the purple precipitate; both which return upon adding a piece of tin. The solutions undiluted being mixed, a dark coloured not a purple precipitate was obtained. Distilled water ought to be used. Well-water gave a violet colour, owing to the earthy particles in it.

Long cylindrical pieces of glass, called Jew's glass, are commonly sold, and much used by manufacturers of glass-toys. This glass, though perfectly colourless, yet, when it is exposed to the heat and flame of a lamp, acquires a beautiful ruby colour, exactly similar to that of pure glass melted with powder of Cassius. As no other known substance but gold gives that colour to glass, we may presume, that this glass contains some of that metal. Its want of colour proceeds from its having been melted in a covered pot; by means of which it is defended from flame or smoke, which seem to be necessary to give to this glass its peculiar colour.

Dr. Lewis observes, that, though a purple or a ruby colour may easily, by the methods published, be applied upon glass or enamels, and introduced into the mass by fusion, the way of equally diffusing such a colour through a quantity of fluid glass is still a secret. That author says, that he has made several trials of this kind, in one of which the glass was uniformly tinged of a ruby colour; and in the other various colours, as yellow, red, and brown, appeared, and were unequally diffused: but he had not discovered the circumstances upon which these differences depend. Orschall in his Treatise, Sol sine Veste, gives a process by which he obtained a fine ruby glass. He directs, that the powder of Cassius should be ground with six times its quantity of Venice glass finely powdered; and that this mixture should be well mingled with a frit consisting of equal parts of borax, nitre, and fixed alkaline salt, and four times as much calcined flint as of any of the salts: but he does not mention the proportion of the powder of Cassius to the frit, nor in what manner the fusion is to be performed.

Kunckel says, that one part of the powder of Cassius is sufficient to give a ruby colour to twelve hundred and eighty parts of glass.

Dr. Franklin observes, that gold-leaf placed betwixt two plates of glass being exposed to an electrical shock, stained the contiguous glass with red spots, which were sunk into the body of the glass. This seems to show, that tin is not essential to the production of this fine colour; which has been farther confirmed to me by a very ingenious manufacturer, who has made many experiments on this in particular among other enamels. He conceives, that nothing more is necessary, than to diffuse equably through the glass a certain portion of gold in a state of extremely minute division; but in this there is no small difficulty, as particles of metallic gold will be almost always perceptible by the microscope. His mode was, to melt gold with antimony, in sufficient quantity to render it easily pulverable: to reduce this alloy to an impalpable powder: to dissolve it in aqua regia, and precipitate the solution by an alkali: and to mix the washed precipitate with a frit. If this enamel were to be applied on gold, a small portion of arsenic added to the frit appeared necessary to bring out the beauty of the colour, it being muddy without this. On the contrary, if it were to be applied on silver, the smallest portion of arsenic was highly injurious.

Precipitate per se. This preparation of mercury is very improperly called a precipitate; because it is not separated from one substance by means of another substance, as all true precipitates are, but is only mercury reduced to a red powder by calcination.

To make this preparation, three or four ounces of mercury are put into a flat-bottomed glass matrass, the neck of which is very long, and the opening of a capillary size. This matrass, the belly of which ought not to be entirely full of mercury, is to be placed in a sand bath, and heated till the bottom of the vessel containing the sand is red-hot. This heat is to be continued during two or three months. The mercury gradually loses its lustre, and part of it is converted into a red powder, which does not mix with the remaining fluid mercury, but floats upon the surface of the mercury; or adheres to the sides of the vessel. The operation may be shortened by using a greater number of matrasses, all which may be placed in the same bath. When enough of this red powder is obtained, it is to be collected and separated from the remaining fluid mercury. This is called precipitate per se, or by itself, or red precipitated mercury without addition.

This preparation of mercury we have received from the alchemists, who spared no pains to change mercury and to fix it. They received great hopes from the change of colour, the want of fluidity, and the diminution of volatility, which the mercury suffers by this operation. Although the mercury is much disguised by these changes, yet it is not greatly altered, because it may be reduced to fluid mercury by heat without addition. It is a combination of mercury with the oxigen of the atmosphere.

Precipitate (Red). If a solution of mercury in nitric acid be reduced to dryness by evaporation, and the nitrat of mercury thence formed be put into an open matrass set in a sand bath, with a fire gradually increasing, the nitric acid will be in part decomposed, and evaporate in a red vapour. While the nitrous gas evaporates, the saline mercurial mass loses its original whiteness, becomes yellow, then orange, and lastly red.

This red matter, when separated from the matrass (which must be broken for that purpose) and pulverized in a glass mortar, is the red precipitate as it is improperly called; it not being a precipitate, but a mercurial oxide combined with nitric acid from which the greater part of the acid has been expelled by the fire, without the application of any intermediate substance.

This precipitate, therefore, when well made, was formerly supposed not to differ from the precipitate per se; but it is in fact a subnitrat of mercury, varying in proportion to the time and care bestowed upon its preparation.

Precipitate (White). Mercury separated from nitric acid by muriatic acid, with which it then unites, has been thus called. It was made by pouring a solution of common salt in distilled water into a solution of mercury in nitric acid, till no more precipitate fell down. When the sediment was collected at bottom, the supernatant liquor was decanted, and the precipitate washed several times with distilled water, and then dried.

This precipitate of mercury is one of those called compound. It is a combination of mercury with the muriatic acid; for in this operation, as well as in the precipitation of the corneous metals, the metallic matter is only separated from the nitric acid by means of the combination it forms with the muriatic acid. In this precipitation, then, the phænomena are similar to those which happen in the formation of luna cornea and plumbum corneum. 1. White precipitate may be made by pure muriatic acid. 2. When it is made by common salt, or other salt containing muriatic acid, two decompositions happen, and two new combinations are formed. The nitric acid, which was originally united with the mercury, combines with the substance that was united with the muriatic acid, and forms a new nitrous salt, which remains dissolved in the liquor. When common salt is employed, nitrat of soda is formed. If muriatic salt with an earthy basis be used, the liquor after the precipitation contains a nitrat with earthy basis. 3. All the mercury, though entirely separated from nitric acid, and united with muriatic acid, is not precipitated on the present occasion, because it is reduced to a saline compound essentially soluble in water; and consequently the liquor contains as much of it as it can dissolve, and another part of it is dissolved by the water employed to wash it.

Lemeri gives another process for making a white precipitate, which consists in dissolving four ounces of sal ammoniac in a pound of water; to which is to be added an equal quantity of corrosive sublimate; all which could not be entirely dissolved alone in that quantity of water, but may by means of the sal ammoniac. Into this solution liquid fixed alkali is to be added till no more is precipitated. The precipitate is very white, and it has been accordingly called white precipitate by several chemists: but it ought not to be confounded with the white precipitate formed by adding muriatic acid or common salt to a solution of mercury in nitric acid; for they are evidently very different.

This white precipitate is the white calx of quicksilver of the London Pharmacopœia, and, according to Fourcroy, is a triple compound consisting of oxide of mercury 81 parts, muriatic acid 16, and ammonia 3.

PRECIPITATE (YELLOW). As chemists have given many different forms to mercury, to adapt it to medicinal uses and to chemical processes; so they have made various precipitates of it, and have given the name of precipitate to other mercurial preparations, which in fact are not precipitates. These were heretofore chiefly denominated from their colours, without adding any epithet, to show that they were mercurial. Thus, white precipitate, yellow precipitate, red precipitate, &c. are preparations of mercury. Yellow precipitate is mercury dissolved by sulphuric acid, afterward precipitated by addition of water alone; it is then in form of a yellow powder, and is a subsulphat. Its more common name was turbith mineral: it has likewise been called yellow emetic mercury; and lastly, by the London college, vitriolated quicksilver.

PREHNITE. This stone was so named from colonel Prehn, who first brought it from the Cape of Good Hope. It much resembles the stilbite, but wants its pearly lustre. It is hard enough to scratch glass. It swells considerably before it melts. Its fracture is irregular in two directions, and laminated in one, and this structure leads to a right prism with rectangular bases. It is electrical by heat.

The crystals of prehnite are generally composed of rhomboidal or hexagonal laminæ, either distinct, or united by the middle, and implanted in their gangue: but these laminæ are curved and a little divergent at their extremities, like the sticks of a fan, and disposed in sheaves, as Werner expresses it. This arrangement, which is peculiar to the crystals of prehnite, renders them at once distinguishable.

They are diaphanous, or merely translucid, and vary in colour from an apple-green to a greenish white. This colour, which is common to all the varieties yet known, forms a pretty good practical characteristic.

According to Klaproth, the prehnite consists of

Silex	44
Alumine	30
Lime	18
Iron nearly	6
Water	2
	100

Its specific gravity varies from 2·6 to 2·69.

Brongniart makes two varieties of the crystallized stone, one of which he calls crystallized prehnite simply, the other *koupholite* prehnite, from the Greek κουφος, light.

The first of these varieties appears under one of the simple or aggregate forms mentioned above, and is sometimes found in very regular hexagonal tablets. Though its crystals are rendered electric by heat, they are symmetrical; and the difference of form observed in other mineral productions between the parts that assume the opposite electricities has not yet been perceived.

This species is found sometimes in considerable masses in the Khamesberg, in the country of the Nimigua Hottentots, on the western coast of Africa. The Dutch settlers use it to ornament their pipes, but it is quickly tarnished. It occurs likewise at la balme d'Auris, near the town of Oysans, in the department of the Isère, in France; where it covers gneiss and gruenstein, and is sometimes impregnated with chlorite, which renders it opake, but seems to impart a remarkable regularity to its crystals: about two or three miles west of Nantes, in a rock of decomposed hornblende: at the peak of Eredlitz, near Barèges, in the Pyrenees: in the vale of Fascha, in the Tyrolese, where it accompanies a radiated zeolite: at Dunglas, in Scotland: and at Arthur's Seat, near Edinburgh.

The koupholite prehnite offers itself in the form of small rhomboidal laminæ, of a dirty white, inclining to yellow or green. They are grouped or scattered on the sides of the cavities of a cellular rock. In other respects it has all the characters of prehnite. Vauquelin analysed it, and found the following to be its constituent principles, there being a loss of one per cent.

Silex	48
Alumine	24
Lime	23
Oxide of iron	4
	99

This variety was discovered by Lelièvre and Gillet in the Pyrenees, near Barèges; and has since been found by Picot-Lapeyrouse at the peak of Eredlitz in the same chain. Its gangue is a cavernous hornstone, mixed with chlorite, and acicular crystals of strahlstein.

Prehnite likewise occurs in compact masses, with a fibrous and often radiated structure. Its masses are globular, but covered with irregular tubercles, though rounded, like the kidney of an ox. It is of a deeper green than the crystallized kinds, and capable of receiving a pretty good polish.

This prehnite is found in the department of the Sarre, within a mile of Reichenbach, near Oberstein. It fills several cavities of a gray porphyry, which include likewise globules and small white crystals of feldtspar, and which is easily decomposed. This prehnite is remarkable too for containing not only oxide of copper, but native copper, according to Faujas. It is found also at Frisky Hall, between Edinburgh and Glasgow; where it occurs in veins composed of parallel fibres in a hornstone passing into basaltes; and in the Isle of Mull.

Prince's Metal. A fine kind of brass, or alloy of copper and zinc. See Copper.

Principles. Among the various divisions or arrangements of chemical principles, that which follows their respective degrees of simplicity must undoubtedly prove the most useful, because the more compounded bodies will easily assume a regular order, when their respective principles are known and properly classed. There is, however, a limit in the advantages that may be derived even from this method of division. The more we succeed in simplifying the principles of bodies, the more difficult it is to determine truly what passes in chemical operations; because these principles, when in their most distinct state, have the aërial form, and cannot therefore be managed or weighed without considerable difficulty. From this cause it is, that, while we have no disputes concerning the changes of combination in grosser or less simple substances, the most eminent chemists often differ in their opinions concerning the transitions of first principles from one combination to another; and are not agreed concerning the existence of some of them. The peculiar properties of bodies may be changed, either by the addition or subtraction of some of their component parts; and it is easy to form a notion, that such a change may also happen by a mere alteration in the disposition or relative arrangement of their parts, without any change in their quantities. To determine which of these events takes place, when we behold only the consequent change, is sometimes impracticable, for want of a sufficient number of facts; and in most cases the complete investigation requires the unprejudiced and patient exertion of all the powers of the mind. It appears proper, therefore, in an elementary arrangement, to fix our attention chiefly on the most palpable component parts of bodies, which are sufficiently simple; and where they are not the simplest, to consider their principles in the analytical method.

The only general division of bodies at present referred to in the writings of modern chemists, is that by which they are classed into three kingdoms, called the animal, vegetable, and mineral kingdoms. The kind of bodies arranged in the first two kingdoms is obvious from the terms; and all other bodies are considered as belonging to the mineral kingdom. See these kingdoms, in the order of the alphabet; also the Table of Chemical Nomenclature, article Nomenclature, and the Table of the Component Parts of Bodies in the Appendix.

Printers' Ink. See Ink.

Proof-bottle. A phial with a round bottom, and thin, so as to be capable of bearing the application of moderate heat, as that of the flame of a lamp; and with a curved tube ground into it. It is used for procuring gases in small quantities. Some are made with a second aperture, for the purpose of puting in the ingredients, without removing the tube. See Plate VI, fig. 1, c.

Propolis. The propolis, bee-glue, or mastic of bees, is well known to be the first matter collected by the bees of a swarm, newly placed in a hive. This substance is resinous, ductile, odorant, and of a reddish brown colour, more or less deep. It is at first soft and very extensible; but it hardens, and at last becomes very solid.

It is not yet known from what part of plants it is extracted: it is believed that it comes from the species of gum-resin which coats and defends most of the buds of trees and shrubs from wet. In the mass it is blackish; but it is semitransparent when in thin plates. The heat of the fingers is sufficient to soften it, and give it all the ductility of wax: but it is more ropy and tenacious. Like wax it may be kneaded between the teeth, without any perceptible taste. Its odour is aromatic, resembling that of melilot, of balsam of Peru, or of the Banana poplar.

Its component parts, as analysed by Vauquelin, were, wax ·14; resin of propolis ·57; extraneous matters ·14; loss, acid, aroma, ·15.—*Bulletin de la Société Philomatique.*

Protoxide. This term is used by Dr. Thomson to denote a metal combined with the least dose of oxigen that will form an oxide with it, and is synonymous with oxide at a minimum.

Prussian Alkali. The prussiat of potash. See Acid (Prussic).

Prussian Blue. See Blue (Prussian).

Pseudocrystal. Some mineral substances appear under a regular form, without having acquired it by the regular process of crystallization. These may with propriety be termed pseudocrystals, false or spurious crystals. Haüy calls them *pseudomorphoses*, as being spuriously formed.

These crystals are of two kinds. The first appear to have been moulded in a cavity previously occupied by a true crystal. How this happens is not known. It is supposed, not without probability, that sometimes the new substance has found the cavity previously evacuated; and at other times that it has gradually destroyed the crystal, and assumed its place

Such spurious crystals are distinguishable from the true by their texture, which is scarcely ever laminar; by their surface, which is commonly dull and rough; by their edges and angles, which are generally blunt; by their being insusceptible of regular mechanical division; and by their exhibiting figures foreign to the substance of which they are composed. Such are the pretended crystals of silex, jasper, compact steatite, and others.

Another kind have apparently been formed by contraction. The substance of these has not been actually dissolved by caloric or by any fluid: it has merely been softened, or rendered less dense; and on contracting by cooling, or by drying, the mass has been divided by fissures into pretty regular polyedra.

These are distinguishable from true crystals by several characteristics. Their angles, which differ in extent in similar figures; without obeying any regular law, constitute the most essential distinction. Their edges are irregularly bent, and have not the precision of those of real crystals; their faces are dull, rough, and filled with irregular depressions; for the most part they are opake; their fracture is almost always earthy; and they have very rarely a lamellar structure.

Clay, marl, granites, schists, sulphat of lime, trap, &c., and in particular basaltes, are the principal substances in nature that exhibit prismatic or rhomboidal crystals by contraction. Some substances produced by art exhibit a similar arrangement, and this circumstance serves to elucidate the origin of those formed by nature. Thus clay, powdered and exposed gradually to a violent heat, the scoriæ of iron-works, and the interior coatings of some furnaces, frequently as they shrink produce polygonal prisms. Mr. Brongniart remarks, that he has observed this fact with respect to clay; and that he has seen in the possession of Mr. Gillet, member of the council of mines, part of the sides of a furnace, in which prismatic polyedra perfectly resembling basaltes were formed.—*Brongniart's Elements of Mineralogy.*

Pseudogalæna. Blende, black jack, or mock lead. An ore of zinc.

Pseudomorphoses. See Pseudocrystal.

Pseudopal. See Cat's-eye.

Puddingstone. Breccias. Stones which consist of a siliceous ground or cement (commonly petrosilex, jasper, or siliceous grit) in which pebbles of silex or agate are interspersed; if these be round or oval, they are called puddingstones; if angular, breccias. Of the coarser sorts mill stones are often made.

Puff-ball. See Lycopodium.

Pulverize. See Powder.

Pumice-stone. Pierre Ponce, Bimstein. This seems rather a volcanic ejection than a volcanic product; its colour is gray, white, reddish-brown, or black; it is hard, rough, and porous, and consists of slender fibres parallel to each other; very light, for it swims on water, and difficultly gives fire with steel. The whitest pumice-stone is the lightest. There is a kind, however, that sinks in water, and is much used in Naples and Sicily in building arches; and a still more compact and heavy kind, that is easy to cut, and employed for corner-stones of buildings, as well as for walls in general.

The lighter sort is used for smoothing the surface of metals, wood, pasteboard, and stone.

Pumice-stone is likewise said to form an excellent glaze for pottery, which contains nothing noxious, and is not affected by any known menstruum.

Dr. Kennedy found potash in the pumice-stone of Lipari; and Klaproth has since given as its component parts, silex 77·5, alumine 17·5, oxide of iron with a little manganese 1·75, soda and potash 3, in 100 parts.

It has lately been asserted by Mr. Donovan, that there is a large quantity of pumice-stone on Cader Idris, in Merionethshire.

Purbeck-stone. A hard sand stone, the cement of which is calcareous.

Purification. By purification is meant any chemical operation by which substances required to be obtained pure and single, are separated from other heterogeneous matters with which they happen to be mixed.

As the several chemical agents and other matters are generally more or less contaminated, and even combined with substances of different natures, and as we require in many accurate experiments that they should be very pure, we must, therefore, apply the proper methods to give them the necessary degree of purity.

But these methods differ very much according to the nature of the substance to be purified. They must be appropriated to their peculiar natures, and also to the nature of the substances to be separated. For the several purifications, we are obliged to employ almost all the operations of chemistry. Hence many operations are only true purifications, although they are not so called. For instance, all the second distillations and sublimations, called rectifications, are nothing else than purifications. They are employed for the purification of volatile substances from others that are fixed, or less volatile. In this class may be ranged the rectifications of oils, of volatile spirits and salts, of alcohol, and even of mineral acids; and the sublimations of sulphur, of arsenic, of cinnabar, of salt of amber, of flowers of benjamin, and of sal ammoniac. See RECTIFICATION and SUBLIMATION.

Also the repeated solutions, filtrations, evaporations, and crystallizations of neutral salts, are only means of purifying them. See CRYSTALLIZATION.

Several calcinations, and particularly those of fixed alkalis, are intended merely to purify them, by depriving them of a greasy matter or superabundant inflammable principle. See POTASH.

Many solutions and precipitations by the humid way, particularly in the operations of parting, and of luna cornea, are performed for the purification of the perfect metals from their alloy. Lastly, the repeated fusions of metallic substances, the smelting of ores, cupellations, and refining, are true purifications of metallic matters. Among all these operations but a very few are called purifications: such as the purification of silver by nitre, and of gold by antimony; of both which we shall now treat.

PURIFICATION OF GOLD BY ANTIMONY. To purify gold from its alloys by antimony, the gold is to be melted in a crucible large enough to contain thrice the quantity of metal. When the gold is melted, twice its weight of sulphuret of antimony powdered is to be thrown upon it; the crucible is to be covered, and the matter left some minutes in fusion: after which, when the mixture is well fused, and so hot that its surface sparkles, it is quickly to be poured into an iron cone previously heated and greased. By striking the cone against the ground, the descent of the metal will be assisted; and when the cone is cold, it is to be inverted, and the matter taken out.

This matter consists of two substances; the upper one of which is composed of the sulphur of the antimony united with the metals with which the gold was alloyed, and the lower is the gold united with a quantity of the antimony proportionable to the quantity of metals which have been separated from the gold, and which are now united with the sulphur of the antimony. This gold may be separated from the sulphuretted metals which cover it, and will be found to be so much less yellow, that is, mixed with so much more antimony, as the gold was more alloyed.

As a single fusion is not generally sufficient to disengage the gold from all its alloy, it ought to be fused again in the same manner, and with the same quantity of sulphuret of antimony; and even a third time, if the gold were much alloyed. It is fusible with less fire the second and third time than the first, from the antimony which is united with it.

This first part of the purification of gold by antimony is founded on a property of sulphur, by which it is incapable of uniting with gold, and is strongly disposed to unite with all other metallic substances, excepting platina and zinc; and also upon this property of sulphur, that it has less affinity with antimony than with any metallic substance with which it can unite. Hence, when gold alloyed with silver, copper, iron, lead, &c., is fused together with sulphuret of antimony, these metals unite with the sulphur, while the antimony disengaged from it unites with the gold. The separation of metals from gold is then really occasioned by the sulphur of the ore of antimony.

This purification of gold is consequently a kind of dry parting, but it succeeds better than the dry parting by sulphur alone. The reason of this difference is, that sulphur, being very volatile and inflammable, is in great measure dissipated and consumed, when it is employed alone, before it can seize the metals with which the gold is alloyed; whereas, when it is already united with a metallic substance, as it is in the sulphuret of antimony, which prevents it from being quickly consumed and dissipated, it may be much more easily applied to the metallic substances alloyed with gold. Notwithstanding this advantage, as a quantity of antimony is always united with the gold, proportionable to the quantity of metallic substances separated by means of the sulphur of the antimony; and as the separation of this antimony from the gold requires much time; when we would purify gold that is much alloyed, suppose under sixteen carats, we ought to add along with the sulphuret of antimony some pure sulphur, that we may have a less quantity of antimony to separate afterward from the gold.

When these first fusions have been well made, the gold obtained is alloyed with only antimony. But as this semimetal is very volatile and very combustible, it may be separated from the gold by a sufficiently long exposure to the action of fire. For this purpose the gold obtained by the former operation is to be put into a large crucible, and heated sufficiently to keep it in good fusion. With this heat the antimony will be dissipated into smoke. If the heat be too strong, some of the gold will be carried off with the antimony. The operation therefore must be performed slowly; and it continues a long time when much of the antimony is united with the gold; but it may be abridged by blowing on the surface of the metallic mass, which greatly assists in the oxidation and evaporation of all bodies, and particularly that of antimony. When a part of the antimony is dissipated, more heat is required to keep the metal fused, and therefore the fire must be increased toward the end of the operation: besides, when only a small quantity of antimony remains, it is so covered by the gold, and protected from the action of the fire and air, that a stronger heat is necessary to evaporate it. The smoke ceases entirely toward the end of the operation, although some antimony still remains united with the gold. The purification is completed by means of a little nitre thrown into the crucible, which effectually oxides the remaining antimony. Sometimes, after these operations, the gold is found to be deprived of much of its usual ductility, which however is easily restored to it by fusing it with nitre and borax.

The ancient chemists called sulphuret of antimony the balneum regis, or the balneum solis, and the lupus metallorum, from this property which it possesses of purifying gold. The sulphur of this mineral does, indeed, seize almost all the metals with which gold can be alloyed; but these metals are not destroyed, but only reduced to sulphurets, forming the scoria, from which they may be obtained. Therefore, when the gold contained much alloy of silver, the scoria is very valuable, since it contains all the silver which was united with the gold. This scoria ought to be preserved and treated like an ore of silver, and thus the metal extracted from it. See PARTING.

PURIFICATION OF SILVER BY NITRE. The silver to be purified by nitre is to be first granulated, and then mixed with a fourth part of its weight of dry nitre, an eighth part of potash, and a little common glass, all in powder. This mixture is to be put into a good crucible, two thirds of which only must be full. This crucible is to be covered with a smaller crucible inverted, and luted to the former, and in the bottom of which a small hole has been made. The crucibles thus disposed are to be placed in a furnace, capable of drawing air sufficiently to make the fire intense enough only to melt the silver. Then charcoal is to be put into the furnace to such a height, that only the top of the inverted crucible shall be uncovered. The coal is then to be kindled, and the vessels to be made moderately red: a hot coal ought to be put upon the small hole in the bottom of the inverted crucible. If a shining light be observed round this coal, and a slight hissing noise be at the same time heard, we may know that the operation proceeds well. The fire must be sustained at the same degree till these appearances cease; when it must be increased so that the silver is well melted, and then the crucibles are to be taken out of the furnace. The larger crucible is to be broken when it is cold, and the silver will be found at the bottom covered with a green alkaline scoria. If the metal be not sufficiently pure and ductile, the operation must be again repeated.

This operation is founded on a property which nitre has of effectually oxiding all imperfect metals; and also upon a property of oxided metals by which they cannot be united with others in their metallic state. This being established, when silver alloyed with copper or other imperfect metals is to be treated with nitre, this salt quickly oxides these imperfect metals by detonating with them; and they are no sooner oxided, than they are rendered incapable of remaining united with the silver. These metallic oxides, being also specifically lighter, rise above the silver, where they meet the alkali of the nitre and the potash, with both which they form a scoria. The silver, being capable of resisting the action of the nitre, is thus disengaged from its alloy, is fused, and collected at the bottom of the crucible.

As the purification of silver is effected by the detonation of nitre with the imperfect metals, and as this detonation is always accompanied with swelling and effervescence, the crucibles must not be too firmly closed, otherwise the effervescence might break them, and some of the contained matter might be lost: therefore a small hole is left in the upper crucible, which serves as a cover to the other: besides, the empty space left in the vessels thus disposed allows the matter contained to swell a little without loss.

This small hole is also very useful to show the proper degree of fire, during the operation, as has been said. The light and the hissing noise, which may be perceived when a coal is applied, are occasioned by oxigen extracted from the nitre, by the decomposition of part of its acid at that violent heat. When these effects are too considerable, and a sensible hissing may be heard at the small hole, even when a hot coal is not applied to it, we may know that the detonation is too violent. In this case the fire must be lessened, otherwise much of the nitre would sublime or be driven off, and together with it some part of the silver would be wasted. And even notwithstanding all the precautions that can be used, this operation can scarcely be performed without some loss of the silver. Small grains of silver are always to be seen in the upper crucible, and about the small hole in it. This inconvenience prevents the operation from being employed to determine the value of the silver, for which purpose cupellation is therefore used. See Silver, Nitre, and Detonation.

Purple Dye. By the mixture of red and blue, we obtain violet, purple, dove colour, pansey, amaranth, lilac, mallow, and a great number of other shades, determined by the nature of the substances, the red colour of which is combined with the blue, by the proportion of these substances, and the different steps of the process.

According to Hellot's observations, stuff which has been dyed scarlet takes an unequal colour when blue is to be united with it. The blue is therefore given first, which even for violet and purple ought not to be deeper than the shade distinguished by the name of sky-blue: a boiling is given with alum mixed with two fifths of tartar, the stuff is then dipped into a bath composed of nearly two thirds as much cochineal as for scarlet, to which tartar is always added. The circumstance which distinguishes the process for purple from that for violet is, that for the former a lighter blue ground is given, and a larger proportion of cochineal is employed. These colours are frequently dyed after the reddening for scarlet, such quantities of cochineal and tartar being added as are thought necessary. The operation is conducted in the same manner as for scarlet.

Lilacs, pigeons-necks, mallows, &c., are commonly dipped in the boiling which has served for violet, after alum and tartar have been added to it; the blue ground having been proportioned to the shade required: the quantity of cochineal is also adjusted in a similar manner: a little solution of tin is added for some reddish shades, such as peach blossom. It must be observed, that though the quantity of cochineal is diminished according to the lightness of the shade required, the quantity of tartar is not lessened, so that the proportion of it compared with that of the cochineal is so much the greater, as the colour required is lighter.

Mr. Poerner is of opinion, that, to obtain the colours composed of red and blue, it is advantageous to employ the solution of indigo in sulphuric acid, because a greater variety of shades is thus more easily procured, and the process is shorter and less expensive. The colours obtained in this way are indeed much less durable than when the blue vat is employed; but Mr. Poerner asserts, that they possess durability, when solution of indigo to which alkali has been added is employed.

He prepares a pound of cloth with three ounces of alum, by boiling it for an hour and a half, and leaving it a night in the liquor after it is cold. He makes the bath with an ounce and a half of cochineal, and two ounces of tartar, boiling it for three quarters of an hour; and then adding two ounces and a half of solution of indigo, he stirs it, and makes it boil gently for a quarter of an hour: he thus obtains a very beautiful violet.

For the different shades which result from the mixture of red and blue, according as one or other of the colours prevails, he increases or diminishes the proportion of the solution of indigo; he increases it as far as five ounces, and diminishes it to five drachms for each pound of cloth: he also reduces the quantity of cochineal, but never below an ounce, because the colour would become too dull: he changes the proportion of tartar, and finally, he varies the preparation given to the cloth, by the addition of tartar or solution of tin in different quantities.

In silk, two kinds of violets are distinguished, the fine, and the false: the last is made either with archil, or brazil-wood.

For fine violet the stuff is first passed through cochineal, and afterward dipped in the vat; the silk is prepared and dyed in the cochineal in the same manner as for crimson, except that neither tartar nor solution of tin, both of which serve to heighten the colour, is employed. More or less cochineal is used, according to the intensity of the shade required. The common proportion for a fine violet is two ounces for each pound of silk. When the silk is dyed, it is washed at the river and beetled twice, then dipped in a vat of greater or less strength, according to the depth we wish to give the violet; lastly, it is washed and dried with the precautions which are proper for all colours dyed in the vat. To give greater strength and beauty to the violet, it is commonly passed through the archil bath; and this custom, which is frequently abused, is indispensable for the light shades, the colour of which would otherwise be too dull.

When the silk has been dyed with cochineal as above directed, a very light blue shade must be given to it for purple; only the deepest shades are dipped in a weak vat; such as are less deep are only dipped in cold water, into which a little of the liquor of the vat has been put, because they would take too much blue in the vat itself, though ever so weak. The light shades of this colour, such as gilly-flower, gridelin, and peach blossom, are made in this way, by diminishing the proportion of cochineal.

The false violets in silk are produced in many different ways; those which are most beautiful, and most in use, are prepared with archil. The strength of the archil bath is adapted to the colour we wish to obtain; the silk is turned in it on the skein-sticks, after having been beetled at the river after scouring: when the colour is thought to be sufficiently deep a pattern is tried in the vat, to see whether it take the violet we wish for. If the shade be found to be of the proper depth. the silk is beetled at the river, and dipped in the vat, as for the fine violets; less of the blue, or less of the archil colour is given, according as we mean that the violet should incline to red or blue.

According to Mr. Guhliche, beautiful violets may be produced in silk by means of the solution of indigo; but they possess little durability, and become reddish, because the colour of the indigo fades first.

A pound of silk is soaked in a bath composed of two ounces of alum and two ounces of solution of tin, after being decanted from the sediment formed in the mixture. The dye bath is prepared with two ounces of cochineal (reduced to powder with a drachm of tartar) and the remainder of the bath which has served as a mordant, with the addition of a sufficient quantity of water; after a slight boiling, such a quantity of solution of indigo is added, as gives the bath a proper shade of violet; the silk is then immersed, and boiled until it has acquired the proper shade; when it is wrung, washed in a stream, and dried in the shade, like all delicate colours. The bath is exhausted by the light shades.

A violet is given to silk, by dipping it in water with which verdegris has been mixed, instead of aluming it, and then giving it a bath of logwood, when it assumes a blue colour, which is changed to violet, either by adding alum to the bath, or by dipping it in a weaker or stronger solution of alum, which gives the particles of logwood a red colour. It is unnecessary to observe, that this violet is of a very fading nature, and only a moderate degree of beauty. One possessing much greater beauty, and to which a considerable degree of intensity may be added, is made by dipping the alumed silk in a bath of brazil-wood, and again, after it has been washed at the river, in a bath of archil. Madder is also employed in dyeing cloth, after it has had a blue ground; couleur de roi, minime, and obscure amaranth, are thus obtained; galls are commonly added to the madder, and for the light shades, brazil-wood; for the deep shades, more or less browning is given, with a solution of sulphat of iron. These colours are rendered more beautiful by the addition of kermes, or more especially of cochineal.

By employing solution of indigo with madder, in the same way as with cochineal, we may, according to Mr. Poerner, obtain brown colours inclining the more to red, the less solution of indigo we employ; alum and tartar may serve for the preparation, but alum must not be put into the bath.

Mr. Poerner employs brazil-wood and solution of indigo, to obtain different colours, which incline more or less to blue and red, by a process similar to that pointed out for cochineal and madder. These are beautiful, but durability cannot be expected in colours obtained by such means. The substances which render them most fixed, are sulphat of lime, zinc, or acetat of copper, or crystallized verdegris, which must be added to the bath.

Logwood is also employed to make sloe, damascene, purple, and other shades. This wood, with the addition of galls, very easily communicates all these colours to wool previously dyed blue. When we wish to brown them, a little sulphat of iron is employed, and by this means we produce shades, which are much more difficultly obtained from durable ingredients, but they possess little stability: durable colours, which have been highly esteemed, have however been obtained from brazil and logwood. Bertholet, from whose art of dyeing the present article is extracted, was indebted to Mr. Decroizille, for the following particulars of the process employed, which he gives in the words of the author.

Mr. Giros de Gentilly is the first who succeeded in France, in obtaining a durable dye from logwood fixed by solution of tin. His first essays were made at Louviers, with Messrs. Petou, nephew, and Frigard, about twelve years ago. From what he had suffered to transpire respecting the substances which composed his mordant, I succeeded in imitating him tolerably well. I made a solution of tin in sulphuric acid, to which I then added muriat of soda, red acidulous tartrit of potash, and sulphat of copper. My success was so great, as to induce Mr. Giros to offer me a partnership in the very lucrative trade in this article, which he carried on at Louviers, Elboeuf, Abbeville, Sedan, and the Pays de Liege. Mr. Giros then taught me a much more convenient mode of forming this compound; it consists in making a solution of tin in a mixture of sulphuric acid, muriat of soda, and water; to this solution, the tartrit and sulphat are added, in the form of powder. Of this mordant we made no less than fifteen hundred quarts in twenty-four hours, in a single leaden vessel moderately heated. We carried on a very profitable trade in this article at the rate of thirty sols (fifteenpence English) per pound for three years, since which time it constantly declined, until we lost it altogether; the reason of which was this: Mr. Giros having suffered his secret to transpire, we had a number of imitators, who at first succeeded in a less degree, but afterward better than ourselves. In a compound consisting of so many ingredients as this, in an operation which is still so obscure as that whereby colours are fixed, it is almost impossible to arrive at perfection by any other means than random trials, which may be infinitely varied by the different proportions, and more especially by the modus agendi, and to a much greater extent, than chemists who had bestowed less time on this subject than I have done would suppose. I am therefore not ashamed to confess, that I was forced to abandon the business, while I saw, and still see, those who are no chemists deriving a very comfortable profit from it. What determined me to abandon it altogether was the invention of the new process for bleaching linen, to the improvement of which I have almost entirely devoted myself.

Having given you the history of the mordant for the prune de Monsieur, I shall mention the mode of employing it, and its effects.

If it be wool in the fleece which is to be dyed, one third of its weight of mordant is required; if it be a stuff, only one fifth is necessary. A bath is prepared of a degree of heat which the hand can bear, with which the mordant is well mixed, and the wool or stuff dipped into it and properly stirred; the same degree of heat being kept up for two hours, and even increased a little at last. It is then taken out, aired, and very well washed: a fresh bath of pure water at the same heat is prepared; a sufficient quantity of the decoction of logwood is added; the stuff immersed, stirred, and the fire increased to a boiling heat, which is continued for a quarter of an hour: the stuff being then taken out, aired, and carefully rinsed, the dyeing is finished. If the decoction of one pound of logwood have been employed for three pounds of wool, and a proportionate quantity for stuffs, which require less, a fine violet is produced, to which a sufficient quantity of brazil-wood gives the shade commonly known by the name of prune de Monsieur.

The colouring substances which are capable of being advantageously fixed on wool by this mordant, are those of logwood, brazil, and fustic. Yellow wood (morus tinctoria) also affords tolerable colours. The colour which is thus given by logwood and brazil is liable to be changed in the fulling, by means of the soap or the urine employed; and this change, which is always produced by alkaline substances, is remedied by a bath very slightly acid, and a little hot, called brightening, for which the sulphuric acid is preferred. The colour comes out as deep and oftener brighter than before the change. Wools dyed by means of this mordant admit of being spun into a more beautiful and finer thread, than when alum has been employed. By leaving out the sulphat of copper, more beautiful colours are obtained from fustic and yellow wood, as well as from weld. Madder gives an orange red colour, but less deep than with an equal quantity of alum; the omission of the sulphat of copper renders the wool much more harsh, and besides, the mordant thus prepared gives but indifferent colours with logwood, and more especially with brazil.

One of the great defects of this mordant, before it was improved, was, and frequently still is, to render the colours uneven; whenever they are uniform, they turn out always very beautiful, harmless, and soft. This process succeeds equally well on silk. By substituting acetat of lead for sulphat of copper, it succeeds tolerably well in cotton and thread previously galled. The employment and conveyance of this mordant are inconvenient, on account of the heavy sediment, which half fills the vessel, under a corrosive liquor, which can only be kept in stone-ware. I have, however, found a remedy for these inconveniences, by omitting the water in the receipt; by which means I have only a kind of paste, the use of which is more convenient, and the carriage two fifths cheaper. Now that common salt is cheap (in France), I may possibly return to the employment of furnishing our dyers with this mordant, of a better quality, in my opinion, than that with which they are supplied, and more especially at a much cheaper rate; but I must first devote some more time to the composition and employment of your lixivium.

Here ends the account of Mr. Decroizille.

The most common method of dyeing thread and cotton violet is first to give them a blue ground in the vat, proportionate to the shade we want, and to dry them; they are then galled, in the proportion of three ounces of galls to a pound: they are left for twelve or fifteen hours in this gall bath, after which they are wrung and dried again. The thread and cotton are then passed through a decoction of logwood, and when well soaked are taken out, and two drachms of alum, and one drachm of dissolved verdegris, for each pound of thread and cotton, are added to the bath; the skeins are then redipped on the skein sticks, and turned for a full quarter of an hour, when they are taken out to be aired; after which they are again completely immersed in the bath for a quarter of an hour, then taken out and wrung. Lastly, the vat which has been employed is emptied; half of the decoction of logwood which had been reserved is poured in, two drachms of alum are added, and the thread dipped afresh, until it is brought to the shade required. The decoction of logwood ought to be stronger or weaker according to the shade we want: this violet stands the action of the air tolerably well, but cannot be compared in durability to that obtained by means of madder; for which see that article.

In the production of violet by cochineal, it may be observed, that the woollen stuff has been disposed to take a crimson by the bath, which contains alum; but the tartar added to the dye bath brings the colour back to red; this is a general property of all acids.

For purple, the red is rendered a little more predominant, by increasing the quantity of the cochineal, and diminishing the intensity of the blue ground.

The shades bordering on these two colours should have a more distinct red, and the same proportion of tartar is preserved, though that of cochineal and the depth of the blue ground are diminished.

For silk, the tartar is omitted: it naturally acquires from cochineal a colour, to which it is only necessary to add a slight blue shade to produce purple; a deeper blue shade gives a violet colour; but to increase the fulness of the violet and give it brightness, archil must be employed.

When the solution of indigo in sulphuric acid is used, the sulphuric acid acts in different ways on the red substance employed; it produces little change in the colour of cochineal, already disposed to a crimson tinge by the aluming; but it would give a fawn colour to madder, upon which acids readily produce this effect: and it does not seem probable, that that substance could be employed with advantage in this process; it is better to employ it in dyeing stuff which has already received a blue ground. Brazil and logwood too seem ill adapted to produce fine colours with the sulphuric solution of indigo, because acids also change them yellow, though in a less distinct degree; but they retain their red colour, as already observed, when their colouring particles are precipitated by oxide of tin.

Berthollet offers the following explanation of the process of Mr. Decroizille, after expressing his diffidence to hazard an opinion unsupported by direct experiment, on so complicated a process:

The sea salt is decomposed by the sulphuric acid, and the muriatic acid thus set at liberty dissolves the tin; a part of the tin is precipitated by the acid of tartar, producing the sediment which has been noticed. The oxide of copper forms the blue with the colouring particles of the logwood; the oxide of tin produces violet with the same wood, and red with the colouring particles of the brazil-wood.

As the liquor retains an excess of acid, it might perhaps be useful to substitute crystals of verdegris to the sulphat of copper, because then the free acid would have less activity; perhaps it might be still better to employ mere verdegris, because that part of the oxide of copper, which is uncombined in it, would unite with the excess of acid, by which means less acid would remain in the liquor; perhaps the quantity of tartar should be diminished, because less of the tin would then be precipitated.

Mr. Haussman has lately found, that the colouring matter of alkanet, extracted by alcohol, gives a fine purple to cotton prepared as for the Adrianople red. See Madder. Its lustre is superior to that of satin, if no galls have been employed. It gives fine colours too on linen, and silk; but the silk must be alumed only, as with oxide of tin alkanet gives only a muddy tinge.

Pus. When any fleshy part of a living animal is wounded, if the divided surfaces do not unite together again on being kept in contact, they inflame, and a thick fluid is secreted, called pus, or matter. This seems to be essential to the formation of a new intermediate substance, by which a union is at length brought about, as well as to the healing of any denuded soft part, where new substance is required. It differs considerably when modified by various diseased actions, but of its several varieties little is at present known. Dr. Thomson has collected all the observations that have hitherto been made on it; the most important of which perhaps are those that serve to distinguish it from other fluids. All the information, however, that has been given respecting it, shall here be stated.

When pus indicates a healing sore, it is called *healthy*, or *good-conditioned*. In this state it possesses the following properties:

It is of a yellowish-white colour, and of the consistence of cream. Its taste is insipid, and it has no smell when cold. Before the microscope it exhibits the appearance of white globules swimming in a transparent fluid.

It produces no change on vegetable blues. When exposed to a moderate heat it gradually dries, and assumes the appearance of horn. When exposed to destructive distillation, Bergman obtained first about one fourth of the pus in the state of insipid water. On increasing the fire, a liquid came over, containing abundance of ammonia, and accompanied by gaseous substances which were not examined. Some concrete carbonat of ammonia sublimed, accompanied by empyreumatic oil. A light brilliant coal remained of difficult incineration. The ashes gave traces of iron.

When pus is left exposed to the air, it gradually becomes acid, according to Hildebrandt; and Haller affirms, that it sometimes gives a red colour to litmus, even when recent. When thrown into water it sinks to the bottom. When agitated the mixture becomes milky; but the pus separates again when allowed to remain undisturbed. However, by repeated agitation, and especially by the application of heat, a milky liquid is obtained, which passes in that state through the filter.

Alcohol thickens pus, but does not dissolve it; neither does pus unite with oils.

Sulphuric acid dissolves it, and forms a purple-coloured solution. When diluted with water, the dark colour disappears, and the pus separates; either sinking to the bottom, or rising to the surface, according to the quantity of water added, and the time that the solution has been allowed to stand. Diluted sulphuric acid does not act upon it.

Concentrated nitric acid effervesces with it, and forms a yellow solution, which when recent is decomposed by water, the pus subsiding in the state of gray flakes.

Muriatic acid also dissolves it when heated, and the pus is separated by water.

With the fixed alkaline lixiviums it forms a whitish ropy fluid, which is decomposed by water; the pus precipitating. Pure ammonia reduces it to a transparent jelly, and gradually dissolves a considerable portion of it.

When nitrat of silver is dropped into the solution of pus in water, a white precipitate separates. Nitrat and oxymuriat of mercury occasion a much more copious flaky precipitate.

Such are the properties of healthy pus hitherto observed by chemists. They indicate a considerable analogy with albumen. Various observations have been made to enable physicians to distinguish pus from the mucus of the internal cavities, especially of the lungs. In cases of copious expectoration, it is sometimes of consequence to know, whether the matter thrown out of the lungs be pus or mucus.

Mr. Charles Darwin made a set of experiments on the subject, and pointed out three criteria, which distinguish pus; 1. Sulphuric acid dissolves it. When the solution is diluted the pus precipitates; but mucus treated in the same manner swims. But this distinction depends upon the quantity of water added, and is therefore ambiguous. 2. Pus is diffusible through diluted sulphuric acid, through water, and through brine; but mucus is not. 3. Alkaline lixiviums dissolve pus; and water precipitates pus thus dissolved, but not mucus. How far the last two distinctions can be trusted, is rather doubtful.

Grassmeyer has proposed the following method, which he considers as complete. Triturate the substance to be tried with an equal quantity of warm water; then add to it an equal portion of a saturated solution of carbonat of potash, and set the mixture aside. If it contain pus, a transparent jelly subsides in a few hours; but this does not happen, if only mucus be present.

When the ulcer is ill-conditioned, the pus secreted in it possesses different properties. It has usually a fetid smell, is much thinner, and to a certain degree acrid. We are in possession of two sets of experiments on this unhealthy pus: one of Mr. Cruickshanks on the pus discharged from what is called the *hospital sore;* another by Dr. Crawford on the matter of *cancers.*

The pus from the hospital sore possesses most of the properties of healthy pus; but is distinguished by its smell, and by some shades of difference when exposed to the action of the metallic precipitates. Lime-water changes its fetid odour, but does not destroy it; sulphuric acid increases it, as do alcohol and the solution of oxide of arsenic in pot-ash. Bark has no effect upon it; but it is destroyed by the nitrat and oxymuriat of mercury, by nitric acid, and by oxygenized muriatic acid. Nitrat of silver does not destroy it.

Mr. Cruickshanks supposes, that the fetid smell is occasioned by the alteration of some part of the true pus. He considers the pus of the hospital sore as a matter *sui generis*, which is capable of generating more, and even of producing an alteration in the system. Hence, to heal the sore, the matter must be destroyed, and prevented from appearing again. This was done by washing the sores with nitrat of mercury, diluted nitric acid, and oxigenized muriatic acid, at every dressing. This method constantly succeeded with Dr. Rollo, except when the sore was too large to admit it to be put in practice completely.

The matter of cancer, examined by Dr. Crawford, gave a green colour to sirup of violets. Potash produced no change, but sulphuric acid extricated a gas, which possessed many of the properties of sulphuretted hydrogen. This gas he supposed to exist in the matter united to ammonia. The presence of this compound explains the effects of the matter of cancer, and virulent matter in general, upon metallic salts. Dr. Crawford found, that the smell of this matter was completely destroyed by oxigenized muriatic acid; and therefore recommends it as a proper substance for washing cancerous ulcers.

Beside the species mentioned above, there are many others, which we know from their effects to be peculiar, though we cannot find any chemical distinctions between them sufficiently well marked. But that they are specifically different cannot be doubted, if we consider, that every one of them produces a disease peculiar to itself. The matter of small pox, of venereal ulcers, of cowpox, &c. may be mentioned as instances.—*Thomson.*

Putrefaction. Every living body, when once deprived of life, performs a retrograde process, and becomes decomposed. This decomposition is called fermentation in vegetables, and putrefaction in animal substances. The same causes, the same agents, and the same circumstances, determine and favour the decomposition of vegetables and animals, and the difference of the productions which are obtained arises from the difference of the constituent parts of each.

Air is the principal agent of animal decomposition, but water and heat prodigiously facilitate its action. "Fermentatio ergo definitur quod sit corporis densioris rarefactio, particularumque aërearum interpositio: ex quo concluditur debere in aëre fieri nec nimium frigido, ne rarefactio impediatur; nec nimium calido, ne partes raribiles expellantur." Becher, Phys. Sub. lib. i. s. 5, p. 313, edit. Francofurti.

An animal substance may be preserved from putrefaction by depriving it of the contact of the air; and this process may be accelerated or retarded by varying or modifying the purity of the same fluid.

In those circumstances wherein we see putrefaction developed without the contact of atmospherical air, the effect is produced by the water, which impregnates the animal substance, becomes decomposed, and affords the element and the agent of putrefaction. Hence no doubt it arises, that putrefaction is observed in flesh inclosed in a vacuum. See Lyons, Tentamen de Putrefactione.

Moisture is likewise an indispensable requisite to facilitate putrefaction; and any substance may be defended from this change by completely drying it. This was performed by Villaris and Cazalet of Bourdeaux, by means of stoves. Meat thus prepared was preserved for several years, without having contracted any bad flavour. Sands and light porous earths preserve the bodies of men only by virtue of the property of exhausting their juices, and drying the solids. From this cause it is, that entire caravans have been discovered in Arabia, consisting of men and camels perfectly preserved in the sands, under which the impetuous winds have buried them. In the library of Trinity College Cambridge, in England, a human body may be seen perfectly preserved, which was found under the sand in the island of Teneriffe.

Too much humidity impedes putrefaction, according to the observation of the celebrated Becher: "Nimia quoque humiditas a putrefactione impedit, prout nimius calor; nam corpora in aqua potius gradatim consumi quam putrescere, si nova semper affluens sit, experientia docet: unde longo tempore integra interdum submersa prorsus a putrefactione immunia vidimus; adeo ut nobis aliquando speculatio occurreret, tractando tali modo cadavera anatomiæ subjicienda, quo diutius a fœtore et putrefactione immunia forent." Phys. Sub. lib. i. s. 5, cap. 1, p. 277.

In order, therefore, that a body may putrefy, it is necessary that it should be impregnated with water, but not that it should be inundated. It is likewise necessary, that this water should remain in the texture of the animal body, without being renewed. This condition is requisite, 1st, To dissolve the lymph, and to present to the air the most putrescible substance with the greatest extent of surface. 2d, In order that the water may itself become decomposed, and by this means afford the putrefactive principle. Putrefaction is retarded and suspended by baking, because the flesh is dried, and by this means deprived of the humidity, which is one of the most active principles of its decomposition.

A moderate degree of heat is likewise a condition favourable to the animal decomposition. By this heat the affinity of aggregation between the parts is weakened, and consequently they assume a stronger tendency to new combinations. Hence it arises, that flesh meat keeps longer during the winter than the summer, and better in cold than in hot countries.

Becher has given a very intelligent sketch of the influence of temperature on animal putrefaction: "Aër calidus et humidus maximè ad putrefactionem facit . . . . . . corpora frigida et sicca difficulter, imo aliqua prorsus non putrescunt; quæ ab imperitis proinde pro sanctis habita fuere. Ita aer frigidus et siccus, imprimis calidus et siccus, a putrefactione quoque præservat; quod in Hispania videmus, et locis aliis calidis, siccocalido aëre præditis, ubi corpora non putrescunt et resolvantur; nam cadavera in oriente in arena, imo apud nos arte in furnis, siccari et sic ad finem mundi usque a putredine præservari, certum est: intensum quoque frigus a putredine præservare; unde corpora Stockholmiæ tota hyeme in patibulo suspensa sine putredine animadvertimus." Phys. Sub. l. i. cap. 1.

Such are the causes, which are capable of determining and favouring putrefaction; and hence we may perceive the best means of preventing, increasing, or modifying it at pleasure. A body will be preserved from putrefaction by depriving it of the contact of atmospherical air: for this purpose nothing more is required, than to place the body in a vacuum, or to envelop it in a covering, which may defend it from the immediate action of the air; or else to envelop it in an atmosphere of some gaseous substance which does not contain oxigen. We shall observe, on this subject, that the effects observed in flesh exposed in carbonic acid gas, nitric oxide, &c., are referable to a similar cause; and it is without sufficient reason, that a conclusion has been drawn, that these same gasses, internally taken, ought to be considered as antiseptic; because, in the cases we have mentioned, they act only by defending the bodies they surround from the contact of oxigen, which is the principle of putrefaction.

Putrefaction may be favoured by keeping bodies at a suitable temperature. A degree of heat from sixty-five to ninety degrees diminishes the adhesion of the parts, and favours the action of the air: but if the heat be greater, it volatilizes the aqueous principle, dries the solids, and retards the putrefaction.

It is necessary therefore, for the decomposition of an animal—1st, That it have the contact of atmospheric air; and the purer this air is, the more speedy will be the putrefaction. 2d, That it be exposed to a moderate degree of heat. 3d, That its texture be impregnated with humidity.

The experiments of Pringle, Macbride,

and Gardane have likewise shown us, that putrefaction may be hastened by sprinkling the animal substances with water containing a small quantity of salt; and it is to a like cause that we ought to refer several processes used in kitchens to produce this effect in food, as well as in the preparation of cheese, the curing of tobacco, the making of bread, &c.

Becher expresses himself as follows on the causes which produce putrefaction in living bodies:—"Causa putrefactionis primaria defectus spiritus vitalis balsamini est; secundaria, deinde, aër externus et ambiens, qui interdum adeo putrefaciens et humidus-calidus est, ut superstitem in vivis etiam corporibus balsaminum spiritum vincat, nisi confortando augeatur; ex quo colligi potest, preservantia a putredine subtilia ignea oleosa esse debere."—This celebrated chemist concludes, from the same principles, that ligatures, copious bleedings, or any debilitation whatever, determine putrefaction. He likewise thinks, that astringents oppose putrefaction only by condensing the texture of the animal parts; for he considers rarefaction or relaxation as the first effect of putrefaction. He thinks, that spirituous liquors act as anti-putrescent merely by animating and stimulating the vis vitæ. He affirms, that the use of salted meats, which heat much, assisted by the moisture very common in ships and sea-ports, produces the scurvy; and he observes, with reason, that the tendency and effect of putrefaction are diametrically opposite to those of generation: "nam sicut in generatione partes coagulantur, et in corpus formantur; ita in putrefactione partes resolvuntur, et quasi informes fiunt."

As the phænomena of putrefaction vary according to the nature of the substances themselves, and the circumstances which accompany this operation, it follows, that it must be very difficult to describe all the phænomena which it exhibits. We shall therefore endeavour to trace only those which appear to be most constant.

Every animal substance exposed to the air at a temperature above 54° of Fahr., and moistened with its own serous humour, putrefies; and the progress of this alteration appears in the following order:

The colour first becomes pale; its consistence diminishes; its texture becomes relaxed; the peculiar smell of fresh meat disappears, and is succeeded by a faint and disagreeable smell. The colour itself at this time inclines to blue; as we see in game which begins to turn, in wounds which fall into suppuration, in the various parts threatened with gangrene, and even in that putrefaction of the curd which forms cheese. Most of our food suffers the first degree of putrefaction before we use it.

After this first period the animal parts become more and more softened, the smell becomes fetid, and the colour of an obscure brown; the fibrous part easily breaks; the texture becomes dry, if the putrefaction be carried on in the open air; but the surface becomes covered with small drops of fluid, if the decomposition be made in vessels which oppose its evaporation.

To this period succeeds that which most minutely characterizes animal putrefaction. The putrid and nauseous smell, which was manifested in the second degree, becomes mixed with a smell of a more penetrating kind, arising from the disengagement of ammoniacal gas: the mass becomes still less and less consistent.

The last degree of decomposition has its peculiar characters. The smell becomes faint, nauseous, and exceedingly active. This, more especially, is contagious, and transmits the seeds of infection to a great distance: it is a true ferment, which deposits itself upon certain bodies, to appear again at long intervals. Van Swieten reports, that the plague, having appeared at Vienna in 1677, and having again appeared in 1713, the houses which had been infected at its first appearance were likewise infected at the second. Van Helmont asserts, that a woman contracted an anthrax at the extremity of her fingers, in consequence of having touched papers impregnated with pestilential virus. Alexander Benedictus has written, that pillows reproduced the contagion seven years after having been infected; that cords had remained infected for thirty years, and likewise communicated it, according to Faustus. The plague at Messina was for a long time concentrated in the warehouses, where merchandize was inclosed with the suspected bales. Mead has transmitted the most alarming facts concerning the durable impression of contagion.

When the putrefying substance is in its last stage, the fibrous texture is scarcely discernible, and has no longer any appearance but that of a soft, disorganized and putrid mass. Bubbles are seen to escape from the surface of this matter; and the whole ends by its drying, and becoming reduced to an earthy matter, which is friable when taken between the fingers.

We do not speak of the production of worms; because it appears to be proved that they owe their origin only to the flies, which endeavour to deposit their eggs upon such bodies as are best suited to support the young they contain. If flesh meat be well washed, and left to putrefy under a sieve, it will pass through all the degrees of putrefaction without the appearance of worms. It has been observed, that worms are of a different species, according to the nature of the disease, and the kind of animal which putrefies. The exhalation, which arises from bodies in these different cases, attracts different species of insects, according to its nature. The opinion of those who believe in spontaneous generation appears to be contrary to the experience and wisdom of nature, which cannot have committed the reproduction and number of the species to chance. The progress of nature is the same for all the classes of individuals; and since it is proved, that all the known species are reproduced in one and the same manner, how can we suppose, that nature departs from her plain and general laws for the small number of individuals, the generation of which is less known to us?

Becher had the courage to make observations, during the course of a year, upon the decomposition of a carcase in the open air; and to observe all the phænomena. The first vapour which rises, says he, is subtile and nauseous: some days after it has a certain sour and penetrating smell. After the first weeks, the skin becomes covered with a down, and appears yellowish; greenish spots are formed in various places, which afterwards become livid and black; a thick mossy or mouldy substance then covers the greater part of the body; the spots open, and emit a sanies.

Carcases buried in the earth present very different phænomena; the decomposition in a burying-ground is at least four times as slow. It is not perfectly ended, according to Mr. Petit, till three years after the body has been interred, at the depth of four feet; and it is slower in proportion as the body is buried at a greater depth. These facts agree with the principles which we have already established: for bodies buried in the earth are subjected to laws of decomposition very different from those which take place in bodies exposed to the open air. In this case the decomposition is favoured by the waters, which filter through the earth, and dissolve and carry with them the animal juices. It is also favoured by the earth, which absorbs the juices with more or less facility. Messrs. Lemery, Geoffroy, and Hunaud have proved, that argillaceous earths exert a very slow action upon bodies; but when the earths are porous and light, the bodies then dry very speedily. The several principles of bodies absorbed by the earth, or carried by the vapours, are dispersed through a great space, imbibed by the roots of vegetables, and gradually decomposed. This is what passes in burying-grounds in the open air; but it is very far from being applicable to the sepulchres which are made in churches and covered places. Here is neither water nor vegetation; and consequently no cause which can carry away, dissolve, or change the nature of the animal fluids: and it is an instance of wisdom in the French government, that has prohibited the burying in churches; a practice which was once a subject of horrour and infection.

The accidents which have happened at the opening of graves and vaults are but too numerous, to render any apology necessary for our speaking a few words respecting the method of preventing them.

The decomposition of a body in the bowels of the earth can never be dangerous, provided it be buried at a sufficient depth, and that the grave be not opened before its entire and complete decomposition. The depth of the grave ought to be such, that the external air cannot penetrate it; that the juices with which the earth is impregnated may not be conveyed to its surface; and that the exhalations, vapours, or gases, which are developed or formed by decomposition, should not be capable, of forcing the earthy covering which detains them. The nature of the earth in which the grave is dug influences all its effects. If the stratum which covers the body be argillaceous, the depth of the grave may be less, as this earth difficultly affords a passage to gas and vapour; but in general it is admitted to be necessary, that bodies should be buried at the depth of five feet, to prevent all these unhappy accidents. It is likewise necessary to attend to the circumstance, that a grave ought not to be opened before the complete decomposition of the body. This decomposition, according to Mr. Petit, is not perfect until the expiration of three years, in graves of four feet depth; or four years when they are six feet deep. This term affords many varieties, according to the nature of the earth, and the constitution of the subjects buried in it; but we may consider it as a medium. The pernicious custom, which allows a single grave to families more or less numerous, ought, therefore, to be suppressed; for in this case the same grave may be opened before the time prescribed. These are abuses, which ought to occupy the attention of government; and it is time that the vanity of individuals should be sacrificed to the public safety. It is likewise necessary, to prohibit burying in vaults, and even in coffins. In the first case, the principles of the bodies are spread into the air, and infect it; in the second their decomposition is slower and less perfect.

If these precautions be neglected; if the dead bodies be heaped together in too confined a space; if the earth be not proper to absorb the juices, and decompose them; if the grave be opened before the entire decomposition of the body—unhappy accidents will, no doubt, be produced; and these accidents are but too common in great towns, where every wise precaution is neglected. An instance of this happened when the ground of the church of St. Bennet at Paris was dug up a few years ago; a nauseous vapour was emitted, and several of the neighbours were affected by it. The earth which was taken out of this grave was unctuous, viscid, and emitted a noisome smell. Messrs. Maret and Navier have left us similar observations.

Boyle relates, that he has preserved lemons, oranges, and other fruits from putrefaction, or other fermentation, during several years, by including them in an exhausted receiver. Doctor Macbride found, that putrefaction was accelerated by enclosing a piece of flesh in an exhausted receiver; but that another piece continued sweet, which was included in an exhausted hollow brass sphere, consisting of two hemispheres joined together. He conjectures, that the cause of this difference might be, that in the latter experiment the vacuum was more perfect than in the former, as the glass receiver did not seem to exclude with sufficient accuracy the external air; and though a partial vacuum may accelerate putrefaction, yet some air may be necessary to this process.

It is well known, that bodies are preserved from putrefaction by covering them with wax, suet, &c. Whether is this effect produced merely by excluding external air, or by preventing the extrication of gas, or both?

Sir John Pringle made experiments, to determine the powers of certain substances to promote or prevent putrefaction. From these experiments he formed the following table, showing the relative antiseptic powers of the saline substances mentioned Having found, that two drachms of beef put into a phial with two ounces of water, and placed in a heat equal to ninety degrees of Fahrenheit's thermometer became putrid in fourteen hours, and that sixty grains of sea-salt preserved a similar mixture of beef and water more than thirty hours, he made the antiseptic power of the sea-salt a standard, to which he compared the powers of the other salts. The algebraic character + signifies, that the substance to which it is annexed had a greater antiseptic power than is expressed by the numbers.

Sea-salt, or the standard	1
Sal gem, or rock salt	1 +
Sulphat of potash	2
Spiritus Mindereri, or distilled vinegar saturated with ammonia	2
Neutral tartrit of potash	2
Muriat of potash	2 +
Crude sal ammoniac	3
Saline mixture	3
Nitre	4 +
Salt of hartshorn	4 +
Salt of wormwood	4 +
Borax	12
Salt of amber	20
Alum	30

N. B. The quantities of spiritus Mindereri and of the saline mixture were such, that each of them contained as much alkaline salt as the other neutral salts.

Myrrh, aloes, assafetida, and terra Japonica, were found to have an antiseptic power thirty times greater than the standard. Gum ammoniacum and sagapenum showed little antiseptic power.

Of all resinous substances camphor was found to resist putrefaction most powerfully. Sir John Pringle believes, that its antiseptic power is 300 times greater than that of sea-salt.

Camomile flowers, Virginian snake-root, pepper, ginger, saffron, contrayerva root, and galls were found to be twelve times more antiseptic than sea-salt.

Infusions of large quantities of mint, angelica, ground ivy, green tea, red roses, common wormwood, mustard, and horseradish, and also decoctions of poppy-heads, were more antiseptic than sea-salt.

Decoctions of wheat, barley, and other farinaceous grains, checked the putrefaction by becoming sour.

Chalk, and other absorbent powders, accelerated the putrefaction, and resolved meat into a perfect mucus. The same powders prevented an infusion of farinaceous grains from becoming mucilaginous and sour.

One drachm of sea-salt was found to preserve two drachms of fresh beef in two ounces of water, above thirty hours uncorrupted in a heat equal to that of the human body, or above twenty hours longer than meat is preserved in water without salt: but half a drachm of salt did not preserve it more than two hours longer than pure water. Twenty-five grains of salt had little or no antiseptic quality. Twenty grains, fifteen grains, but especially ten grains only of sea-salt were found to accelerate and heighten the putrefaction of two drachms of flesh. These small quantities of sea-salt did also soften the flesh more than pure water.

The same learned and ingenious physician made experiments, to discover the effects of mixing vegetable with animal matters.

Two drachms of raw beef, as much bread, and an ounce of water, being beaten to the consistence of pap, and exposed to ninety degrees of heat, according to Fahrenheit's thermometer, began to ferment in a few hours, and continued in a fermentation during two days. When it began to ferment and swell, the putrefaction had begun; and in a few hours afterward the smell was offensive. Next day the putrid smell ceased, and an acid taste and smell succeeded. Fresh alimentary vegetables, as spinach, asparagus, scurvy-grass, produced similar effects as bread on flesh, but in a weaker degree. From several other experiments he found, that animal substances excite the fermentation of vegetable substances, and that the latter substances correct the putrescency of the former.

By adding saliva to a similar mixture of flesh, bread, and water, the fermentation was retarded, moderated, but rendered of twice the usual duration, and the acid produced at last was weaker than when no saliva was used.

By adding an oily substance to the common mixture of flesh, bread, and water, a stronger fermentation was produced, which could not be moderated by the quantity of saliva used in the former experiment, till some fixed alkaline salt was added; which salt was found, without saliva, to stop suddenly very high fermentations.

He did not find, that small quantities of the following salts, sal ammoniac, nitre, sulphat of potash, muriat of potash, salt of hartshorn, salt of wormwood, were septic, as small quantities of sea-salt were.

Sugar was found to resist putrefaction at first, as other salts do; and also to check the putrefaction after it had begun, by its own fermentative quality, like bread, and other fermentative vegetables.

Lime-water made some small resistance to putrefaction.

Port wine, small beer, infusions of bitter vegetables, of bark, and the juice of antiscorbutic plants, retarded the fermentation of mixtures of flesh and bread. But an unstrained decoction of bark considerably increased that fermentation.

Crabs eyes accelerated and increased the fermentation of a mixture of flesh and bread.

Lime-water neither retarded nor hastened the fermentation of such a mixture: but when the fermentation ceased, the liquor was neither putrid nor acid, but smelled agreeably.

Flesh pounded in a mortar was found to ferment sooner than that which had not been bruised.

The tough inflammatory crust of blood was found to be most putrescent, next to which the crassamentum, or red coagulated mass, and lastly the serum.

Dr. Macbride's experiments confirm many of these above related, especially those which show, that the fermentation of vegetable substances is increased by a mixture of animal or putrescent matter; that the putrescency of the latter is corrected by the fermentative quality of the former; and that the putrefaction and fermentation of mixtures of animal and vegetable substances were accelerated by additions of absorbent earths, and of Peruvian bark. He also found, that, although unburnt calcareous earths were septic, quick-lime and lime-water prevented putrefaction, but that they destroyed or dissolved the texture of flesh.

The experiments of the author of the Essai pour servir à l'Histoire de la Putrefaction show, that metallic salts, resinous powders, extracts of bark, and opium, are very powerfully antiseptic, and that salts with earthy bases are less antiseptic than any other salts. Dr. Valli has found twelve or fifteen grains of nitrat of mercury preserve a pint of soup for four months, without any loss of weight, or alteration of colour, in the nitrat. And Van Mons says, that a few grains of oxide or citrat of mercury will preserve broth sweet for years.

Putty. The oxide of tin, known by the name of putty, is generally used to polish various hard bodies, as glass, metallic specula for reflecting telescopes, &c. When fused with lead and sand it produces enamel; and serves also to cover earthen-ware, giving to it a glassy and neat surface for use.

Glazier's putty is made by kneading powdered chalk or whiting, with common linseed oil, so as to form a stiff paste.

Puzzolana. This is a volcanic production of a gray, brown, yellowish, or blackish colour, loose, granular, or dusty and rough, porous and spongy, resembling a clay hardened in fire, and then reduced to a gross powder. It contains, mixed with it, various heterogeneous substances: its specific gravity is from 2·5 to 2·8, and it is in some degree magnetic: it scarcely effervesces with acids, though partially soluble in them: it melts easily per se: but its most distinguishing property is, that it hardens very suddenly when mixed with ⅓d of its weight of lime and water, and forms a cement, which is more durable in water than any other. According to Bergman's analysis, one hundred parts of it contain from 55 to 60 of siliceous earth, 19 or 20 of argillaceous, 5 or 6 of calcareous, and from 15 to 20 of iron. It is evidently a martial argillaceous marl that has suffered a moderate heat. Its hardening power arises from the dry state of the half-baked argillaceous particles, which makes them imbibe water very rapidly, and thus accelerates the desiccation of the calcareous part; and also from the quantity and state of the iron contained in it. It is found not only in Italy, but also in France, in the provinces of Auvergne and Limoges, and also in England, and elsewhere.

Not only the volcanic puzzolana, but the poor siliceous iron-stones are capable of forming a very hard cement, that will set in water. They should be calcined so as to be of a deep brown for this use; if more slightly torrefied, they make a very hard cement in the open air.

Pycnite. This, the schoerlite of Klaproth, white schoerl of Altenberg of Romé de Lisle, schoerl-like beryl of Brochant, leucolithe of Delamétherie, has hitherto been found only in the form of long canulated prisms, united in parallel bundles. These have the appearance of some colourless beryls, and originate like them from a regular hexaëdron, but are disfigured by longitudinal furrows.

In point of hardness the pycnite a little exceeds quartz; its powder feels rough to the touch; and its crystals are easily broken perpendicularly to their axis. Its specific gravity is 3·51. This and its hardness are the only physical characters that distinguish it from the beryl; but in its chemical composition it differs from it more widely. According to Vauquelin's analysis it consists of

Alumine	-	0·60
Silex	- -	0·30
Fluoric acid	-	0·06
Lime	- -	0·02
Water	-	0·01
		0·99

leaving a loss of ·01.

Bucholz makes the proportion of fluoric acid amount to 17 per cent.

Its colour varies from a yellowish white to a reddish white.

The pycnite has not yet occurred in separate or well-formed crystals. It enters into the composition of a rock formed of quartz and dark gray mica, at Altenberg in Saxony; and is said to have been found on the mountain Rabenstein, near Swisel, in Bavaria; but it is not quite certain, that the last-mentioned substance is really pycnite. —*Annales de Chimie.—Brongniart.*

Pyritaceous Limestone. This stone is called by the French Pierre de St. Ambroix. It is of an iron-gray colour, interspersed with shining particles. Its texture is compact, and scarcely gives fire with steel. Its specific gravity is 2·7034.

It is soluble in acids, and mostly with effervescence: oxides in a strong fire, make nitre slightly detonate: and if distilled, affords a small portion of sulphuric acid, and some sulphur sublimes.

Its component parts are 75 of mild calcareous earth, and 25 of pyrites, in which are contained 14 of argil, 7 of quartz and sulphur, and 4 of iron.

Pyrites. Certain metallic combinations, which contain a very large proportion of sulphur, are known by this name. They are not indeed entitled to any particular class distinct from ores; yet their abundance and other properties are sufficient to justify the insertion of a separate article.

Although sometimes pyrites contains more metal than some ores, yet generally it contains less metal, and a larger quantity of mineralizing substances, sulphur and arsenic, and particularly of unmetallic earth. The connexion of these matters is also much stronger in pyrites than in ores, and they are accordingly much harder; so that almost every pyrites can strike sparks from steel. From this property of striking sparks from steel they have been called pyrites, which is a Greek word signifying fire-stone. Pyrites was formerly used for fire-arms, as we now use flints; hence it was called carbine stone. It is still named by some, marcasite. Perhaps no other kind of natural body has received so many names. Persons curious to know the other names less used than those we have mentioned, may find them in Henckel's Pyritologia. We think, with that celebrated chemist, that the subject has been perplexed by this multiplicity of names; for before his great and excellent work, the notions concerning pyrites were very confused and inaccurate.

Pyrites differs also from ores by its forms and positions in the earth. Although pyritous minerals generally precede, accompany, and follow veins of ores; they do not, properly speaking, themselves form the oblong and continued masses called veins, as ores do, but they form masses sometimes greater and sometimes smaller, but are always distinct from each other. Large quantities of them are often found unaccompanied by ores. They are formed in clays, chalks, marls, marbles, plasters alabasters, slates, spars, quartz, granites, crystals; in a word, in all earths and stones. Many of them are also found in pit-coals, and in other bituminous matters.

Pyrites is also distinguishable from ores by its lustre and figure, which is almost always regular and uniform, externally or internally, or both. Some ores, indeed, like those of lead, many ores of silver, and some others, have regular forms, and are in some manner crystallized; but this regularity of form is not so universal, and so conspicuous in ores as in pyrites. The lustre of pyrites seems to be caused by its hardness, and the regularity of its form by the quantity of mineralizing substances which it contains.

By all these marks we may easily, and without analysis, distinguish pyrites from true ores. When we see a mineral that is heavy, possessed of metallic lustre, and of any regular form, the mass of which appears evidently to be entire, that is, not to have been a fragment of another mass, and which is so hard as to be capable of striking sparks from steel, we may be assured, that such a mineral is a pyrites, and not an ore.

The class of pyrites is very numerous, various, and extensive. They differ one from another in the nature and proportions of their component parts, in their forms, and in their colours. The forms of these minerals are exceedingly various. No solid regular or irregular can easily be conceived, that is not perfectly imitated by some kind of pyrites. They are spherical, oval, cylindrical, pyramidal, prismatical, cubic; they are solids with 5, 6, 7, 8, 9, 10, and more sides. The surface of some is angular, and consists of many bases of small pyramids, while their substance is composed of these pyramids, the points of which all unite in the centre of the mass.

Pyritous minerals differ also in their component substances. Some of them are called sulphureous, martial, cupreous, arsenical, as one or other of these substances predominates. We must observe with Henckel, whose authority is very great on this subject, that in general all pyrites are martial, as ferruginous earth is the essential and fundamental part of every pyrites. This earth is united with an unmetallic earth, with sulphur or arsenic, or with both these matters; in which case the sulphur always predominates over the arsenic, as Henckel observes. He considers these as the only essential principles of pyrites, and believes, that all the other matters, metallic or unmetallic, which are found in it, are only accidental; among which he even includes copper, although so much of it exists in some kinds of pyrites, that these are treated as ores of copper, and sometimes contain even 50 lbs. of copper each quintal. Many other metals, even gold and silver, are sometimes combined in pyrites; but these are less frequent, and the precious metals always in very small quantities; they are therefore justly to be considered as accidental to pyrites. The different substances composing pyrites sensibly affect its colours. Henckel distinguishes them in general into three colours, white, yellowish or a pale yellow, and yellow. He informs us, that these three colours are often so blended one with another that they cannot be easily distinguished, unless compared together.

The white pyrites contain most arsenic, and are similar to cobalt and other minerals abounding in arsenic. The Germans call them mispickel, or mispilt. Iron and arsenic form the greatest part of this pyrites. As arsenic has the property of whitening copper, some pyritous minerals almost white, like that of Chemnitz in Misnia, are found to contain forty pounds of copper per quintal, and are so much whitened by the arsenic, that they are very like white pyrites. But Henckel observes, that these pyritous matters are very rare, and are never so white as the true white pyrites, which is only ferruginous and arsenical.

Yellowish pyrites is chiefly composed of sulphur and iron. Very little copper and arsenic are mixed with any pyrites of this colour, and most of them contain none of these two metallic substances. This is the most common kind of pyrites: it is to be found almost everywhere. Its forms are chiefly round, spherical, oval, flattened, cylindrical; and it is composed internally of needles or radii, which unite in the centre or in the axis of the solid.

Yellow pyrites receives its colour from the copper and sulphur which enter into its composition. Its colour, however, is inclined to a green, but is sufficiently yellow to distinguish it from the other two kinds of pyrites, particularly when they are compared together. To make this comparison well, the pyrites must be broken, and the internal surfaces must be placed near each other. The reason of this precaution is, that the colour of minerals is altered by exposure to the air.

Persons accustomed to these minerals can easily distinguish them. The chief difficulty is to distinguish white pyrites from cobalt and other minerals, which also contain some copper, and much arsenic.

Hence then we see, that arsenic is the cause of whiteness in pyrites, and is contained in every pyrites of that colour; that copper is the principal cause of the yellow colour of pyrites, and that every pyrites which is evidently yellow contains copper; that sulphur and iron produce a pale yellow colour, which is also produced by copper and arsenic; hence some difficulty may arise in distinguishing pyrites from its colours. We may also observe that sulphur and arsenic, without any other substance, form a yellow compound, as we see from the example of orpiment or yellow arsenic. Thus, although the colours of the pyrites enable us to distinguish its different kinds, and to know their nature at first sight, particularly when we have been accustomed to observe them; yet we cannot be entirely certain concerning the true nature of these minerals, and even of all minerals in general, that is, to know precisely the kinds and proportions of their component substances, but by chemical analysis and decomposition.

Beside the above-mentioned matters which compose pyrites, it also contains a considerable quantity of unmetallic earth, that is, an earth which cannot by any process be reduced to metal. Henckel, Cramer, and all those who have examined this matter, mention this earth, and prove its existence.

We ought to observe, that this earth is combined with the other principles of the pyrites, and not merely interposed between its parts. It must therefore be distinguished from other earthy and stony matters mixed accidentally with pyrites, and which do not make a part of the pyrites, since they may be separated by mechanical means, and without decomposing that mineral: but the earth of which we now treat is intimately united with the other constituent parts of the pyrites, is even a constituent part of pyrites, and essential to the existence of this mineral, and cannot be separated but by a total decomposition of it.

According to Henckel, this unmetallic earth abounds much in the white pyrites, since he found from the analysis which he made, that the iron, which is the only metal existing in these pyrites, is only about $\frac{1}{2}$th part of the fixed substance, that remains after the arsenic has been expelled by torrefaction or sublimation.

A much larger quantity of iron is in the pale yellow pyrites, according to Henckel. The proportion of iron is generally about twelve pounds to a quintal of pyrites, and sometimes fifty or sixty pounds: this is therefore called martial pyrites. It contains about $\frac{1}{4}$th of its weight of sulphur, and the rest is unmetallic earth.

The quantity of unmetallic earth contained in the yellow or cupreous pyrites, which are also martial, since, as we have observed, iron is an essential part of every pyrites, has not yet been determined. They probably contain some of that earth, though perhaps less of it than the others.

The nature of this unmetallic earth of pyrites has not been well examined. Henckel thinks, that it is an earth disposed already by nature to metallization, but not sufficiently elaborated to be considered as a metallic earth. See the articles METALS and METALLIZATION. This opinion is not improbable; but as alum may be obtained from many pyrites, may we not suspect, that this unmetallic earth is of the nature of alumine? See ALUM and EARTHS, ALU-

MINE. Perhaps also this earth is different in different kinds of pyrites. The subject deserves to be well examined.

Although pyrites is not so valuable as true ores, because in general it contains less metal, and but exceedingly little of the precious metals; and because its metallic contents are so difficult to be extracted, that, excepting cupreous pyrites, which is called pyritous copper ore, it is not worked for the sake of the contained metal; yet it is applied to other purposes, and furnishes us with many useful substances; for from it we obtain all our green and blue vitriols, much sulphur, arsenic, alum, and orpiment. See the principal processes by which these substances are extracted from pyrites, under ORES, and the respective articles.

As every pyrites contains iron, and most of them contain also sulphur; as the pyrites most frequently found contains only these two substances with the unmetallic earth; and as iron and sulphur have a singular action upon each other, when they are well mixed together and moistened; hence many kinds of pyrites, particularly those which contain only the principles now mentioned, sustain a singular alteration, and even a total decomposition, when exposed during a certain time to the combined action of air and water. The moisture gradually penetrates them, divides, and attenuates their parts; and the sulphur is acidified, attacks the martial earth, and also the unmetallic earth, and forms with the fixed principles of the pyrites different salts; so that a pyrites, which was once a shining, compact, very hard mineral, becomes in a certain time a grayish, saline, powdery mass, the taste of which is saline, austere, and stiptic.

Lastly, if this mass be lixiviated with water, crystals of sulphat of iron, and sometimes of alum, according to the nature of the pyrites employed, may be obtained by evaporation and crystallization.

This alteration and spontaneous decomposition of pyrites is called efflorescence and vitriolization; because the pyrites becomes covered with a saline powder, and because vitriol is always formed. This vitriolization is more or less quickly accomplished in pyrites according to its nature. It is a kind of fermentation excited by moisture amongst the constituent parts of these minerals; and it is so violent in those which are most disposed to it, that is, in the pale-yellow pyrites, which contain chiefly sulphur and iron, that when the quantity of these is considerable, not only a sulphureous vapour and heat may be perceived, but also the whole kindles and burns intensely. The same phænomena are observable, and the same results are formed, by mixing well together and moistening a large quantity of filings of iron and powdered sulphur; which experiment Lemeri has made, to explain the causes of subterranean fires and volcanoes.

We cannot doubt, that, as the earth contains very large masses of pyrites of this kind, they must undergo the same changes when air and moisture penetrate the cavities containing them; and the best natural philosophers agree, that very probably this surprising decomposition of pyrites is the cause of subterranean fires, of volcanoes, and of mineral waters, sulphuric, aluminous, sulphureous, hot and cold.

No other pyrites is subject to this spontaneous decomposition, when exposed to humid air, but that which is both martial and sulphureous, that is the pale-yellow pyrites. The arsenical pyrites, or that which contains little or no sulphur, is not changed by exposure to air. This latter kind is harder, heavier, and more compact than the former. The pyrites which is angular and regularly shaped, is chiefly of this kind. Wallerius, in his Mineralogy, proposes to distinguish this kind of pyrites by the name of marcasite. When cut, it may be polished so well as to give a lustre almost equal to that of diamonds; but without refracting or decomposing the light; for it is perfectly opake. It was employed some years ago in the manufactory of toys, as of buckles, necklaces, &c., and is called in commerce marcasite. See WATERS (MINERAL), and ORES.

PYROMETER. An instrument contrived for measuring the expansions and contractions of bodies by change of temperature. See EXPANSION.

We shall here give an account of Mr. Wedgwood's, abridged from the papers of the inventor in the Phil. Trans. vols. lxii and lxiv; and subjoin a brief description of that lately constructed by Guyton, from the Annales de Chimie, vol. xlvi.

A measure for the higher degrees of heat, such as the common thermometers afford for the lower ones, would be an important acquisition both to the philosopher and the practical artist. The latter must feel the want of such a measure on many occasions: particularly when he attempts to follow, or apply to use, the curious experiments of Mr. Pott, related in his Lithogeognosia, and other modern writers upon similar subjects. When we are told, for instance, that such and such materials were changed by fire into a fine white, yellow, green, or other coloured glass, and find that these effects do not happen, unless a particular degree of fire have fortunately been hit upon, which degree we cannot be sure of succeeding in again—when we are disappointed by having the result at some times an unvitrified mass, and at others an overvitrified scoria, from a little deficiency or excess of heat—when we see colours altered not only in shade but in kind, and in many cases destroyed by a small augmentation of the heat which had produced them—how much is it to be wished, that the authors had been able to convey to us a measure of the heat made use of in their valuable processes!

Mr. Wedgwood, in a long course of experiments for the improvement of the manufacture he is engaged in, found some of his greatest difficulties to arise from not being able to ascertain the heat, to which the experiment-pieces had been exposed; and having no other resource, he was obliged at first to content himself with such measures as his own kilns and the different parts of them afforded. Thus the kiln in which his glazed ware is fired furnishes three measures, the bottom being of one heat, the middle of a greater, and the top still greater: the kiln in which the biscuit ware is fired furnishes three or four others, of higher degrees of heat; and by these he marked his registered experiments. But these measures were neither fully adequate to his own views, nor capable of being communicated to others: their use is confined to a particular structure of furnaces, and mode of firing: and upon any alteration in these, they would become useless and unintelligible, even where now they are best known. And indeed as this part of the operation is performed by workmen of the lowest class, it is impossible to depend upon any great accuracy even in one and the same furnace. It has accordingly often happened, that the pieces fired in the top of the kiln in one experiment have been made no hotter than those fired in the middle in another, and vice versa.

The force of fire, in its higher as well as lower stages, can no otherwise be justly ascertained than by its effects upon some known body. Mr. Wedgwood observed, that compositions of oxides of iron with clay assumed, from different degrees of fire, such a number of distinct colours and shades as promised to afford useful criteria of the respective degrees.

With this idea he prepared a quantity of such a composition, and formed it into circular pieces, about an inch in diameter, and a quarter of an inch thick. A number of these were placed in a kiln, in which the fire was gradually augmented, with as much uniformity and regularity as possible, for near sixty hours. The pieces, taken out at equal intervals of time during this successive increase of heat, and piled in their order upon one another in a glass tube, exhibited a regular and pretty extensive series of colours; from a flesh colour to a deep brownish-red, thence to a chocolate, and so on to nearly black, with all the intermediate tints between these colours. A back being fixed to the tube, like the scale of a thermometer, and the number of the pieces marked upon it respectively opposite to them, it is obvious, that these numbers may be considered as so many thermometric divisions or degrees; and that if another piece of the same composition be fired in any other kiln, or furnace not exceeding the utmost heat of the first, it will acquire a colour corresponding to some of the pieces in the tube, and thus point out the degree of heat, which that piece, and consequently such other matters as were in the fire along with it, have undergone.

It must however be confessed, that for general use, a thermometer on this principle is liable to objection, as ideas of colours are not perfectly communicable by words; nor are all eyes, or all lights, equally adapted for distinguishing them, especially the shades which approach near to one another; and the effects of vapours, in altering the colour, may not in all cases be easily guarded against.

In considering this subject attentively, another property of argillaceous bodies occurred to Mr. Wedgwood; viz. the diminution of their bulk by fire. This he found to be a more accurate and extensive measure of heat than the different shades of colour.

He found that this diminution takes place in a low red heat; and that it proceeds regularly, as the heat increases, till the clay becomes vitrified, and consequently to the utmost degree that crucibles or other vessels made of this material can support. The total contraction of some good clays, which he examined in the strongest of his own fires, is considerably more than one fourth part in every dimension.

If, therefore, we can procure at all times a clay sufficiently apyrous or unvitrescible, and always of the same quality in regard to contraction by heat; and if we can find means of measuring this contraction with ease and minute accuracy, Mr. Wedgwood thought, that we should be furnished with a measure of fire sufficient for every purpose of experiment or business.

We have in different parts of England immense beds of clay; each of which, at equal depths, is pretty uniform in quality throughout its whole extent. Mr. Wedgwood found, that some of the purest Cornish porcelain clays seem the best adapted, both for supporting the intensity, and measuring the degrees of fire.

For preparing and applying this material to thermometric purposes, he proposes the following method.

The clay is first to be washed over, and, while in a dilute state, passed through a fine lawn. It must then be made dry and put up in boxes.

While the clay is thus kept dry in boxes, as well as while it continues in its natural bed, it is secure from alterations in quality, which clays in general are subject to undergo, when exposed for a long course of years to the joint actions of air and moisture. In the lawns Mr. Wedgwood made use of the interstices were each less than 100,000th part of an inch. If Mr. Wedgwood mean, as I suppose he does, that the square interstices of his lawn were each less than the 100,000th part of a square inch, the number of threads in an inch were about 320.

The dry clay is to be softened for use with about two fifths of its weight of water; and formed into small pieces, in little moulds of metal six tenths of an inch in breadth, with the sides pretty exactly parallel, this being the dimension intended to be measured, about four tenths of an inch deep, and one inch long. To make the clay deliver easily, it will be necessary to oil the mould, and make it warm.

These pieces, when perfectly dry, are put into another iron mould or gauge, consisting only of a bottom, with two sides, five tenths of an inch deep; to the dimensions of which sides the breadth of the pieces is to be pared down.

For measuring the diminution which they are to suffer from the action of fire, another gauge is made, of two pieces of brass, twenty-four inches long, with the sides exactly straight, divided into inches and tenths, fixed five tenths of an inch asunder at one end, and three tenths at the other, upon a brass plate, so that one of the thermometric pieces, when pared down in the iron gauge, will just fit the wider end. Let us suppose this piece to have diminished in the fire one fifth of its bulk, it will then pass on to half the length of the gauge; if diminished two fifths, it will go on to the narrowest end; and in any intermediate degree of contraction, if the piece be slid along till it rests against the converging sides, the degree at which it stops will be the measure of its contraction, and consequently of the degree of heat it has undergone.

These are the outlines of what appeared to Mr. Wedgwood necessary for the making and using of this thermometer; and he expressed his hope, that the whole process would be found sufficiently simple, and easy of execution. It may nevertheless be proper to take notice of a few minuter circumstances, and to mention some observations which occurred in the progress of the inquiry.

As there ought to be a certainty of the clay being easily and at all times procurable in sufficient quantity, and on moderate terms, Mr. Wedgwood offered to the Royal Society a sufficient space in a bed of the Cornwall clay, to supply the world with thermometric pieces for numerous ages.

In order to be assured that the clay made use of for these thermometers is perfectly similar, it will be best to dig it out of the earth in considerable quantity at once, an extent of some square feet or yards in area, and to the depth of six or seven yards or more from the surface, and to mix the whole thoroughly together, previous to the farther preparation already mentioned.

This clay, dried by the summer heat, or in a moderately warm room, or with more heat before a fire, has not been observed to differ in degree of dryness. After being so dried, it loses about a hundredth part of its weight in the heat of boiling water, about as much more in that of melted lead, and thence to a red heat ten parts, in all $\frac{12}{100}$. Each of these heats soon expels from the clay its determinate quantity of matter, chiefly air; after which, the same heat, though continued for many hours, has no farther effect. Mr. Wedgwood had some hopes, that the gradation of the common thermometer might be continued, upon this principle, up to the red-heat at which the shrinking of the clay commences, so as to connect the two thermometers together by one series of numbers; but the loss of weight appears not to be sufficiently uniform or proportional to the degree of heat to answer that purpose, for it was found to go on quicker, and bladders tied to the mouths of the vessels in which the pieces were heated became more rapidly distended, at the commencement of redness, than at any other time. From a low red-heat to a strong one, such as copper melts in, the loss of weight was only about two parts in a hundred; though the difference between these two heats appears to be much greater, than what the same loss corresponds to in the lower stages. After this period, the decrease of weight entirely ceased.

The vapours expelled from the clay, caught separately in the different degrees of heat, seemed, from the few trials made with them, to consist of common air mixed with carbonic acid. They all precipitated lime-water, that which was first extricated exceeding weakly, the others more and more considerably; but the last not near so strongly as the air expelled from limestone in burning. None of them were inflammable.

The thermometric pieces may be formed much more expeditiously than in the single mould, by means of an instrument used for similar purposes by potters. It consists of a cylindrical iron vessel, with holes in the bottom, of the form and dimensions required. The soft clay put into the vessel is forced by a press down through these apertures, in long rods, which may be cut while moist, or broken when dry, into pieces of convenient lengths. It was hoped, that this method would of itself have been sufficient, without the addition of the paring gauge, making proper allowance, in the size of the holes, for the shrinking of the clay in drying. But it was found, that a variety of little accidents might happen to alter the shape and dimensions of the pieces, in a sensible degree, while in their soft state; so that it will be always safest to have recourse to the paring gauge for ascertaining and adjusting their breadth when perfectly dry, this being the period at which the pieces are exactly alike with regard to their future diminishing; so that, if they be now reduced to the same breadth, we may be sure, that they will suffer equal contractions from equal degrees of heat afterward, whether they have been made in a mould, or by a press, or in any other way; neither is any variation in the length or thickness of these pieces of the least consequence, provided one of the dimensions, that by which they are afterward to be measured, is made accurate to the gauge.

It will be proper to bake the pieces, when dry, with a low red-heat, in order to giv them some firmness or hardness, that they may, if necessary, be able to bear package and carriage; but more especially to prepare them for being put into an immediate heat, along with the matters they are to serve as measures to, without bursting or flying, as unburnt clay would do. We need not be solicitous about the precise degree of heat employed in this baking, provided only, that it does not exceed the lowest degree which we shall want to measure in practice; for a piece that has suffered any inferior degrees of heat answers as well for measuring higher ones, as a piece which has never been exposed to fire at all. In this part of the preparation of the pieces, it may be proper to inform the operator of a circumstance, which, though otherwise immaterial, might at first disconcert him: If the heat be not in all of them exactly equal, he will probably find, that, while some have begun to shrink, others are rather enlarged in their bulk; for they all swell a little just on the approach of redness. As this is the period of the most rapid produce of air, the extension may perhaps be owing to the air having at this moment become elastic to such a degree, as to force the particles of the clay a little asunder, before it obtains its own enlargement.

Each division of the scale, though so large as the tenth of an inch, answers to a 600dth part of the breadth of the little piece of clay. We might go to much greater nicety, either by making the divisions smaller or the scale longer; but it is not apprehended, that any thing of this kind will be found necessary: and indeed, in proceeding much farther in either way, we may possibly meet with inconveniencies sufficient to counterbalance the apparent additional accuracy of measurement.

The divisions of this scale, like those of the common thermometers, are unavoidably arbitrary; but the method here proposed appears sufficiently commodious and easy of execution, the divisions being adjusted by measures everywhere known, and at all times obtainable; for however the inches used in different countries may differ in length, this cannot affect the accuracy of the scale, provided that the proportions between the wider and narrower end of the gauge are exactly as five tenths of those inches to three tenths, and the length 240 of the same tenths; and that the pieces in their perfectly dry state, before firing, fit precisely to the wider end. When one gauge is accurately adjusted to these proportional measures, two pieces of brass should be made, one fitting exactly into one end, and the other into the other; these will serve as standards for the ready adjustment of other gauges to the dimensions of the original.

By this simple method we may be assured, that thermometers on this principle, though made by different persons, and in different countries, will all be equally affected by equal degrees of heat, and all speak the same language: the utility of this last circumstance is now too well known to need being insisted on.

If a scale two feet in length should be reckoned inconvenient, it may be divided into two, of one foot each, by having three pieces of brass fixed upon the same plate; the first and second, five tenths of an inch apart at one end, and four tenths at the other; the second and third, four tenths at one end, and three tenths at the other; so that the first reaches to the 120th division, and the second from that to the 240th.

As this thermometer, like all others, can express only the heat felt by itself, the operator must be careful to expose the pieces to an equal action of the fire with the body the heat of which he wants to measure by them. In kilns, ovens, reverberatories, under a muffle, and wherever the heat is pretty steady and uniform, the means of doing this are too obvious to need being mentioned. But in a naked fire, where the heat is necessarily more fluctuating, and unequal in different parts of the fuel, some precaution will be required.

The thermometer-piece may generally be put into the crucible, along with the subject matter of the experiment. But where the matter is of such a kind as to melt and stick to it, the piece may be previously enclosed in a little case made of crucible clay.

The smallness of the pieces will admit of this being done without inconvenience, at least in any but the smallest crucibles, as the pieces themselves may be diminished to any size that may be found proper, provided only that one of the dimensions, five tenths of an inch, be preserved in the manner before mentioned.

For the very smallest sort of crucibles, the case may be put in close to the crucible, so as to form as it were an addition to its bulk on the outside. If it be asked, why the case is not always thus put in by the side of the crucible? it is answered, that in judging of the heat of large crucibles from a thermometer-piece placed on the outside of them, we may sometimes be deceived, as the piece in its little case has been found to heat sooner than the matter in the larger vessel; but in small ones, as the crucible and case are nearly alike in bulk, there is little danger of errour from this cause.

These thermometer-pieces possess some singular properties, which we could not have expected to find united in any substance whatever, and which peculiarly fit them for the purposes they are here applied to.

1. When baked by only moderate degrees of fire, though they are, like other clays, of a porous texture, and imbibe water; yet, when saturated with the water, their bulk continues exactly the same as in a dry state.

2. By very strong fire, they are changed to a porcelain or semivitreous texture: nevertheless, their contraction, on farther augmentations of the heat, proceeds regularly, as before, up to the highest degree of fire that Mr. Wedgwood has been able to produce.

3. They bear sudden alternatives of heat and cold; may be dropped at once into intense fire; and, when they have received its heat, may be plunged as suddenly into cold water, without the least injury from either.

4. Even while saturated with water in their porous state, they may be thrown immediately into a white heat, without bursting, or suffering any injury.

5. Sudden cooling, which alters both the bulk and texture of most bodies, does not at all affect these, at least not in any quality subservient to their thermometric uses.

6. Nor are they affected by long continuance in, but solely by the degree of heat they are exposed to. In three minutes, or less, they are perfectly penetrated by the heat which acts upon them, so as to receive the full contraction, which that degree of heat is capable of producing, equally with those which had undergone its action during a gradual increase of its force for many hours. Strong degrees of heat are communicated to them with more celerity than weak ones; perhaps the heat may be more readily transmitted in proportion as the texture becomes more compact.

These facts have been ascertained by many experiments, the particulars of which are omitted, because they would swell this article much beyond the bulk intended.

The use and accuracy of this thermometer for measuring, after an operation, the degree of heat which the matter has undergone, will be apparent. The foregoing properties afford means of measuring it also easily and expeditiously, during the operation, so that we may know when the fire is increased to any degree previously determined upon. The piece may be taken out of the fire in any period of the process, and dropped immediately into water, so as to be fit for measuring by the gauge in a few seconds of time. At the same instant, another piece may be introduced into the place of the former, to be taken out and measured in its turn; and thus alternately, till the desired degree of heat is obtained. But as the cold piece will be two or three minutes in receiving the full heat, and corresponding contraction; to avoid this loss of time, it may be proper on some occasions to have two or more pieces, according to convenience, put in together at first, that they may be successively cooled in water, and the degrees of heat examined at shorter intervals. It will be unnecessary to say any thing farther upon precautions or procedures, which the very idea of a thermometer must suggest, and every experimenter will readily find means to obviate.

It only now remains that the language of this new thermometer be understood, and that it may be known, what the heats meant by its degrees really are. For this purpose a great number of experiments have been made, from which the following results are selected:

The scale commences at a red-heat, fully visible in day light; and the greatest heat that Mr. Wedgwood obtained in his experiments is 160°. This degree he produced in an air furnace about eight inches square.

Mr. Alchorne tried the necessary experiments with the pure metals at the Tower, to ascertain at what degrees of this thermometer they go into fusion; and it appears, that Swedish copper melts at 27, silver at 28, and gold at 32.

Brass is in fusion at 21. Nevertheless, in the brass and copper foundries, the workmen carry their fires to 140° and upwards; but for what purpose they so far exceed the melting heat, or whether so great an additional melting heat be really necessary, Mr. Wedgwood says he has not learned.

The welding heat of iron is from 90 to 95; and the greatest heat that could be produced in a common smith's forge 125.

Cast-iron was found to melt at 130°, both in a crucible in Mr. Wedgwood's furnace, and at the foundry; but could not be brought into fusion in the smith's forge, though that heat is only 5° lower. The heat by which iron is run down among the fuel for casting is 150°.

As the welding state of iron is a softening or beginning fusion of the surface, it has been generally thought, that cast iron would melt with much less heat than what is necessary for producing this effect upon the forged; whereas, on the contrary, cast iron appears to require, for its fusion, a heat exceeding the welding heat 35 or 40°, which is much more than the heat of melted copper exceeds the lowest visible redness.

Thus we find, that though the heat for melting copper is by some called a white heat, it is only 27° of this thermometer. The welding heat of iron, or 90°, is likewise a white heat; even 130°, at which cast iron is in fusion, is no more than a white heat; and so on to 160° and upward is all a white heat still. This shows abundantly how vague such a denomination must be, and how inadequate to the purpose of giving us any clear ideas of the extent of what we have been accustomed to consider as one of the three divisions of heat in ignited bodies.

A Hessian crucible in the iron foundry, viz. about 150°, melted into a slag-like substance. Soft iron nails, in a Hessian crucible in Mr. Wedgwood's furnace, melted into one mass with the bottom of the crucible, at 154°: the part of the crucible above the iron was little injured.

The fonding heat of the glass furnaces Mr. Wedgwood examined, or that by which the perfect vitrification of the materials is produced, was at one of them 114° for flint glass, and 124° for plate-glass; at another it was only 70° for the former: which shows the inequality of heat, perhaps unknown to the workmen themselves, made use of for the same purpose. After complete vitrification, the heat is abated for some hours to 28° or 29°, which is called the settling heat; and this heat is sufficient for keeping the glass in fusion. The fire is afterward increased, for working the glass, to what is called the working heat; and this Mr. Wedgwood found, in plate-glass, to be 57°.

Delft-ware is fired by a heat of 40 or 41°; cream-coloured or queen's-ware, by 86°; and stone-ware, called by the French poterie de grès, by 102°; by this strong heat, it is changed to a true porcelain texture. The thermometer-pieces begin to acquire a porcelain texture about 110°.

The above degrees of heat were ascertained by thermometer-pieces fired along with the ware in the respective kilns. But this thermometer affords means of doing much more, and going farther in these measures than could at first have been expected; it will enable us to ascertain the heats by which many of the porcelains and earthen-wares of distant nations and different ages have been fired: for as burnt clay, and compositions in which clay is a prevailing ingredient, suffer no diminution of their bulk by being repassed through degrees of heat which they have already undergone, but are diminished by any additional heat, as has been before observed, if a fragment of them be made to fit into any part of the gauge, and then fired along with a thermometer-piece till it begins to diminish, the degree at which this happens, points out the heat by which it had been fired before. Of several pieces of ancient Roman and Etruscan wares, which Mr. Wedgwood examined, none appeared to have undergone a greater heat than 32°, and none less than 20°; for they all began to diminish at those or the intermediate degrees.

By means of this thermometer, some interesting properties of natural bodies may likewise be discovered or more accurately determined, and the genus of the bodies ascertained. Jasper, for instance, is found to diminish in the fire, like an artificial mixture of clay and siliceous matter; granite, on the contrary, has its bulk enlarged by fire; while flint and quartzose stones are neither enlarged nor diminished. These experiments were made in fires between 70° and 80° of this thermometer. A sufficient number of facts like these, compared with each other, and with the properties of such natural or artificial bodies as we wish to find out the composition of, may lead to various discoveries, of which Mr. Wedgwood had already found some promising appearances; but many more experiments were wanting, to enable him to speak with that certainty and precision on these subjects which they appear to deserve.

A piece of an Etruscan vase melted completely at 33°; pieces of some other vases and Roman ware about 86°; Worcester china vitrified at 94°; Mr. Sprimont's Chelsea china at 105°; the Derby at 112°; and Bow at 121°; but Bristol china showed no appearance of vitrification at 135°. The common sort of Chinese porcelain does not perfectly vitrify by any fire Mr. Wedgwood could produce; but began to soften about 120°, and at 156° became so soft as to sink down, and apply itself close upon a very irregular surface underneath. The true stone nankeen, by this strong heat, does not soften in the least, nor does it even acquire a porcelain texture, the unglazed parts continuing in such a state as to imbibe water and stick to the tongue. The Dresden porcelain is more refractory than the common Chinese, but not equally so with the stone nankeen. The cream-coloured or queen's ware bears the same heat as the Dresden, and the body is as little affected by this intense degree of fire.

Mr. Pott says, that to melt a mixture of chalk and clay in certain proportions, which proportions appear from his tables to be equal parts, is among the masterpieces of art. This mixture melts into a perfect glass at 123° of this thermometer.

The whole of Mr. Pott's or any other experiments may, by repeating and accompanying them with these thermometric pieces, have their respective degrees of heat ascertained, and thereby be rendered more intelligible and useful to the reader, the experimenter, and the working artist.

Mr. Wedgwood found from the analysis of the clay of which the thermometric pieces are formed, that it consists of two parts of pure siliceous earth to three parts of pure argillaceous or aluminous earth.

Mr. Wedgwood afterward endeavoured to connect his thermometer with that of Fahrenheit's, by means of a silver expansion-piece as an intermediate measure. In order to procure a gauge for this purpose like that by which the thermometer-pieces are measured, he made choice of tobacco-pipe clay, mixed with charcoal in fine powder, in the proportion of three parts of the charcoal to five of the clay by weight. By a free access of air, in the burning by which the gauge is prepared for use, the charcoal is consumed, and leaves the clay extremely light and porous; from which circumstance it bears sudden alterations of cold and heat, often requisite in these operations, much better than the clay alone.

A clear idea may be obtained of this species of gauge, by conceiving two rulers or flat pieces a quarter of an inch thick fixed flat upon a smooth flat plate, a little farther asunder at one end than at the other; so that they may include between them a long converging canal, in which a piece of metal is so adjusted as to fit exactly at the wider end of the canal, which is divided on one side into a number of small equal parts, and which may be considered as performing the offices both of the tube and scale of the common thermometer. When a piece of metal is heated to an exact equality with the gauge, the excess of the expansion of one above the other can be measured, which is, sufficient for purposes where only a uniform and graduated effect of fire is required.

In order to obtain a corresponding interval between Fahrenheit's thermometer and this intermediate scale, the silver piece and gauge were laid together for some time in spring water of the temperature of 50° of Fahrenheit: the point which the piece went to in this cold state was marked (0) near the narrow end of the gauge.

The heat of boiling water was taken without difficulty, by keeping the apparatus in boiling water itself during a sufficient space of time for the full heat to be communicated to it. The expansion of the silver by this heat, that is, by an increase of the heat from 50° to 212°, or a period containing 162° of Fahrenheit, was just 8° of the gauge or intermediate thermometer; whence one of these degrees, according to this experiment, contains just 20°¼ of Fahrenheit.

For the boiling heat of mercury, it was necessary to proceed in a different manner; not to convey the heat from the mercury to the instrument, but to convey it equally to them both from another body. Mr. Wedgwood, therefore, made a small vessel for holding the mercury in the gauge itself. The plate which forms the bottom of the canal serves also for the bottom of the vessel which is situate close to the side of the canal, and as near as possible to that part of it in which both the silver piece and the divisions required for this particular experiment, are contained.

The gauge, with some mercury in the vessel, was laid upon a smooth and level bed of sand, on the bottom of an iron muffle kept open at one end; the fire increased very gradually till the mercury boiled, and then continued steady, so as just to keep it boiling, for a considerable time. The boiling heat of mercury was thus found to be 27°½ of the intermediate thermometer, which answering to an interval of 550° of Fahrenheit, makes one degree of this equal to just 20° of his.

The next object to be ascertained was an interval of correspondence between this intermediate gauge and the thermometer for strong fire.

In these experiments Mr. Wedgwood found it was impossible to obtain in common fires, or in common furnaces, a uniform heat through the extent even of a few inches. He therefore had recourse to the fire of an enamelling oven, which was of such a magnitude as to exceed perhaps some hundreds of times the bulk of the matters required to be heated. A muffle being placed in this furnace, the gauge was fixed in it as before with the silver piece. Some of the clay thermometer-pieces were set on end upon the silver piece, with that end of each downward which is marked to go foremost in measuring it; that is, they were in contact with the silver in that part of their surface by which their measure is afterward ascertained.

The fire about the oven was slowly increased for some hours, and kept as even and steady as possible. Upon opening a small door, which had been made for introducing the apparatus, and looking in from time to time, it was observed, that the muffle, with the adjacent parts of the oven and ware, acquired a visible redness at the same time; and, in the progress of the operation, the eye could not distinguish the least dissimilarity in the aspect of the different parts; whereas in small fires, the difference not only between the two ends of the muffle, but in much less distances, is such as to strike the eye at once.

When the muffle appeared of a low red-heat, such as was judged to come fully within the province of his thermometer, it was drawn forward toward the door of the oven; and its own door being then nimbly opened by an assistant, Mr. Wedgwood pushed the silver piece as far as it would go. But as the division which it went to could not be distinguished in that ignited state, the muffle was lifted out, by means of an iron rod passed through two rings made for that purpose, with care to keep it steady, and avoid any shake that might endanger the displacing of the silver piece.

When the muffle was grown sufficiently cold to be examined, he noted the degree of expansion which the silver piece stood at, and the degree of heat shown by the thermometer pieces measured in their own gauge; then returned the whole into the oven as before, and repeated the operation with a stronger heat, to obtain another point of correspondence on the two scales.

The first was at 2°¼ of his thermometer, which coincided with 66° of the intermediate one; and as each of these last has been before found to contain 20° of Fahrenheit's, the 66 will contain 1320; to which add 50, the degree of his scale to which the (0) of the intermediate thermometer was adjusted, and the sum 1370 will be the degree of Fahrenheit's corresponding to his 2°¼.

The second point of coincidence was at 6°¼ of his, and 92° of the intermediate; which 92 being, according to the above proportion, equivalent to 1840 of Fahrenheit, add 50 as before to this number, and his 6°¼ is found to fall upon the 1890th degree of Fahrenheit.

It appears hence, that an interval of four degrees upon Mr. Wedgwood's thermometer is equivalent to an interval of 520° upon that of Fahrenheit; and consequently one of the former to 130° of the latter; and that the (0) of Mr. Wedgwood corresponds to 1077°½ of Fahrenheit.

From these data it is easy to reduce either scale to the other through their whole range; and from such reduction it will appear, that an interval of near 480° remains between them, which the intermediate thermometer serves as a measure for; that Mr. Wedgwood's includes an extent of about 32000 of Fahrenheit's degrees, or about 54 times as much as that between the freezing and boiling points of mercury, by which mercurial ones are naturally limited; that if the scale of Mr. Wedgwood's thermometer be produced downward, in the same manner as Fahrenheit's has been supposed to be produced upward, for an ideal standard, the freezing point of water would fall nearly on 8° below (0) of Mr. Wedgwood's, and the freezing point of mercury a little below 80°½; and that, therefore, of the extent of now measurable heat, there are about $\frac{5}{10}$ths of a degree of his scale from the freezing of mercury to the freezing of water; 8° from the freezing of water to full ignition; and 160° above this to the highest degree he has hitherto attained.

Mr. Wedgwood concludes his account with the following table of the effects of heat on different substances, according to Fahrenheit's thermometer, and his own.

	Fahr.	Wedg.
Extremity of the scale of his thermometer -	32277°	240°
Greatest heat of his small air furnace -	21877	160
Cast-iron melts - - -	17977	130
Greatest heat of a common smith's forge -	17327	125
Welding heat of iron, greatest - - - -	13427	95
Welding heat of iron, least - - - - -	12777	90
Fine gold melts - -	5237	32
Fine silver melts - -	4717	28
Swedish copper melts -	4587	27
Brass melts - - -	3807	21
Heat by which his enamel colours are burnt on -	1857	6
Red-heat fully visible in day-light - -	1077	0
Red-heat fully visible in the dark -	947	1
Mercury boils - -	600	$3\frac{673}{1000}$
Water boils - -	212	$6\frac{658}{1000}$
Vital heat - - -	97	$7\frac{542}{1000}$
Water freezes - -	32	$8\frac{42}{1000}$
Proof spirit freezes -	0	$8\frac{288}{1000}$
The point at which mercury congeals, consequently the limit of mercurial thermometers, about -	40	$8\frac{596}{1000}$

In a scale of HEAT drawn up in this manner, the comparative extents of the different departments of this grand and universal agent are rendered conspicuous at a single glance of the eye. We see at once, for instance, how small a portion of it is concerned in animal and vegetable life, and in the ordinary operations of nature. From freezing to vital heat is barely a five-hundredth part of the scale; a quantity so inconsiderable, relatively to the whole, that in the higher stages of ignition, ten times as much might be added or taken away, without the least difference being discernible in any of the appearances from which the intensity of fire has hitherto been judged of. Hence at the same time we may be convinced of the utility and importance of a physical measure for these higher degrees of heat, and the utter insufficiency of the common means of discriminating and estimating their force. Mr. Wedgwood adds, that he has often found differences, astonishing when considered as a part of this scale, in the heats of his own kilns and ovens, without being perceivable by the workmen at the time, or till the ware was taken out of the kiln.

Guyton's pyrometer consists of a bar of platina, 45 millimetres (1·77 inch) long, 5 wide, and 2 thick, placed horizontally in a groove formed in a cake of hardened white clay, so highly baked as to leave no cause for apprehending any farther contraction. The bar rests at one of its extremities against the part of the mass that terminates the groove; the other end presses against a bended lever, the short arm of which is 2·5 millimetres long, and the other 50 millimetres. The arms are at right angles to each other, and the long one, which traverses a graduated arc of a circle, carries a nonius, that divides each degree on the arc into ten parts. Thus, according to Mr. Guyton, an expansion of the rod may be determined correctly to the 200dth part of a millimetre, or about a 500dth part of an inch.

To prevent the position of the index from being changed in removing the instrument from the furnace, a plate of platina is fixed so as to form a spring against its extremity.

PYROPE. The Bohemian garnet, carbuncle of Reuss, is called by Werner pyrop; and from the quantity of magnesia found in it by Klaproth, it would seem to have a sufficient claim to be considered as a stone of a distinct species, though Vauquelin represents it to be as free from this earth as any of the garnets.

Klaproth's analysis gives for its component parts,

Silex . . .	0·40
Alumine . .	0·285
Magnesia . .	0·10
Lime . . .	0·085
Oxide of iron . .	0·165
Oxide of manganese .	0·0025
	0·9875

leaving a loss of 0·0125.

Vauquelin's, on the contrary, gives,

Silex . .	0·36
Alumine .	0·22
Lime . .	0·03
Oxide of iron	0·41
	1·02

Here we find no trace either of magnesia or of manganese, and the iron is present in much larger quantity; so that, unless the magnesia were accidentally present in Klaproth's garnet, they could not both be the same stone.

The pyrope has not yet been found in a crystalline form, occurring only in rounded or angular grains: it is commonly transparent; its fracture vitreous and perfectly conchoidal; and its colour of a poppy or blood red, sometimes tinged with orange.

Pyrophorus. By this name is denoted an artificial product, which takes fire or becomes ignited on exposure to the air. Hence, in the German language, it has obtained the name of luft-zunder, or air-tinder. It is prepared from alum by calcination, with the addition of various inflammable substances. Homberg was the first that obtained it, which he did accidentally in the year 1680, from a mixture of human excrement and alum, upon which he was operating by fire. This chemist, upon the strength of some information communicated to him, was endeavouring to extract by distillation from human excrement an oil, that should transmute mercury into silver; in this attempt, however, he was disappointed, as might naturally be expected. Lemeri the younger, afterward, in the year 1713, showed, that it could not only be prepared from this substance, but also (on being previously mixed with alum) from various other bodies that are capable of being charred. After this, Mr. de Savigny made it appear, that by the addition of any inflammable body whatever, a pyrophorus may be made of all such substances as contain sulphuric acid combined either with earth, or with alkaline salt, or with a metallic substance. Notwithstanding this, the preference is given to alum, because its earth best retains the sulphuric acid in the fire, and hence the operation succeeds best with this salt.

The preparation is managed in the following manner: Three parts of alum are mixed with from two to three parts of honey, or sugar; and this mixture is dried over the fire in a glazed bowl, or an iron pan, diligently stirring it all the while with an iron spatula. At first this mixture melts, but by degrees it becomes thicker, swells up, and at last runs into small dry lumps. These are triturated to powder, and once more roasted over the fire, till there is not the least moisture remaining in them, and the operator is well assured that it can liquefy no more: the mass now looks like a blackish powder of charcoal. For the sake of avoiding the previous above-mentioned operation, from four to five parts of burned alum may be mixed directly with two of charcoal powdered. This powder is poured into a phial or matrass, with a neck about six inches long. The phial, which however must be filled three quarters full only, is then put into a crucible, the bottom of which is covered with sand, and so much sand is put round the former, that the upper part of its body also is covered with it to the height of an inch; upon this the crucible, with the file, is put into the furnace, and surrounded with red-hot coals. The fire, being now gradually increased till the phial becomes red-hot, is kept up for the space of about a quarter of an hour, or till a black smoke ceases to issue from the mouth of the phial, and instead of this, a sulphureous vapour exhales, which commonly takes fire. The fire is kept up till the blue sulphureous flame is no longer to be seen; upon this the calcination must be put an end to, and the phial closed for a short time with a stopper of clay or loam. But as soon as the vessel is become so cool as to be capable of being held in the hand, the phial is taken out of the sand, and the powder contained in it transferred as fast as possible from the phial into a dry and stout glass made warm, which must be secured with a glass stopper.

We have made a very good pyrophorus by simply mixing three parts of alum with one of wheat-flour, calcining them in a common phial till the blue flame disappeared; and have kept it in the same phial, well stopped with a good cork when cold.

If this powder be exposed to the atmosphere, the sulphuret attracts moisture from the air, and generates sufficient heat to kindle the carbonaceous matter mingled with it.

Beside this, other compositions, which, in like manner, take fire on exposure to the open air, have been by degrees made known to us: 1. The scoria of the martial regulus of antimony, or antimony freed from sulphur by the intervention of iron and nitre, as well crude as also after being dissolved, have been observed to take fire spontaneously, when laid upon a hot stone, or in the sun. Of the truth of the latter case, Wiegleb says he is assured by his own experience. 2. The residuum of the acetat of copper is another pyrophorus. 3. Some assert, that they have observed an inflammation ensue from honey and flour calcined according to the rules laid down above. 4. According to Geoffroy, a calcined mass of three parts of black soap, and one of diaphoretic antimony, has been known to take fire spontaneously. 5. Meuder has observed, that a pyrophorus is obtained, when equal parts of orpiment and iron-filings are sublimed together, and ten parts of this sublimate are triturated in a mortar along with twelve of nitrat of silver. 6. A pyrophorus is produced, according to Penzky, when two drachms of white sand, three of common salt, one of sulphur, two of sulphuric acid, and half an ounce of muriatic, are mixed together and distilled in a glass retort. In this operation a sublimate is said to be obtained, which bursts out in flames, as soon as it comes into contact with the air. 7. The spontaneous precipitate of osteocolla, from a solution of it in sulphuric acid, after having been separated by means of a filter, and dried, took fire in a warm place. 8. Pott observed the same phænomenon in the earth of the residuum after the distillation of urine, that had been putrid for a considerable time. 9. To these may also be referred a mass composed of equal parts of sulphur and iron-filings; which, when thoroughly moistened with water, after some time grows hot, swells, and at last breaks out into vapour, smoke, and flame.

Those pyrophori that require a heat greater than that of the usual temperature of the atmosphere for their accension, may be termed imperfect pyrophori. They may be compared to the imperfect phosphori, and are in fact intermediate substances between the true pyrophori and ordinary combustible bodies.

Several different mixtures, and torrefied substances, form a kind of imperfect pyrophori, and have more than once occasioned fires, from no suspicion of their properties being entertained. See COMBUSTION (SPONTANEOUS).

PYROPHYSALITE. This stone, the name of which, derived from πυρ fire and φυσαλις a bubble, was given it on account of its emitting bubbles when exposed to the flame of the blowpipe, was found by Mr. Gahn, at Finbo, near Fahlun, about three quarters of a league west of the town, on the road to Sundborn. The nodules are imbedded in a granite composed of white quartz, feldtspar, and silvery mica, the laminæ of which are rhomboidal, and in hexagonal prisms. The nodules are separated from the rock by thin scales of mica, covered by a talcous substance of a greenish yellow colour.

It differs from feldspar, to which it appears to have most resemblance, in having but one determinate direction in which it can be split, while feldspar has two. The specific gravity of feldspar too is but 2·704, and beside it is much less difficult to fuse.

Its colour is white, and sometimes of a greenish white, and occasionally small superficial blue spots of fluat of lime may be observed on it.

It is found in masses, forming oblong nodules most commonly of no determinate figure, but sometimes approaching an irregular rhomboid. Hence no exact measure of its angles can be taken, though apparently its lateral angles are about 118° and 62° reciprocally.

Its fracture is unequal, foliated, and very shining in one direction only, which seems to be that formed by the inclination of 90° or 100° to the axis of the rhomboid. It may be cleft, though less decidedly, in two other directions nearly parallel to the sides of the rhomboid. If broken transversely, it has little or no lustre. The fragments are of an indeterminate form, angular, with sharp edges, on which it is a little translucid. They strike fire with steel, and are hard enough to scratch glass easily, but are scratched by quartz. It is difficult to reduce to powder. Its specific gravity is 3·451.

The powder of the purest fragments, projected into a hot spoon, emits a greenish phosphoric light, that is but of short duration.

Before the blowpipe, without any addition, it is nearly infusible: but if the heat be urged to a high degree, it renders it white, opake, and its surface is surrounded by small bubbles, which issue from it hastily, and burst if the temperature be kept up. This is a very decided characteristic appearance, from which the substance has received its name.

With borax it fuses easily into a colourless transparent glass.

Soda attacks it with a little effervescence, and produces a porous mass.

The following analysis was undertaken conjointly by Messrs. Hisinger and Berzelius:

Two hundred grains of pyrophysalite, reduced to fine powder in a mortar, acquired an increase of weight of four grains.

a. These 204 grains, having been kept at a red-heat in the fire for three hours, lost 1·5 grain.

b. On adding 600 grains of carbonat of potash, and exposing the mixture to a red-heat for three hours in a platina crucible, a colourless mass was obtained, perfectly soluble in muriatic acid. This solution being evaporated to dryness, and diffused in water with a very little muriatic acid, the silex was obtained, which, after having been washed and heated red-hot for half an hour, weighed 66·25 grains.

c. The solution in water was precipitated by carbonat of potash, which was added in excess, taking care to keep the liquor boiling during the process. The precipitate obtained was dissolved in caustic potash, except a small portion of a yellowish powder.

d. To the liquor precipitated by carbonat of potash muriatic acid was added in excess, and caustic ammonia, without the liquor undergoing any change: a proof that it contained neither glucine, zircon, nor yttria.

e. To the solution in caustic potash, muriat of ammonia was added, and it was boiled till the ammonia was expelled in vapour. The alumine obtained by this process was carefully washed, and heated red-hot. In this last operation, when the incandescence was carried to a high degree, the mass emitted a fuming vapour; an unexpected phænomenon, that did not take place at a less elevated temperature. As these gentlemen conceived this vapour to be muriat of ammonia, part of which might have remained in the mass, it was heated red-hot in the fire till full two hours longer. After this the alumine weighed 107·5 grains. In another experiment, when the alumine had been exposed to a lower degree of heat, and for a quarter of an hour only, 116 grains were obtained, which were reduced to 107 5 by calcination. In these experiments an aluminous salt was found to attach itself to the edges of the lid that covered the crucible, but the smallness of its quantity did not allow its nature to be examined. Another time, instead of exposing the alumine to heat, they dissolved it in sulphuric acid, and added a little potash, when the result was a crystallization of sulphat of alumine, which continued to the last drop. The sulphuric acid, in dissolving the alumine, left a residuum of two grains of silex.

f. The yellow powder, which was not attacked by the caustic potash (*c*), was dissolved in nitromuriatic acid. Being evaporated to dryness, and redissolved in water, a grain and half of silex were separated from it. By adding to the liquor succinat of ammonia, a precipitate of oxide of iron, weighing 1·75 grain, was obtained; and on adding caustic ammonia one grain of alumine was precipitated. The remaining liquor being boiled with carbonat of potash, some carbonat of lime was separated, which, after being heated red-hot in the fire, weighed 1·75 grain. This portion of lime dissolved in weak sulphuric acid without effervescence, forming with it sulphat of lime.

Thus, if we subtract the four grains of silex gained from the mortar in reducing the stone to powder, we find the proportions given by 100 parts of it to be

Alumine . .	53·25
Silex . . .	32·88
Lime . . .	0·88
Oxide of iron .	0·88
	87·89
Loss by calcination	0·75
Loss in the analysis	11·36
	100

The last-mentioned loss, which was experienced in several trials, led these gentlemen to suspect the presence of an alkali. In consequence, they heated the stone with nitrat of barytes, dissolved in sulphuric acid the mass obtained by this operation, and poured ammonia into the solution. The saline liquor being evaporated, and the salt heated red-hot in a platina crucible, they imagined in what remained they discovered traces of a salt with an alkaline base, mixed with sulphat of lime, but the quantity of which was too small to ascertain its weight. They supposed it probable too, that this salt might have been produced by the reagents. Thus it remained to examine, whether this stone did not contain an acid, as the fluoric for instance.

In order to determine this, they saturated with muriatic acid the liquor that remained after the precipitation of the earthy substances in the preceding experiments, and then added muriat of lime. No precipitate, however, was obtained. They then determined to boil for an hour a portion of the stone, previously reduced to powder, in sulphuric acid. Employing a glass retort in this operation, they placed a vessel filled with lime-water to receive the gasses that should pass over during the solution. None however came over, except what was contained in the vessels, and the lime-water underwent no alteration. But they saw that the upper part of the retort, and part of the receiver, had been corroded by fluoric acid. This acid, therefore, actually exists in the stone, though perhaps in small quantity, or strongly united with its base.

Mr. J. G. Gahn observed a more considerable extrication of it, by treating with sulphuric acid the powder of this stone previously fused with an alkali. In the experiment of Messrs. Hisinger and Berzelius with nitrat of barytes, this change could scarcely be perceived. Hence they still entertained a suspicion, that the fluoric acid, which adheres strongly to alumine, might have carried off a portion of this earth with it at a high temperature, as was observed by Mr. Klaproth in his experiments on the topaz. Thus in their experiments a loss of both fluoric acid and alumine may have occurred at the same time.

Finally, they conceive the presence of fluoric acid will explain that striking emanation of bubbles, which is exhibited by this stone when exposed to the flame of the blowpipe: it appears, that part of the acid united to its earthy base produces a very fusible substance, while another is extricated in the form of vapour. This supposition is strengthened by the observation of Mr. Gahn, that the topaz, particularly that of Brazil, when exposed to a very violent heat, emits bubbles similar to those produced on the pyrophysalite.

As the topaz contains alumine and silex, with a portion of fluoric acid, perhaps the pyrophysalite ought to be classed mineralogically between the topaz and the pyenite, which, according to Mr. Bucholz, contains 0·17 of fluoric acid; see Pycnite: but Haüy thinks, that it should be considered merely as a variety of the topaz.—*Annales de Chimie.*

Pyrotechnics. The art of making fireworks. In this art the chief objects are to produce a stream of fire, or an explosion. Gunpowder included in a strong paper implement affords the latter effect; the fiery stream is produced by mixing the ingredients of gunpowder together in different proportions, and pulverizing them without wetting. These burn more slowly than grained gunpowder. A sky-rocket is formed by ramming this composition into a paper tube, to which an arrow or tail is connected. The explosive stream gives the rocket a progressive motion by its reaction. Rockets are sometimes used in war; but as they are most commonly exhibited for mere amusement, it is usual to include gunpowder in the head of the rocket with balls of a still more slowly burning compound, with additions to vary the colour they exhibit at the instant of the explosion, and for a few seconds afterward.

Lights are also made for signals and station-marks. But as all these objects are in some measure remote from the explanation of scientific chemistry, the reader is referred to treatises written expressly on this art. See Rocket.

Pyroxene. The black volcanic schoerl, as it has been called by some, the volcanite of Delametherie, octaëdral basaltine of Kirwan, augit of Werner, is thus named by Haüy, greatly resembles hornblende in colour, form, and apparent texture.

It has a very obvious lamellated texture in a longitudinal direction, but uneven transversely. It is harder than the peridot, and less easy to fuse by the blowpipe, yet a small fragment of any of its varieties may be fused completely into a black enamel. These characters hold both in the crystallized and amorphous pyroxene; but when crystallized, which it most usually is, it is more easy to be distinguished.

The common form of its crystals is a short compressed prism of six or eight sides, terminated by two oblique culminating faces. The junctures of the laminæ lead to an oblique prism with rhombic bases, the sides of which have an inclination of 92° 18′ and 87° 42′, which is the primitive form. The specific gravity of this stone is from 3·2265 to 3·4771.

Its colour is commonly a pure bottle green, or deep green, frequently not to be distinguished from black, though sometimes it is gray, or even white; but whatever the colour appears in the mass, unless it be white, when powdered it is green.

According to the analysis of Vauquelin, this stone consists of

Silex	0·52
Lime	0·13
Alumine	0·03
Magnesia	0·10
Oxide of iron	0·15
Manganese	0·02
	0·95

Trommsdorff says, that it contains near 5·18 per cent of potash; and only 7 of oxide of iron. In other respects he does not differ much from Vauquelin.

What appears to be merely a variety of the pyroxene, and is so classed by Brongniart, has been distinguished by the name of *coccolite*, from its being in small, irregular, rounded grains, or in masses composed of such grains easily separable. These are of a green colour, more or less deep, and have yet been found only in veins at Arendahl in Norway, and Mericia in Sweden, and in the iron mines of Hellestad and Assebo in Sudermania.

The augite pyroxene in small black or green crystals is found principally in those volcanic productions which bear the most evident marks of their origin, or in the most recent lavas and scoriæ. In these it is frequently abundant, and when the lava is decomposed its crystals readily separate from it. Some pulverulent lavas or volcanic ashes, such as those of Stromboli and Etna, seem to be entirely composed of small crystals of pyroxene.

Most mineralogists consider this stone not as a volcanic product, but as having existed in the rocks that furnished the matter of the lava. Patrin, however, supposes that it has been formed in the lava itself, while in a state of fusion, as we see crystals formed in glass: and Dr. Thomson observed acicular crystals of pyroxene sublimed on the walls of the church of la Torre, which was surrounded by the lava of the eruption in 1794.

Pyroxene is less common in rocks not evidently volcanic, and still more rare in primitive rocks. That which occurs in basaltes with peridot and hornblende is in larger crystals, and these are more green and brilliant than when it is found in other situations. But it is met with in rocks that are unquestionably of aqueous origin. Dolomieu has observed it in a rock intermediate between trap and petrosilex, and mixed with green serpentine, above Gedra, in the valley of Gavarnia, in the Pyrenees; where it is in well defined and shining crystals, of a tolerably pure and deep green. It is likewise mentioned as existing in amygdaloides, &c.

Some of the crystals of pyroxene affect the magnetic needle.—*Brongniart.*

Q.

QUADRUM, a grit-stone with a calcareous cement. When it contains about 50 per cent, or more, of silex, it belongs to this species; it contains also a small proportion of alumine and iron; it hardens by exposure to the air, and then strikes fire with steel, and effervesces slightly with acids: it is sometimes crystallized in rhomboids, as at Fontainbleau. One hundred parts of this contain, by the experiments of Mr. Lassone, 62·5 of silex, and 37·5 of carbonat of lime.

The saxum margariticum of Linnæus belongs also to this species: it consists of quartz in a calcareous cement.

QUARTATION, is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus, when gold alloyed with silver is to be parted, we are obliged to facilitate the action of the aqua fortis by reducing the quantity of the former of these metals to one fourth part of the whole mass; which is done by sufficiently increasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting; and even many authors extend this name to the operation of parting. See PARTING.

QUARTZ. Some chemists make a distinction between quartz and rock-crystal. Cronstedt arranges the latter as a species of the former, as does Kirwan also. In general, those crystals of the siliceous order which are clear and perfect, and do not crack in the fire, are called rock-crystals. See CRYSTAL (ROCK). And those which are coloured, full of flaws, rounded, and irregular, are called quartz.

The transparent quartz or rock-crystal is either colourless and crystallized in hexagonal pyramids, and then called mountain-crystal, or in various other forms, or irregular. Its specific gravity is from 2·64 to 2·7; its texture is lamellar and generally shattery, and its appearance is glassy. It cracks and loses its transparency when heated; it possesses all the other properties of pure siliceous earth. Bergman has extracted from 100 parts of mountain-crystal, about six of alumine, and one of lime. So also has Mr. Abilgaard, quoted by Kirwan. Yet Gerhard says, that some are so pure as to contain neither. He also says, that the irregular crystals, though colourless, being long digested in acids, afforded, when treated with pure prussiat of potash, some traces of iron.

The purest and most transparent of these crystals form the false diamond, called Bristol or Kerry stone, diamant d'Alençon, &c.

The coloured transparent crystals derive their tinge generally from metallic particles in exceeding small proportion; they all lose their colour when heated; these form the false gems. The most remarkable are the

Red, from Oran in Barbary; false rubies.
Yellow, from Bohemia; false topazes.
Green; false emeralds and prases.
Violet, } from Bohemia and Saxony.
Blue, }

It is said, that brown crystals may be cleared by boiling them in tallow.

The opake quartz or pebbles are also crystallized, or irregularly figured, either white, gray, or yellowish, or tinged of other colours by metallic particles. The former are less pure than those of the first series, containing a larger proportion of clay, or at least the clay is less perfectly united with the siliceous part. Their specific gravity is from 2·4 to 2·7; their surface either rough, or smooth and shining, the last are called fat quartz: the texture either lamellar or granular; they crack like the former in fire, and become of a duller colour; when rubbed against each other, they emit a phosphoric smell. They are often found in round masses in the beds of rivers.

The coloured opake quartz are either, 1. Black, being mixed with a large proportion of iron. 2. Red. According to Cronstedt they contain copper, but Bergman could find none in them. 3. Blue, from Uto in Sweden. And 4. Green, found at Adelsdorf in Sweden.

Though the powdery state of other stones does not deserve any particular notice, yet that of quartz or silex does, from the great use that is made of it, and from its seeming to possess properties which are incompatible with it in a grosser state. It is of various colours, and incapable of forming a mass, or hardening with water. The purest is white, the minute particles of which, when inspected through a lens, are transparent. It is seldom perfectly pure. Mr. Achard says, that the fine white sand of Freyenwald, which is used for the porcelain manufactories, contains one third of its weight of clay and calcareous earth; but Kirwan is inclined to suppose, that this is a petrosilex in powder.

QUARTZ (ELASTIC). Sandschiefer, flexible stone. This stone, remarkable for a certain degree of elastic flexibility, was brought about thirty years ago from the diamond mines of the Brazils. It is met with likewise in Thuringia. It is supposed, however, to have been known in the sixteenth century, and to be described by Gassendi, in his Life of Peiresc, as a flexible whetstone. In its form and appearance it resembles the Turkey hone, or novaculite.

On inspecting with a lens the integrant parts of the stone, which may be easily separated by pounding or trituration, they appear to be flat, longish scales, perfectly clear and pellucid; some truncated more obtusely, others less; some longer and thinner, others broader and shorter. These are all interwoven in one single direction, and implicated in such a manner, that each junction resembles a vertebra, or hinge. To this mode of aggregation its elasticity may apparently be ascribed. If the stone be held upright, and shaken, it vibrates with some noise to and fro; and on ceasing to shake it, its parts conjoin again firmly by a force like a spring. It phosphoresces when scraped with a knife in the dark. Specific gravity 2·624 according to Kirwan; but Gerhard gives 3·75 of a specimen. It strikes fire with steel, and cuts glass with ease. By Klaproth's analysis, 100 parts contain silex 96·5, alumine 2·5, oxide of iron 0·5.—*Klaproth.*—*Kirwan.*

Quartz (Rhombic). See Feldt-Spar.

Quercitron. Dr. Bancroft has made known the use of the bark of a kind of oak, called yellow oak in New England, and has obtained an exclusive right to the traffic of this bark in France and England: he calls it quercitron.

According to Dr. Bancroft, the quercitron bark may be advantageously substituted for weld in the printing of linens; but it must be only simply infused in warm water, and only one part employed, instead of ten of weld.

To dye wool yellow, Dr. Bancroft advises, that solution of tin and alum should be put into the bath with the quercitron. Silk ought to be treated in the same manner as with weld: if a very bright yellow be required, it must be prepared with solution of tin.

It appears from some information, for which Berthollet was indebted to Mr. Brown, that many manufacturers of printed linens in England at present prefer this bark to weld, because it is considerably cheaper, and the ground whitens more easily. Some find it advantageous to mix a certain proportion of decoction of weld with the quercitron bath, which should be exposed to only a gentle heat. Mr. d'Ambourney asserts, that, to obtain the advantages set forth by Dr. Bancroft, the wool must be first prepared with solution of tin, and then his process followed.

Quick-lime. See Earths, art. Lime.

Quicksilver. See Mercury.

Quinquina. See Cinchona.

Quintessence. As the essence of any medicinal substance, or that in which its chief virtue resided, was supposed by the old chemists to be obtainable in a condensed form by distillation; so they imagined, that it was still farther condensed and purified by subsequent distillations. Hence they used the term quintessence, or result of the fifth distillation, to denote any thing thus brought to its highest degree of purity as they conceived. It is now obsolete.

R.

Radical. That which is considered as constituting the distinguishing part of an acid by its union with the acidifying principle, or oxigen, which is common to all acids. Thus sulphur is the radical of the sulphuric and sulphurous acids. It is sometimes called the base of the acid, but base is a term of more extensive application.

Radical Vinegar. See Acid (Acetic).

Rag-stone. The colour of this stone is gray; its texture obscurely laminar, but the laminæ consist of a congeries of grains of a quartz appearance, coarse and rough; its specific gravity is 2·779; it effervesces with acids, and gives fire with steel. It is used as a whetstone, frequently without the application either of water or oil.

Whence it comes to us I know not, but its appearance resembles the pumice in every respect except density, in which this greatly exceeds. Its component parts in Kirwan's tables are 70 silex, 5 alumine, 25 carbonat of lime, and 5 iron, as he thinks. This differs from the Rowley Rag, which see.

Rain. See Meteors.

Rainbow-stone. See Moon-stone.

Rancidity. The change which oils undergo by exposure to the air.

Fixed oil, exposed for a certain time to the open air, absorbs oxigen, and acquires a peculiar odour of fire, an acrid and burnt taste, at the same time that it becomes thick and coloured. If oil be kept in contact with oxigen in a bottle, it becomes more speedily rancid, and the air is absorbed. Scheele observed the absorption of a portion of the air, before the theory was well ascertained. Oil is not subject to alteration in closed vessels.

It appears, according to the observation of Chaptal, that oxigen, combined with the mucilage, constitutes rancidity; and that, when combined with the oil itself, it forms drying oil.

The rancidity of oils is therefore an effect analogous to the oxidation of metals. It essentially depends on the combination of oxigen with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the processes used to counteract or prevent the rancidity of oils.

When olives are prepared for the table,

every endeavour is used to deprive them of this principle, which determines their fermentation; and for this purpose various methods are used. In some places they are macerated in boiling water charged with salt and aromatics; and after twenty-four hours digestion they are steeped in clear water, which is renewed till their taste is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood-ashes, after which they are washed in clear water.

But in whatever manner the preparation is made, they are preserved in a pickle impregnated with some aromatic plant, such as coriander and fennel. Some persons preserve them whole; others split them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All these processes evidently tend to extract the mucilaginous principle, which is soluble in water, and by this means to preserve the fruit from fermentation. When the operation is not well performed, the olives ferment and change. Chaptal affirms, that, if the olives be treated with boiling water to extract the mucilage before they are submitted to the press, a fine oil will be obtained, without danger of rancidity.

When the oil is made, if it be strongly agitated in water, the mucilaginous principle is disengaged; and the oil may be afterward preserved for a long time without change. The author above mentioned preserved oil of the marc of olives, prepared in this manner, for several years in open bottles without any alteration.

The torrefaction, to which several mucilaginous seeds are subjected before the extraction of the oil, renders them less susceptible of change, because the mucilage has been destroyed.

Mr. Sieffert has proposed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle, which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be considered as the principle of the rancid ferment.

Rapakivi. See **Granite.**

Rayonnante. This name, bearing the same meaning in French as *strahlstein* in German, is used for this stone by Brochand. The *rayonnante en gouttière* of Saussure, however, is an ore of uranium.

Reagent. In the experiments of chemical analysis, the component parts of bodies may either be ascertained in quantity as well as quality by the perfect operations of the laboratory, or their quality alone may be detected by the operations of certain bodies called reagents. Thus the infusion of galls is a reagent, which detects iron by a dark purple precipitate; the prussiat of potash exhibits a blue with the same metal; &c. See **Analysis** and **Waters (Mineral).**

Realgar. The red sulphuretted ore of arsenic. This has already been noticed under the head **Orpiment**, which is the yellow sulphuretted ore of the same metal: but as a more minute examination of them, with a view to determine the real state of their component parts, instituted by Mr. Thenard, and published in the Annales de Chimie, has come to our hands since that article was sent to press, it may be satisfactory to the reader to find it here.

Orpiment and realgar, he observes, are two ores of arsenic sufficiently abundant. The first is almost always in the form of laminæ of a pure yellow colour; and the second is as generally a red mass more or less brown. Bucquet asserted, that these compounds were formed of oxide of arsenic, and sulphur, in the same proportions, and ascribed their difference of colour to the different degree of heat employed in preparing them. Bergman likewise admitted the oxide of arsenic, as well as sulphur, in both; but he imagined they differed in colour because they contained different proportions. These opinions, supported by some experiments that were capable of deceiving, prevented chemists for some time from forming a decided opinion: that of the Swedish chemist however prevailed; and since the creation of the new theory, and the reform of chemical language, orpiment and realgar are described in chemical treatises under the names of yellow sulphuret of oxide of arsenic, and red sulphuretted oxide of arsenic. Nevertheless some have lately thought, that these two substances differed less with respect to their proportions of sulphur, than those of their oxigen.

Thus it has been successively supposed, 1st, that orpiment and realgar were homogeneal compounds containing burned arsenic: 2dly, that they were oxides more or less sulphuretted: and 3dly, that they were oxides more or less oxided as well as more or less sulphuretted.

The partisans of the first opinion ground it on the fact, that by heating equal quantities of arsenious acid and sulphur in a less or greater degree, the product is sometimes orpiment, at others realgar: therefore, say they, if their colour differ, it is owing to the heat, which occasions a different arrangement of their particles.

Those of the second refer to the analysis of orpiment and realgar in the humid way. As they obtained from the latter much more oxide of arsenic, and less sulphur, than from the former, their conclusion appeared to them just.

Those of the third argue from analogy. They imagine, that, when a metallic solution is precipitated by a hidrosulphuret, the sulphuretted oxide that is formed was always of the colour of the oxide it contained.

It is easy to perceive, that none of these reasonings are free from objection: and hence I have imagined it would not be useless, to subject both orpiment and realgar to a fresh examination, in order to find with precision how they differ from each other.

But before I speak of the experiments, however, which I have made with them, I ought to quote what prof Proust says of orpiment in the Journal de Physique, vol. xlix. pp. 411, 412: particularly as I am perfectly of his opinion respecting the nature of this compound:

"Things happen differently," says Mr. Proust, "when, instead of applying potash to the sulphuret of antimony, we add it to the ore of arsenic: the sulphuretted hidrogen, that is formed while the arsenic becomes oxided, does not adhere to this oxide, on precipitating it with an acid, as happens to that of antimony. The hidrogen acts a very different part during this precipitation: it is employed in disoxiding the arsenic, in order that it may attach itself as a metal to the sulphur, and produce the yellow sulphuret, which we call orpiment: for the hidrosulphuret of arsenic, and the sulphuretted oxide, are two combinations that apparently do not exist. If we dissolve white arsenic in thoroughly saturated hidrosulphuret of potash, and afterward add an acid, orpiment is precipitated without the least disengagement of gas, without the slightest smell: but on the one hand the sulphuretted hidrogen is no longer to be found, and on the other the arsenic in the orpiment is in the metallic state: in this precipitation, therefore, water is formed. The pure regulus of arsenic is not soluble in the arsenical hidrosulphuret."

If I might be permitted to make one observation on this passage in Mr. Proust's paper, I would say, that, it seems to me, the experiments adduced by this learned chemist are not altogether sufficient to prove the nonexistence of oxigen in orpiment; for we may account for the result, whether we admit the existence of sulphuretted hidrogen in this compound, or that of an oxide less oxided than the white oxide of arsenic. Mr. Proust has said nothing of realgar.

Both orpiment and realgar, if reduced to powder, and projected on burning coals, melt, swell up, and emit sulphurous acid; but all these phænomena are more obvious with realgar. Heated in close vessels, the fusion and tumefaction are the same, and they are sublimed without changing their nature, consequently without giving out any sulphurous acid.

Sulphur fused with realgar converts it into orpiment, while arsenic fused with orpiment converts it into realgar.

The sulphuric, nitric, nitrous, and oxigenized muriatic acid, are, as is well known, the only ones that attack orpiment and realgar.

Sulphuric acid acts perceptibly with greater power on orpiment than on realgar. In both cases sulphurous acid is formed, and likewise arsenious acid; but more sulphurous acid, and less arsenious, are produced with the orpiment.

Nitric acid is decomposed by both these substances, even without the assistance of heat; and orpiment affords with it more sulphur, and less arsenious acid than realgar.

With oxigenized muriatic acid, and with the nitromuriatic, the same results are obtained as with the nitric.

The alkalis, particularly potash and soda, easily dissolve both, even cold. Hidroguretted sulphuret of potash and arsenite of potash are formed; since on pouring limewater into the solution a pretty copious white precipitate is obtained, which, treated with carbonat of potash, affords a liquor, that yields, on adding a sufficient quantity of muriatic acid, and evaporating to a proper point, a great deal of arsenious acid.

All these experiments show, that more sulphur is contained in orpiment than in realgar, and some of them lead us to suspect, that no oxigen is present in either. The following will serve farther to establish the former fact, and will place the latter in a stronger light.

It is very certain, that if arsenic were in the state of oxide in these compounds, they might easily be formed by employing arsenious acid and sulphur. But on heating these substances together in a retort, &c., we obtain for a long time nothing but sulphurous acid: it is not till this gas nearly ceases to come over, that orpiment or realgar is formed. It may be said, indeed, that arsenic is less oxided in these sulphurets than in arsenious acid; but the existence of such oxides has never been proved. When arsenious acid is reduced by any method whatever, even by means of hidrogen gas, nothing is ever obtained but arsenious acid and arsenic, suspend the process at what period of it you please; and probably, if there were any fixed intermediate degrees of oxidation, they would be detected by proceeding in this way. Be this as it may, by combining sulphur with arsenic in different proportions in close vessels, we obtain at pleasure orpiment or realgar.

Three parts of sulphur and four of arsenic from orpiment: one of sulphur and three of arsenic from realgar. Realgar enters into fusion at a very low temperature, and continues fluid long after the retort is withdrawn from the fire. Orpiment requires a somewhat higher heat to fuse it. Both rise by sublimation, and adhere to the neck of the retort. The orpiment is transparent, and of a hyacinth colour, so that at first it might be taken for a sort of realgar; but native orpiment itself assumes this colour on being melted, and both, that is the native orpiment after its beautiful colour has been thus changed and the artificial, become of a very pure and lively yellow by pulverization. It is not the same with the orpiment produced in the humid way. The colour of this is similar to that of native orpiment that has never been exposed to heat; and it is in every respect similar to it, whether it be the product of a mixture of arsenious acid and sulphuretted hidrogen, or of a soluble arsenite, hidrosulphuret, and an acid.

Thus it appears demonstrated, that yellow orpiment in shining scales, and even endued with a sort of elasticity, is formed in some fluids; while realgar is produced by arsenic and sulphur melted together; and that, since orpiment assumes a hyacinth colour on fusion, similar compounds may possibly exist in nature, and have been mistaken for realgar.

However this may be, it is established beyond a doubt, that orpiment and realgar contain no oxigen: they are sulphurets of arsenic more or less sulphuretted. In orpiment the arsenic is to the sulphur in the proportion of four to three, in realgar in that of three to one. If more than three parts of sulphur be combined with four of arsenic, a yellow compound is obtained, the colour of which is not very lively, and approaches more or less to that of sulphur: in like manner, if less than one part of sulphur be united with three of arsenic, a compound of a browner colour than common realgar is formed: and as sulphur and arsenic are capable of combining together in a great number of different proportions, the shades that sulphuret of arsenic may present to us must be very numerous.

Receiver. Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

Receivers ought to be made of glass, not only because this matter resists the action of the strongest and most corrosive substances, but also because, being transparent, it allows the operator to see through it, and to judge, by the frequency of the drops, whether the distillation proceed too fast or too slow, and also whether the quantity and nature of the substances which come over be such as are required.

Almost all receivers are a kind of bottles of different sizes, of a spherical form, the necks of which are cut short, and each of which is pierced with a small hole in its lateral or upper part, to give vent to the air or vapours which are too expansive. Receivers of this form are called balloons. See Balloon.

Some receivers are matrasses with long necks. These are generally adapted to the beaks of glass alembics. This long neck serves to keep the belly of the receiver, where the liquor is collected, at a proper distance from the fire.

Receivers have different forms for particular operations. Such are those which have two or three beaks, either to be adapted to other receivers, or to admit at the same time the necks of several distillatory vessels, when the intention of the operator is, that the vapours of different substances should meet in the same receiver. Such also are receivers for essential oils, which are very convenient for the distillation of these oils. To obtain the essential oil of aromatic plants, these plants must be distilled with water. The plant and the water are to be put together into a cucurbit, and the water, which is to receive a boiling heat, rises in distillation, carrying with it the essential oil, which also has the property of rising with this degree of heat. See Oils.

As a large quantity of water must be employed, that the plant may always be kept immersed in the alembic, and consequently as a good deal of it rises in proportion to the oil, any receiver of ordinary size would be soon filled with water with a little oil floating upon its surface, and would require to be frequently changed; which would be very troublesome, and would occasion a loss of part of the oil.

These inconveniences are avoided by using receivers contrived purposely for such distillations. They are so made, that they are never full, but that the water runs out, and leaves the oil behind. They are a kind of glass cucurbits, which contract as they rise higher; so that their neck, or upper opening, is but nearly of a convenient size to receive the beak of the worm. These receivers have another opening about the middle of the swelling or belly; and to this opening is joined a glass tube, which bends and rises vertically along the outer part of the receiver, so as to be within two inches and a half as high as the upper opening. At this height the tube bends again towards the side opposite to the body of the receiver, to pour into another vessel the liquor which rises there. It forms the figure of S.

When this receiver is to be used, it is to be placed vertically under the beak of the worm. During the distillation, the liquor rises to an equal height in the body of the receiver and in the crooked tube: when therefore the height of the liquor in the receiver becomes greater than the height of the tube, it must begin to flow from the mouth of this tube into another vessel placed on purpose to receive it: but as essential oils are either lighter or heavier than water, and as they are therefore always collected either above or under the water, and as the liquor which discharges itself through the tube is taken from the middle part of the receiver, therefore nothing but water can be evacuated at the mouth of the pipe, while the oil always remains in the receiver. Thus, with such a receiver, we may distill without the trouble of changing the vessels; which is certainly very advantageous.

Rectification. By rectification is meant the exact purification of certain substances, by means of distillation or sublimation.

This operation is necessary to disengage many chemical products or agents from a mixture of extraneous matters which destroy their purity. Thus, for instance, sulphuric acid, when first obtained from sulphat of iron, or from sulphur, is always mixed with a considerable quantity either of sulphurous acid, or of superabundant water, which weakens it. It is separated from both these matters by a second distillation, in which they, being more volatile than the acid, are carried off; which second distillation is called concentration or rectification of sulphuric acid.

Also, when animal and vegetable matters are decomposed by distillation, all the portion of oil that is not volatile, contained in these substances, does not rise but with a degree of fire so strong as to burn a part of them, and to raise along with them a considerable portion of saline substances, which being mixed with the oily part considerably alter its purity. To purify these oils, which from their burnt smell are called empyreumatic, new distillations must be applied, in which, by means of a less heat, the most volatile and purest part of these oils is separated from the most empyreumatic and saline parts, which remain at the bottom of the retort: this is called the rectification of empyreumatic oils. See Oil.

The alcohol obtained by a first distillation of liquors which have undergone the spirituous fermentation, is overcharged with a large quantity of water and light oil, which rise along with them in this first distillation. The product of this distillation has been called aqua vitæ. It is an ardent spirit, very far from the degree of dephlegmation and purity which alcohol ought to have, to render it fit for chemical operations, and for several compounds commonly used, such as perfumed waters and liqueurs for the table. This spirit is to be purified by new distillations, slowly conducted with a gentle fire and water-bath; by means of which the most volatile part, that always rises first with the least heat, and which is the true alcohol, is separated from the less volatile part, that remains in the alembic, and which contains the phlegm and oil of wine by which the alcohol was rendered impure. The first liquor of these second distillations or rectifications is called rectified spirit of wine. See Alcohol.

The volatile salts obtained in the decomposition of certain oily substances, as volatile alkalis, from decomposed animal matters, are always very impure, and spoiled by much fetid empyreumatic oil, which rises along with them. They are purified and disengaged by subjecting them to new distillations or sublimations with a well-conducted heat. The same observation is applicable to muriat of antimony, artificial cinnabar, phosphorus, and to many other chemical products, which are always impure when obtained by a first operation, and must therefore be purified by a second distillation or sublimation. All these second operations, intended merely to purify matters, are called rectifications. They are not generally attended with much difficulty. We shall not therefore enter into the details of them; but we shall only observe, that all rectifications are founded upon the same principle. They all consist in separating substances more volatile from substances less volatile; and the general method of effecting this is to apply only the degree of heat which is necessary to cause this separation. See Distillation and Sublimation.

Red Cabbage. For the use of this as a test, see Brassica Rubra.

Reddle, *or* Red Chalk, an ore of iron in the state of red oxide commonly used as a pigment. Red lead pencils, as they are vulgarly called, are made of this substance.

Red Lead. See Minium, also Reddle.

Reduction, *or* Revivification. This word, in its most extensive sense, is applicable to all operations by which any substance is restored to its natural state, or which is considered as such: but custom confines it to operations by which metals are restored to their metallic state, after they have been deprived of this, either by combustion, as the metallic oxides, or by the union of some heterogeneous matters which disguise them, as fulminating gold, luna cornea, cinnabar, and other compounds of the same kind. These reductions are also called revivifications.

Metals converted into oxides have not their peculiar colour, lustre, ductility, nor even consistence and gravity. They have the appearance of earths, the parts of which are unconnected, unless they have sustained a fire violent enough to fuse them; and then they become brittle vitrified matters.

But these metallic earths, oxides, or glasses, are capable of being again restored to the combustible state, and of recovering all the metallic properties. For this purpose their calcination must not have been too complete, and some other combustible matter must be applied in a state favourable for combination. These oxides, particularly of such metals as cannot be radically oxided, as lead, bismuth, iron, and copper, may recover their combustible state, and may be reduced, even without fire or fusion, merely by the contact of volatile inflammable matter; for instance, by sulphuretted hidrogen; or they may be reduced in the humid way, that is, when they are precipitated by some proper substance. See Phosphorus, also Precipitate.

But we must observe, that metals reduced by either of these methods are only superficially so, when the metallic masses are considerably large; and that when the metals thus reduced consist of fine molecules, these molecules, though well reduced and provided with all their metallic properties, remain always disjoined and separated from each other; either because they are not small enough or because they have not time to unite and agglutinate together, as they have when they are combined by nature; for metals are certainly formed naturally by these methods: but the operations of our laboratories are very different from those of nature. Accordingly, in practical chemistry a much more expeditious method for making these reductions is employed; which is fusion.

The reduction of metallic oxides by fusion is generally a quick and easy operation. It however requires certain attentions and management; which are,

1. To mix accurately the metallic oxide to be reduced with the proper quantity of the combustible matter which is to reduce it.

2. To add to the mixture some saline or vitreous matter capable of facilitating the fusion and separation of the reduced metal from the scoria.

3. To prevent any communication with external air, that the inflammable addition may not be burnt and consumed.

4. To keep the fire low at first, that the too great swelling, which is generally occasioned by the extrication of volatile or elastic matter, may be prevented; and to raise the fire toward the end, so that not only the metal, but also the supernatant scoria, may be perfectly fused. For if the scoria was not well fused and tenacious, it would retain much of the reduced metal, and prevent it from falling down to the bottom of the crucible.

The operations must be very exactly performed, especially in essays of ores, in which the precise quantity of metal is required to be known. These essays of ores are in some measure the only reductions of this kind which are performed in practical chemistry, as the reduction of pure metallic oxides differs from the former in only requiring a less quantity of flux; because these oxides do not, as the ores do, contain a difficultly fusible earthy or stony matter: we therefore refer to the article **Ores**. Here it may be observed, that when we treat very volatile semimetals, as zinc and arsenic, the reduction ought to be made in vessels perfectly close; for instance, in an earthen retort. We find these metallic matters after the reduction sublimed in the vault or neck of the retort.

The reduction of metals which do not easily lose their combustible state, as gold, silver, and mercury, is of another kind. As these metals can only be disguised by the union they have contracted with some heterogeneous substance, they are to be reduced simply by the addition of some intermediate substance capable of separating from them the matter which is united with them. These intermediate substances must therefore differ according to the matter united with the metal.

For instance, fulminating gold may be reduced by fusing it with sulphur, or with fixed alkali; because either of these substances is capable of separating the ammonia, which gives the fulminating property to gold. See **Gold (Fulminating)**. Luna cornea also is reduced by fusing it with a large quantity, as for instance with twice its weight of fixed alkali; because in this reduction the muriatic acid united with the silver is to be separated, and the fixed alkali is capable of effecting that separation. The reduction of luna cornea is attended with difficulties, because this compound is semivolatile and very penetrating; so that when it is exposed to fire, some part of it is always lost, whether it exhales in vapours or penetrates the crucible. Several chemists recommend the reduction of luna cornea by fusing it with fat matters, which, from experience, Macquer declares to be a very bad method; for the muriatic acid has a strong affinity with silver, and has no disposition to unite with fats. See **Silver**.

Luna cornea may also be well reduced by precipitation, and by treating it with other metals which have more affinity than silver to muriatic acid, such as tin, iron, antimony. Margraaf gives, in his Opuscules Chemiques, a process which deserves a place here; because, according to this excellent chemist, a very pure silver is obtained, and without any loss. It consists in mixing well in a glass mortar luna cornea with some concrete ammonia, in the proportion of above five drachms of luna cornea to an ounce and a half of volatile salt, to which a little water is to be added to give to the mixture a soft consistence. The mixture swells with a kind of effervescence. After it has been triturated a quarter of an hour, three ounces of very pure mercury revived from cinnabar are to be added. The trituration is to be renewed for two or three hours, and half a drachm of ammonia is to be added, to replace that which is dissipated; and afterward a larger quantity of water. Upon the addition of this water appears a fine amalgam of silver, which is to be washed several times, till the water comes off clear. This amalgam is then to be distilled; by which the mercury is expelled, and all the silver which was contained in the luna cornea remains pure, excepting about four grains which have been washed away.

The mercury of cinnabar is to be reduced or separated from sulphur, by mixing with the cinnabar any substance which has greater affinity with sulphur than mercury has; such as fixed alkalis, absorbent earths, iron, copper, lead, silver, or antimony. Filings of iron are generally employed in this operation, an equal weight of which is to be mixed with the cinnabar, and the whole distilled together, by which the mercury will be raised and collected at the bottom of the receiver under some water placed there to facilitate its condensation. The sulphur of the cinnabar remains in the retort united with the intermediate substance employed for the separation. This mercury is called mercury revived from cinnabar; and is justly considered as very pure. See Metals.

Refining is a term used in chemistry and several arts to signify the purification of some substance, particularly of metals, as gold, silver, copper, iron, &c.

We shall here treat only of the refining of gold and silver; and for the refining of other substances we refer to their several articles.

Gold and silver may be refined by several methods, which are all founded on the essential properties of these metals, and acquire different names according to their kinds. Thus, for instance, gold, having the property which no other metal, not even silver, has, of resisting the action of sulphur, of antimony, of nitric acid, of muriatic acid, may be purified by these agents from all other metallic substances, and consequently may be refined. These operations are distinguished by proper names, as purification of gold by antimony, parting, concentrated parting, dry parting. In a similar manner, as silver has the property, which the imperfect metals have not, of resisting the action of nitre, it may be refined by this salt: but the term refining is chiefly applied to the purification of gold and silver by lead in the cupel. We shall therefore treat only of this latter manner of purifying these metals, referring for the others to the words Purification and Parting; which see.

The refining of gold and silver by lead in the cupel is performed by the destruction, vitrification, and scorification of all the extraneous and destructible metallic substances with which they are alloyed.

As none but the perfect metals can resist the combined action of air and fire without being oxided, and thus changed into earthy or vitreous matters incapable of remaining any longer united with substances in a metallic state; there is a possibility of purifying gold and silver from all alloy of imperfect metals merely by the action of fire and air; only by keeping them fused till all the alloy is destroyed: but this purification would be very expensive, from the great consumption of fuel, and would be exceedingly tedious. Macquer says, he has seen silver alloyed with copper exposed longer than sixty hours to a glass-house fire, without being perfectly refined: the reason of which is, that, when a small quantity only of imperfect metal remains united with gold or silver, it is covered and protected from the action of the air, which is necessary for the combustion of the imperfect metals, as of all combustible matters. See Oxidation.

This refining of gold and silver merely by the action of fire, which was the only method anciently known, was very long, difficult, expensive, and imperfect: but a much shorter and more advantageous method has been discovered. This method consists in adding to the alloyed gold and silver a certain quantity of lead, and in exposing afterward this mixture to the action of the fire. Lead is one of the metals which are most quickly and easily oxided: but at the same time this metal has the remarkable property of being very easily melted into a vitrified and powerfully vitrifying matter, called litharge. See Litharge.

The lead, which is to be added to the gold and silver to be refined, or which happens naturally to be mixed with these metals, produces in their refining the following advantages: 1. By increasing the proportion of imperfect metals, it prevents them from being so well covered and protected by the perfect metals. 2. By uniting with these imperfect metals, it communicates to them a property it has of being very easily oxided. 3. Lastly, by its vitrifying and fusing property, which it exercises with all its force upon the oxided and naturally refractory parts of the other metals, it facilitates and accelerates the fusion, the scorification, and the separation of these metals. These are the advantages procured by lead in the refining of gold and silver.

The lead, which in this operation is scorified, and scorifies along with it the imperfect metals, separates from the metallic mass, with which it is then incapable of remaining united. It floats upon the surface of the melted mass, because it loses also part of its specific gravity: and lastly it vitrifies.

These vitrified and melted matters, accumulating more and more upon the surface of the metal while the operation advances, would consequently protect this surface from the contact of air, which is absolutely necessary for the scorification of the rest, and would thus stop the progress of the operation, which could never be finished, if a method had not been contrived for their removal. This removal of the vitrified matter is procured either by the nature of the vessel in which the melted matter is contained, and which being porous absorbs and imbibes the scorified matter as fast as it is formed; or by a channel cut in the edge of the vessel, through which the matter flows out.

The vessel in which the refining is performed is flat and shallow, that the matter which it contains may present to the air the greatest surface possible. This form resembles that of a cup, and hence it has been called cupel. The furnace ought to be vaulted, that the heat may be applied upon the surface of the metal during the whole time of the operation. Upon this surface a crust or dark-coloured pellicle is continually forming. In the instant when all the imperfect metal is destroyed, and consequently the scorification ceases, the surface of the perfect metals is seen, and appears clean and brilliant. This forms a kind of fulguration or coruscation. By this mark the metal is known to be refined. If the operation be so conducted, that the metal sustains only the precise degree of heat necessary to keep it fused before it be perfectly refined, we may observe, that it fixes or becomes solid all at once in the very instant of the coruscation; because a greater heat is required to keep silver or gold in fusion, when they are pure, than when alloyed with lead.

The operation of refining may be performed in small or in large quantities, upon the same principles, but only with some differences in the management.

Large quantities of silver are thus purified, after the operations by which that metal is obtained from its ores. This silver, being always much alloyed, is to be mixed with a sufficient quantity of lead to complete its purification, unless lead has been added in its first fusion from the ore, or unless it has been extracted from an ore which also contains lead; in which latter case it is alloyed naturally with a sufficient quantity, or more than sufficient, for the refining of it. See ORES OF SILVER. One of the ores of this kind, which is treated in the best manner, is the ore of Ramelsberg in Saxony. The several operations, which are practised in this country abounding in mines and excellent metallurgists, have been exactly described by Schlutter. We shall here give a succinct extract of the method of purifying large quantities of silver, from Hellot's translation of Schlutter's work.

The workmen give the name of *the work* to the lead containing silver obtained by smelting the ore of Ramelsberg. The first operation, called fining, upon this mass of lead and silver, is performed in a furnace called a reverberatory furnace, from the vaulted form, which makes the heat reverberate upon the surface of the metal. This furnace is so constructed, that the flame of the wood, which is put into the fire-place through a hole called the fire-hole, is directed so as to circulate over the work within the furnace. The flame is thus directed by a current of air, which is introduced through the ash-hole, and passes out at an opening made at the side of the place where the work is. The wood is considerably saved by this direction of the flame. In the furnace a large cupel or test is to be disposed. This test is to be made with ashes of beech wood well lixiviated, that the salt may be washed from them. See CUPEL. In some foundries different matters are added to the ashes, as sand, lime, clay, calcined spar, or gypsum. We may observe, concerning these additions, that they would be very injurious, and would make the test melt, if a strong heat were applied; but the heat requisite for fining is only moderate.

When the test is well prepared and dried, all the work is to be put into it at once, which is generally sixty-four quintals: the fire is then to be made in the fire-place with faggots; but the fusion is not to be too much hastened, first, that the test may have time to dry thoroughly, which is very essential; for if any moisture remained when the metal is melted, an explosion might happen: secondly, because the work of the ore at Ramelsberg, and of most others, is rendered impure by the mixture of many metallic matters, which ought to be separated, otherwise they would spoil the litharge, and give a bad quality to the lead afterward obtained from that litharge. These extraneous matters found in the work of Ramelsberg are, copper, iron, and matt. As these substances are hard and refractory, they do not melt so soon as the work, if the heat be moderate; and besides, as they are specifically lighter than the mixture of lead and silver, they float upon the surface of these two metals when melted, in form of a pellicle or skin, which is to be taken off. These impurities are called the scum or first dross. The remainder forms also a scum, which appears when the work has received more heat, but before the litharge has begun to form. This is a scoria, which is to be carefully taken off, and is called the second dross.

When the operation is come to this point, it is to be continued by means of bellows, the air of which is directed not on the wood, but on the surface of the metals, by means of iron plates placed for that purpose before the blast-hole, and which are called papillons. This air is not intended to increase the fire, but to facilitate the combustion of the lead, and to push the litharge to a channel in the opposite side of the test. This channel is called the way of the litharge, because through this passage all the litharge, which is not imbibed by the test, flows out of the furnace. The litharge which is found in the middle of the largest lumps is friable, and crumbles into powder-like sand. It is put into casks, each of which contains five quintals of it, and is sold by the name of saleable litharge. The quantity of this is about one half or one third of the whole litharge that is formed. It is used for various purposes, and particularly for glazing earthen ware. The other part, which remains, is called cold litharge. It is remelted and reduced to lead. This fusion is called cold fusion, and the lead produced from it, called cold lead, is good and saleable, when the work has been well purified from the extraneous matters mentioned above. The tests impregnated with litharge are added to the same kind of ore when smelted; because they contain not only much litharge, which may be reduced to lead, but also some silver, in all refinings, whether in the large or small way, as Mr. Tillet observes.

When about two thirds of the work are converted into litharge, no more litharge is formed: the silver is then covered with a sort of white skin, which the refiners call lightening: and they call the metal lightened silver, or fined silver." The silver thus fined is not pure: every marc of it contains about four gros of lead: the purification of it is completed in the ordinary method; that is, by a second cupellation with a hotter fire; which latter purification is called refining, and the persons who perform it are called refiners. The workmen employed in this first operation, or fining, give improperly the name lightening to the white skin formed on the surface of the silver, when brought only to a certain degree of fineness; for we know that in essays the lightening or coruscation above mentioned does not appear but when the silver is perfectly fine, or at least as fine as it can be made by cupellation.

A fining of sixty-four quintals of work of Ramelsberg yields about eight or ten marcs of fine silver, thirty-five or forty quintals of litharge, that is, from twelve to eighteen of saleable litharge, from twenty-two to twenty-three of cold litharge, from twenty to twenty-two quintals of tests, and six or seven quintals of dross. The operation lasts from sixteen to eighteen hours.

If the silver before these operations were alloyed by gold, it retains this gold still after the fining and refining. The gold, if the quantity be considerable enough, may be separated by parting. The operations for the purification of gold by cupellation are perfectly the same as those of silver. If the gold to be fined contains silver, this silver remains with it after the operation, because both these metals resist the action of lead. The silver may afterward be separated by parting.

Refraction. The inflection or deviation of a ray of light from its rectilinear course, on passing out of one medium into another of different density, when the surfaces of those mediums are not at right angles with the course of the ray.

As the refractive power of bodies is uniform, Dr. Wollaston observes, it may frequently be employed with advantage to ascertain the purity or identity of substances; and in the Philosophical Transactions for 1802 he has given a figure and description of an ingenious instrument for measuring refractions.

Mr. Biot has likewise applied it as a mean of ascertaining the component parts of transparent substances. It was from this property Newton concluded, that not only the diamond, but water, must contain a combustible substance: and Mr. Biot has found by experiment, that the refractive power of a mixture is always proportional to those of its component parts, allowance being made for the density of the mixture, if any considerable variation in this respect be produced. Thus he finds, that the refraction of atmospheric air is precisely what ought to be produced by a mixture of oxigen 21, nitrogen 78·7, and carbonic acid 0·3. Hence, when the elements of a compound are known, we may always deduce their proportions from its refractive power.

The following table of refractive powers is by Dr. Wollaston. Those that have no figures subjoined to them were not actually measured.

Diamond (Newton)	2·44
Plumbago	——
Native sulphur (double)	2·04
Glass, consisting of lead 6 and sand 1,	1·987
Glass of antimony	1·98
Jargon	1·95
Spinelle ruby	1·812
Arsenic	1·811
Muriat of antimony	variable
White sapphire	1·768
Gum dragon	——
Iceland spar (strongest)	1·657
Sulphat of barytes (double)	1·646
Balsam of Tolu	1·60
Guaiacum	1·596
Benzoin	——
Flint glass	1·586
Ditto	1·583
Horn	——
Phosphorus	1·579
Mica	——
Opium	——
Amber	1·547
Rock crystal (double)	1·547
Old plate glass	1·545
Colophony	1·543
Boxwood	——
Bees-wax	1·542
Oil of sassafras	1·536
Red sealing-wax	——
Spermaceti (cold)	——
Sugar, after fusion,	——
Arseniat of potash	——
Mastic	——
Elemi	——
White wax (cold)	——
Oil of cloves	1·535
Copal	1·535
Anime	1·535
Radcliffe crown glass	1·533
Pitch	——
Centre of crystalline of fish, and dry crystalline of an ox	1·530
Canada balsam	1·528
Crown glass (common)	1·525
Selenite	1·525
Caoutchouc	1·524
Gum lac	——
Dutch plate glass	1·517
Human cuticle	——
Gum arabic	1·514

Balsamof capivi	1·507
Oil of amber	1·505
English plate glass	1·504
French plate glass	1·500
Oil of nutmeg	1·497
Sulphat of potash	1·495
Tallow (cold)	1·49
Iceland spar (weakest)	1·488
Camphor	1·487
Linseed oil	1·485
Butter (cold)	1·480
Essence of lemon	1·476
Oil of turpentine (common)	1·476
——————— (rectified)	1·470
Oil of almonds	——
——— olives	1·469
——— peppermint	1·468
——— lavender	1·467
Tallow (*melted*)	1·460
Aum	1·457
Spermaceti (*melted*)	1·446
Crystalline lens of an ox	1·447
to	1·380
Computed average of ditto	1·430
Sulphuric acid	1·435
Fluor spar	1·433
Nitric acid (sp. gr. 1·48)	1·410
Alcohol	1·37
White of an egg	1·36
Ether	1·358
Vitreous humour of an eye	1·336
Water	1·336
Atmospheric air (Hauksbee)	1·00032

Philos. Trans.—Journ. de l' Instit. Nat.

REFRACTORY. This word is applied to infusible substances, or such as cannot be fused by the heat of common furnaces.

REFRIGERATORY. A refrigeratory is a copper vessel soldered round the capital of the alembic. Its use is to contain cold water, which is to be renewed when it is heated, and the hot water is to be let out at a cock fitted to the refrigeratory for this purpose. The intention of this renewal of the water of the refrigeratory is to keep perpetually cool the capital of the alembic, that the vapours of the liquor which rise in distillation may be condensed more easily and more quickly.

These refrigeratories were much used formerly, and all alembics were furnished with them: but modern distillers find that this vessel is not attended with the advantages it was formerly believed to possess; for the distillation cannot succeed unless the capital of the alembic be as hot, or almost as hot, as the cucurbit. Mr. Baumé observed, that, when the capital was cooled by very cold water, the distillation was soon stopped, and did not again begin till the capital was considerably heated.

The refrigeratory has for these reasons been much neglected, and a worm substituted in place of it, which is indeed a kind of refrigeratory, but different from the other in this respect, that it is adapted to the nose of the alembic, instead of surrounding the capital.

This remedy appears however to be in some measure inadequate, because the head produces a considerable return of the spirit, even without a refrigeratory. It seems, nevertheless, that the inconvenience of this last addition arises merely from the large aperture of the neck. See ALCOHOL.

REGISTER. Registers are openings in different parts of furnaces, which are to be shut occasionally with stoppers of burnt clay. By means of registers we may govern the fire as we please; for, by opening or shutting them properly, we may not only increase or diminish the activity of the fire, but also we may apply its action more to one part of the furnace than another, by giving direction to the current of air, which passes through it.

Notwithstanding the utility of registers, they are too much neglected. Many chemists have disused registers, probably because they did not find the advantages from them which they expected. The reason of this is, that registers have hitherto been ill made. Their principal fault is, that they are generally too small. A register cannot have its proper effect, unless it have an opening of two, three, or four inches for a furnace the internal diameter of which is a foot: but we frequently see furnaces of eighteen or twenty inches in diameter with registers, the openings of which are scarcely eight or ten lines. Besides, all who use furnaces are far from understanding their construction.

REGULUS. The name regulus was given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fusion, called this metal, thus collected, regulus, as containing gold, the king of metals. It was afterward applied to the metal extracted from the ores of the semimetals, which formerly bore the name that is now given to the semimetals themselves. Thus we had regulus of antimony, regulus of arsenic, and regulus of cobalt.

RESEDA LUTEOLA. See WELD.

RESIN. The name of resin is used to denote inflammable substances soluble in alcohol, usually affording much soot by their combustion. They are likewise soluble in oils, but not at all in water; and are more or less acted upon by the alkalis.

All the resins appear to be nothing else but volatile oils, rendered concrete by their combination with oxigen. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion.

Resins in general are less sweet than the balsams. They afford more volatile oil, but no acid or saline matter, by distillation.

There are some among the known resins which are very pure, and perfectly soluble in alcohol, such as the balsam of Mecca and of Capivi, turpentines, tacamahaca, elemi: others are less pure, and contain a small portion of extract, which renders them not totally soluble in alcohol; such are mastic, sandarach, guaiacum, labdanum, and dragon's blood.

What is most generally known by the name of resin simply, or sometimes of yellow resin, is the residuum left after distilling the essential oil from turpentine. If this be urged by a stronger fire, a thick balsam, of a dark reddish colour, called balsam of turpentine, comes over; and the residuum, which is rendered blackish, is called black resin, or colophony.

Resinite. The silex resinite of Brongniart, common resinite quartz of Haüy*, semiopal of some, is a species of agate. A conchoidal fracture, shining like that of a resin, with very keen edges, is its distinguishing characteristic. It is likewise very easy to break, its hardness being inferior to that of most of the genus, so that it never takes a high polish It varies from semitransparent to nearly complete opacity.

Its colour, of which it exhibits almost every kind, is never very vivid. Frequently it is very pure, but often variegated.

Its specific gravity varies much, but is in general trifling. It does not exceed 2·540.

In the resinites the silex is not so abundant, as in most species. That of Telkobanya contains according to Klaproth 0·47 of iron, which appears an enormous quantity. They have in general about eight per cent of water.

The resinite differs from the pechstein of Werner in being infusible by the blowpipe; from the opal, in wanting its mutability of colour; and from the cacholong, which, however, it nearly approaches, in not having its milky whiteness. From the jaspers it differs in its fracture, which is not dull like theirs, its lightness, and other properties. Dolomieu was one of the first to establish this distinction among the stones commonly called pitchstones.

The resinite is found in nearly the same situations as the other species of silex. It is pretty common in volcanic rocks and basaltes. It is likewise found in crystallized rocks, as granites and porphyries, particularly in the veins traversing these rocks, and containing silver.

Sometimes it takes the place of certain organised substances, as wood, and retains its texture. Werner has made a particular species of this by the name of *holzopal*, or wood opal.

The resinite silex is found near Orleans in carbonat of lime, of a gelatinous semitransparency. At Recolènes, in Auvergne, its colour is of a deep orange yellow, with zones of a very light brown yellow; it is full of cavities, and its surface is decomposed into a yellowish powder. At Châtelaudren, in Brittany, it is in thin splintered strata of an orange yellow colour; its fracture is very shining, and its colours are arranged in parallel bands. At Campo, in the island of Elba, it is partly carious, partly compact; and of a white colour like that of the jelly of starch, or of a reddish yellow. The white part, as it is decomposed, becomes dull and opake like chalk. It occurs in various other countries: and Mr. von Humboldt has brought a variety from Zimapan in Mexico, which has the bright yellow colour and shining fracture of the finest amber. It is sometimes opaline.—*Brongniart.*

Resolution. Many fossils, particularly of the siliceous kind, to render them soluble in acids, require a preparation with fixed alkalis, previous to their being analysed, which operation is called resolution.

Klaproth recommends, that the fossil, finely powdered, should be boiled to dryness with caustic alkali, and then kept at a red-heat for several hours in a silver crucible. Lowitz, however, observes, that there are several objections to keeping the mass in this way in a state of ignition; and that the analysis will succeed equally well, if hot distilled water be poured upon the mass as soon as it has boiled dry, and this be repeated two or three times when necessary. The mixture should be stirred frequently, and the operation may thus be performed over a lamp. If large tough bubbles arise during the process, this, he says, is an indication that the operator will not be disappointed.—*Crell's Chem. Annals.*

Respiration. See Animal Kingdom.

Retinasphaltum. See Bitumen.

Retort. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck, so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named retorts. The most capacious part of the retort is called its belly. Its upper part is called the arch or roof of the retort, and the bent part is the neck.

Retorts differ in form and materials: their bellies are generally round: some of them are oblong, and shaped like a cucurbit; these are called English retorts. They are preferable for the distillation of matters which are subject to swell, and to pass into the receiver before they are decomposed.

A retort which has a little hole pierced in its roof is called a tubulated retort. This hole must be capable of being exactly closed with a stopper of proper materials. Retorts of this kind are employed in distilla-

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* The resinite petrosilex of Haüy is the pitchstone.

tions, where some matter must be introduced into the retort after the receiver is joined to it.

If the retort be well made, the abovementioned inclination of its neck must be most favourable to distillation. When the neck is too much inclined, the receiver cannot be conveniently luted to it, and is also by this form brought too near the furnace. If the neck be too little inclined, the vapours or liquors, which rise in distillation, can scarcely flow into the receiver from want of sufficient descent, and only circulate in the belly of the retort. Retorts, when too narrow in their bending, are very faulty. This form must be an impediment to distillation: the passage therefore from the belly to the neck of the retort must be free and wide, and gradually diminishing to the extremity of the neck or the mouth of the retort.

Retorts of different materials are used in chemical operations, of common glass, crystal-glass, stone-ware, and iron. Retorts of glass are used for all operations, which require a less heat than is sufficient for their fusion. Earthen retorts are necessary, where great heat is requisite, as in the preparation of phosphorus. Iron retorts are not much used, as they can only serve for the distillation of substances, which cannot act upon this metal; and as these substances are few in number, they can seldom be employed but for the distillation of mercury, and of animal matters.

Reussin. A salt in small masses, of a snowy whiteness, with a conchoidal and scaly fracture, found at Sedlitz in Bohemia. It is a compound of sulphat of soda, sulphat of magnesia, and muriat of magnesia.—*Brongniart.*

Reverberatory. See Apparatus.

Revivification. See Metals,

Rhapontic. The roots of certain docks and some other plants raised in Europe approach to rhubarb in appearance, participate in some degree of its medicinal virtues, and are ranked among the officinal simples, under the names of Monks' Rhubarb and Rhapontic. The common monks' rhubarb is the root of the rumex patientia, broad-leaved garden-dock or patience. The rhapontic of the physic garden of Berlin, is the rumex alpinus, round-leaved mountain- or garden-dock. The true rhapontic, however, or common rhubarb, is the rheum rhaponticum of Linnæus. It grows wild on the mountain Rhodope in Thrace, whence it was brought into Europe, about the year 1610, by Alpinus: it bears the hardest winters of this climate, and is not unfrequent in our botanic gardens. It is of a dusky colour on the surface, and of a loose spongy texture, considerably more astringent, but less purgative than rhubarb.

Sixteen drachms of this root yielded Neumann with alcohol seven drachms and a scruple of extract, and afterward with water, three drachms and a half, five drachms and half a scruple remaining undissolved. On inverting the procedure, and treating the same quantity of the root first with water and afterward with alcohol, he obtained ten drachms two scruples of watery, and one scruple of spirituous extract; the residuum weighed five drachms and a few grains.

The extracts made at first, whether by water or by spirit, contain the active matter of the rhapontic, both the second extracts having little or no taste. The yellow colour of the root is more perfectly taken up by spirit than by water, and more concentrated in the spirituous than in the watery extract. The spirituous extract is also stronger in taste than the watery: on first tasting, they both prove sweetish, but soon after discover a degree of pungency.

The footstalks of the leaves, and their large ribstalks, peeled, being of an acid taste, make very good tarts.

Rhodium. A new metal discovered among the grains of crude platina by Dr. Wollaston. The mode of obtaining it in the state of a triple salt combined with muriatic acid and soda has been given under the article Palladium. This may be dissolved in water, and the oxide precipitated from it in a black powder by zinc.

The oxide exposed to heat continues black; but with borax it acquires a white metallic lustre, though it remains infusible. Sulphur, or arsenic, however, renders it fusible, and may afterward be expelled by continuing the heat. The button however is not malleable. Its specific gravity appears to exceed 11.

Rhodium unites easily with every metal that has been tried, except mercury. With gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becoming encrusted with a black oxide when slowly cooled. One sixth of it does not perceptibly alter the colour of gold, but renders it much less fusible. Neither nitric nor nitro-muriatic acid acts on it in either of these alloys; but if it be fused with three parts of bismuth, lead, or copper, the alloy is entirely soluble in a mixture of nitric acid with two parts of muriatic.

The oxide was soluble in every acid Dr. Wollaston tried. The solution in muriatic acid did not crystallize by evaporation. Its residuum formed a rose-coloured solution with alcohol. Muriat of ammonia and of soda, and nitrat of potash, occasioned no precipitate in the muriatic solution, but formed with the oxide triple salts, which were insoluble in alcohol. Its solution in nitric acid likewise did not crystallize, but silver, copper, and other metals precipitated it.

The solution of the triple salt with muriat of soda was not precipitated by muriat, carbonat, or hidrosulphuret of ammonia, by carbonat or prussiat of potash, or by carbonat of soda. The caustic alkalis however throw down a yellow oxide, soluble in excess of alkali; and a solution of platina occasions in it a yellow precipitate.

The title of this product to be considered as a distinct metal has been questioned; but the experiments of Dr. Wollaston have since been confirmed by Descotils.—*Philos. Trans.* —*Journ. de Phys.*

Rhodium Lignum, rose wood, a wood or root brought from the Canary islands, and confounded with aspalathus, a simple of considerable esteem among the ancients, but which has not come to the knowledge of latter times.

The writers on botany and the materia medica are much divided about the lignum rhodium, not only with regard to the plant which affords it, but likewise in their accounts of the drug itself. This confusion seems to have arisen from an opinion, that the rhodium and aspalathus are the same; whence different woods brought into Europe for the unknown aspalathus were sold again by the name of rhodium.

As to aspalathus, the ancients themselves disagree; Dioscorides requiring by this appellation the wood of a certain shrub freed from the bark, and Galen the bark of a root. At present we have nothing under this name in the shops. What was heretofore sold among us as aspalathus were pieces of a pale-coloured wood brought from the East Indies, and more commonly called calambour.

The lignum rhodium of the shops is usually in long crooked pieces, full of knots, which when cut appear of a yellow colour like box, with a reddish cast: the largest, smoothest, most compact, and deepest coloured pieces should be chosen; and the small, thin, or pale ones rejected. The taste of this wood is lightly bitterish, and somewhat pungent; its smell very fragrant, resembling that of roses: when long kept, it seems to lose its smell; but on cutting or rubbing one piece against the other, it smells as well as at first. Distilled with water, it yields an odoriferous essential oil, in very small quantity. Rhodium is at present in esteem only upon account of its oil, which is employed as a high and agreeable perfume in scenting pomatums and the like. It is likewise said to be much employed by ratcatchers, either to entice the rats to the traps, or to cover the smell left by handling them. But if we may reason from analogy, this odoriferous simple might be advantageously applied to nobler purposes; a tincture of it in alcohol, which contains in small volume the virtue of a considerable quantity of the wood, bids fair to prove a serviceable cordial, not inferior perhaps to any thing of this kind.

Rhubarb. An ounce of rhubarb, reduced into gross powder, yielded with alcohol three drachms of extract, and afterward with water two drachms two scruples and a half; the residuum weighed two drachms twelve grains. By applying water first to another ounce, five drachms two scruples and a half of extract were obtained, and of the residuum five grains only were soluble in alcohol. Rhubarb appears from these experiments to contain much more gummy or mucilaginous than resinous matter; and hence spirituous tinctures of it are not precipitated or rendered milky by addition of water, like the tinctures of most other vegetables.

The yellow colour of rhubarb is remarkably less destructible than any other vegetable yellows. Aquafortis, and other acids, which destroy the colour of saffron, turmeric, &c. make no change in that of rhubarb, or at most render it only turbid. Ammonia heightens the colour, and inclines it to red. Fixed alkaline salts have this effect in a greater degree. Solutions of sulphat of iron and other chalybeate liquors change the colour of infusions of rhubarb to an inky blackness; a mark that this root is possessed of an astringent quality. The spirituous extract does not purge, although the extract made by water after spirit does, as if its purgative quality resided chiefly in a combination of gummy and saline matter. Mr. Model affirms, that a considerable quantity of sulphat of lime is contained in rhubarb. In one experiment, he obtained six ounces of sulphat of lime, from four pounds of rhubarb: and in another experiment he obtained no less than an ounce of sulphat of lime from two ounces and five drachms of old rhubarb.

Risigal. See Realgar.

Roasting of Ores. See the Metals and Ores.

Rochelle Salt. Tartrite of potash and soda. See Acid (Tartarous).

Rock Crystal. See Crystal (Rock), also Quartz.

Rock Wood. The ligniform asbestus.

Rockets. In the art of making fireworks, gunpowder constitutes the chief ingredient; but the proportion of it is very frequently varied, according to the different uses for which it is intended. For making rockets, meal-powder only is commonly employed, and mixed with an additional quantity of sulphur and nitre, according to the different purposes for which they are designed; on which account the last ingredient is generally brought into the form of a powder, by solution and evaporation, during which latter operation it is continually stirred.

The mechanical operations of the abovementioned art not belonging to this work, we shall only make mention of the different compositions, which are to be made upon chemical principles, as laid down by Wiegleb. For fuses, seven parts of meal-powder, five of nitre, and three of sulphur; and for rockets, thirty-six parts of nitre, eight of sulphur, and fourteen of charcoal are to be taken in both these the intention is, that the powder shall only be fired by degrees.

For blue-balls are to be mixed together thirteen parts of nitre, three of sulphur, $\frac{17}{12}$ parts of resin, $\frac{7}{16}$ of saw-dust, and $\frac{2}{16}$ of charcoal. Light-balls require, for the dry sort, two parts of nitre, $\frac{1}{2}$ a part of sulphur, $\frac{1}{16}$ of resin, $\frac{1}{3}$ of saw-dust, and $\frac{1}{2}$ a part of meal-powder; for the fusible, 8 parts of sulphur, 2 of nitre, and 4 of meal-powder. Fire-balls are composed of twenty parts of corned powder, ten of pitch, six of nitre, four of sulphur, one of tallow, one of hemp, and two of linseed-oil. Water-rockets require eight parts of meal-powder, thirty-six of nitre, seven of sulphur, and one of resin. As these particular masses of fire are destined to resist the air and water, and nevertheless to burn for a certain time, the oleaginous and combustible additions are requisite, among which, the intent of the saw-dust appears to be to prolong the conflagration. Among these also may be reckoned the Greek-fire, which in fact was not invented by a Greek, but by Callinicus of Heliopolis, who is said to have used it at the siege of Constantinople. It cannot be decided with certainty what it properly was, or of what it was composed. According to the description of it given in history, it was a liquid substance, that was easily kindled, and extinguished with difficulty, which burned upon water, and was thrown, enclosed in bottles and pitchers, into the enemies' ships, by which means they were set on fire. It is very probable, that pitch, sulphur, linseed-oil, oil of turpentine, or petroleum, made a considerable part of its composition.

The variously coloured fire-works depend on various additions, by which the natural colour of gunpowder, when on fire, may be altered, and in which metallic substances, for the most part, such as antimony, zinc, marcasite, verdigrise, &c., are employed. Thus also clean filings of iron produce what is called brilliant, or white fire.

Rod (Divining). The divining wand is an instrument, by means of which many persons have formerly pretended, and some do now pretend, to discover under what parts of the earth metals, treasures, ores, water, salt, &c., lie hidden, without digging the ground. They say, this discovery may be made by a person holding the wand horizontally, and by walking along in places where these matters are expected; and that when he arrives at a place, under which any of the above-mentioned matters lie, the wand will be forcibly inclined toward that place: but that this experiment should succeed, much faith seems to be required in the person who holds the wand, or rather in the spectators. Macquer positively affirms, that the power of this wand is a chimera, which owes its reputation to avarice, ignorance, and credulity.

The famous Father Kircher, in his Mundus Subterraneus, in which many interesting particulars are found concerning mines, derides these superstitious practices, and denies from his own experience, the truth of the assertions concerning them. He seems however to have some faith in sympathies, and proposes even new divining wands of his own invention; the effects of which, though more dependent on physical causes, are not however more certain. He believes, for instance, that a wand, one end of which should be made of sal-gem, and the other of wood, being suspended and balanced above a mine of salt, would be inclined toward the ground; and he supports his opinion by an experiment. This experiment consists in evaporating over the fire a solution of sal-gem below the wand, which is by no means really made to incline by the salt. We need not be deeply learned in chemistry to discover, that the wand would have inclined in the same manner, if Father Kircher had evaporated pure water, instead of a solution of sal gem; because the water would have equally well attached itself to the saline end of the wand: consequently this experiment proves nothing.

The same author proposes also to discover mines of mercury by employing a wand, one end of which is made of gold and the other of wood, in hopes that the emanations of the mercury would attach themselves to the gold rather than to the wood, and would make it incline downward. But this effect certainly cannot be produced, unless the mercury was evaporating; for which purpose two conditions are necessary: 1. The mercury must be in a native metallic state, and not mineralised, as it is in cinnabar; and 2. It must also be exposed to the heat of some subterranean fire, by which it is volatilized and sublimed, the ordinary heat of the earth being far too little for this purpose. This second physical or chemical divining wand proposed by Father Kircher is therefore no better than the former; and probably the same judgment may be passed upon all other wands made upon the same principles, and in imitation of these. Lastly, the same author positively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of some wood that has no sympathy with water, over a subterranean water, and that he observed the end of the wand which was made of alder incline toward the earth.

In addition to the above, which is from Macquer, I must remark, that the divining rod still possesses considerable reputation among the mere miners in our metallic counties. They pretend to establish, from observation, that the experiment does not succeed unless the rod be held in the hand; or in other words, that an inanimate suspension will not be sufficient to produce the effect: And farther, that there are certain individuals, in whose hands the rod will be acted upon, but that with far the greater majority it has no effect. I will not here relate any of the narratives, which have come to me at second and third hand, wherein very rational precautions are affirmed to have been made in the trials; neither shall I give an opinion, where for want of experience I have no good ground to form one. But I think the object is entitled at least to some portion of inquiry, instead of a decided rejection, which might formerly with equal reason have been applied to some of the phænomena of magnetism, electricity, &c.

When we find, for example, that the same electric shock affects one individual strongly, another less, and a third not at all; when we find, that the nervous energy is excited, and produces motion in limbs recently amputated, when certain metals are applied conjunctively and not alone, such as tin and silver, iron and gold, zinc and silver or gold:—when we observe, that silver laid upon the tongue, and zinc inserted in the nostril, produce the appearance of a flash of lightning to the living individual the instant they are made to touch; which, though to most persons evident and striking, is much more so to some than to others; – it seems to be not improbable, that other energies may exist among metals and minerals, which may show themselves in the divining rod or otherwise.

Roethel. Reddle or red chalk.

Roof. Chemists and metallurgists use this word, to denote the internal superior surface of certain cavities. Thus they say the roof of a retort; the roof of a mine, &c.

Rosemary. This is a native of Spain, Italy, and the southern parts of France, where it grows in abundance upon dry gravelly grounds; in the like soils it thrives best with us, and likewise proves stronger in smell, than when produced in moist rich ones: this observation obtains in almost all the aromatic plants.

Rosemary has a fragrant smell, and a warm pungent bitterish taste, approaching to those of lavender; the leaves and tender tops are strongest; next to these the cup of the flower; the flowers themselves are considerably the weakest, but most pleasant. Aqueous liquors extract great share of the virtues of rosemary leaves by infusion, and elevate them in distillation; along with the water arises a considerable quantity of essential oil, of an agreeable strong penetrating smell. Pure spirit extracts in great perfection the whole aromatic flavour of the rosemary, and elevates very little of it in distillation: hence the resinous mass left upon abstracting the spirit proves an elegant aromatic, very rich in the peculiar qualities of the plant. The flowers of rosemary give over great part of their flavour in distillation with pure spirit; by watery liquors their fragrance is much injured; by beating, destroyed. The officinal preparations of rosemary are, an essential oil from the leaves, or from the herb in flower, a conserve of the flowers, and a spirit formerly called Hungary-water, from the flowery tops. The tops are used also in the compound spirit of lavender, and soap liniment.

Roses. The essential oil, otto, or attar of roses, is a very costly perfume, on account of the small quantity the flower yields. One hundred pounds of flowers, gently distilled with a hundred and fifty pounds of water till half the water is come over; and this water cohobated on a similar quantity of flowers, with the addition of fifty pounds of water; are said to produce in India about four drachms of oil. Homberg, however, obtained an ounce from a hundred pounds of roses, and Hoffmann more than two ounces; but in these instances the calyx of the flower was rejected.

Sandal-wood raspings, and in Cashemire a sweet-scented grass, are often mixed with the roses, to increase the quantity of oil: but the sandal-wood may be detected by the smell, and both by the oil not congealing at the common temperature of the atmosphere.

It generally assumes the irregular form of whitish scales, or laminæ; but Steinacher says, that by standing at rest on the water a pellicle will be formed, interspersed with little hexaedrons, much resembling crystals of snow.

Rotten Stone. Tripoli; Terra Tripolitana. Is known by its quality of rubbing or wearing hard bodies, and making their surfaces shine, the particles of the tripoli being so fine as to leave even no perceptible scratches on the surface. This polish may likewise be produced by other fine clays, when they have been burnt a little. The tripoli grows somewhat harder in the fire, and is very refractory: it is with difficulty dissolved by borax, and with still greater difficulty by the microcosmic salt: it becomes white by ignition: when crude, it imbibes water, but is not diffusible in it. It tastes like common chalk, and is rough or sandy between the teeth, although no sand can by any means be separated from it. It has no quality in common with other kinds of earths, by which it might be considered as a variety of any other. That which is here described is of a yellow colour, and is sold by the colourmen, who do not know where it is found.

This earth was formerly brought to us from Tripoli in Barbary, whence this name was given to it. Fabroni enumerates the following characters:

1. This earth does not effervesce with any of the acids: and,

2. It becomes not only hard in the fire; but when considerable heat is applied, its surface becomes vitrified.

3. All tripolis, except those found in England, require a red colour by being burnt.

4. They are fusible with the calcareous earth, as well as with borax and with microcosmic salt. But,

5. When washed in water, no other substance separates from them. However,

6. Sometimes the muriatic acid and the sulphuric may be extracted by distillation from these earths.

It is found either solid, of a rough texture; a brown or yellowish colour; or spotted like marble; or else, friable and compact; of a granulated texture, and brown or yellowish colour. It is this last sort which is found in England.

Da Costa says he has procured the kind of yellow tripoli mentioned by Cronstedt from Scotland, where it had lately been discovered. But the rotten stone, so called, is another sort, found in Derbyshire. It is in common use here among workmen for all sorts of finer grinding and polishing, and is also sometimes used by lapidaries for cutting of stones.

This, according to Ferber, is a tripoli mixed with calcareous earth.

Kirwan affirms, that tripoli is evidently a volcanic product. For a coal-mine at St. Estienne having accidentally taken fire, and the fire in its progress having extended to some strata of schistus and bitumen, tripoli was found in those parts of the strata, that the fire had acted upon, but not in any other. *Mem. Par.* 1769. p. 276. quoted by Kirwan.

Tripoli is found also of a gray, white, and red colour. Acccording to Haasse it contains 90 parts of silex, 7 of alumine, and 3 of oxide of iron. Sometimes a little magnesia has been extracted from it; and generally the alumine and iron are in greater proportions.

ROUCOU. See ANNOTTO. In addition to which article, the following is extracted from Berthollet.

The watery decoction of annotto has a strong smell, and a disagreeable taste. Its colour is of a yellowish red, and it is somewhat turbid. An alkaline solution changes it to an orange yellow, which is brighter and more pleasing; and a small quantity of a whitish substance is separated from it, which remains suspended in the liquor. If we boil annotto in water with an alkali, it dissolves much better than in water alone, and the liquor is of an orange colour.

Acids form with this liquor an orange-coloured precipitate soluble in alkalis, which communicate to it a deep orange colour; the supernatant liquor retains only a pale yellow.

Solutions of common salt and sal-ammoniac produce no sensible change.

The solution of alum gives a considerable quantity of orange precipitate, which is deeper than that which acids produce; the liquor remains of a pleasant lemon colour, bordering a little on green.

Sulphat of iron forms a precipitate of an orange brown; the liquor remains of a pale yellow.

Sulphat of copper gives a precipitate of a yellowish brown, somewhat brighter than the former; the liquor preserves a greenish yellow colour.

A solution of tin produces a lemon-coloured precipitate, which is deposited very slowly.

When annotto is used, it is always mixed with an alkali, which facilitates its solution, and gives a colour less inclining to red. It is cut in pieces, and boiled in a caldron, with an equal weight of cendres gravelées, provided the desired shades do not require a smaller proportion of alkali; the cloth may be then dyed in this bath, either with these ingredients alone, or with the addition of others to modify the colour; but it seldom happens that annotto is used for wool, because the colours it imparts are too fading, and may be obtained of a more durable nature by other means. Hellot employed it in dyeing a stuff prepared with alum and tartar, but the permanency of the colour was not much increased. It is almost solely used for silk.

For silks to be dyed of an aurora, or of an orange colour, it is sufficient to scour them with twenty pounds of soap to the hundred; after they have been well cleansed they may be immersed in a bath of water, with which more or less of the alkaline solution of annotto, according to the shade required, has been carefully mixed. The heat of this bath ought to be between tepid and boiling water.

When the silk has acquired an uniform colour, one of the hanks must be taken out, washed and wrung, to see whether the colour be sufficiently full; and if it be not, more solution of annotto must be added, and it must be turned again. This solution preserves its colour unchanged.

When the desired shade has been obtained, nothing remains but to wash the silks, and to beetle them twice, by a stream of water, to free them from the superfluous annotto, which would injure the beauty of the colour.

When raw silk is to be dyed, such as is naturally white must be chosen, and it must be dyed in the annotto bath, which ought only to be tepid, or even cold, that the alkali may not dissolve the gum of the silk, and destroy its elasticity, which we wish to preserve.

What has been now said respects the silk intended to receive the aurora colour: to make the orange, which contains more red, after dyeing with annotto, it is necessary to redden the silks with vinegar, alum, or lemon juice. The acid, in saturating the alkali used to dissolve the annotto, destroys the yellow shade which the alkali had imparted, and restores its natural colour, which inclines a good deal towards red.

For the very deep shades it is the practice at Paris, as Macquer informs us, to alum them; and if the colour is not yet red enough, to pass them through a weak bath of brasil-wood. At Lyons, the dyers, who use carthamus, sometimes employ the old baths made with that ingredient for the deep orange colours.

When orange colours have been reddened with alum, they must be washed in a stream of water; but it is not necessary to beetle them, unless the colour be too red.

Shades which preserve a reddish hue may likewise be obtained by a single operation, namely, by employing, in the preparation of the annotto bath, a smaller quantity of alkali than that above directed.

Mr. Guhliche advises us not to employ heat in the preparation of annotto. He directs, that it should be put into a glass vessel, or one of earthen-ware with a vitreous coat, and that as much solution of pure alkali should be added as will cover it, and that this mixture should be left at rest for twenty-four hours; that the liquor should then be decanted, and filtered, and the residuum repeatedly washed with water, leaving the mixture at rest each time for two or three days, till the water no longer receives any colour; that these liquors should be all mixed together, and put into a well-stopped vessel, and kept for use.

He directs too, that the silk should be steeped for twelve hours in a solution of alum, in the proportion of two ounces of the salt to a pound of the silk, or in water acidulated with his acetocitric acid, for the manner of preparing which see **Vegetable Acid Spirit**; when taken out of this mordant, it is to be well wrung.

The silk thus prepared is put into the annotto bath quite cold, and kept there, and stirred about until it has acquired the proper shade, or it is kept at a degree of heat far below ebullition; when taken out of the bath, it is washed, and dried in the shade.

For the brighter shades, a liquor is employed, which is less loaded with colour, to which may be added a little of the acid liquor, which has been used as a mordant, or the dyed silk may be passed through acidulated water.

If we wish to have the last shades with less of an orange cast, and approaching to nankin, a small quantity of solution of galls in white wine may be added to the bath.

To give an orange colour to cotton, Mr. Wilson directs the annotto to be ground while it is kept moistened, boiled in water with double its weight of alkali, left to settle for half an hour, and the clear liquor to be put into a heated vessel; in this the cotton is to be immersed, when it will take an orange colour. A hot solution of tartar is then to be poured into the bath, so that it may become weakly acidulated; it is to be again turned in it on the skein sticks, or wound upon the winch when in the piece; in this way the colour becomes more lively, and fixes better; and lastly the cotton is slightly washed, and dried by the heat of a stove.

Rouge. See **Carthamus.**

Rouge (Polishing). This is a powder employed by goldsmiths to give the last polish to their work, which they commonly call colouring it. The finest is of a high red colour, and very soft to the touch. It is said to be a very pure native red oxide of iron. Sometimes it is of a red inclining to purple, and has the appearance of a very fine crocus martis: but this is of inferior quality. Chaptal asserts, that if pieces of old hat, in the dyeing of which iron is used, be immersed a few minutes in sulphuric acid, the iron will pass to the state of red oxide, and they will become excellent polishers.

Rowley Rag. This stone, which is a species of basalt, is of a dusky or dark gray colour, with numerous minute shining crystals, some of which seem to be feldtspar, the others hornblende. The town of Birmingham is paved with it.

Its texture is fine grained, and confusedly crystallized. By exposure to the air, it acquires an ochrey crust.

Its specific gravity is 2·748, or according to Mr. Watt 2·868, and when fused into glass, 2·749.

Heated in an open fire, it becomes magnetic.

In strong heat it melts per se, but with more difficulty than basaltes.

According to Dr. Withering's analysis, 100 parts of it contain 47·5 of silex, 3·25 of alumine, and 20 of oxide of iron.

Rubicelle. This name has been applied to a red gem from Brazil, but authors do not agree in its characters. Some consider it as the Brazilian topaz coloured red by the action of fire; while others say, that fire destroys the red colour of the rubicelle. At present the term is not used by scientific writers.

Ruby. This stone was formerly considered as allied to the diamond, and called *adamas ruber*. Various stones too have been styled rubies, that are essentially different; and others have been considered as distinct from it, that are now classed by mineralogists in the same family.

The ceylanite, or pleonaste of Haüy; the spinel, or balass ruby; the sapphire; emery; corundum; and adamantine spar; constitute six species of ruby according to Dr. Thomson; and to these he considers the automalite as allied, which however may be deemed an ore of zinc, as it contains 28 per cent. of its oxide.

Brongniart, giving spinelle as the specific name, confines it to two subspecies, the ruby spinel, and pleonast spinel. Of the former of these he makes five varieties, distinguished by their colours: the scarlet, or common spinel ruby; the balass ruby. which is of a rose colour; the almandine ruby, of a violet red; the rubicelle ruby, of a yellowish red; and the blackish red. He observes, that what has been called the oriental ruby differs from the sapphire only in colour; that the Brazilian ruby is a red topaz; the Bohemian ruby, a rose-coloured quartz; the Barbary ruby, a garnet; the rock ruby, another garnet; and the false ruby, a red fluat of lime.

The ceylanite, or pleonaste, is commonly found in rounded masses, but sometimes crystallized. Its primitive form is a regular octaedron, but more commonly the edges are wanting. Its colour is a dark indigo blue, passing into a greenish black when closely examined: specific gravity from 3·76 to 3·79. It scratches quartz slightly.

The spinel, or balass ruby, is rather harder than the preceding species, specific gravity from 3·57 to 3·7. Its colour is red, passing on the one side to blue, on the other to yellow and brown. It is usually crystallized; and its primitive form is the octaedron: but it occurs also in tetraedrons, rhomboidal dodecaedrons, and four-sided prisms terminated by quadrangular pyramids. It is valued at the rate of thirty shillings the carat.

The sapphire is the hardest of all stones, the diamond excepted: specific gravity from 4 to 4·083. It is infusible alone before the blowpipe, but melts with borax with effervescence. Its colours are blue and red. From a Prussian blue it passes into indigo blue, and into azure, violet, lavender, lilac, and sky blue, and deep green; from lilac blue into peach-blossom, crimson, cochineal, and carmine red; also into rose red, reddish white, and yellowish white: from lavender blue into pearl and bluеish gray, and blueish white.

The name sapphire is confined by the jewellers to the blue; the pale blue, frequently called luchs sapphire, from the German *luchs* a lynx; and the white sapphire. The red, as before observed, they call oriental ruby. When this is perfect, and above 3½ carats weight, Dutens says it is more valuable than a diamond of the same size: if it weigh one carat it is worth ten guineas; if two carats, forty; if three, 150; if six, above 1000. A good blue sapphire of 10 carats is valued at 50 guineas; one of 20, at 200: that is, the carat at 10*s.* 6*d.* is multiplied into the square of the weight. It is said, that the sapphire loses its colour by fire, and remains so hard and transparent, as to pass sometimes for a diamond. Mr. Achard however found some at least, that were not altered in colour by fire: and it is to be observed, that the sapphire causes only a single refraction of light. The sapphire is preferable to the common ruby for jewelling the pallets of escapements, and the holes of wheel-pivots, in astronomical watches and clocks, on account of its hardness and homogeneity. Of all these alumine is the chief constituent part. A hundred grains of sapphire, analysed by Klaproth, gave him 98·5 of alumine, 1 of oxide of iron, and 0·5 of lime. Chenevix however found 5·25 of silex, with 92 alumine, in the blue; and 7 of silex, with 90 of alumine, in the red. The latter likewise afforded him 0·2 more of oxide of iron, but he detected no lime in either. In the ceylanite Descotils found 12 per cent. of magnesia; and in the spinel Vauquelin found 8·78 of this earth, with 6·57 of oxide of chrome, but no iron.—*Thomson.—Brongniart.—Klaproth.—Phil. Trans.—An. de Chim.—Journ. des Mines.*

Ruby (Arsenical). Realgar, or the red combination of arsenic and sulphur, obtains a degree of transparency by fusion and cooling, and is then distinguished by this name.

Rust. Metals are said to rust when their surface becomes oxided by exposure to air and moisture. The oxide is also called rust. The word is more particularly applied to iron.

Rutile. An ore of titanium, so called by Werner; the titanite of Kirwan; the sagenite of Saussure. It is hard, brittle, in colour varying from light hyacinth to a dark brownish red, crystallized in four- or six-sided prisms, or needles; specific gravity about 4·2.

Rutilite. The calcareo-siliceous titan ore of Kirwan, the titanite of Klaproth. It has been found only in very small four-sided rhomboidal prisms, of a brownish red, or dark reddish brown colour; specific gravity about 3·5.

Rye is the seed of *secale cereale*, a plant cultivated in the northern parts of Europe, in considerable quantity, as an article of food. Bread made of it is much denser than wheaten bread, and has a brownish colour, with a peculiar sweetish taste, which to most persons is rather agreeable. It is seldom used in this country alone, and less frequently than formerly mixed with wheat, when it was not uncommon in some of the northern counties. The mixture of wheat and rye was called *meslin*.

We are indebted to Einhof for an elaborate analysis of rye-meal. He published the result of his experiments in the summer of 1305.

A determinate portion of rye-meal was formed into a paste, and washed in pure water till this liquid ceased to acquire any colour, or to take up any thing. The liquid, after filtration, had a yellowish colour, an insipid taste, and a smell like that of new whey. It slightly reddened litmus paper, and was rendered muddy by carbonat of potash, sulphat of silver, and infusion of galls. When raised to the boiling temperature, it became muddy, and a number of white flakes separated. These, when collected and edulcorated, had the appearance of curd. They dissolved in alkaline lixivia, were insoluble in alcohol, and possessed the properties of vegetable albumen. When the liquid was concentrated by evaporation, it deposited a small additional portion of albumen. This being separated, the liquid was evaporated to the consistence of honey, and digested in alcohol repeatedly, till nothing more was taken up. The residue was of a grayish white colour, and insipid to the taste: water dissolved it slowly, and the solution, being evaporated, deposited more flakes of albumen. What remained had the appearance of a solution of gum arabic, and, when evaporated to dryness, left behind it a portion of gummy matter.

The alcoholic solution became muddy when mixed with water. The alcohol being drawn off by distillation, there remained in the retort an aqueous solution, of a vinous yellow colour, with large brownish flakes swimming in it. These flakes, when collected, were found to possess the properties of gluten. They formed a glutinous mass with cold water, the bulk of which contracted when the water was made to boil. Boiling alcohol dissolved it; but ether took up only the colouring matter. Alkalis dissolved it, and acids threw it down again from its solution.

The watery solution, thus freed from the gluten, being evaporated, left an extract of a vinous yellow colour. By repeated digestions in alcohol, dilutions with water, and evaporations, it was freed from a portion of gluten, which still adhered to it. Its taste was then sweet, but harsh; its colour vinous yellow; and it was soluble in water, alcohol, and ether. It was considered as the saccharine matter of rye.

The rye meal, thus freed from the matters soluble in water, was mixed with a great quantity of water, and by repeatedly agitating the liquid, and decanting it off after standing some time, it was separated into two portions; namely, a grayish-coloured substance, which, being lightest, did not so soon subside, and a white powder, which possessed the properties of starch. The gray-coloured substance, by repeated digestions in alcohol and water, was separated into three portions; namely, gluten, starch, and the coat of the rye seeds. Such are the constituent parts of rye-meal according to Einhof. The following are the proportions of these different substances detected by this chemist, in the best rye seeds and rye-meal. Of good rye seeds 3840 parts were composed of

Husk	930
Moisture	390
Pure meal	2520
	3840

The same quantity of good rye-meal contained

Albumen	126
Gluten, not dried	364
Mucilage	426
Starch	2345
Saccharine matter	126
Husk	245
Loss	208
	3840

But the proportions of these substances must vary extremely according to the soil, the climate, and the age of the rye. The gluten of rye differs in several particulars from that of wheat. It is less tenacious and more soluble. When it was allowed to ferment, Einhof perceived a strong smell of nitric acid, which is peculiar to this species of gluten. The starch of rye bears a striking resemblance to that of wheat. Like this last, it does not form a colourless solution with boiling water, and always precipitates at last, when the solution is left a sufficient time at rest.

Einhof did not examine the ashes of rye; but from the experiments of Schrader we know, that the same quantity analysed by Einhof, namely, 3840 parts, yielded the following fixed substances:

Silex	3·90
Carbonat of lime	3·35
Carbonat of magnesia	3·55
Alumine	0·35
Oxide of manganese	0·80
Oxide of iron	0·22
	12·17

Thomson.

S.

SAFFLOWER. See Carthamus, and Saffron (Bastard).

Saffranon. A preparation of the flowers of carthamus, made in Egypt by washing them in brackish water, and drying them in the shade.

Saffre. See Zaffre.

Saffron. Crocus sativus C. B. et Lin. The chives or fleshy capillaments, growing at the end of the pistil of the flower, carefully picked and pressed together into cakes.

There are three sorts of saffron met with in the shops, two of which are brought from abroad, the other is the produce of our own country; this last is greatly superior to the two former, from which it may be distinguished by its blades being broader. When in perfection it is of a fiery orange-red colour, and yields a deep yellowish tincture: it should be chosen fresh, not above a year old, in close cakes, neither dry nor yet very moist, tough and firm in tearing, of the same colour within as without, and of a strong, acrid, diffusive smell.

Both water and alcohol extract the colour and virtue of saffron. The former liquor improves the smell and heightens the colour, while alcohol seems rather to weaken both. By drying two ounces and a half of the best saffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding strong smell, but had not the appearance of oil. This is the active part of the saffron, which disorders the head and senses. Six drachms of extract were obtained from an ounce of dried saffron by means of water, and five drachms and one scruple were obtained from another ounce by means of alcohol. Alcohol acquired no smell or taste by distillation from dried saffron; but water being thus distilled acquired a strong smell.

It is used in medicine as a cordial aromatic, and is likewise considered as an anodyne and sudorific.

A strong infusion of it in water is employed in colouring maps.

Saffron (Bastard). Some account of this article, with the manner of preparing rouge from it, has been given under the article Carthamus; but as a more ample account of the manner in which it is used in dyeing cannot but be acceptable to the manufacturer, we shall here enter into it more at large.

Carthamus, or bastard saffron (carthamus tinctorius), of which the flower only is used in dyeing, is an annual plant cultivated in Spain, Egypt, and the Levant. There are two varieties of it; one with larger leaves, the other with smaller. The latter is said to be that of Egypt, where it makes a considerable article of trade.

Carthamus was formerly cultivated in Thuringia and Alsatia; but the preference given to that of the Levant has occasioned its culture to be nearly abandoned in the more northern climates. The celebrated Beckmann, who has published a very interesting dissertation on carthamus, has endeavoured to discover the difference between that produced with us, and that brought from the Levant: but, previous to relating his observations, it will not be amiss to give an account of the properties of this substance, such as it is employed in dyeing.

Carthamus contains two kinds of colouring matter; the one yellow, the other red. The first alone is soluble in water: its solution is always turbid: with reagents it exhibits the appearances commonly observed in yellow colouring matter: acids render it lighter; alkalis make it deeper, and more approaching to orange: both produce a small portion of fawn-coloured precipitate, by means of which it becomes clearer. Alum forms with it a deep yellow precipitate in small quantity; solution of tin, and other metallic solutions, precipitates which have nothing remarkable.

Alcohol acquires but a slight tincture from the flowers, after all the yellow substance has been extracted by repeated washings. If these flowers be put into a solution of caustic alkali, they become yellow, and the liquor which is pressed out is of a deep yellow colour. On saturating the alkali with an acid, the liquor becomes turbid, reddish, and gradually deposits a very small quantity of a reddish yellow precipitate. With solutions of alum, zinc, and tin, a yellow precipitate is formed; and with solutions of iron and copper, a precipitate inclining to green. If instead of a solution of caustic alkali, a solution of mild alkali be used, acids produce with it a more copious precipitate of a redder hue; but the redness differs according to the acid employed. Alum also produces with the latter alkaline solution, a red precipitate, which is so light, that it generally swims on the surface of the liquor. This colouring matter is so delicate, and so easily changed, that, if heat be employed to dissolve it, the precipitates produced by acids will not have so fine a colour.

Mr. Beckmann has observed, that the carthamus of Thuringia contained much more of the yellow matter than that of the Levant; that, in other respects, the red matter of the former was by no means inferior in beauty to that obtained from the latter; yet that, to produce equal effects, half as much more of it was required. He next examined, whether this difference depended on the climate, or only on the mode of preparation.

Hasselquist relates, in his Travels in Egypt, that when the flowers of carthamus are gathered, they are pressed between two stones, to squeeze out the juice. After this they are washed several times with water, which in Egypt is naturally salt. When taken out of the water they are pressed between the hands, and then spread on mats, placed on the flat roofs of their houses, where they are covered in the day time, that the sun may not dry them too fast, but left exposed to the dew at night. They are occasionally turned, and, when sufficiently dry, taken in, and kept for sale under the name of saffranon.

If the carthamus of the Levant, such as it is in commerce, be compared with that of Thuringia, the former will be found to be more pure, a little moist, and in compressed masses; the latter drier, and more elastic. These differences depend on the preparation. Writers on agriculture, deceived by the erroneous name of bastard saffron given to carthamus, have supposed, that it should be treated like saffron. Hence they direct it to be gathered in a dry season, and dried with care. Mr. Beckmann thinks, on the contrary, that the mode adopted in Egypt ought to be imitated. He ad-uses even to add a little salt to the water used in preparing it, to give it the quality it has naturally in Egypt.

The flower of carthamus has a fine colour of fire, but in drying it grows yellow. It should not be gathered till it grows dry; and it is better, if it has been rained upon in that state, though the contrary opinion is erroneously held. The want of rain may be supplied by watering the flowers morning and evening. When they are gathered, the seeds may be still left to ripen.

The intention of these directions is to promote the separation of the yellow matter, the abundance of which constitutes the difference between the carthamus of our climates and that of the Levant. Carthamus should be kept in a moist place, as its becoming too dry would be injurious.

There are many reasons to induce us to enrich our agriculture with this production. The seeds of carthamus are very good food for birds, and particularly for parrots, whence they have received the name of grain de perroquet. A useful oil might be expressed from them, and the residue given to cattle. The dry leaves and stalks would serve as fodder for sheep and goats in the winter; and those stalks which are too large might be used as fuel, after they had stripped them. Mr. Beckmann has found the carthamus ripen well at Gottingen, where the soil is sandy. The ground should be moderately dunged, and the plant neither transplanted nor watered.

No use is made of the yellow substance of carthamus; but to extract that part, it is put into a bag and trodden in water till no more colour can be pressed out. The flowers, which were yellow, become reddish in this operation, and lose nearly half their weight: it is in this state they are used.

The yellow substance might, however, be employed; and Mr. Poerner has made many experiments on the subject. The principal results of his experiments were, that wool without any preparation takes from it a yellow colour, which is not permanent; but that which it takes after having been prepared with alum and tartar, though not very lasting, is better. Mr. Beckmann asserts, that cloth prepared with tartar, or with tartar and alum, acquires from it a good yellow colour; and that carthamus contains more yellow colouring matter than an equal weight of fustic itself.

To extract the red part of carthamus, and afterward apply it on the stuff, recourse is had to the property alkalis possess of dissolving it, and it is precipitated by means of an acid. It has been found, that lemon-juice produces the finest colour. Mr. Beckmann says, that, next to this, the sulphuric acid produces the best effect, provided a proper quantity only be used: too much of it would alter and destroy the colour. According to Scheffer, the juice of the berries of the service-tree (sorbus aucupatorius) may be substituted for lemon-juice. It is thus prepared: The berries are bruised in a mortar with a wooden pestle, and the expressed juice is left to ferment: it is then bottled, and the clear part, which is most acid, becomes fitter for use the longer it is kept. This operation requires some months, and should be undertaken only in summer.

It has been seen, that the process consists in extracting the red colouring matter by means of an alkali, and precipitating it with an acid. From this precipitate is procured the rouge used by ladies; for the mode of preparing which see Carthamus.

Wool may be dyed red by means of carthamus, as Mr. Beckmann has experienced; but this red soon changes toward an orange: and as the finest and most various reds may be obtained from cochineal, which are at the same time much more permanent than those of carthamus, the use of the latter for wool is relinquished.

Carthamus is used for dyeing silk poppy colour, a bright orange red (nacarat), cherry, rose, and flesh-colour. The processes differ according to the intensity of the colour to be given, and the degree in which it approaches that of fire: but the carthamus bath, which varies in the mode of using, is prepared as follows:

After having extracted the yellow matter of the carthamus, and opened the cakes, it is put into a deal trough, where it is sprinkled at different times with soda, or cendres gravelées, the former of which is best, well powdered and sifted, in the proportion of six pounds to a hundred, mixing it well as the alkali is put in. This operation is called *amestrer*. The carthamus thus mixed with the alkali is put into a small trough with a grated bottom, first lining it with a closely woven cloth. When this trough is nearly half filled, it is placed upon the large one, and cold water is poured on it, till the lower trough is full. The carthamus is then set over another trough, till the water comes from it almost colourless. A little more alkali is then added, and fresh water is poured on. These operations are repeated till the carthamus is exhausted, and becomes yellow.

The silk being distributed on the rods in hanks, lemon-juice, which comes from Provence in casks, is poured into the bath, till it is of a fine cherry-colour. This is called turning the bath. Having stirred the bath well, the silk is dipped in, and turned on the skein-sticks as long as it appears to get any colour. For poppy-colour, it is taken out, wrung, drained on the pegs, and passed through a new bath, where it is treated as in the former. It is then dried, and passed through fresh baths, washing and drying it after every operation, till it has obtained the depth of colour required. When it is at the proper point, it is brightened, by turning it seven or eight times in a bath of hot water, to every bucket of which about a gallon of lemon-juice is to be added.

When silk is to be dyed poppy or fire colour, it must be first scoured as for white, and must then have a slight annotto ground, in the manner described in that article. This silk ought not to be alumed.

Bright orange, reds, and deep cherry colours, are treated exactly in the same way as poppy colour, except that they have not the annotto ground, and that they may be dipped in the baths that have been already used for poppy colour, which will exhaust them. Fresh baths are never made for these colours, unless the dyer has no occasion for a poppy.

The lighter cherry-colours, rose-colours of every shade, and flesh-colours, are made from baths of the second and third runnings of the carthamus, which are weaker than the first. In these the deepest shades are first dipped.

The lightest of all these shades, which is a very pale flesh-colour, requires a little soap to be put into the bath: this softens the colour, and prevents it from taking too quickly or unevenly. The silk is then washed, and brightened a little in the bath which has been used for brightening the deeper colours.

All these baths are used as soon as they are made, and as quickly as possible, as by keeping they lose much of their colour, which would even be entirely lost after a time. They are also used cold, because the red feculæ lose their colour on being exposed to heat. The reader must have observed, that in the above experiments, caustic alkalis attack the delicate colour of carthamus, and turn it yellow: on this account crystals of soda should be preferred to any other alkali. At least we should choose one that contains most carbonic acid, as salt of tartar.

To lessen the expense of carthamus, it is usual, for deep shades, to mix with the first and second bath about a fifth of the bath of archil.

When raw silk is to be dyed, that which is very white should be chosen and treated as boiled silk, with this difference only, that the poppy-colours, bright orange, reds, and cherry colours, are passed through baths that have been used for the same colours for scoured silk, because the raw silk in general takes colours more readily.

Poppy-colour prepared in an acid liquor resists the action of vinegar, but it soon changes and fades in the air. Scheffer says, that when he used the juice of services instead of lemon-juice, the colour stood somewhat longer.

Mr. Beckmann has made some experiments on applying the red colour of carthamus to cotton. Having macerated cotton two hours in melted lard, he washed it well, and dyed it in the common way, with carthamus deprived of its yellow matter. This cotton took a deeper colour than some which had undergone no preparation. Soap succeeded equally well, and olive-oil still better. Mr. Beckmann then dipped his cotton in oil repeatedly, drying it each time. After the last drying he washed and dried it, and then passed it through the yellow bath of carthamus, to which he added galls and alum. Finally, he dyed it with the alkaline solution of carthamus and lemon-juice. By these means he obtained a fine full red. Cotton treated in the same manner, without having been impregnated with oil, took a colour of the same kind, but less full, and less capable of standing the action of the air. From these experiments he thinks, that cotton, to be dyed with carthamus, should receive a preparation similar to that given it for the Adrianople red.

To dye cotton poppy-colour, Mr. Wilson directs the carthamus, thoroughly freed from the yellow colouring matter, to be put into a vessel, at the bottom of which is a hair-sieve, and to pour on it a solution of pearl-ashes, mixing them well, and leaving them to stand all night. The next morning the liquor is to be drawn off by a cock at the bottom of the vessel, and the cotton to be dyed is to be put into it and turned by means of a winch. In the mean time a solution of tartar is prepared, and left to settle; and whilst it is yet hot, it is poured into the carthamus-bath, till the liquor is rendered a little sour. The cotton must continue to be turned in this, till it has acquired the proper shade. It is then washed lightly, and dried in a stove. In this way it obtains a fine colour.

To give cotton a scarlet, it must first be dyed yellow in the manner directed under the article ANNOTTO, and whilst yet wet, must be dyed with carthamus, in the manner just described. It thus acquires a fine scarlet; but it is not permanent, and will not stand washing.—*Berthollet.*

SAFFRON OF METALS, *or* CROCUS METALLORUM, is sulphuret of antimony, half deprived of its sulphur, partly oxided by detonation with nitre, and afterward deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians.

SAFFRON OF STEEL, *or* CROCUS MARTIS. The red oxide of iron.

SAGAPENUM. A concrete juice brought from Alexandria, either in distinct tears, or run together in large masses. It is outwardly of a yellowish colour; internally, somewhat paler, and clear like horn; grows soft upon being handled, and sticks to the fingers: its taste is hot and biting; the smell disagreeable, by some compared to that of a leek, by others to a mixture of asafœtida and galbanum.

An ounce of the purer sort, examined by Neumann, with alcohol yielded in digestion five drachms and six grains of resinous extract: the remainder, boiled with water in a close vessel so long as it gave out any thing to the menstruum, yielded five scruples and eight grains of gum, one drachm and five grains being left undissolved. Another ounce, treated first with water, gave two drachms two scruples and a half of gummy extract; and afterward with alcohol, four drachms and one grain of resin, one drachm and six grains being left. The distilled spirit is sensibly, and the distilled water strongly, impregnated with the flavour of the sagapenum: along with the water arises a considerable portion of actual oil.

Sagenite. An ore of titanium, the reticular rutilite, was thus called by Saussure.

Sago. This is the produce of an oriental tree, the cycas circinalis L., which has generally been considered as belonging to the palms, though some have classed it as a fern. According to du Petit-Thouars, however, it forms a class distinct from both.

The medullary part of the tree of a middle age or growth, is beaten with water, and made into cakes, which are used by the Indians as bread. They likewise put the powder into a funnel, and wash it with water over a hair-sieve, which allows only the finer part to pass through the water. The water, on standing, deposits the fecula; which, being passed through perforated copper-plates, is formed into the grains called sago. It forms an agreeable jelly with water, milk, or broth, and is much used in phthisical and convalescent cases.

Sahlite. Mr. Dandrada first noticed this stone in the silver mine of Sahla, in Westermannland, in Sweden, whence he gave it this name, which Werner has adopted. He afterward found it at Buoen, near Auen, in Norway. Abildgaard and Haüy call it *malacolite*.

The texture of this mineral is very foliaceous, and it is easily divisible into tetraëdral prisms, the sides of which are nearly at right angles to each other. These prisms appear to be divisible in the direction of their diagonals. Their sides are all equally smooth, but not shining. Their transverse fracture is rough, and dull, and sometimes exhibits faces in an oblique direction to the axis, so that its primitive form should be an oblique four-sided prism.

It is not very hard, as it scarcely marks glass, and may be scratched with a knife. Its specific gravity is 3·2307. Before the blowpipe it melts into a transparent glass.

When crystallized it is in four-sided or eight-sided prisms, of a grayish green, or light green colour. The laminæ of these crystals are translucid, and some have the appearance of having been scratched with parallel strokes.

It has been analysed by Vauquelin, who obtained from a hundred parts silex 53, lime 20, magnesia 19, alumine 3, oxide of manganese and iron 4, = 99.

Haüy has shown, that it bears a considerable resemblance to the pyroxene in its structure, to which it bears a considerable analogy in its component parts likewise.

Patrin has met with this stone in Siberia, in a bed of aqua marina, in the mountain Odon-Tchelon, near the river Amoor. The transverse divisions of the crystals he collected are shining and oblique. These crystals were accompanied with mica, aqua marina, and a phosphorescent crystallized carbonat of lime.—*Thomson.*—*Brongniart.*

Sal Alembrotu. A compound muriat of mercury and ammonia. See Alembrotu.

Sal Ammoniac. Muriat of ammonia.

Sal Ammoniac (Secret). Sulphat of ammonia, so called by its discoverer Glauber.

Sal Catharticus Amarus. Sulphat of magnesia.

Sal de Duobus. Sulphat of potash.

Sal Diureticus. Acetat of potash.

Sal Gem. Native muriat of soda.

Sal Glauberi. Sulphat of soda.

Sal Martis. Green sulphat of iron.

Sal Mirabile, *or* **Sal Mirabile Glauberi.** Sulphat of soda.

Sal Mirabile Perlatum, *or* **Sal Perlatum.** Phosphat of soda.

Sal Polychrest Glaseri. Sulphat of potash.

Sal Prunella. Nitrat of potash, cast into flat cakes or round balls, after its water of crystallization has been expelled by fusion.

Salep. The powder of the orchis root. The farina of potatoes is said to be an excellent substitute for salep, and less liable to spoil by keeping.

Saliva. The fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of saliva. All the properties of this liquor, which had been observed by philosophers before the middle of the eighteenth century, have been collected by Haller: but since that time several additional facts have been related by Fourcroy, du Tennetar, and Brugnatelli; and a very numerous set of experiments have been published by Mr. Siebold in 1797, in his Treatise on the Salivary System.

Saliva is a limpid fluid like water, but much more viscid: it has neither smell nor taste. Its specific gravity, according to Hamberger, is 1·0167; according to Siebold, 1·080. When agitated it froths like all other adhesive liquids; indeed it is usually mixed with air, and has the appearance of froth.

It mixes readily neither with water nor with oil; but by trituration in a mortar it may be so mixed with water as to pass through a filter. It has a great affinity for oxigen, absorbs it readily from the air, and gives it out again to other bodies. Hence the reason why gold or silver, triturated with saliva in a mortar, is oxidized, as du Tennetar has observed; and why the killing of mercury by oils is much facilitated by spitting into the mixture. Dr. Saunders ascertained long ago, that mercury soon disappears when triturated with saliva. He found the mucus of the throat still more efficacious, and the mucilage of gum arabic, with which Dr. Plenck of Vienna made an elegant mercurial mixture, as well as a pill, the most efficacious of all. Hence also, in all probability, the reason that saliva is a useful application to sores of the skin. Dogs, and several other animals, have constantly recourse to this remedy, and with much advantage.

When boiled in water, a few flakes of albumen precipitate. From the experiments of Dr. Bostock we learn, that this albumen is not in a state of solution. It is separated by the filter, and subsides of its own accord when the liquid is diluted with water. In his analysis, this coagulated albumen amounted to 0·4 of the solid matter contained in the saliva examined.

When saliva is evaporated, it swells exceedingly, and leaves behind it a thin brown-coloured crust; but if the evaporation be conducted slowly, small cubic crystals of muriat of soda are formed. The viscidity of saliva, and the property which it has of absorbing oxigen, and of being inspissated, announce the presence of mucus as a component part. This is fully confirmed by the effect of neutral acetat of lead, which produces a copious precipitate in saliva. Dr. Bostock considers the mucus as constituting about half of the solid contents of saliva.

When saliva is distilled in a retort, it froths very much. One hundred parts yield 80 parts of water nearly pure, then a little carbonat of ammonia, some oil, and an acid, which perhaps is the prussic. The residuum amounts to about 1·56 parts, and is composed of muriat of soda, phosphat of soda, and phosphat of lime.

The acids and alcohol inspissate saliva; the alkalis disengage ammonia; oxalic acid precipitates lime; and the nitrats of lead, mercury, and silver, precipitate phosphoric and muriatic acids.

From these facts it follows, that saliva, beside water, which constitutes at least four fifths of its bulk, contains the following ingredients:

1. Mucilage,
2. Albumen,
3. Muriat of soda,
4. Phosphat of soda,
5. Phosphat of lime,
6. Phosphat of ammonia.

But it cannot be doubted, that, like all the other animal fluids, it is liable to many changes from disease, &c. Brugnatelli found the saliva of a patient labouring under an obstinate venereal disease impregnated with oxalic acid.

The concretions which sometimes form in the salivary ducts, &c., and the tartar, or bony crust, which so often attaches itself to the teeth, are composed of phosphat of lime.

Such are the properties of human saliva. The saliva of the horse was analysed by Hepel Delachenier in 1780. He collected twelve ounces of it in the space of twenty-four hours by puncturing the salivary duct. Its colour was greenish yellow, its feel soapy, it had a weak disagreeable smell, and a saline taste. Boiling water and alcohol coagulated it in part, as did the acids. When sulphuric acid was used, sulphat of soda was obtained. It putrefied in about fourteen days; and when allowed to evaporate spontaneously, it left a black residuum, like earth. When distilled, it yielded an insipid watery liquor, crystals of carbonat of ammonia, a thick black empyreumatic oil, carburetted hidrogen, and carbonic acid; and a charcoal remained.

It is rather surprising, that no experiments have been hitherto made on the saliva of dogs; though the *hydrophobia* has been usually ascribed to the infusion of the saliva of that animal rendered morbid by disease*.

The Pancreatic Juice has never been examined with much attention; but it does not appear, from the experiments that have been made, to differ much from saliva.—*Thomson.*

Salmiac. A word sometimes used for sal ammoniac.

Salt. Salts or saline bodies formerly constituted a principal division of chemical matters. The characters attributed to them were a strong tendency to combination, sapidity, solubility in water, and incombustibility. But the accuracy of modern science has shown, that these properties, and all others which can be selected to distinguish such bodies which are admitted to be saline, are attended with considerable uncertainty. The tendency to combination is universal, and no less strong in many other bodies than in a large number of the salts. Sapidity is evidently no less general. Solubility in water is scarcely perceptible in a great number of saline compounds, and is a marked character in others not saline, such as alcohol, ether, mucilage, serum, and the like. Neither is the incombustibility of salts more exclusive than their other attributes. The mineral kingdom abounds with incombustible matters which are not salts; and there

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* The remarks of Dr. Mead in his *Essays on Poisons* are too hypothetic and absurd to be transcribed.

are salts, such as the acid of benzoin, ammonia, and others more compounded, which are not destitute of this property. The true limits which divide salts from other bodies have not therefore been ascertained. Whence it seems reasonable to infer, not so much the difficulty of the subject, as that the division itself appears to be of little utility.

Solubility in water is retained by modern chemists as a distinctive character of salts, but in an arbitrary and indistinct way. Thus it is remarked, that all bodies known only by the name of salts are soluble in less than two hundred times their weight of boiling water. A surer way of rendering this distinction useful consists in attending to the component parts. Alkalis, acids, and such compounds as they enter into, are distinguished generally by the name of salts. The two former are called simple salts. Compounds of alkalis and acids are called neutral salts when neither predominates. If the acid be deficient, or in excess, this state is frequently denoted by prefixing sub, or super, to the word marking the acid; as subcarbonat of soda, supertartrit of potash. When the acid is in excess the salt is sometimes distinguished by the epithet acidulous. Bergman distinguishes the compounds of acid and metal by the name of middle salts, but it may perhaps be more convenient to use the accepted term metallic salts. No appropriate name has been given to the combinations, in which the saline character is produced by an alkali without an acid.

An enumeration of all the salts, simple and compound, together with an account of their characters, would comprehend the whole of chemical science. For there are no bodies in nature which are not capable of uniting with some saline substance. We shall, therefore, refer the reader to the articles ACIDS and ALKALIS, for the properties of those salts, and their compounds; and to the respective earths and metals, for the salts of which they constitute the bases. For a general arrangement or enumeration and their component parts, the article NOMENCLATURE, and the Table of Principles in our Appendix, may be consulted.

SALT (AMMONIACAL, FIXED). Muriat of lime.

SALT (AMMONIACAL, SECRET) OF GLAUBER. Sulphat of ammonia.

The term SALT is in general use, to denote, by way of eminence, the muriat of soda, the use of which in common life is so extensive; and the equivalent term is thus employed in most languages. As it is an article of so much importance, the reader probably will not be displeased to find here, in addition to what has been said under ACID (MURIATIC), the following account of the most remarkable salt mines and brine-springs in various parts of the world, with some particulars respecting their situation and the manner in which they are worked, extracted chiefly from Brongniart's Mineralogy.

To begin with Europe: there are in *Spain* a considerable number of brine-springs, and some mines of sal gem. Several of these are in lofty situations. Mr. Bowles, who makes this observation, remarks too, that all the salt-springs issue from the foot of some mountain. Such are those of the Pyrenees.

The mine of Cardonna in Catalonia, near the mountain of Montserrat, is remarkable for this, that the salt forms a homogeneal mass, without any appearance of stratum or crevice, raised about a hundred and eighty yards above the earth, and extending about three miles in circumference. Neither the depth of this heap of salt, nor the nature of the ground on which it rests, is known. The salt composing it is white, or red, or light blue, and is not accompanied with sulphat of lime, which is a rare occurrence.

The mine of Valtierra, in the kingdom of Navarre, near the Ebro, is in a chain of hills at a considerable elevation above the level of the sea. It is enclosed in sulphat of lime.

Beside these, the mine of Servato, in the Pyrenees, is mentioned; and the spring of Salinas, between Vittoria and Mondragon, in the most elevated part of Guipuscoa.

In la Mancha, at Almengranilla, there is a mass of salt similar to that of Cardonna. It is seventy yards in diameter, mixed with sulphat of lime, and covered with the same stone, including crystals of red quartz; above which are siliceous puddingstones, and a stratum of carbonat of lime.

The mines of sal gem, that are wrought at Poza, near Burgos, in Castille, have a remarkable situation, being placed in a vast crater. Mr. Fernandez has found pumice-stones, puzzolana, and other volcanic productions there.

Sal gem is likewise found near Aranjuez and Ocanna, in the transition hills between Sierra-Morena and Madrid.

No mine of sal gem has hitherto been found in *France*, but there are a tolerable number of brine-springs, of which I shall mention those of

Sallies, at the foot of the Pyrenees, near Orther, in the department of the Lower Pyrenees. The soil is calcareous. Sulphat of lime is found in the neighbourhood of the spring.

Salies, to the south of Toulouse, in the department of the Upper Garonne.

Salins and Montmorot, in the department of the Jura. In the first of these two the water contains about 0·15 of salt.

Dieuze, Moyenvoe, and Château-Salins, in the department of the Meurthe. These contain upon an average about 0·13 of salt. These springs, of which there are about twenty, are at no great distance from one another: the first are at the foot of the chain of Jura, the second at the foot of the Vosges. The product of these brine-springs supplies Switzerland with salt.

Montiers, in the department of Mont-Blanc, and consequently in the midst of the higher Alps.

In the same department, near St. Maurice, is the salt rock of Arbonne, which is at a considerable elevation, being near the region of perpetual snow. This is a gypseous stone impregnated with muriat of soda: the salt is extracted by solution in water, and the insoluble matter remains porous and light.

Near Lampertsloch, in the department of the Lower Rhine, are the salt-springs of Sultz; and in the department of the Rhine and Moselle are those of Kreutznach.

Beside these, other brine-springs are mentioned, of which no use has been made, in the department of Côte d'Or; a small salt-lake near Courthezon, in the department of Vaucluse; and several brine-springs, which are now neglected, in the department of the Lower Alps, between Castellane and Tallard. There are some also in the department of the Yonne, at Andreaux and at Camarade; in the department of the Arriège; and in other places.

The only mines of rock-salt in *England* are those in the neighbourhood of Northwich in Cheshire. These were discovered 1670. The first stratum of salt occurs at the depth of about forty yards. The strata vary in thickness, are of a wavy structure, and alternate with strata of clay, under which they are found. The salt is in some places red, in others transparent. The ground over them consists of strata of red clay, coarse-grained sandstone, blue clay, sulphat of lime, and indurated clay. These mines are the most productive of any in the world. The salt is worked by running galleries into the strata, and leaving pillars of it to support the roof, symmetrically arranged, which gives the whole a beautiful appearance. It appears to be free from sulphat of lime.

The brine-springs of our country were known long before the rock-salt was found. When the miners, in searching for them, bore through the stratum of clay that lies over them, they spring up with great force.

Germany abounds in salt, particularly in the dissolved state, or brine-springs. These occur almost every where, from Westphalia and the shores of the Baltic, through Pomerania, into Swabia and Austria. About sixty are mentioned, which supply the general consumption throughout Germany. Of these the following are the chief, proceeding from north to south, and from west to east.

In Westphalia, the brine-springs of Rehme, not far from the Ems. These are situate in a plain. Their water is concentrated by graduation.

In the circle of Lower Saxony, the springs of Lunenburg, in the city of the same name, in the electorate of Hanover. These waters do not require to be concentrated by graduation, and they afford no sulphat of lime; which is the more surprising because there are hills of sulphat of lime near the springs.

Near Brunswic is the salt-spring of Saltzdalen. The spring is at the depth of seventy yards.

Among the brine-springs in the duchy of Magdeburg, those of Halle are to be remarked. Their waters are sufficiently rich in salt, not to require the process of graduation to concentrate them.

In Upper Saxony, in the county of Mansfeldt, are the brine springs of Artern, six leagues from Eisleben. These afford about two thousand tuns a year. A great deal of sulphat of lime is deposited by them.

In Prussian Pomerania is that of Colberg; and in Swedish Pomerania, that of Greifswald, on the shores of the Baltic sea.

In the circle of the Upper Rhine, in Hesse, are the brine-springs of Allendorff, on the Werra.

In Franconia, toward the northern part of the circle, are those of Kissingen and Schmalkalde.

It is to be observed, that many of these brine-springs are included within a circle of about a hundred miles, of which the city of Hanover is the centre. In the plains at the foot of the mountains of the Hartz and Thuringerwald no mines of rock-salt have been found.

We must now proceed to the south of Germany, leaving the mountains of Bohemia, with the circles of Upper Saxony and the Upper Rhine, to the north, before we meet with any more salt. In fact there are salt-mines or brine-springs in Swabia, Bavaria, the Tyrolese, the electorate of Saltzburg, and Upper Austria.

The mines of Tyrol are situate in a very high mountain, two leagues from the city of Halle, on the river Inn, near Innspruck. The sal gem there forms an irregular mass, including fragments of the schist, the *wacke* of Werner, which forms the base of the mountain.

The salt here is wrought in a peculiar manner. Parallel galleries are run into the mass; in these galleries dikes are formed, and water is let into them, where it remains from five to twelve months. When the water is saturated, it is drawn off by pipes, and the solution is evaporated.

In the circle of Austria, the salt mine of Hallein, on the Salza, in the electorate of Saltzburg, is one of the richest in Germany. The mountain that includes it is composed of saline schists, which are wrought like those of Halle in the Tyrolese just mentioned, but the water is suffered to stand on the salt only two or three weeks. No pillar is left in the vast cavern formed by the galleries, that have been cut into it successively.

The salt-mine of Berchtesgaden, near the former two, is wrought in a similar manner, but it contains more sal gem in mass.

At Reichenhall there are thirty-four brine-springs, containing from one part and half to thirty parts of salt in a hundred of water, from all of which salt is extracted.

Salt is found likewise at Aussee, in the western part of Styria; and near it, but in Upper Austria, at Gmuenden, Hallstadt, and Ischel.

In *Switzerland* the brine-springs of Bex, in the canton of Berne, are celebrated for the beauty of the subterranean works, that have been executed in search of these deep sources, and to bring them to the surface. The soil in which they are found is a schistous marl, containing some slender veins of sal gem. It appears to include large blocks of carbonat of lime, and to be itself enchased as it were in beds of sulphat of lime rendered impure by a brown clay. The surrounding soil is covered with the same sulphat of lime as occurs in the subterranean excavations. Sulphur has been found in the carbonat of lime. These brine springs require graduation.

In *Italy* brine-springs are mentioned near Naples; and in Farther Calabria, near Altamonte, at the foot of the Apennines. These springs contain sulphat of lime also.

In the middle of the island of Sicily, and toward the western part, there are brine-springs, near Castro Giovani, Calatascibetta, Regalmuto, Cattolica, and other places.

It appears from the preceding account, that the majority of brine-springs and mines of rock-salt are found at the foot of high mountainous chains. The mines of Transylvania, Upper Hungary, Moldavia and Poland, are further proofs of this general principle. These mines, which are very numerous, and important with regard to their extent, the vast bodies of salt they contain, and their product, are found along the chain of the Carpathian mountains, and spread nearly in an equal degree on each side of the chain. They accompany these mountains to the extent of more than two hundred leagues, from Wieliczka in Poland, toward the north, to Fokszian, or Rymnick, in Moldavia, to the south.

The stripe of land that contains the salt-mines or brine-springs is near forty leagues broad in some parts. In it may be reckoned about sixteen mines, that are worked for salt; forty-three indications of mines, that have never been wrought; and four hundred and twenty or four hundred and thirty brine-springs.

The most remarkable of these are, beginning in the north-east and proceeding in a southerly direction, those of Wieliczka, Bochnia, and Samber, in Poland; and some brine-springs in Buchovina and Moldavia, particularly near Ockna. On the south-west of the chain, following the same direction, are those of Sowar, near Eperies, in Upper Hungary; of Marmarosch, in Hungary; of Dees, Torda, Paraïd, and Visackna, near Hermannstadt, in Transylvania; &c.

The salt-mines of Wieliczka, near Cracow, and those of Bochnia, which appear to be a branch of them, are celebrated from the accounts given of them by almost every traveller in that country, many of whom have represented them in too strong colours. They are very ancient, having been worked ever since the year 1251. In other respects they have nothing to distinguish them above others, except the extent of the works in the beds of rock-salt, the dimensions of which still remain unknown. The ground that covers them is composed, like that over most other salt-mines, of alternate strata of sand, marl, pebbles, and marl including large blocks of salt. Such of these blocks as are first found are mingled with clay, and called *green salt*. The purest salt is called *schibika*. These mines are about two hundred and eighty yards deep.

In the mine of Bochnia the salt presents itself in a stratum at once, and not in detached pieces. The strata of clay, as well as those of salt, are undulated, and not of a uniform thickness. The salt is sometimes brown, at others reddish, and at others transparent. The different coloured salt is not arranged in parallel layers. The strata dip at an angle of about forty degrees with the horizon. Townson informs us, that very beautiful specimens of fibrous muriat of soda are found in it.

At Thorda the mass of salt is divided into horizontal but undulated strata. These strata are two or three centimetres (near eight or twelve inches) thick. The lowest are the most undulated.

You go down into the salt-mines of Wieliczka by six shafts of four or five yards in diameter. Various structures have been formed in the body of the salt itself. We find there a stable, chambers, and chapels, all the parts of which, as pillars, altars, and statues, are of salt. The shafts and galleries are perfectly dry, so that you are more incommoded with dust than dirt. There are springs, however, both of salt water and of fresh, in these mines. It appears, that the air is not so foul in them as in most salt-mines; but the workmen do not reside in them, as some have asserted. In certain parts of the mine hidrogen gas sometimes collects, and takes fire.

The salt is cut out in little ascending steps. It is formed into parallelopipedons weighing about eighty or a hundred pounds, or into cylinders, which are put into casks. This mine produces about six thousand tuns of salt every year.

Near Ockna, in Moldavia, there is a hill of rock-salt, in many parts of which the salt appears exposed to view.

The mines on the south-east of the Carpathian chain appear more numerous, and are dispersed through a greater space of ground than those on the north-east. They are in general very near the surface. Some of those in Transylvania are so to such a degree, that persons are appointed to cover the salt with turf, when it is washed bare by the rain. These masses, however, are so thick, that their bottom has never been found. If they be not worked to the depth of more than a hundred and seventy or eighty yards, it is because the extraction of the salt becomes then too expensive. In the county of Marmarosch they have been wrought to the depth of upward of two hundred yards. These mines contain likewise a great deal of petroleum; and the ground in which they are contained is every where furrowed by rivers. The mud interposed between the water of these and the salt is imagined to prevent the salt from being dissolved by them.

At Paraid, in Transylvania, there is a valley, the bottom and sides of which are of pure salt. Walls of salt appear there sixty or seventy yards high.

The mine of Eperies is three hundred and sixty yards deep.

In the salt-mines of Marmarosch water has been found included in the substance of the salt rock.

The mines on the south-west of the Carpathian mountains are generally wrought by means of shafts. There are at least two to each mine; one for the workmen, the other for drawing up the salt. The salt is cut out in ascending steps, which produces empty spaces of a conical form in the midst of the strata. The ladders reach perpendicularly to the bottom of this conical space, so that within it they stand perfectly detached. Thus the greater part of the body of salt is extracted, leaving empty spaces, which are conical, and which communicate with one another by means of galleries. It has been thought, that, in order to leave less salt, it would be better to give these spaces the shape of a parabola, or rather even a square, with vertical walls meeting together in the form of an ogee. The salt is so plentiful, that the miners are paid only for such pieces as weigh upward of eighty pounds; the others being rejected as useless. When the workmen are incommoded by water, it is drawn up in leathern bags, to be emptied out of the mine.

The Transylvanians and Moldavians extract salt from their brine-springs, by throwing the water on wood fires, as the Gauls and Germans did in former days.

No salt-mine or brine-spring is known either in *Sweden* or in *Norway*.

There are a great number of both, and particularly of salt lakes, in *Russia*. The latter is peculiar to this country, there being no salt lakes in any other part of Europe.

Among these is the salt lake of Tor, toward the northern extremity of Little Tatary.

There are similar salt lakes in the Crimea, which appear to belong to the same system.

At Balachna, on the banks of the Wolga, are some very rich brine-springs.

We now proceed to *Asia*.

In Russia in Asia we find the brine-springs of Permia, of which there are a great number, at the foot of the mountains of Poyas.

About eighty wersts from Yena Tayeoska, in the desert between the Wolga and the Ouralian mountains, there is a mine of rock-salt.

In the government of Astracan, to the north of the Caspian sea, in the environs of Orenburg, and in the country of the Bashkirians, salt lakes are very common; and the water evaporating during the summer, the salt appears crystallized on their surface, and round their borders. When this water is highly concentrated, it has a deep red colour. The salt formed in them has often the same hue; and when this is the case it diffuses a very perceptible violet smell.

One of these is the salt lake of Elton, above Astracan, in the reentering angle formed by the Wolga. The Kalmucks call it the Golden Lake, because of its red appearance when the sun shines on it.

The lake of Bogdo, situate near this, yields a perfectly white salt, free from sulphat of magnesia, and preferred to that of lake Elton.

Near Astracan too is the mine of Iletzki, celebrated for the quantity of salt it furnishes. The salt lies at no great depth, and rests on a very hard clay. The soil above it is sandy, and full of holes containing water saturated with salt.

In *Siberia* there is a mine of rock-salt, on the right bank of the Kaptendoi; and on that of the Kawda are fourteen brine-springs. Others are found in the government of Kolivan, and in the environs of Irkutsk, near the lake Baikal, in the centre of Asiatic Russia. Lastly, the country near the Caspian sea is so impregnated with muriat of soda, that in the environs of Gourief the fogs and dew, that settle on people's clothes and on plants, are saline.

Among the *Mungal Tatars* the soil is so thoroughly penetrated with muriat of soda, that the people lixiviate it, and evaporate the solution, to obtain the salt.

That part of *China* which borders on Tatary contains salt mines, and the ground is strongly impregnated with salt.

Salt is found in the same manner throughout almost the whole table-land of *Great Tatary*, *Tibet*, *Indostan*, and particularly *Persia*, where very extensive plains are seen covered with saline efflorescences. This is eminently the case near Bender-Congo.

The isle of Ormus, at the mouth of the Persian Gulf, appears to be one large rock of salt.

This substance is likewise found in solid masses near Balach on the eastern frontier of Persia; in the environs of Ispahan, in Media; in the mountains that surround Komm, to the north of Ispahan; &c.

The salt-mines of *America* are less known, but they appear to be numerous in that quarter of the globe, and to exist under the same circumstances as in the old continent.

There are salt-mines or brine-springs in *Kentucky*, the western part of the United States, between Limestone and Lexington, behind the Alleghany mountains. These are at places called Licks, whither the elks and buffaloes formerly repaired in herds to lick the soil impregnated with salt.

In *California* salt is found in a very pure state, and in large solid masses

The mountain of Xaragua in the island of *St. Domingo* affords salt; and in the same island there is a very remarkable salt lake about twenty-two leagues in circumference, called Henriquelle. The water, which is inhabited by lizards, alligators, and land tortoises, all of a large size, is deep, clear, bitter, salt, and of a disagreeable smell. Near the middle of the lake is an island about six miles long and three broad, well stocked with goats, whence it has the name of Cabrito Island; and in this island is a spring of fresh water.

Salt lakes occur in others of the West India islands.

In *Peru* there are several mines of sal gem in very hard masses. What is remarkable in their position is, that they are in the highest part of the country, as for instance in Potosi. The most usual colour of the salt is a jasper-violet.

There are likewise salt plains in South America. One of great extent is mentioned in the environs of Lepis, toward the northern extremity of Peru. Another in Chili, in the provinces of Copiapo and Coquimbo, which are nearest to Peru And, lastly, in the southern extremity of America, near St. Julian's Bay, in Patagonia, there is a salt marsh two miles long.

These are the principal places in the globe where salt is found. It occurs likewise, but in less quantity, in springs of mineral water holding other saline substances in solution, such as those of Balaruc, Bourbon, Bourbon-Lancy, Lamotte, &c.

Though salt is generally used in small quantities, its use is so general and constant, that a vast quantity is consumed merely for seasoning our food. A still more considerable quantity is employed in salting various kinds of provision, chiefly animal, but some vegetable, to preserve it for use. Considered in this light it is of great importance, affording employment to a number of persons, and furnishing several articles of commerce. Hence it was natural, that endeavours should be made to extract it as cheaply as possible, in every place where nature offers it to us with bountiful profusion.

The mines of rock-salt are commonly wrought as has been mentioned above. Plate VIII. exhibits a perpendicular section through the middle of the salt-mine of Visachna, on the south-west of the Carpathian mountains.

1. A stratum of vegetable mould.

2. Stiff yellow clay.

3. Gray and yellow clay, mixed with spots and veins of sand and ochre.

4. Grayish blue clay.

5. Fine white sand.

6. Black, fat, bituminous clay, immediately covering the bed of salt.

7. The body of salt, divided into inclined strata. This has been penetrated to the depth of about two hundred yards. It is traversed by veins, (8, 8) of a bituminous clay, of the same nature as that at 6. This clay contains sulphat of lime.

A. The shaft by which the salt is drawn up.

C. The shaft through which the workmen pass up and down by means of a ladder placed in it.

D. A shaft that receives the rain-water, and conducts it to the drain F.

B. A shaft that receives rain-water, and conducts it into the gallery E.

E, E, E. Sections of two circular galleries surrounding the shafts A and C, which collect the waters that penetrate between the strata of clay, and conduct them to the drain F, through which they are carried off

H, H. A conical space hollowed out of the rock-salt in working it.

a a, a a. Pieces of timber driven into the bed of salt, and supporting all the wood work of the shafts.

b b, b b. Sheep-skins, nailed on these pieces of timber, to keep them from wet.

c, c. Bags in which the salt is drawn up.

d, d, d. Cuts for extracting the salts in oblong squares.

e, e. Blocks of salt ready to be put into the bags and drawn up.

When this salt is impure. it must be dissolved in water, in order to purify it.

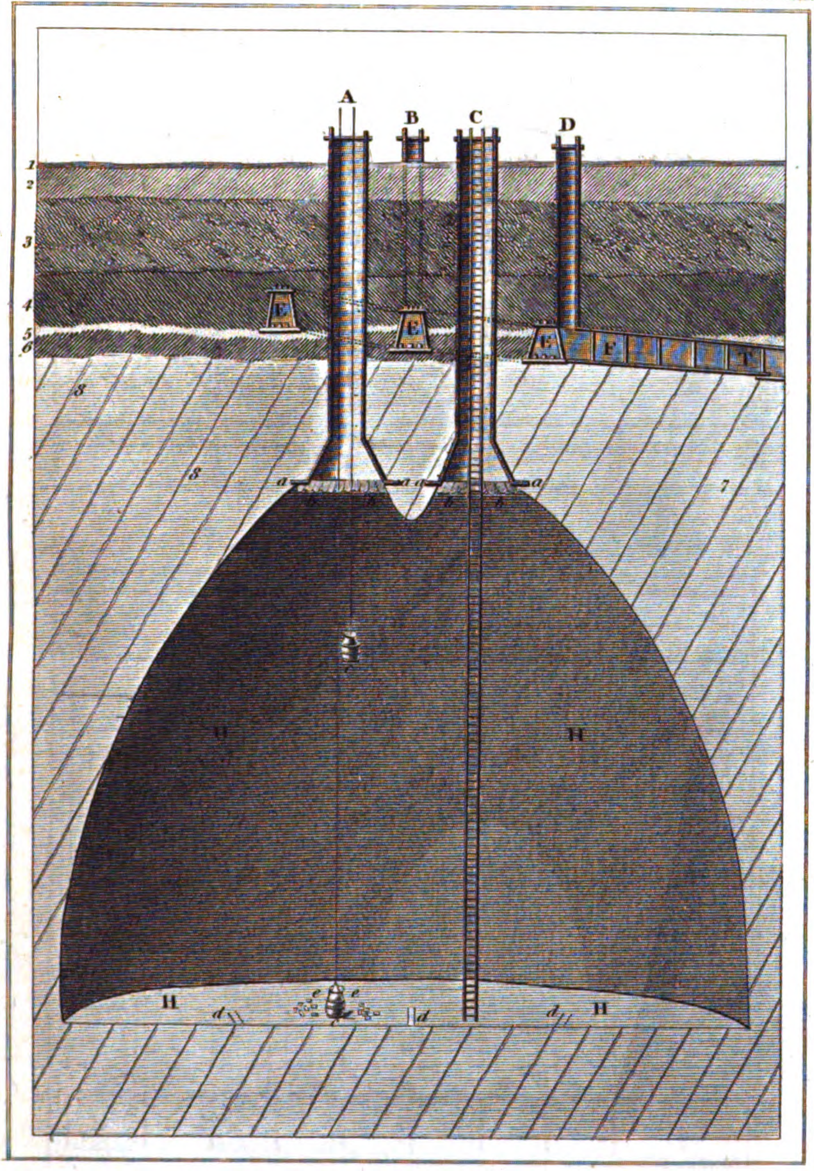
The water of the ocean contains our most ample store of salt, but not the richest. If we had no means of obtaining the muriat of soda from it but by the heat of fires, salt would be an expensive article of consumption. Recourse therefore has been had to two methods of attaining this purpose: 1st, by natural evaporation: 2d, by natural and artificial evaporation combined.

In the first case the salt is extracted by means of brine-pits. These are large shallow pits, the bottom of which is very smooth, and formed of clay. They are made near the sea-shore, and consist of

1st. A large reservoir, deeper than the proper brine-pits, and dug between them and the sea. This reservoir communicates with the sea by means of a channel provided with a sluice. On the sea shore these reservoirs may be filled at high water, but the

SALT MINE.

Plate VIII.

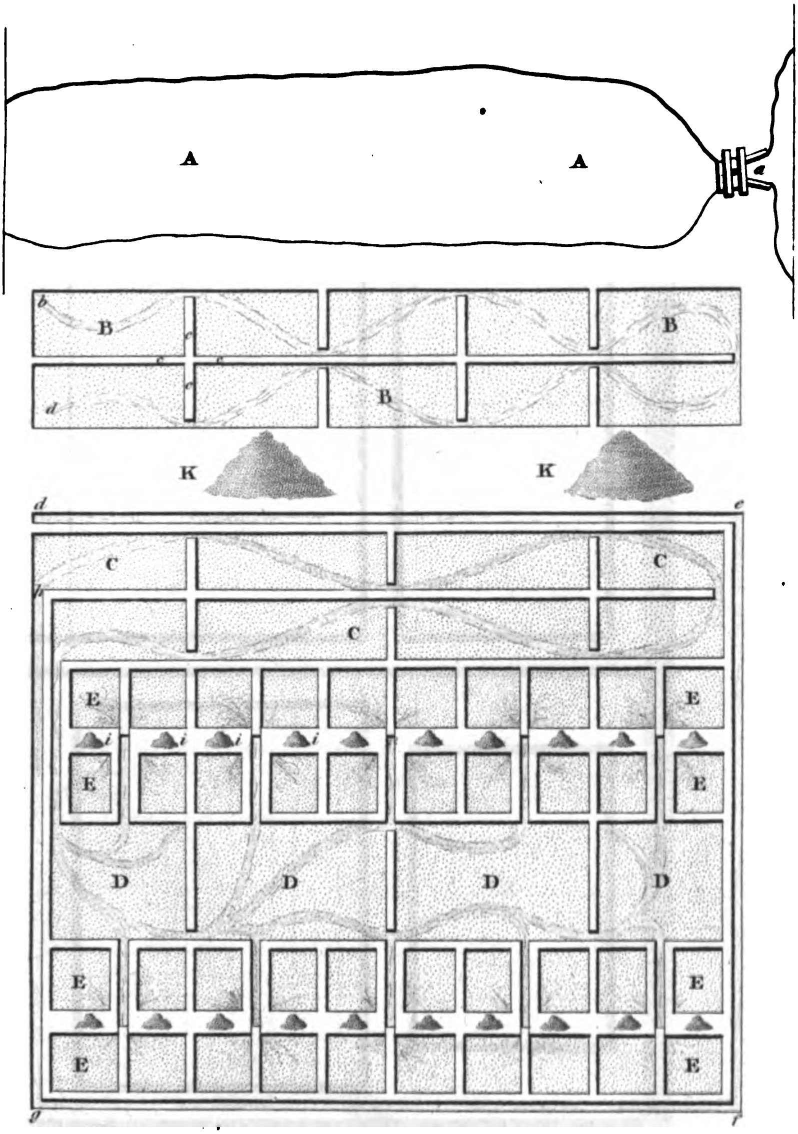


Cooper Sculp.

Published Aug.t 1, 1808, by R.d Phillips, Bridge Street, Blackfriars, London.

BRINE PITS.

Plate IX.



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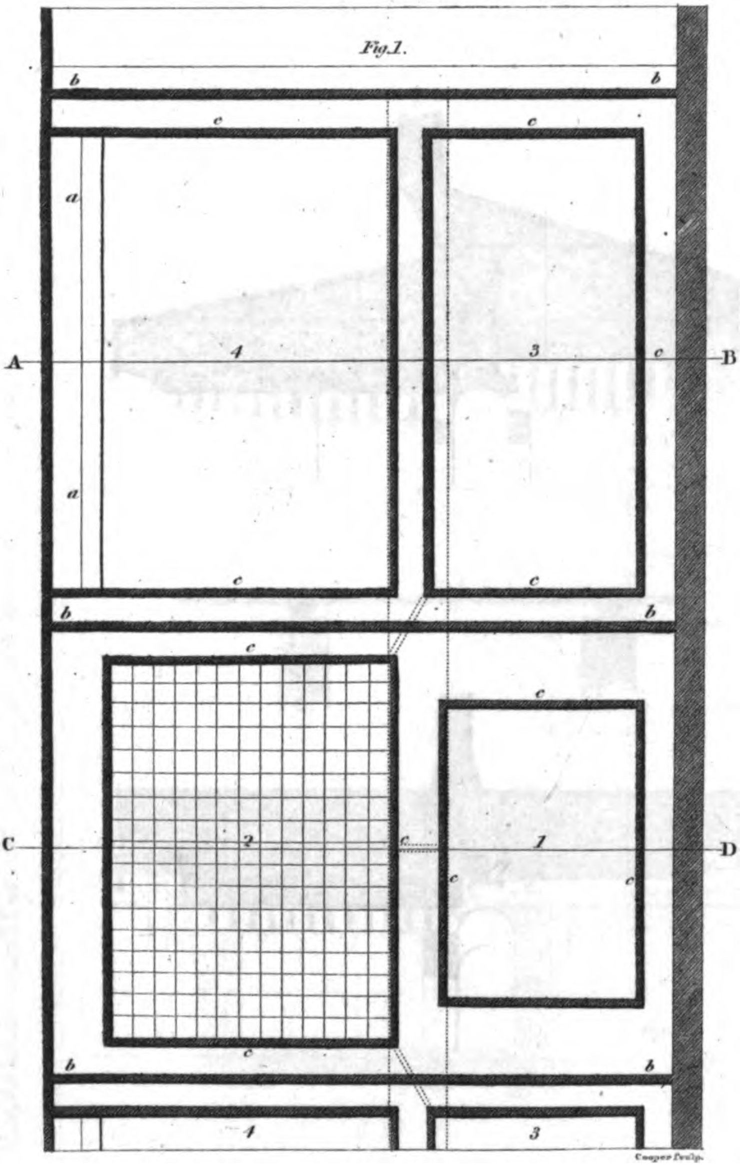
SALT WORKS.

Plate X.

Evaporating Pans.



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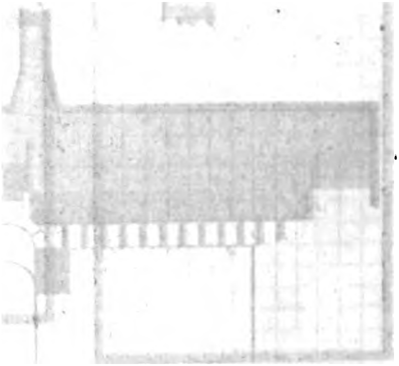


SALT WORKS.

Plate XI.

Bavarian Method of evaporating Salt Waters.

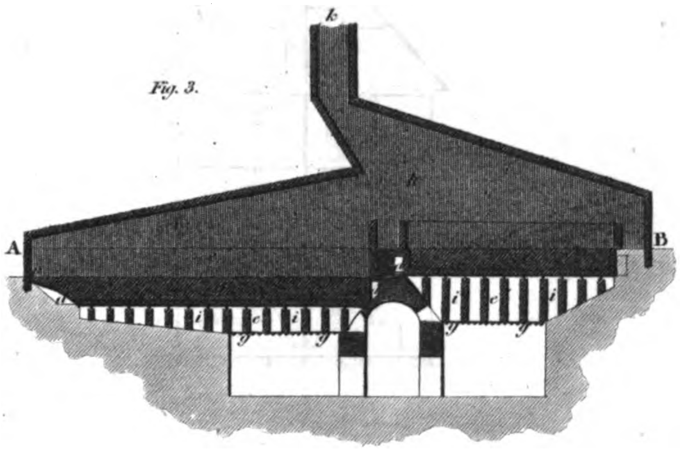
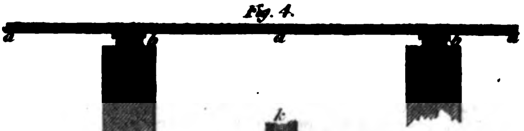


Fig. 3.

Fig. 4.



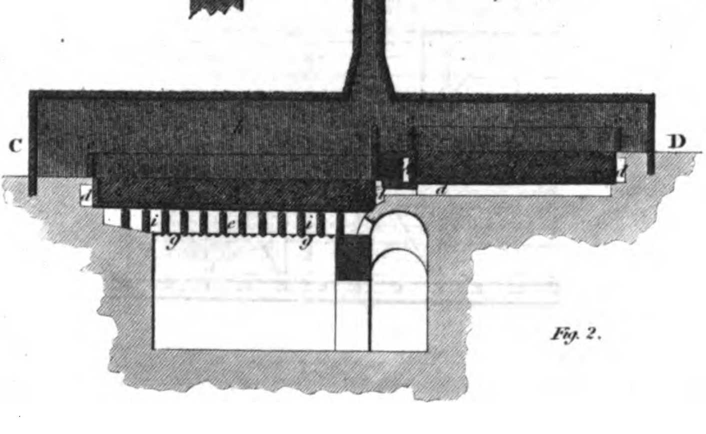


Fig. 2.

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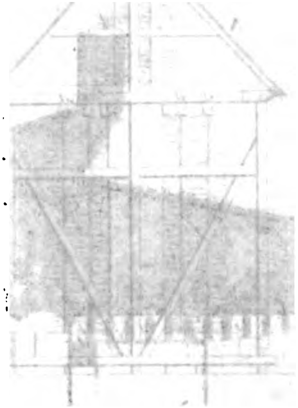
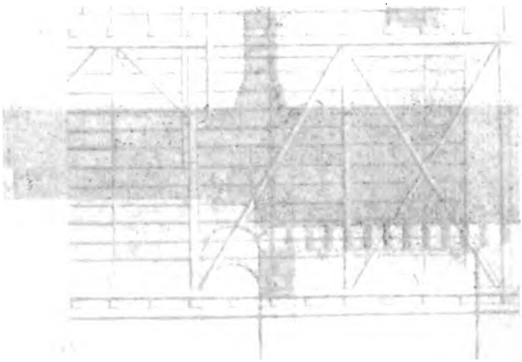
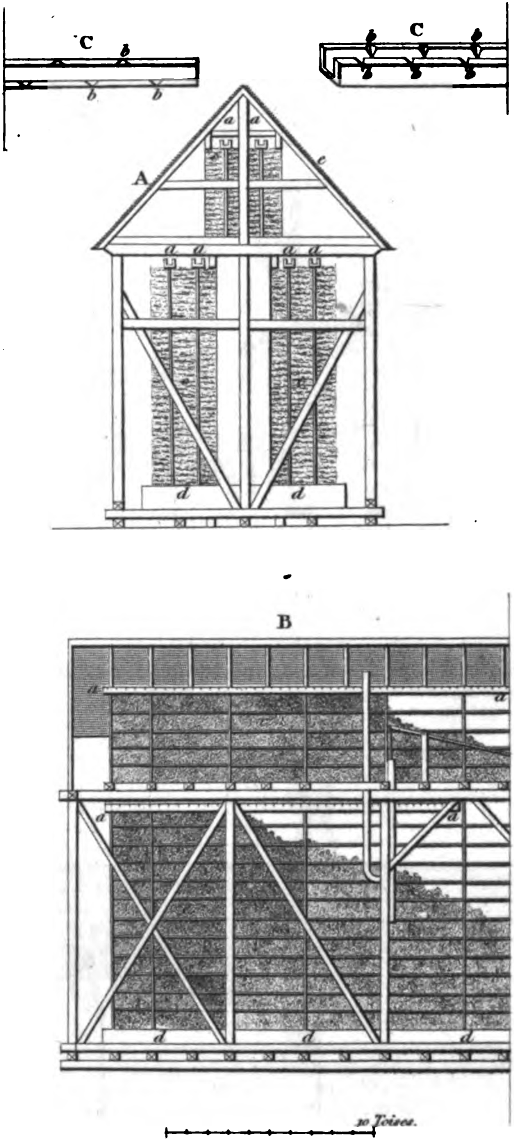




SALT WORKS

Plate XII.

Graduation-house.



Cooper Sculp.

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tides are rather inconvenient than advantageous to brine-pits.

2dly. The brine-pits properly so called, which are divided into a number of compartments by means of little banks. All these compartments have a communication with each other, but so that the water frequently has a long circuit to make from one set to another. Sometimes it has four or five hundred yards to flow before it reaches the extremity of this sort of labyrinth. The various divisions have a number of singular names, by which they are technically distinguished, and differing much in different places.

The brine-pits should be exposed to the north, north-east, or north-west winds.

Plate IX. exhibits a plan of a set of brine-pits.

A, A. The great reservoir, into which the water flows through the sluice *a*.

B, B, B. The second reservoir. Into this the water enters by a subterranean channel at *b*, and, circulating through the several divisions in the direction of the shaded line, finds its exit at *d*.

c, c, c, c. Narrow banks of earth separating the divisions.

C, C, C. The third reservoir. The water, on quitting the second reservoir, enters through an aperture at *d* the long narrow channel *d*, *e*, *f*, *g*, *h*, whence it flows into C, C, C, as it had before done B, B, B.

D, D, D, D. The fourth reservoir, into which the water flows as shown in the plate from the third reservoir; and from which it is ultimately distributed among the small square basins E, E, E, E, E, E, E, E.

i, *i*, *i*, *i*. Heaps of salt drawn out of the basins E, E, and left to drain.

K, K. The salt collected together in larger heaps, and left to drain still more.

The water of the sea is let into these reservoirs in the month of March. It affords, as is apparent, a vast surface for evaporation. The first reservoir is intended to detain the water till its impurities have subsided, while at the same time the evaporation commences in it. From this the other reservoirs are supplied, as their water evaporates. The salt is considered as on the point of crystallizing, when the water begins to grow red. Soon after this a pellicle forms on the surface, which breaks, and falls to the bottom. Sometimes the salt is allowed to subside in the first compartments, sometimes it is made to pass on to others, where a larger surface is exposed to the air In either case the salt is drawn out, and left upon the borders of the pans to drain and dry. In this way it is collected two or three times a week toward the end of the operation.

The salt thus obtained partakes of the colour of the bottom on which it is formed; according to the nature of which it is white, red, or gray. The last is frequently called green salt. Sea-salt has the inconvenience of tasting bitter, if used immediately after it is made. This is owing to the muriat of lime and sulphat of soda, with which it is contaminated. By exposure to the air for two or three years it is in part freed from these salts.

Brine-pits are almost as numerous as salt-mines and brine-springs. Those of Portugal have the repute of furnishing the best salt. It is large-grained and almost transparent. The Irish give a preference to it for salting beef. The salts next in esteem are those of Sicily, Sardinia, and Spain.

The salt manufactured in France is appropriated to other uses, particularly for salting fish. There are brine pits on the shores of the Mediterranean, in the department of the Mouths of the Rhone, and that of the Herault, near Aiguemortes. Those of Peccais are at the place last mentioned. The series of operations differs a little from that just described, but the principles are the same.

On the Atlantic coast are those of the bay of Bourgneuf, of Croisic, of Brouage, of Tremblade, and of Marenne, in the department of the Lower Charente.

In the second mode of extracting salt from sea-water a very smooth plain of sand is formed on the sea-shore, at such a height as to be covered only at spring tides. In the interval this sand dries in part, and is covered with a saline efflorescence, which is removed, and set by. When a sufficient quantity of this is obtained, it is washed in pits with sea-water, which thus becomes saturated with salt. This water is placed in large shallow leaden pans, the superfluous water is evaporated by the help of fire, and thus fine white salt is obtained. This process is followed on the coasts of the department of the Channel, near Avranches.

It is said too, that the sea-water may be concentrated by freezing, the part that is frozen containing much less salt than that which is not: but in this way it cannot be concentrated beyond sixteen or seventeen degrees.

The process of congelation cannot be employed for brine-springs that contain sulphat of magnesia, because this salt decomposes the muriat of soda at so low a temperature; sulphat of soda being formed, with muriat of magnesia, a deliquescent salt, that impedes the crystallization of the muriat of soda, and injures its quality.

Another process was employed by the Romans in their salt works at Cervia and Ostia. They piled up the salt in heaps, and burned osiers around them. This hardened the surface of the salt so that it had the appearance of being vitrified, and the rain that fell slid off, without dissolving any of the salt. The water in the heap, being also prevented from evaporating by it, carried with it, as it drained off, all the deliquescent salts, and thus rendered the salt itself more pure and dry.

Lastly, at Walloe in Norway graduation houses are employed to concentrate the sea-water, which is said to be there at five degrees. By this mean, and the addition of a little Northwich salt, it is brought to the strength of thirty-two degrees, and evaporated in furnaces, as will be described below.

When the water of brine-springs is sufficiently impregnated with salt to contain at least fifteen parts in a hundred of water, that is to say, is at fifteen degrees, it is subjected directly to evaporation. The pans or basins in which this is performed are sometimes of lead, but more commonly of iron. They are very large, but shallow. Their bottom is flat and smooth, though composed of several pieces; but these pieces of iron have projecting edges on the outside of the pan, which are fastened together by screws, so as to form a very secure and even joint. During the evaporation sulphat of lime is deposited, which must be removed with care. Little flat tin pans are placed on the borders of the large pan to receive this, and are removed when the salt begins to crystallize; but this method is insufficient. Toward the end of the operation the salt mixed with sulphat of lime begins to adhere to the bottom of the pan, and forms a crust not easily removed. Mr. Nicolas has proposed, to dissolve this in water holding but little salt in solution.

This crust, which contains a great deal of sulphat of lime, is so hard, that it is frequently thrown away as useless. Mr. Unger has turned it to considerable advantage, by powdering it under stampers, and dissolving the salt it contains in some of the water of the same brine-springs, which is thus rendered much stronger. These crusts are produced by the salts, which the water lets fall on that part of the pan, where it is converted from the liquid into the aëriform state. If it were evaporated without ebullition, this would not take place.

Mr. Cleiss, inspector of the salt-works of Bavaria, has lately introduced at Moyenvie a method of evaporation, which appears to prevent most of these inconveniences.

The pans are composed of square plates of cast iron, of 4 millimetres (1·573 line) in thickness, and 4·76 centimetres (18 inches) long on each side. These plates are joined by their edges, which are turned downward, and consequently without the pan; and they are firmly united by a piece in the form of a square gutter, which receives the edges, and is secured by a great number of screws.

An evaporating-house is composed of six pans, of this construction, disposed in two rows; but these pans have different uses, which require a particular arrangement.

That in the middle of the back row is the smallest; and it has no particular fireplace, but it is heated by the junction of the chimneys from the other fire-places. The salt water deposits its impurities in this, which is called the small pan.

From the small pan the salt water passes into the graduating pan, which is lower than the first, and placed in the middle of the front row. The water is there kept in a state of constant ebullition, is concentrated in it to 20 degrees, and deposits a part of its sulphat of lime.

From the graduating pan the salt water passes into the preparing pans, which are lower than it, and placed at the two extremities of the back row. In these it is also kept constantly boiling, is completely concentrated, and deposits all its sulphat of lime. It is then passed into the crystallizing pans, which are still lower than the preparing pans, and placed at the two extremities of the front row. In these the water scarcely boils, and the salt crystallizes.

Each pan, with the exception of the small pan, has a particular fire-place, the chimneys of which pass round the sides of the pan, and unite under the small pan, by which means there is little heat lost.

These pans are placed two and two in chambers of wood, the joints of which are well secured, and by which they are completely surrounded. These chambers are low, and their ceilings are perforated in the middle with holes terminating in a tube, by means of which the aqueous vapour is disengaged with rapidity. The chambers for the preparing and crystallizing pans have their ceiling pyramidical, or in the form of a hopper reversed, while that for the small pan and the graduating pan is horizontal.

The saline waters are passed successively into these four kinds of pans; and the workmen go into the chambers, in the midst of the vapour, to open the communications. This operation is performed every six hours, and the water in each pan is restored to the level at which it stood six hours before. Every three hours the salt in the crystallizing pans is collected, and is brought with scoops to elevations on the front edge of the crystallizing pans, where it drains. It is afterward carried into drying rooms, which surround the outside of the chambers. These are spaces covered with iron plates, and warmed by heat-tubes leading from the fire-places.

Once a week they take away the sulphat of lime, throw out the mother-waters, and break the shell, that is to say, the incrustations of salt which adhere to the bottoms of the pans. Every three weeks the work is entirely stopped, to repair the pans, an operation which is performed by the workmen themselves.

It has been found, that this method of evaporation affords a saving of more than one third of the fuel.

An improvement has lately been made in this process at Dieuse: the small pan has been suppressed, and the drying rooms have been replaced by auxiliary pans, in which a coarse salt is made.

The heated drying rooms are useless, when the humidity of the salt arises from the muriat of lime it contains.

Explanation of Plates X *and* XI.

Fig. 1. Plan of the pans.

No. 1. Small pan.

No. 2. Graduating pan.

No. 3. Preparing pan.

No. 4. Crystallizing pan.

The arrangement of the plates of iron, which compose these pans, is shown in No. 2.

a, *a*. Elevation on which the salt is placed to drain, as it is taken from the crystallizing pans.

b, *b*, *b*. Wooden partitions, which separate the chambers.

c, *c*, *c*. A raised wooden ledge, which surrounds the pans.

Fig. 2. Section of the evaporating chamber, which contains the pans 1 and 2, in the line C, D.

d, *d*, *d*. Heat-tubes, which give heat to the small pan, and contribute to heat the others.

e, *e*, *e*. Fire-place for the pans.

i, *i*, *i*. Pillars of cast iron, over the gratings *g*, *g*, *g*, which support the bottoms of the pans.

h. Wooden chamber, which contains the two pans.

k. Opening by which the vapours escape.

Fig. 3. Section of the evaporating chamber, which contains the pans 3 and 4, in the line A, B.

a. Elevation on which the salt from the crystallizing pans is placed to drain.

The other letters indicate the same parts as in the preceding figures.

Fig. 4. Method in which the plates of iron are joined, to form the pans.

a. The iron plate.

b. The iron gutter, which receives the edges of the plates, and is strongly fastened with screws.

i, *i*. Pillars of cast iron, which support the bottom of the pan.

Sometimes the water is evaporated to dryness, but this is rarely done, because for this the water must contain no muriat of soda. Commonly the mother-water is left, containing chiefly the deliquescent salts, which are muriats of lime and magnesia. These salts, while they increase the bulk of the mother-water, add also to the consumption of fuel, and render the salt obtained bitter and deliquescent.

Mr. Gren proposes to decompose them in the large way by the addition of lime and sulphat of soda. In this case two substances are precipitated, one of which is insoluble, the magnesia; and the other, the sulphat of lime, is but little soluble. The saline water may then be evaporated entirely, and the salt obtained will be pure and dry.

Lastly, to save fuel is always made an object in these works. The form of the furnaces, and the dimensions of the pans, are calculated to obtain this important end.

In most works where saline waters are evaporated a smell by no means disagreeable is perceived. This appears to arise from the small portion of bitumen, which is almost always mixed with salt in its mines.

When saline waters contain but a small quantity of salt, the evaporation of it by fire in its natural state would be too expensive. It must be concentrated therefore by some cheaper mode.

Now it is well known, that, to promote and accelerate the evaporation of a fluid, it should be made to present a large surface to the air. To effect this, the water is pumped up to the height of nine or ten yards, and made to fall on piles of faggots built up in the shape of a wall. The water, distributed uniformly over these by means of troughs, is minutely divided in its descent, and thus experiences a considerable evaporation. The same water is frequently pumped up twenty times or more, to bring it to the degree of concentration necessary. This operation is called *graduating*, and the piles of thorn-faggots thus erected are termed *graduation-houses*.

These piles are covered with a roof, to shelter them from the rain, are made about five yards thick, and are sometimes more than four hundred yards long. They should be so constructed, that their sides may face the prevailing winds.

Plate XII represents a graduation-house at Bex, with the improvements lately made in it by Mr. Fabre.

A. Transverse section of the building.

B. Longitudinal section.

c, *c*, *c*. The faggots of thorns, piled up in two tiers below, and one above.

a, *a*. Wooden troughs, to distribute the salt water over these faggots.

C, C. Plan and perspective view of these troughs.

b, *b*, *b*. Angular notches, through which the water runs out in slender streams, presenting a large surface to the air.

e. Roof, covered with tiles, not laid flat, but raised so as to admit a free circulation of air between them.

d, d. Reservoir, into which the concentrated salt water flows, and from which it is pumped up to the troughs, to be distributed afresh over the faggots.

The state of the air has a considerable influence on the celerity of the concentration. A cool, dry, and moderate wind is favourable to it: while dull, damp, and foggy weather sometimes even adds to the quantity of water.

As the water is concentrated, it deposits on the faggots a coat of selenite, or sulphat of lime, which at length becomes so thick, that their place must be supplied with fresh ones.

When the water is brought to six- or seven-and-twenty degrees by graduation, the evaporation is completed in pans, as has been described.

A process has been adopted at Montier, which, lessening the quantity of fuel employed, renders the operation less expensive. When the water has been concentrated by graduation, and afterward by artificial evaporation so as to be brought to about thirty degrees, which is near the point of saturation, it is made to flow over a number of strings hanging perpendicularly. These strings acquire a coating of salt, which is removed when about two inches thick. A gathering of salt of this thickness may be made twice or three times a year.

Lastly at Artern, in the electorate of Saxony, salt has been endeavoured to be obtained from brine-springs by the action of the sun alone, without having recourse to fire. The water is concentrated by graduation: it is then exposed to the sun in very shallow wooden vats, raised above the ground, and provided with a wooden roof, which may be put on or taken off at pleasure.

Weak saline waters may be graduated in some degree by leaving them to stand in deep reservoirs. In this way the lower part of the water is sometimes raised from containing no more than one per cent of salt to contain fourteen per cent.

Such are the principles of the different methods of extracting or manufacturing salt. In its common state it is in the form of loose granular crystals. These should always be dry: if they be not, the salt has not been perfectly freed from the deliquescent muriats, with which it is often contaminated in its natural state, and consequently is impure; or water has been thrown over it by the vender, to increase its weight, a practice which, I am sorry to say it, is sometimes followed by those, who pay more regard to profit than to probity. In some countries it is formed into loaves, by compressing it in a mould with a small portion of water.

The principal uses of the muriat of soda have already been mentioned under the article muriatic acid. In addition it may be observed, that almost all graminivorous animals are fond of it, and that it appears to be beneficial to them, when mixed with their food. Wood steeped in a solution of it, so as to be thoroughly impregnated with it, is very difficult of combustion: and in Persia it is supposed to prevent timber from the attack of worms, for which purpose it is used in that country. Bruce informs us, that in Abyssinia it is used as money: and it is very probable, that the pillars of fosail glass, in which the Abyssinians are said by Herodotus to have enclosed the bodies of their relations, were nothing but masses of rock-salt, which is very common in that part of Africa.

Salt was supposed by the ancients to be so detrimental to vegetation, that, when a field was condemned to sterility, it was customary to sow it with salt. Some modern agriculturists, however, consider it as a useful manure, though the experiments on this point do not agree. Probably it is most useful in this way when most impure, and not used in too large a quantity.

Salt (Arsenical, Neutral) of Macquer. Superarseniat of potash.

Salt (Bitter, Cathartic). Sulphat of magnesia.

Salt (Common). Muriat of soda. See Acid (Muriatic); also end of the article Salt.

Salt (Digestive) of Sylvius. Acetat of potash.

Salt (Diuretic). Acetat of potash.

Salt (Epsom). Sulphat of magnesia.

Salt (Febrifuge) of Sylvius. Muriat of potash.

Salt (Fusible). Phosphat of ammonia.

Salt (Fusible) of Urine. Triple phosphat of soda and ammonia.

Salt (Glauber's). Sulphat of soda.

Salt (Green). In the mines of Wieliczka the workmen give this name to the upper stratum of native salt, which is rendered impure by a mixture of clay.

Salt (Marine). Muriat of soda.

Salt (Marine, Argillaceous). Muriat of alumine.

Salt (Microcosmic). Triple phosphat of soda and ammonia.

Salt (Nitrous Ammoniacal). Nitrat of ammonia.

Salt of Amber. Succinic acid.

Salt of Benzoin. Benzoic acid.

Salt of Canal. Sulphat of magnesia.

Salt of Colcothar. Sulphat of iron.

Salt of Egra. Sulphat of magnesia.

Salt of Lemons (Essential). Superoxalat of potash.

Salt of Saturn. Superacetat of lead.

Salt of Sedlitz. Sulphat of magnesia.

Salt of Seignette. Triple tartrit of potash and soda.

Salt of Soda. Subcarbonat of soda.

Salt of Sorrel. Superoxalat of potash.

Salt of Tartar. Subcarbonat of potash.

Salt of Vitriol. Purified sulphat of zinc.

Salt of Wisdom. A compound muriat of mercury and ammonia. See Alembroth.

Salt (Perlate). Phosphat of soda.

Salt (Polycurest) of Glaser. Sulphat of potash.

Salt (Sedative). Boracic acid.

Salt (Spirit of). Muriatic acid was

formerly called by this name, which it still retains in commerce.

Salt (Sulphureous) of Stahl. Sulphit of potash.

Salt (Wonderful). Sulphat of soda.

Salt (Wonderful Perlate). Phosphat of soda.

Saltpetre. Nitrat of potash.

Sand. Sand is an assemblage of small stones. It is usually produced by the mechanical division arising from agitation in water. All stones but those of the siliceous order are so soft, that the comminution thus produced is usually carried in them to an extreme degree, so as to form dust, or mud; and their disposition to unite or adhere together commonly produces stones of a different texture from that before possessed by the particles. In this way it appears, that chalks, clays, marls, and other consistent matters may be formed out of harder or more symmetrical materials worn down. But the siliceous earth being not only very hard, but likewise indisposed to adhere together, retains the form of sand, as soon as the parts have become so small as to be deficient in the weight requisite to enable the parts to shake and break each other. Sand is therefore always understood to denote a siliceous matter.

The chief uses of sand in chemistry are in compositions for pottery and glass. Some sands are more and some less fusible, according to the various hard stones from which they may have originated. The size of the particles is of some importance in these works. As an alkali in fusion dissolves siliceous earths in less time the greater the surface of action, or, which is the same thing, the finer the particles of sand, this kind is accordingly preferred for vitrifications.

Sand-Bath. See Bath.

Sandarac. A name sometimes given to the combination of arsenic and sulphur.

Sandarac Gum. A resin in yellowish white tears, possessing a considerable degree of transparency. It was supposed to be obtained from the juniper-tree, and said to occupy a place between the bark and the wood; but the fact is, that the juniper does not grow in Africa, whence only sandarac is brought. According to Mr. Schousboe, a Danish traveller, the tree that produces it is a species of *thuia*, that does not exceed twenty or thirty feet in height, and ten or twelve inches in the diameter of the trunk; and is the cypressus fructu quadrivalvi, equiseti instar articulata. It exudes from the trunk and branches of the tree, like common gums. Its powder is well known by the name of pounce, to be applied to paper when the size has been scraped off by erasion. It is not a pure resin, though water appears to have little if any action upon it. Three or four tears were put into pure alcohol. No remarkable appearance happened; but the next day it was found dissolved with a mucilaginous fluid at the bottom of the vessel, which by agitation became uniformly diffused through the fluid, and rendered it semiopake. Resin is soluble in tallow, by the assistance of heat; but gum sandarach, treated in the same manner, emitted bubbles, swelled up, and enlarged its dimensions greatly; then became brown, imperfectly fluid, and emitted smoke or fume of the peculiar smell of the resin. The tallow did not appear to have suffered any other alteration, than that it became brownish. The gum sandarac, apparently not at all dissolved, was crisp or friable.

Sandiver, *or* Glass-Gall. This is a saline matter, which rises as a scum in the pots or crucibles in which glass is made.

This matter is chiefly composed of sulphat of soda, common salt, sulphat of potash, or other neutral salts, which cannot enter into vitrification, and which were originally contained in the ashes or alkalis employed in the composition of glass. Glass-gall is used to facilitate the fusion of certain ores, and in essays; but this matter must vary much, according to the kinds of alkali or ashes from which it is produced.

Sandyx. A name used either as synonymous with sandarac, for a native sulphuret of arsenic, or for a compound which consists chiefly of this sulphuret.

Sap, or Water-colours, are of that nature, that they are capable of being entirely dissolved in water, but are by no means miscible with oils. They are of a viscid nature; whence they stand in no need of any cementing substance, neither do they dry easily for this same reason, and are transparent. All colouring juices and extracts inspissated by evaporation may be used with this intention: as for instance, a decoction of Brazil wood prepared with alum, and inspissated; extract of saffron, refined Brunswick green, crystallized verdegrise, an aqueous extract of litmus with the addition of a little alkali, gamboge, sapgreen, and the inspissated decoction of the green husks of walnuts. Of these, sapgreen is prepared from the expressed juice of buckthorn-berries not perfectly ripe (Rhamnus catharticus Lin.) by gentle evaporation to the consistence of honey. The sap must be well clarified before it is evaporated. When it is inspissated, as much alum, or, which is still better, sugar of lead, is to be mixed with it by little and little over the fire, as is requisite to produce the finest green colour. A redundancy of these additions is prejudicial. The complete exsiccation must be made with a gentle heat in saucers. The litmus above mentioned, which however contains a blue sap-colour, is prepared in the large way in the manufactories of Holland. Ferber gives the following description of it: Archil (Lichen rocella) is to be mixed with urine, limewater, slaked lime, and some potash, in several large cisterns, which must be kept under shelter, and suffered to stand for several weeks. By this means the mass is rendered soft, and passes over to a kind of fermentation or evolution of its particles, and of the colouring matter contained in them. Now and then it is stirred, and suffered to stand macerating, till the mass is become quite blue, and is converted into a muddy kind of pulp. Upon this the whole mixture is ground in a mill constructed for the purpose, and the pulpy magma dried in moulds. Hither also may be referred the fine sap-blue discovered by Dr. Struve. In order to make this, a quarter of an ounce of indigo is to be reduced to powder, and triturated in a glass mortar with two ounces of good oil of vitriol. After this, four ounces of alum are to be dissolved in warm water, to which must be added two ounces of a solution of tartar in water, or as much as is requisite for completing the precipitation. The precipitate is then to be edulcorated and filtered; and when it is almost dry, the above-mentioned solution of indigo is to be mixed with it. In this manner is obtained a fine blue colour, void of all acrimony, which may be mixed with water ad libitum; with which silk, leather, and bones may be tinged of different shades; and which with some gum forms also a fine sap-colour.

Saponaria Officinalis Lin. Soapwort, bruisewort; the herb and root.

This grows wild, though not very common, in low wet places, and by the sides of running waters; a double-flowered sort is frequent in our gardens. The leaves have a bitter, not agreeable taste; agitated with water, they raise a saponaceous froth, which is said to have nearly the same effects with solutions of soap itself, in taking out spots from cloths, and the like. The roots taste sweetish and somewhat pungent, and have a light smell like those of liquorice: digested in rectified spirit, they yield a strong tincture which loses nothing of its taste or flavour in being inspissated to the consistence of an extract.

This elegant root has not come much into practice among us, though it promises from its sensible qualities to be a medicine of considerable utility. It is greatly esteemed by the German physicians as an aperient, corroborant, and sudorific; and preferred by the College of Wirtemberg, Stahl, Neumann, and others, to sarsaparilla. —*Lewis.*

Sapphire. See Ruby.

Sarcocolla is a gum-resin, of an ounce of which six drachms were found to be soluble by alcohol, and seven drachms and a half by water.—*Neumann.*

Sardonyx. This is a mixture of the chalcedony and carnelian, sometimes stratumwise, and sometimes confusedly blended, or mixed together. That which is striped with white and red strata serves as well to cut in cameo as the onyx. The white with red dendritical figures much resembles that agate, which is called the Mocha stone, but with this difference, that the figures are red instead of black.

Sarsaparilla. From sixteen drachms of this root Neumann obtained by water six drachms of gummy extract, and from an equal quantity he obtained by alcohol four drachms of resinous extract.

Sassafras. The wood of this tree contains the heaviest of all known essential oils. Of this oil Hoffmann obtained an ounce and six drachms from six pounds of the wood; and Neumann obtained from an equal quantity of wood, two ounces. From an ounce of sassafras four scruples of extract were obtained by means of alcohol; and from an equal quantity of the wood two drachms were extracted by water.

Sassolin. A white salt, interspersed with some spots of a dun colour, grouped in stalactites, soft and greasy to the touch, and easily pulverised, found on the borders of the thermal water of Sasso, near Sienna. Analysed by prof. Mascagni, it was found to contain boracic acid ·86, sulphat of magnesia, with a little iron, ·11, sulphat of lime ·03.

Saturation. Some substances unite in all proportions. Such, for example, are acids in general, and some other salts with water; and many of the metals with each other. But there are likewise many substances which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain proportion. Thus water will dissolve only about one fourth of its weight of common salt, and if more be added it will remain solid. A fluid, which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance does not deprive the fluid of its power of acting on and dissolving some other bodies, and in many cases it increases this power. For example, water saturated with salt will dissolve sugar; and water saturated with carbonic acid will dissolve iron, though without this addition its action on this metal is scarcely perceptible.

The word saturation is likewise used in another sense by chemists: the union of two principles produces a body, the properties of which differ from those of its component parts, but resemble those of the predominating principle. When the principles are in such proportion that neither predominates, they are said to be saturated with each other; but if otherwise, the most predominant principle is said to be subsaturated or undersaturated, and the other supersaturated or oversaturated.

The former kind of saturation is remarked in ether with water, essential oils with alcohol, and most neutral salts with water. If we mix together and agitate good ether with water, a part of the ether unites with the water, nearly in the proportion of one to ten; so that if one part of ether be added to ten parts of water, all the ether disappears by being diffused through the water, as the count de Lauraguais observes. If the quantity of ether be more than one tenth part of the water, the overplus will float distinct upon the surface, like an oil.

Also alcohol can dissolve only a determinate quantity of each kind of essential oil, which quantity varies according to the kind of oil, and to the state in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a resinous state, and the smaller quantity of them is soluble. And also the more highly rectified the alcohol is, the larger quantity of oil it dissolves.

Water is the proper solvent of neutral salts. It is capable of dissolving any of them, but most of them only in a certain quantity; and this point of saturation of water differs with different salts and degrees of heat applied. Macquer takes notice, that the point of saturation is most distinct with those salts, which contain a small quantity only of the water of crystallization, and which are nearly equally soluble in hot and in cold water. Such are sulphat of potash, and, still more, common salt.

When the water is once saturated with these kinds of salts, the strongest and longest boiling does not dissolve a grain more, and the overplus of the salt remains entire at the bottom of the boiling water: but boiling water dissolves an equal or even an unlimited quantity of some salts, chiefly of those which contain much water in their crystallization, such as sulphat of soda, alum, borax, sulphats of iron and copper, and others of that kind. The water of crystallization of these salts is alone sufficient to keep them dissolved by means of heat. Hence, when they are exposed to fire without water, they suffer a liquefaction, which is very different from fusion, and is nothing else than a solution of the salt in the water of its crystallization, and consequently lasts only till this water is evaporated. The point of saturation of water for these salts seems to be indeterminate.

Of those substances which are capable of uniting without being precisely saturated, the most remarkable are, water with the pure acids or alkalis, and alcohol with most of the deliquescent salts. Such also are almost all metals uniting with each other: although many of these substances have a great affinity to each other, as the acids and alkalis with water, yet all their general tendency to combination is not exhausted in these kinds of union. On the contrary, in these, the last-mentioned author thinks, that their union is little else than a very accurate and intimate mixture. For their dissolving power is not satisfied by such an union, but is almost entirely preserved. We need not therefore be surprised, that no precise or determinate point of saturation is observed betwixt these substances. We may say, in general, that the point of saturation is so much more exact, distinct, and determinate, as the bodies which unite together have a stronger affinity, as they more completely exhaust upon each other their dissolving power, or as their relative saturation is more nearly equal to their absolute saturation.

The examination of the several degrees of saturation, which substances may sustain by combining together, is an object of great importance in chemistry. This matter has been scarcely begun, and yet it well deserves the attention of chemists, as it would greatly advance the science.

SATURNITE. By this name Kirwan distinguishes a substance said by Monnet to be found in the lead mines of Poullaouen in Brittany, and separated from the lead ore during its torrefaction. According to him, it resembles lead in its colour and specific gravity, is soluble in the same acids, and with the same phænomena; but is much more fusible, very brittle, easily scorified and volatilized, and refuses to mix with lead when in fusion. It were to be wished, that it was better examined.

SATYRIUM. Orchidis masculæ radix. Lin. Orchis: the root.

This plant is frequent in shady places and moist meadows: each plant has two oval roots, of a whitish colour, a viscid sweetish taste, and a faint unpleasant smell. They abound with a glutinous slimy juice. With regard to their virtues, like other mucilaginous vegetables, they thicken the thin serous humours, and defend the solids from their acrimony: they have also been celebrated, though on no very good foundation, for analeptic and aphrodisiac virtues; and frequently made use of in these intentions. Their powder is the salep of the shops.

SAUNDERS. The wood of the tree called red saunders contains a red colouring material used in dyeing. Its colour resides wholly in a resinous matter, and hence it is extractable by alcohol, and not by water. The red colour of saunders imparted to alcohol becomes, by diluting the tincture with more spirit, yellow. The resin gave a deep red colour to oil of lavender, and a pale red to oil of almonds, and to oil of aniseeds; but no colour to oil of amber, or to oil of turpentine. The wood of the tree called yellow saunders is from its fragrance sometimes employed as a perfume. From sixteen ounces of the rasped wood, digested some days in salt water, two drachms of essential oil were obtained by cohobation. Two drachms of gummy extract may be obtained from two ounces of the wood by water; and from an equal quantity of wood, two drachms and a half of resinous extract may be obtained by alcohol.—*Neumann.*

Saussurite. This variety of jade, the *jade tenace* of Haüy, *jade de Saussure* of Brongniart, *lehmanite* of Delametherie, was found first in rounded pebbles on the shores of the lake of Geneva by Theodore von Saussure, and afterward in the mountain of Mussinet, near Turin. It enters into the composition of this mountain, which consists chiefly of serpentine penetrated with hydrophanous silex. In both places this jade is not pure, but constitutes the base of a rock composed of green and brown smaragdite. It has been found with the same stone in Corsica. It is likewise said to occur in the sands near Potsdam, and near Aschaffenburg, of a yellowish white colour, and mingled with smaragdite.

The colour of this stone is rather more green than that of the lapis nephriticus. It is at least as hard, and takes a higher and less greasy polish. It fuses before the blowpipe in a similar manner. Its mean specific gravity is 3·340.

According to Mr. Saussure's analysis, one hundred parts of this jade contain

Silex - - -	44
Lime - - -	4
Alumine - -	30
Iron - - -	12·5
Soda - - -	6
With an atom of manganese and of potash	
	96·5

Scammony is a gummy resinous juice, which exudes from the root of a species of convolvulus, in which incisions are purposely made at a certain season of the year. An ounce of Smyrna scammony yielded with water half an ounce of gummy extract; and the residuum yielded with alcohol two drachms of resin, leaving two drachms of impurities undissolved. By applying alcohol at first to an ounce of the same scammony, two drachms and two scruples of resinous extract were obtained; and from the residuum water extracted half an ounce of gum, the indissoluble part amounting here to four scruples only.—*Neumann.*

Schaumearth. *Schaumerde* of Brochant, silvery chalk of Kirwan, *chaux carbonatée nacrée talqueuse* of Brongniart. This is usually of a fine yellowish or pearly white colour, friable, of a scaly or silky texture, and soft to the feel.

It is found at Gera in Misnia, at Eisleben in Thuringia, and in the north of Ireland, in cavities of stratiform lime-stone.

Its constituent parts, according to the analysis of Bucholz, are

Lime - -	51·5
Carbonic acid	39
Silex - -	5·7
Oxide of iron	3·3
Water -	1
	100·5

Thomson.—Brongniart.

Scheelin. This name is employed by different mineralogists as a generic term for the ores of tungsten, or scheelium. There are but two species known, the calcareous scheelin, tungsten, or tungstat of lime; and the ferruginous scheelin, or wolfram.

Scheelium. The metal more generally known by the name of tungsten is thus called by some in honour of the celebrated Swedish chemist, Scheele, by whom its oxide was first discovered.

Schibika. The purest rock-salt, thus called in the mines of Wieliczka.

Schieferkohle. Slate-coal. This name is applied by Werner to a perfectly bituminous coal, breaking with a straight slaty fracture. Most of our best coals, that cake in burning, and afford large cinders, instead of consuming quickly to white ashes, are of this kind.

Schieferspath. Slate spar, argentine of Kirwan, *chaux carbonatée nacrée* of Haüy. This stone occurs in beds in primitive mountains. It likewise forms the base of a rock mixed with chlorite, sulphuret of lead, and sulphuret of zinc. It has been found in the Vosges, in Saxony, in Norway, in Sardinia, in Cornwall, and other places.

It is brittle, easily fractured, its very thin laminæ are curved and undulated, and is sufficiently soft to be scratched by the nail. Its colour varies from milk-white, to yellowish, greenish, or reddish white, with a pearly lustre. Its specific gravity is 2·740.

From one hundred parts Bucholz obtained

Lime - -	55
Carbonic acid	41·7
Oxide of manganese	3
	99·7

Mr. Phillips, however, found no manganese in his analysis, and gives the following as its component parts:

Lime - -	54·70
Carbonic acid	43·30
Water -	0·50
Silex - -	0·05
Oxide of iron	0·80
	99·35

Thomson.—Brongniart.

Schistus. This name has been given to all fissile stones, though it is more commonly, and by some exclusively, applied to those of the argillaceous genus. Thus it includes the novaculite, or Turkey hone; as well as the slates, which constitute the greater part of the schisti, so that they are frequently considered as nearly synonymous terms. See Slate.

Schmelzstein. The mineral thus called by Werner, *dipyre* by Haüy, and *leucolite* of Mauléon by Delametherie, was found by Messrs. Gillet-Laumont and Lelièvre on the right bank of the Gave or brook of Mauléon in the western Pyrenees, in a gangue of white or reddish steatite mixed with sulphuret of iron.

It is in small prismatic crystals of a grayish or reddish white colour, united in bundles. These crystals have a tolerably glassy lustre, and are sufficiently hard to scratch glass. Their longitudinal fracture is foliated; their transverse, conchoidal. Their primitive form appears to be a regular hexahedral prism. The specific gravity of the schmelzstein is 2 630.

Before the blowpipe it melts and froths; and is slightly phosphorescent when thrown on hot coals. Brongniart considers these as two characteristics by which it may readily be known: but taken by themselves they do not sufficiently distinguish it from the pyrophysalite.

It has been analysed by Vauquelin, who obtained from one hundred parts:

Silex . .	60
Alumine .	24
Lime . .	10
Water . .	2
	96

Thomson.—Brongniart.

Schoerl, a compound stone of the siliceous order, more or less perfectly united to from 0·46 to 0·83 of its weight of alumine, from one fourteenth to one ninth of lime, to one fifth or one sixth of oxide of iron, and from one forty-eighth to one fifty-eighth of magnesia.

Its distinguishing properties are; 1st, either a sparry or semivitrified appearance, like an enamel or a slag; 2d, a filamentous or scaly texture, which distinguishes it from garnets; the filaments either separate from each other, or conjoined and plated; 3d, fusibility per se in a moderate heat; 4th, a specific gravity from 3 to 3·6, rarely 4, and only when loaded with iron; 5th, its hardness nearly equal to that of crystal.

According to Kirwan it has two varieties:

I. Transparent. This is always crystallized in some polygonal form; its texture is obscurely sparry; its colour brown, reddish brown, greenish or yellowish brown, or violet: its specific gravity from 3 to 3·6.

A reddish brown prismatic schoerl of this sort, from Vesuvius, contained, according to Bergman, forty-eight per cent. of siliceous earth, forty of alumine, five of lime, one of magnesia, and five of iron. The usual fluxes affect this species.

The filamentous sort resembles asbestos, and differs externally only in transparency, and breaking with an even surface.

II. Opake. These are of all colours; white, black, red, brown, greenish, and violet: the filaments are conjoined and parallel, or diverge, as from a common centre. Those of a scaly or sparry appearance are generally greenish or black, and are called hornblende. They are frequently crystallized in regular forms, and often so soft as to be scraped with a knife.

A hundred grains of the black crystallized sort from Albano afforded Bergman fifty-eight of silex, twenty-seven of alumine, five of lime, one of magnesia, and 5 of iron. 3 *Berg*. 207. Other sorts have afforded fifty per cent. of siliceous earth, thirty of alumine, one or two of magnesia, and eighteen or twenty of iron.

The white sort probably contains less iron.

All these sorts become reddish by calcination.

Bar schoerl, stangen schoerl of the Germans, according to Kirwan was lately found in the Carpathian mountains by Mr. Fichtel, embodied in limestone, and crystallized in prisms; it slightly effervesces with acids.

According to Mr. Bindheim, one hundred parts of it contain 61·6 of silex, 21·6 of lime, 6·6 of alumine, 5 of magnesia, 1·6 of iron, and 3 of water. 3 Schrift. Naturforsch. Freunde, p. 452.

The fossil called Hungarian red schoerl, which some from its colour and fracture have reckoned a garnet, Mr. Klaproth has found to be an ore of Titanium. Its spec. grav. is 4·18.

Schrifterz. Aurum graphicum, graphic gold ore. See Tellurium, of which it is an ore.

Scòrdium. An ounce of the dried leaves of scordium yielded with water four drachms and a half of gummy extract, and afterward with alcohol fifteen grains of resin. Another ounce, treated first with alcohol, gave three drachms of resinous extract, and afterward with water five scruples and a half of gum. A tincture, made in highly rectified alcohol, contains more of the active and less of the mucilaginous parts of this plant, than one made with a weaker spirit.

Scoria. The dross, or imperfectly vitrified and porous substance, that swims on the surface of a metallic mixture, or ore, in the furnace where metals are smelted or refined.

Scorification. The reducing of a metal to scoriæ, in order to separate it from some other metal less susceptible of being thus acted on by the fire.

Sea-froth. Meerschaum. See Keffekil.

Sea-salt. Muriat of soda. See Acid, (Muriatic) and Salt.

Sea-Salt (Regenerated.) Muriat of potash.

Sea-Wax. Maltha, a semicompact bitumen.

Sebat. A neutral compound of sebacic acid.

Sedative Salt. Boracic acid.

Sel de Seignette. The triple tartrit of potash and soda, or Rochelle salt. See Acid (Tartarous.)

Selenite. Sulphat of lime.

Semimetal. See Metals.

Semiopal. See Opal.

Sena. The leaf of the cassia senna Lin. This is a shrubby plant cultivated in Persia, Syria, and Arabia; whence the leaves are brought, dried, and picked from the stalks, to Alexandria in Egypt, and thence imported into Europe. They are of an oblong figure, sharp-pointed at the ends, about a quarter of an inch broad, and not a full inch in length; of a lively yellowish green colour, a faint, not very disagreeable smell, and a nauseous taste. Some inferior sorts are brought from Tripoli and other places; these may easily be distinguished by their being either narrower, longer, and sharper-pointed; or larger, broader, and round-pointed, with small prominent veins; or large and obtuse, of a fresh green colour, without any yellow cast.

An ounce of choice sena, treated with fresh parcels of alcohol, afforded Neumann two drachms twenty-three grains of resinous extract; and afterward with water, two drachms two scruples of gummy extract, three drachms and three grains remaining undissolved. Another ounce, treated first with water, gave four drachms and half a scruple of gummy, and afterward with alcohol only twenty-eight grains of a resinous extract, which appeared to contain some gross oily matter, and hence was with difficulty reduced to dryness; the residuum weighed three drachms and a scruple.

In distillation alcohol brings over nothing; the distilled water is impregnated with the smell of the sena, but discovers no appearance of essential oil. The activity of the sena is greatly weakened by evaporation, especially if the process be performed by a boiling heat in an open vessel, the extract proving far less purgative than an equivalent quantity of the infusion from which it was made. The resinous extract is more ungrateful in taste than the watery, and contains the green colour of the leaf. Some aromatic, as ginger, and some acid, as supertartrit of potash, are commonly added to it, to prevent the griping and nausea it is apt to occasion.

Senegal *or* **Seneca Gum.** Gum Senegal, brought from the island of that name on the coast of Africa, consists of large clear pieces, remarkably transparent when broken, and of a contorted appearance on the surface. It is said to be used as food by the Africans, at least occasionally, in their travels through the deserts. It is thought not to differ from gum Arabic, of which it is said to supply the place in the shops. Gum Senegal is considered as one of the strongest of gums, and forms a considerably thicker or more gelatinous mucilage with water than the rest. The principal consumption of this article is among the calico-printers, who use it to give thickness or body to the solutions, which they apply to piece-goods by means of stamps or blocks.

Serpentine. In respect to colour as well as composition, this stone is susceptible of great variety; for it is found either white, green, brown, reddish brown, yellow, light blue, black, spotted, or streaked with veins of different colours. Its texture is either indistinct, obscurely laminar, or fibrous. It is harder than soap-rock, but not so hard as to give fire with steel; and less smooth to the touch, but susceptible of a good polish; looks like marble, and is often in thin pieces semitransparent. Specific gravity from 2·26 to 2·7. A serpentine analysed by Mr. Knock gave silex 45, magnesia 33, magnetic iron 14, carbonat of lime 6·25, alumine 0·25, with a little muriat of magnesia and water, in 100 parts. In the serpentines of Saxony Klaproth found no alumine.

The greener sorts of this stone have been called nephritic. Their colour Mr. Klaproth suspects to be owing to nickel. But the term lapis nephriticus is commonly applied to Jade.

Serum. The watery part of the blood. See Blood.

Serum Lactis. Whey. See Milk.

Shale. A mineral that occurs among coal, and appears to be a mixure of clay and bitumen. It is in masses of a brownish black colour, has a straight slaty fracture. It emits a pale flame, and burns white.

Shea. An African tree, that produces a kind of butter. See Butter.

Shells. Marine shells may be divided, as Mr. Hatchett observes, into two kinds: These that have a porcellaneous aspect, with an enamelled surface, and when broken are often in a slight degree of a fibrous texture; and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl.

The porcellaneous shells appear to consist of carbonat of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ.

The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure which is lamellar, the gluten forming their membranes, regularly alternating with strata of carbonat of lime. In these two the gluten is much more abundant.

Mr. Hatchett made a few experiments on land shells also, which did not exhibit any differences. But the shells of the crustaceous animals he found to contain more or less phosphat of lime, though not equal in quantity to the carbonat, and hence approaching to the nature of bone. Linnæus therefore he observes was right, in considering the covering of the echini as crustaceous, for it contains phosphat of lime. In the covering of some of the species of asterias too a little phosphat of lime occurs; but in that of others there is none.—*Phil. Trans.*

Siberite. A red tourmalin from Sibetia, thus called by Lermina, and by Delamétherie *daourite*.

Siderite. Phosphuret of iron, so called by Bergman.

Sideroclepte. This mineral, of which little is known, is of a yellowish green colour, and translucid. Its lustre is slight and greasy. It has a smooth compact fracture, and is sufficiently soft to be scratched by the nail.

Before the blow-pipe it does not melt, but acquires a deep shining black colour.

It was found by Saussure in the pores of the volcanic lavas in the Brisgau, in a mammillary form, both separate and in groups. Some specimens had the appearance of being formed of concentric strata. —*Brongniart.*

Sidneia. A supposed new earth found in some sand brought from Sidney Cove, New South Wales. Mr. Hatchett however has since shown, that this sand contains nothing but silex, alumine, oxide of iron, and plumbago.

Sienite. This is a compound rock, the essential parts of which are feldtspar and hornblende, the feldtspar being the predominant ingredient, and most commonly of a red colour. It usually occurs along with porphyry, and when both are together the sienite generally forms the uppermost part of the hill.

The structure of sienite is granular, and the grains vary greatly in size. When small-grained sienite contains large crystals of feldtspar, it is called *porphyritic sienite.* When the two principal ingredients are so small and intimately mixed, that they cannot be distinguished by the naked eye, and such a rock contains crystals of feldtspar and quartz, it is denominated *sienite porphyry*.

Sienite, like porphyry, contains few foreign beds; but it is rich in ores, containing gold, silver, iron, tin, copper, lead, &c. These however are always in veins.

The rocks of sienite are often divided into columns: and like the newer porphyry it frequently occurs in round masses.—*Thomson.*

Silex, or Siliceous Earth. See **Earths**, also **Glass**.

Silk is a fibre or thread spun by the silkworm, to form a nidus for its preservation in the chrysalis state. It is wound off in the manufactories, and afterward joined or spun into thicker threads. We do not possess any explanation of the process, by which silk, which in the body of the insect has the form of a glutinous unorganized mass, becomes consistent, firm, and very strong, in an exceedingly short time after it has been drawn out into thread. Anglers have a practice of cutting the body of a silk-worm, and drawing out the whole of the silky contents into a string of a few inches long, which speedily acquires consistence, has the appearance of catgut or fiddle-string, but is more transparent, and is on that account less visible under water when used as a fishing-line. Chappe has made very interesting researches as to the management of this matter. He dissects the vessels out of the silk-worm, washes them with water, and then dilutes their contents by trituration with about one third of its weight of water. By this preparation they could be blown into permanent globes, and otherwise formed. See *Annales de Chimie*, xi. 113.

Silk appears to be a sort of dried gummy matter. It differs from vegetable substances, 1. in affording ammonia by distillation: 2. in affording nitrogen gas by treatment with nitric acid: 3. in affording a peculiar oil, which is separated from it when the nitric acid converts it into oxalic acid, as has been shown by Berthollet. It seems to be a compound, consisting of a vegetable mucilage, with a peculiar animal oil, which renders it pliant, ductile, and elastic.

Silk is naturally coated with a substance, which has been considered as a gum, to which it owes its stiffness and elasticity; that which is most commonly met with in France contains, besides, a yellow colouring matter.

Most of the purposes for which silk is employed require, that it should be deprived not only of its colouring matter, but also of its gum. Both these purposes are answered by means of soap, and the term scouring (décreusage) is applied to this operation, by which it acquires its suppleness and whiteness. The scouring ought not to be so complete for silks which are to be dyed, as for those which are intended to remain white; and a difference ought even to be made, according to the colour we mean the silk should have.

This difference consists chiefly in the quantity of soap employed: thus, for common colours, it is generally thought sufficient to boil the silk for three or four hours in a solution of twenty pounds of soap for each hundred of silk, taking care to fill up the kettle with water from time to time, that there may be always a sufficient proportion of fluid. The quantity of soap is increased for those silks which are to be dyed blue, and more especially for those that are to be scarlet, cherry-colour, &c.; because for these colours the ground must be whiter than for such as are less delicate. In treating of each colour, the quantity of soap proper for the silk intended to receive it is mentioned.

When silk is to be employed white, it undergoes three operations. The first is called by the French dégommage, and by our workmen shaking over; it consists in keeping the hanks of silk in a solution of thirty pounds of soap to a hundred of silk: this solution ought to be very hot, but not boiling: when that part of the hanks which is immersed is entirely freed from its gum, which is known by the whiteness it acquires, the hanks are turned upon the skein-sticks, so that the part which was not before immersed may undergo the same operation; they are then taken out of the kettle and wrung out, according as the operation is completed.

The second operation is the cuite or boiling. The silk is put into bags of coarse cloth, five-and-twenty or thirty pounds in each bag, which is called a boiling bag (poche); a bath of soap is prepared like the former, but with a less quantity of soap; in this the bags are boiled for an hour and a half, taking care to keep them constantly stirred, that those which touch the bottom of the kettle may not receive too much heat.

The third operation is called bleaching, or whitening, which is principally intended to give the silk a slight cast, to make the white more pleasing; and from which it derives different names, such as china white, silver white, azure white, or thread white. A solution of soap is prepared, the proper strength for which is determined by its mode of frothing when agitated: for the china white, which should have a slight tinge of red, a small quantity of annotta is added, and the silk is shaken over in it, until it has acquired the desired shade. To the other whites, more or less of a blue tinge is given by adding a little blue to the solution of soap, though some had before been put into the cuite.

To prepare the azure, fine indigo is taken; and after being well washed two or three times in moderately warm water, it is ground fine in a mortar, and boiling water poured on it: it is then left to settle, and the liquor alone is employed, which retains only the most subtile parts: this is called azure. A small quantity of the liquor of a fresh vat of indigo may be substituted for azure.

At Lyons, where they make a more beautiful white than at Paris, no soap is used in the third operation; but after the second, the silks are washed, fumigated with sulphur, and azured with river water. In this method it is of importance to employ very clear water.

When the silk has become very uniform, and has acquired the desired shade, it is wrung out and dried.

The white obtained by these means is not yet sufficiently bright for the silk intended for white stuffs; but must still be exposed to the vapour of sulphur.

As soap seems to impair the lustre of silk, the academy of Lyons, in 1761, proposed as the subject of a prize dissertation, to find a method of scouring silks without soap; and the prize was adjudged to Mr. Rigaut, of S. Quentin, who proposed substituting for soap a solution of soda, or carbonat of soda, so much diluted with water as not to injure the silk; but some inconvenience must have attended the practice of this method, as it is not adopted, though generally known, and easy of execution.

The Abbé Collomb has published some observations highly worthy of attention, respecting the scouring of silk by the action of water alone. Having perceived, that a skein of yellow silk, which he had boiled for about three hours in common water, had lost nearly one eighth of its weight, he repeated the boiling twice, and thereby brought the diminution to nearly one quarter.

The silk which has suffered this loss of weight still retains a yellow or rather chamois colour, which renders it unfit for white stuffs, or for such as are intended to receive any colour the beauty of which depends on the whiteness of the ground upon which it is applied: but it takes those colours very well, which cannot be injured by the tinge it retains; thus the black which it took seemed preferable to that of silk scoured with soap.

The silk remains very firm and strong after this operation; the threads of it, compared with similar ones scoured with soap, supported weights which broke the others.

Eight hours of brisk ebullition are required to dissolve the whole gummy coat of silk, and it thereby loses a little more than one fourth of its weight; but the boiling ought to be continued longer when the barometer is low, because the greater the weight of the atmosphere, the higher is the degree of heat at which water boils.

This consideration led Mr. Collomb to try the effect of boiling silk in Papin's digester; and he found, that only one hour and a quarter were required to complete the solution of the gummy coat, although the degree of heat must have been inferior to that which produced many of those effects observed by philosophers in that concentrated kind of ebullition.

Berthollet says, that he saw a pattern of silk stuff scoured by Mr. Collomb: it seemed to have the qualities which he mentions; but it had less suppleness and softness than silk scoured with soap.

Mr. le Camus, a learned naturalist of the academy of Lyons, gave Berthollet a small quantity of the substance separated from silk by the water in one of Mr. Collomb's operations; it was black, brittle, and of a shining fracture, and afforded by distillation the usual products of animal substances; it dissolved easily in warm water, and left very little residuum on the filter; the solution, which was transparent, and of a greenish yellow colour, was not sensibly affected by acids or alkalis. Solution of alum produced in it a dirty white precipitate; that of copper, a dark brown precipitate; that of sulphat of iron, a brown precipitate; solution of tin in aqua regia, a white precipitate; acetit of lead, a brown precipitate. All these precipitates were in small quantity, and more or less viscous. The infusion of galls and that of sumach produced a white precipitate.

Alcohol does not dissolve this substance even by ebullition, taking up only a yellow colouring matter; this solution, by evaporation, afforded a residuum of scales of an amber yellow.

Berthollet added some drops of muriatic acid to nearly two ounces of alcohol, and boiled it on twenty grains of the silk gum: a solution took place; but, on cooling, this substance put on the appearance of jelly.

The substance taken from the silk in the scouring, then, appears to be of an animal nature, and therefore the soap-suds used in that operation soon become putrid; when separated from the silk, it is easily dissolved in water, but not in alcohol. Though not of a vegetable nature, it may with considerable propriety be called a gum. That part which gives it the yellow colour is soluble in alcohol, and when it is separated the gum becomes brown. It is not improbable, that this colour is occasioned by the heat, to which it is exposed in the boiling, because when only the yellow colouring part is separated by Mr. Beaumé's process, which will presently be described, the silk is whitened.

In Mr. Collomb's process the gum is separated, and takes with it only some of the colouring particles; and in the process of scouring by soap the gum and the yellow colouring particles are carried off together.

Berthollet boiled some yellow silk in a retort, where, as the vapours did not escape so freely as from an open vessel, a degree of heat must have been produced superior to that of water boiling in the open air. After having been boiled for four hours, the silk had lost one fourth of its weight, but it had almost entirely retained its colour.

The same chemist boiled another pattern in the same way, in a quantity of water impregnated with common salt; it became whiter, but lost less of its weight, though the degree of heat was certainly increased by the addition of the salt, which restrained the evaporation of the water: possibly a part of the salt had united with the silk. Experiments might be made with other salts; and perhaps we should find some, that, without injuring the silk, might be more useful in dissolving the gum and colouring particles.

When the silk is intended for the manufacture of blonds and gauzes, its natural elasticity and stiffness should be preserved: the greatest part of what is produced in France is of a yellow colour, but it is the white China silk that is principally used for these purposes; this is so dear, that the French manufacturers cannot vie with the English, from whom they get it, as the English always reserve the finest for their own manufactures. It has therefore been a desideratum, to find out the means of depriving the yellow silk of its colouring particles, without destroying the gum, and thereby depriving the silk of its elasticity. Mr. Beaumé has solved this interesting problem, but has kept his process secret: some artists, however, to whom he had intrusted it, or who had been led to the discovery by their own observations, succeeded in the execution of it; but the process appears to be liable to accidents, which by occasioning loss increase expense; so that hitherto, notwithstanding the advantages it presents, it has not been carried into execution. The following is an account of what has transpired respecting it:

A mixture is made with 12 ounces of muriatic acid and 48 lbs. of alcohol, in which 6 lbs. of silk are immersed. This liquor being poured off as soon as it is slightly coloured, alcohol alone is to be poured over the silk, till no more colouring matter is taken up by it. A mixture of alcohol and acid like the first is then to be poured on the silk, in which it is to stand two or three days. Lastly the silk is to be washed in cold water. The muriatic acid must be pure, and not contain any nitric acid, which makes the silk yellow. To give it an uniform white colour seems to be one of the most difficult parts of the process, especially when the operation takes place on large quantities. There is likewise great difficulty in dyeing the whitened silk, so as to prevent its curling; it ought certainly to be kept constantly stretched during the drying. The alcohol that has been impregnated with the colouring part must be again separated from it, so as to serve for subsequent operations, otherwise the process would be too expensive; for this purpose it is to be distilled by a gentle heat, in a glass or stoneware vessel.

It appears from the experiments above related, that the muriatic acid is useful in this process, by softening the gum, and thus assisting the alcohol to dissolve the colouring particles combined with it.

Mr. Giobert has lately given another process for destroying the colouring matter of silk, preserving its gluten, and scouring it at little expense, without using soap.

He employs oxigenized muriatic acid, largely diluted with water, so as to destroy the colouring matter, without acting upon the silk itself farther than giving it a yellow tinge, its common effect upon animal substances: and this tinge he takes off by sulphurous acid. After these alternate immersions the silk may be scoured in boiling water. He confesses however, that to operate upon the gluten by the acids so that the water shall carry it off, and yet not to weaken the silk, is an operation too nice for the generality of workmen.

The preparation with alum must be considered as one of the general operations in dyeing silk; for without aluming, the greatest part of the colours applied would possess neither beauty nor durability.

The preparation with alum consists in mixing in a tun, or vat, about forty or fifty pails of water with forty or fifty pounds of Roman alum, that has been previously dissolved in warm water; this must be carefully stirred during the mixture, to prevent the crystallization of the alum.

After having washed and bathed the silk, and wrung it out with the jack and pin *, in order to separate any soap it may have retained, it is immersed in the alum liquor, where it is left for eight or nine hours; after which it is wrung out by hand over the vat, and washed in a stream of water.

In the above quantity of liquor one hundred and fifty pounds of silk may be prepared without the addition of any more alum; but when it begins to grow weak, which those who are in the habit of employing it can easily distinguish by the taste, twenty or twenty-five pounds of dissolved alum must be added as before, and this addition must be repeated, until the liquor acquires a disagreeable smell; and then it may be employed in the preparation of stuffs intended for darker colours, such as browns and marones, till it has lost all its strength.

The preparation of silk with alum is always made in the cold, because when the liquor is employed hot the lustre of the silk is liable to be impaired.—*Berthollet on Dyeing.—Journ. de Phys.—An. de Chim.—Chaptal's Chem.*

Silvan. Tellurium, so called by Werner.

Silver is the whitest of all metals, considerably harder than gold, very ductile and malleable, but less malleable than gold; for the continuity of its parts begins to break when it is hammered out into leaves of about the hundred and sixty thousandth of an inch thick, which is more than one third thicker than gold leaf: in this state it does not transmit the light. Its specific gravity is moderate, being inferior to platina, gold, mercury, and lead. It ignites before melting, and requires a strong heat to fuse it. The heat of common furnaces is insufficient to oxide it: but the heat of the most powerful burning lenses vitrifies a portion of it, and causes it to emit fumes; which, when received on a plate of gold, are found to be silver in the metallic state. It has likewise been partly oxided by twenty successive exposures to the heat of the porcelain furnace at Sèvres. By passing a strong electric shock through a silver wire, it may be converted into a black oxide: and by a powerful galvanic battery silver leaf may be made to burn with a beautiful green light. Lavoisier oxidized it by the blowpipe and oxigen gas: and a fine silver wire burns in the kindled united stream of oxigen and hidrogen gasses. The air alters it very little: though it is disposed to obtain a thin purple or black coating from the sulphurous vapours, which are emitted from animal substances, drains, or putrefying matters. This coating, after a long series of years, has been observed to scale off from images of silver exposed in churches; and was found, on examination, to consist of silver united with sulphur.

Silver is soluble in the sulphuric acid when concentrated and boiling, and the metal in a state of division.

The muriatic acid scarcely acts upon it, unless oxigenized: but the nitric acid, if somewhat diluted, dissolves it with great rapidity, and with a plentiful disengagement of nitrous gas; which, during its extrication, gives a blue or green colour to the acid, that entirely disappears if the silver made use of be pure; if it contain copper, the solution remains greenish; and if the acid contain either sulphuric or muriatic acid, these combine with a portion of the silver, and form scarcely soluble compounds, which fall to the bottom. If the silver contain gold, this metal separates in blackish-coloured flocks.

The nitric acid dissolves more than half its weight of silver; and the solution is very caustic, that is to say, it destroys and corrodes animal substances very powerfully. This action appears to depend on the strong disposition of the silver to become revived; by which it communicates oxigen to them, so that the animal substances undergo a process equivalent to combustion.

The solution of silver, when fully saturated, deposits thin crystals as it cools, and also by evaporation. These are called lunar nitre, or nitrat of silver. A gentle heat is sufficient to fuse them, and drive off their water of crystallization. In this situation the nitrat, or rather subnitrat, for the heat drives off part of the acid, is of a black colour, may be cast into small sticks in a mould, and then forms the lapis infernalis, or lunar caustic used in surgery. A stronger heat decomposes nitrat of silver, the acid flying off, and the silver remaining pure. It is obvious that, for the purpose of form-

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* This is a contrivance for wringing more strongly than can be done by the hands alone; the pin introduced through the hank at one end, or into a twist of the cloth, is secured in a fixed position, while the other end or twist is fixed to the hook of the jack, which can be forcibly turned round by means of a winch connected with it. When this degree of force is not necessary, and the hands only are employed in the operation, it is called wringing out by hand.

ing the lunar caustic, it is not necessary to suffer the salt to crystallize, but that it may be made by evaporating the solution of silver at once to dryness; and as soon as the salt is fused, and ceases to boil, it may be poured out. The nitric acid driven off from nitrat of silver is decomposed, the products being oxigen and nitrogen.

Although the nitric acid dissolves silver with such great facility, it appears to do this only in consequence of its great power to oxide the metal; for the sulphuric and muriatic acids have a greater attraction for the oxide. They accordingly take it from that acid, and form salts; which, as we have already observed, fall to the bottom on account of their difficult solubility. The sulphat of silver, which is formed by pouring sulphuric acid into the nitric solution of silver, is sparingly soluble in water; and on this account forms crystals, which are so small, that they compose a white powder. The muriatic acid precipitates from nitric acid the saline compound called luna cornea, or horn silver; which has been so distinguished, because, when melted and cooled, it forms a semitransparent and partly flexible mass, resembling horn. It is supposed that a preparation of this kind has given rise to the accounts of malleable glass. This effect takes place with aqua regia, which acts strongly on silver, but precipitates it in the form of muriat, as fast as it is dissolved.

If any salt with base of alkali, containing the muriatic acid, be added to the nitric solution of silver, the same effect takes place by double affinity; the alkaline base uniting with the nitric acid, and the silver falling down in combination with the muriatic acid.

Since the muriatic acid throws down only silver, lead, and mercury, and the latter of these two is not present in silver that has passed cupellation, though a small quantity of copper may elude the scorification in that process, the silver which may be revived from its muriat is purer than can readily be obtained by any other means. When this salt is exposed to a low red heat, its acid is not expelled; and a greater heat causes the whole concrete either to rise in fumes, or to pass through the pores of the vessel. To reduce it, therefore, it is necessary that it should be triturated with its own weight of fixed alkali, and a little water, and the whole afterward exposed to heat in a crucible, the bottom of which is covered with soda: the mass of muriat of silver being likewise covered with the same substance. In this way the acid will be separated from the silver, which is reduced to its metallic state.

As the precipitate of muriat of silver is very perceptible, the nitric solution of silver is used as a test of the presence of muriatic acid in waters; for a drop of this solution poured into such waters will cause a very evident cloudiness. The solution of silver is also used by assayers to purify the nitric acid from any admixture of muriatic acid. In this state they call it precipitated aqua fortis.

Mr. Chenevix has found, that a hyperoximuriat of silver may be formed, by passing a current of oxigenized muriatic acid gas through water in which oxide of silver is suspended; or by digesting phosphat of silver with hyperoximuriat of alumine. It requires only two parts of hot water for its solution, and this affords on cooling small, white, opake, rhomboidal crystals. It is likewise somewhat soluble in alcohol. Half a grain, mixed with half as much sulphur, and struck or rubbed, detonates with a loud report and a vivid flash.

Compounds of silver with other acids are best formed by precipitation from its solution in nitric acid; either by the acid itself, or by its alkaline salts. Phosphat of silver is a dense white precipitate, insoluble in water, but soluble in an excess of its acid. By heat it fuses into a greenish opake glass. Carbonat of silver is a white insoluble powder, which is blackened by light. The fluat and borat are equally soluble. Distilled vinegar readily dissolves the oxide of silver, and the solution affords long white needles, easily crystallized.

Mr. Steinacher, an apothecary of Paris, observes, that sulphat of silver is decomposed by the action of sulphat of lime. The following experiment, says he, is a direct proof of this. I took some very limpid lime-water, and added a few small drops of pure sulphuric acid. The solution remained clear, and had an excess of acid. To this I added a little of my acid sulphat of silver, which immediately occasioned a flocculent precipitate. After this had been washed, it was not soluble in muriatic acid. This fact proves, that the oxide of silver enjoys a very considerable power of cohesion, and renders me very circumspect in forming a judgment of the experiments for deciding the presence of muriatic acid in delicate fluids from the single phænomenon of precipitation by means of any solution of silver, and without examining the other circumstances, that might occasion the insolubility of the oxide of silver.

The precipitates of silver, which are formed by the addition of alkalis or earths, are all reducible by mere heat, without the addition of any combustible substance. The fulminating combination of ammonia with silver exhibits one of the most astonishing instances of chemical detonation hitherto known. See FULMINATION.

A detonating powder has been sold lately at Paris as an object of amusement. It is inclosed between the folds of a card, cut in two lengthwise; the powder being placed at one end, and the other being notched, that it may be distinguished. If it be taken by the notched end, and the other be held over the flame of a candle, it soon detonates, with a sharp sound, and violent flame. The card is torn, and changed brown; and the part in contact with the composition is covered with a slight metallic coating, of a grayish white colour.

This compound, which Mr. Descotils calls detonating silver, to distinguish it from the fulminating silver of Mr. Berthollet, may be made by dissolving silver in pure nitric acid, and pouring into the solution, while it is going on, a sufficient quantity of rectified alcohol: or by adding alcohol to a nitric solution of silver with considerable excess of acid.

In the first case the nitric acid, into which the silver is put, must be heated gently, till the solution commences, that is till the first bubbles begin to appear. It is then to be removed from the fire, and a sufficient quantity of alcohol to be added immediately, to prevent the evolution of any nitrous vapours. The mixture of the two liquors occasions an extrication of heat; the effervescence quickly recommences, without any nitrous gas being disengaged; and it gradually increases, emitting at the same time a strong smell of nitric ether. In a short time the liquor becomes turbid, and a very heavy, white, crystalline powder falls down; which must be separated, when it ceases to increase, and washed several times with small quantities of water.

If a very acid solution of silver previously made be employed, it must be heated gently, and the alcohol then added. The heat excited by the mixture, which is to be made gradually, soon occasions a considerable ebullition, and the powder immediately precipitates.

It would be superfluous to remind the chemist, that the mixture of alcohol with hot nitric acid is liable to occasion accidents, and that it is consequently prudent to operate in small quantities.

This powder has the following properties:

It is white and crystalline; but the size and lustre of the crystals are variable. Light alters it a little. Heat, a blow, or long continued friction, causes it to inflame with a brisk detonation. Pressure alone, if it be not very powerful, has no effect on it. It likewise detonates by the electric spark. It is slightly soluble in water. It has a very strong metallic taste.

Concentrated sulphuric acid occasions it to take fire, and is thrown by it to a considerable distance. Dilute sulphuric acid appears to decompose it slowly.

Muriatic acid, whether concentrated or weak, decomposes it immediately, and forms with it muriat of silver. The quantity of muriat it produces indicates, that it contains about 0·71 of metallic silver. A pretty evident smell of prussic acid is perceived the first moment of the mixture, but Mr. Descotils never could discover any other traces of it.

Nitric acid decomposes it by the help of a boiling heat; and the products are nitrat of silver, and nitrat of ammonia, if it be continued long enough.

It is decomposed by sulphuretted hydrogen; the ammonia and vegetable matter remaining in the liquor.

Caustic potash decomposes it; black oxide of silver being separated, and ammonia disengaged.

It is soluble in ammonia; but by a slow evaporation it may be separated from it, retaining its original colour and other properties, particularly that of denotating by heat, and not by simple contact.

Its most important property to be considered, with respect to the use made of it, is its action on the animal œconomy. Mr. Pajot-la-Forêt, who has made a great many experiments on this subject, has found, that very small doses are sufficient to destroy pretty strong animals, as cats. They all expired in the most dreadful convulsions. It is unquestionably one of the most violent poisons to be found among metallic compounds.

Chemists have long been acquainted with the compound acid called aqua regia, from its action being exerted on few of the metals except gold. But the discovery of a compound acid acting still more exclusively upon silver is due to one of our contemporaries, Mr. Keir. The effects of aqua regia have been described, considered and explained by a great variety of authors. Those of Mr. Keir's compound acid are confined to the Philosophical Transactions; a work which, though its circulation extends to every part of the globe, is comparatively speaking confined to few hands. For this reason, it appears proper to give an ample account of the experiments of this chemist.

Mr. Keir's paper consists of two parts: the first shows the effects of compounding the sulphuric and nitric acids in dissolving metals; and the other describing some curious appearances, which occur in the precipitation of silver from its solution in nitric acid by iron, and by some other substances.

PART I. Section I.

Effects of compounding the Vitriolic and Nitric Acids upon the Dissolution of Metals.

No two substances, says Mr. Keir, are more frequently in the hands of chemists and artists than sulphuric acid and nitre; yet, he says, he has found, that a mere mixture of these, when much concentrated, possesses properties, which neither the sulphuric nor nitric acid, of the same degree of concentration, have singly, and which could not easily be deduced à priori, by reasoning from our present knowledge of the theory of chemistry.

Having found by some previous trials, that a mixture composed of nitre, dissolved in sulphuric acid, was capable of dissolving silver easily and copiously, while it did not affect copper, iron, lead, cobalt, gold, or platina; he conceived, that it might be useful in some cases of the parting of silver from copper, and the other metals above mentioned; and having also observed, that the dissolving powers of the mixture of sulphuric and nitric acids varied greatly in different degrees of concentration and oxigenation, he thought an investigation of these effects might be a subject fit for philosophical chemistry, and might tend to illustrate the theory of the dissolution of metals in acids: with these views he made the following experiments:

Experiment I.

Into a long-necked retort, the contents of which, including the neck, were 1400 grain measures, 100 grain measures of sulphuric acid were put, of the usual density at which it is prepared in England, *i. e.* of the specific gravity of 1·844, and 100 grains of pure and clear nitre, which were then dissolved in the acid by the heat of a water bath. To this mixture 100 grains of standard silver were added; the retort was set in a water bath, in which the water was made to boil, and a pneumatic apparatus was applied, to catch any gas which might be extricated.

The silver began to dissolve, and the solution became of a purple or violet colour. No air was thrown into the inverted jar, excepting a little of the common air of the retort, by means of the expansion which it suffered from the heat of the water-bath, and from some nitric oxide gas which appeared in the retort, and which, having afterward condensed, occasioned the water to rise along the neck of the retort, and mix with the solution. The remaining silver was then separated and weighed, and it was found, that 39 grains had been dissolved; but probably more would have been dissolved, if the operation had not been interrupted by the water rushing into the retort.

Experiment II.

In the same apparatus, 200 grains of standard silver were added to a mixture of 100 grains of nitre, previously dissolved in 200 grain measures of sulphuric acid; and in this solvent 92 grains of the silver were dissolved, without any production of gas. The solution, which was of a violet colour, having been poured out of the retort while warm (for with so large a proportion of nitre, such mixtures, especially after having dissolved silver, are apt to congeal with small degrees of cold), in order to separate the undissolved silver from it, and having been returned into the retort without this silver; 200 grains of water were poured into the retort, upon which a strong effervescence took place between the solution and the water, and 3100 grain measures of nitric oxide gas were thrown into the inverted jar. Upon pouring 200 grains more of water into the retort, 600 grain measures of the same gas were expelled. Farther additions of water yielded no more gas; neither did the silver, when afterward added to this diluted solution, give any sensible effervescence, or suffer a greater loss of weight than two grains.

Experiment III.

In the same apparatus, 100 grains of standard silver were exposed to a mixture of 30 grains of nitre dissolved in 200 grain measures of sulphuric acid: and in this operation 80 grains of silver were dissolved, while at the same time 4500 grain measures of nitric oxide gas were thrown into the inverted jar. When the undissolved silver was removed, 200 grains of water were added to the solution, which was of a violet colour, and upon the mixture of the two fluids an effervescence happened; but only a few bubbles of nitric oxide gas were then expelled.

Experiment IV.

In the same apparatus 100 grains of standard silver were exposed to a mixture of 200 grain measures of sulphuric acid, 200 grains of nitre, and 200 grains of water; and in this operation 20 grains of the silver were dissolved without any sensible emission of gas.

Mr. Keir remarks, that in these experiments the copper contained in the standard silver gave a reddish colour to the saline mass, which was formed in the solution, and seemed to be an oxide of copper interspersed through the salt of silver. This was all the difference he could perceive between the effects of pure and standard silver dissolved in this acid.

Tin was next exposed to the same mixture of sulphuric acid and nitre, in the same apparatus, and in the same circumstances; care being always taken to add more metal than could be dissolved, that by weighing the remainder, the quantity capable of being dissolved might be found, as had been done with the experiments on silver: the results were as follow:

Experiment V.

No tin was dissolved or oxided by the mixture in the proportion of 200 grain measures of sulphuric acid to 200 grains of nitre, nor by another mixture in the proportion of 200 grain measures of sulphuric acid to 150 grains of nitre, and consequently no gas was produced in either instance.

Experiment VI.

With a mixture in the proportion of 200 grain measures of sulphuric acid and 100 grains of nitre, the tin began soon to be acted upon, and to be diffused through the liquor; but no extrication of gas appeared, until the digestion had been continued two hours in boiling water; and then it took place, and gave a frothy appearance to the mixture, which was of an opaque white colour, from the powder of tin diffused among it. In this experiment the quantity of tin thus oxided was 73 grains, and the quantity of nitric oxide gas extricated during this action on the tin was 8500 grain measures. Then, upon pouring 200 grains of water into the retort, a fresh effervescence took place between the water and the white opaque mass, and 4600 grain measures of nitric oxide gas were thrown into the inverted receiver.

Experiment VII.

With a mixture in the proportion of 100 grain measures of sulphuric acid to 30 grains of nitre, 30 grains of tin were dissolved or oxided, and the nitric oxide gas, which began to be extricated much sooner than in the last-mentioned experiment with a larger proportion of nitre, amounted to 6300 grain measures. Water added to this solution of tin did not produce any effervescence.

Experiment VIII.

With a mixture in the proportion of 200 grain measures of sulphuric acid, 200 grains of nitre, and 200 grains of water, 133 grains of tin were acted on with an effervescence, which took place violently, and produced 6500 grain measures of nitric oxide gas.

The several mixtures above mentioned, in different proportions of nitre and sulphuric acid, by the help of the heat of a water-bath oxided mercury into a white or grayish powder. Nickel was also partly oxided and partly dissolved by these mixtures. It was not perceived, that any other metal was affected by them, excepting that the surfaces of some of them were tarnished.

These mixtures of sulphuric acid and nitre, the author observes, were apt to congeal by cold, those especially which had a large proportion of nitre. Thus, a mixture of 1000 grain measures of sulphuric acid, and 480 grains of nitre, after having kept fluid several days in a phial not so accurately stopped as to prevent altogether the escape of some white fumes, congealed at the temperature of 55° of Fahrenheit's thermometer; whereas some of the same liquor, having been mixed with an equal part of sulphuric acid, did not congeal with a less cold than 45°. The congelation is promoted by exposure to air, by which white fumes rise, and moisture may be absorbed, or by any other mode of slight dilution with water.

Dilution of this compound acid with more or less water alters considerably its properties, with regard to its action on metals. Thus, in its concentrated state it does not act on iron; but by adding water it acquires a power of acting on this metal, and with different effect, according to the proportion of the water added. Thus, by adding to two measures of the compound acid one measure of water, the liquor is rendered capable of oxiding iron, and forming with it a white powder, but without effervescence. With an equal measure of water effervescence was produced. With a larger proportion of water the iron gave also a brown colour to the liquor, such as nitrous acid acquires from iron, or communicates to a solution of sulphat of iron in water.

Dilution with water renders this compound acid capable of dissolving copper, zinc, and probably those other metals, which are subject to the action of the dilute sulphuric or nitric acids.

SECTION II.

New Process for separating Silver from Copper.

The properties of this liquor in dissolving silver easily without acting on copper, have rendered it capable of a very useful application in the arts. Among the manufactures at Birmingham, that of making vessels of silver plated on copper is a very considerable one. On cutting out the rolled plated metal into pieces of the required form and sizes, there are many shreds, or scraps as they are called, unfit for any purpose but the recovery of the metals by separating them from each other. The easiest and most œconomical method of parting these two metals, so as not to lose either of them, is an object of some consequence to the manufacturers. For this purpose, two modes were practised: one, by melting the whole of the mixed metals with lead, and separating them by eliquation and testing; and the second, by dissolving both metals in sulphuric acid, with the help of heat, and by separating the sulphat of copper, by dissolving it in water, from the sulphat of silver, which is afterward to be reduced and purified. In the first of these methods, there is a considerable waste of lead and copper; and in the second, the quantity of sulphuric acid employed is very great, as much more is dissipated in the form of sulphurous acid gas than remains in the composition of the two sulphats.

Some years ago, the author communicated to an artist the method of effecting the separation of silver and copper, by means of the above mentioned compound of sulphuric acid and nitre; and as it is now commonly practised by the manufacturers in Birmingham, he thinks it is much more œconomical, and it is certainly much more easily executed, than any of the other methods: for nothing more is required than to put the pieces of plated metal into an earthen glazed pan; to pour upon them some of the acid liquor, which may be in the proportion of eight or ten pounds of sulphuric acid to one pound of nitre; to stir them about, that the surfaces may be frequently exposed to fresh liquor, and to assist the action by a gentle heat from 100° to 200° of Fahrenheit's scale. When the liquor is nearly saturated, the silver is to be precipitated from it by common salt, which forms a muriat of silver, easily reducible by melting it in a crucible with a sufficient quantity of potash; and, lastly, by refining the melted silver if necessary, with a little nitre thrown upon it. In this manner the silver will be obtained sufficiently pure, and the copper will remain unchanged. Otherwise, the silver may be precipitated in its metallic state, by adding to the solution of silver a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper.

The property which this acid mixture possesses of dissolving silver with great facility, and in considerable quantity, will probably render it a useful menstruum in the separation of silver from other metals; and as the alchemists have distinguished the peculiar solvent of gold under the title of aqua regis, a name sufficiently distinctive, though founded on a fanciful allusion; so, if they had been acquainted with the properties of this compound, they would probably have bestowed on it the appellation of aqua reginæ.

SECTION III.

Change of Properties communicated to the Mixture of Sulphuric and Nitric Acids by Disoxigenization.

The above-described compound acid may be disoxigenized in different methods, of which the author mentions three:

First. By digesting the compound acid with sulphur, by means of the heat of a water-bath: the liquor dissolves the sulphur with effervescence, loses its property of yielding white fumes; and, if the quantity of sulphur be sufficient, and the heat applied be long enough continued, it exhibits red nitrous vapours, and assumes a violet colour.

Secondly. If instead of dissolving nitre in concentrated sulphuric acid, this acid be impregnated with nitric oxide, by making this gas pass into the acid, the compound will be in a less oxigenized state. This impregnation of sulphuric acid with nitric oxide, was first described, and some of the properties of the impregnated liquor noticed, by Dr. Priestley.

Thirdly. By substituting nitrat of ammonia instead of nitre in the mixture with sulphuric acid.

The compound prepared by any of these methods, but especially by the first and second, differs considerably in its properties, with regard to its action on metals, from the acid described in the first section. It has been observed, that the latter compound has little action on any metals, but silver, tin, mercury, and nickel. On the other hand, the less oxigenized compound not only acts on these, but also on several others. It forms with iron a beautiful rose-coloured solution, without application of any artificial heat; and in time a rose-coloured saline precipitate is deposited, which is soluble in water, with a considerable effervescence. It dissolves copper, and acquires from this metal, and also from cobalt, zinc, and lead, pretty deep violet tinges. Bismuth and antimony were also attacked by this less oxigenized acid.

To ascertain more exactly the effects of this acid on some metals, the author made the following experiments, with a liquor prepared by making nitric oxide gas pass through sulphuric acid during a considerable time.

Experiment I.

To 200 grain measures of the sulphuric acid, impregnated with nitric oxide, put into a retort with a long neck, the capacity of which, including the neck, was 1150 grain measures, 144 grains of standard silver were added, and the mouth of the retort was immersed in water, under an inverted jar filled with water, to catch the gas which might be extricated.

The acid began to dissolve the silver with effervescence, without application of heat; the solution became of a violet colour, and the quantity of nitric oxide gas received in the inverted jar was 14700 grain measures. Upon weighing the silver remaining, the quantity which had been dissolved was found to be 70 grains. When water was added to the solution, an effervescence appeared, but only a very small quantity of gas was extricated. By means of the water, a white saline powder of silver, soluble in a larger quantity of water, was precipitated from the solution. The solution of silver, when saturated and undiluted, congeals readily in cool temperatures, and, when diluted to a certain degree with water, gives foliated crystals

Experiment II.

In the same apparatus, and in the same manner, 100 grain measures of this impregnated sulphuric acid were applied to iron. An effervescence appeared without application of heat, the surface of the iron acquired a beautiful rose-colour, or redness mixed with purple. and this colour gradually pervaded the whole liquor, but disappeared on keeping the retort some time in hot water. Notwithstanding a considerable apparent effervescence, the quantity of air expelled into the inverted jar was only 400 grain measures, of which one quarter was nitric oxide, and the rest nitrogen. The solution was then poured out of the retort, and the iron was found to have lost only two grains in weight. The solution was returned into the retort without the iron, and 200 grains of water were added to it; upon which a white powder was immediately precipitated, which redissolved with great effervescence. When 2000 grain measures of nitric oxide gas had been expelled into the inverted jar, without application of heat, the retort was placed in the water-bath, the heat of which rendered the effervescence so strong, that the liquor boiled over the neck of the retort, so that the quantity of gas extricated could not be ascertained.

Experiment III.

In the same manner, 11 grains of copper were dissolved in 100 grain measures of impregnated sulphuric acid. The solution was of a deep violet colour, and at last was turbid. The quantity of nitric oxide gas expelled into the inverted jar, during the operation, was 4700 grain measures. When the copper was removed, and 200 grains of water were added to the solution, an effervescence took place, 1700 grain measures of nitric oxide gas were expelled, and the solution then acquired a blue colour.

Experiment IV.

With the same quantity of impregnated sulphuric acid, tin was reduced in weight 16 grains: the liquor acquired a violet colour, became turbid by the suspension of the oxide of tin, and 4100 grain measures of nitric oxide gas were extricated without heat, and 4900 with heat.

Experiment V.

Mercury treated in the same manner formed a thick turbid liquor, which was rendered clear by adding unimpregnated sulphuric acid. The liquor soon afterward acquired a purple colour, the mercury sunk to the bottom, in the form of a white powder; and the purple liquor, when a solution of common salt in water was added to it, showed no signs of containing mercury in a dissolved state.

The nitric oxide with which the sulphuric acid is impregnated shows no disposition to quit the acid by exposure to air; but on adding water, the gas is expelled suddenly with great effervescence, and in red fumes. Thus,

Experiment VI.

Upon adding 240 grains of water to 60 grain measures of impregnated sulphuric acid, 2300 grains of nitric oxide gas were thrown into the receiver; but as the action of the two liquors is instantaneous, the quantity of gas expelled from the retort, before its neck could be immersed in water and placed under the receiver, must have been considerable. The whole of the gas, however, was not extricated by means of the water; for the remaining liquor dissolved five grains of copper, while 800 measures of nitric oxide gas were thrown into the retort.

From the preceding experiments Mr. Keir deduces the following facts:

1. That a mixture of the sulphuric and nitric acids in a concentrated state, has a peculiar faculty of dissolving silver copiously.

2. That it acts upon, and principally oxides tin, mercury, and nickel (the latter of which, however, it dissolves in small quantity); and that it has little or no action on other metals.

3. That the quantity of gas produced while the metal is dissolving is greater, relatively to the quantity of metal dissolved, when the proportion of nitre to the sulphuric acid is small, than when it is large; and that when the metals are dissolved by mixtures containing much nitre, and with a small production of gas, the solution itself, or the metallic salt formed in it, yields abundance of gas when mixed with water.

4. That dilution with water renders the concentrated mixture less capable of dissolving silver, but more capable of acting on other metals.

5. That this mixture of highly concentrated sulphuric and nitric acids acquires a purple or violet colour when deprived of part of its oxigen, either by addition of inflammable substances, or sulphur, or by its action on metals, or by very strong impregnation of sulphuric acid with nitric oxide.

6. That this disoxigenation was found to communicate to the mixture the power of dissolving, though in small quantities, copper, iron, zinc, and cobalt.

7. That water expels from a highly disoxigenized mixture of concentrated sulphuric and nitric acids, or of sulphuric acid impregnated with nitric oxide, a great part of its contained gas; and that therefore this gas is not capable of being retained in such quantity by dilute as by concentrated acids. Water unites with the mixture of sulphuric acid and nitre without any considerable effervescence.

To these observations the author subjoins another fact, viz. that when to the mixture of sulphuric acid with nitre a saturated solution of common salt in water is added, a powerful aqua regia is produced, capable of dissolving gold and platina; and this aqua regia, though composed of liquors perfectly colourless, and free from all metallic matter, acquires at once a bright and deep yellow colour. The addition of dry common salt to the concentrated mixtures of sulphuric and nitric acids produces an effervescence, but not the yellow colour; for the production of which, therefore, a certain proportion of water seems to be necessary.

PART II.

On the Precipitation of Silver from Nitric Acid by Iron.

Mr. Keir introduces his account of the experiments, which are the subject of this part of his paper, by remarking, that Bergman relates, that, upon adding iron to a solution of silver in nitric acid, no precipitation ensued, although the affinity of iron to acids in general is known to be much stronger than that of silver; and although even with regard to the nitric acid other experiments evince the superior affinity of iron: for as iron precipitates copper from this acid, and as copper precipitates silver, we must infer, he observes, the greater affinity of iron than that of silver. In the course of Bergman's experiments, however, some instances of precipitation occurred, which he attributed to the peculiar quality of the irons thus employed. With a view to discover the circumstances, and to investigate the cause of this irregularity and exception to the generally received laws of affinity, Mr. Keir made the following experiments:

Experiment I.

A piece of fine silver was digested in pure and pale nitric acid; and while the dissolution was going on, and before the saturation was completed, a portion of the solution was poured upon pieces of clean and newly-scraped iron wire into a wine glass, and a sudden and copious precipitation of silver ensued. The precipitate was at first black, then it assumed the appearance of silver, and was five or six times larger in diameter than the piece of iron wire which it enveloped. The action of the acid on the iron continued some little time, and then it ceased; the silver redissolved, the liquor became clear, and the iron remained bright and undisturbed in the solution at the bottom of the wine glass, where it continued during several weeks, without suffering any change, or effecting any precipitation of the silver.

Experiment II.

When the solution of silver was completely saturated, it was no longer affected by iron, according to Bergman's observation.

Experiment III.

Mr. Keir having found, that the solution acted on the iron, and was thereby precipitated before it had been saturated, and not afterward, he was desirous of knowing, whether the saturation was the circumstance which prevented the action and precipitation. For this purpose he added to a portion of the saturated solution some of the same nitric acid, of which a part had been employed to dissolve the silver; and into this mixture, abounding with a superfluous acid, he threw a piece of iron, but no precipitation occurred. It was thence evident, that the saturation of the acid was not the only circumstance which prevented the precipitation.

Experiment IV.

To another portion of the saturated solution of silver some red smoking nitrous acid was added; and upon trial, it was found, that iron precipitated the silver from this mixture, and that the same appearances were exhibited, which had been observed with the solution previously to its saturation.

Experiment V.

The same effects were produced when sulphuric acid was added to the saturated solution of silver, and iron afterward applied.

Experiment VI.

To some of the same nitric acid, of which a part had been employed to dissolve the silver, a piece of iron was added; and while the iron was dissolving, some of the saturated solution of silver was poured into the liquor; upon which a precipitation of silver took place instantly; although when the same acid had been previously mixed with the solution of silver, and the iron was then added to the mixture, no precipitation had ensued.

Experiment VII.

The quantity of sulphuric acid, or of the red fuming nitrous acid, necessary to communicate to the saturated solution of silver the property of being acted on by iron, varies according to the concentration, and to the degree of oxigenation of the acid added; so that a less quantity than is sufficient does not produce any apparent effect. Nevertheless, when the solution of silver is by addition of these acids brought nearly to a precipitable state, the addition of alcohol will, in a little time, render it capable of acting on iron.

It appears then, that a solution of silver is not precipitated by iron in cold, unless it have a superabundance of disoxigenized acid.

Experiment VIII.

Heat affects the action of a solution of silver on iron; for if iron be digested with heat in a perfectly saturated solution of silver, such as a solution of crystals of nitrat of silver in water, the silver will be deposited in its bright metallic state on different parts of the iron; and the iron, which has been acted on by the solution, appears in form of a yellow ochre.

Experiment IX.

Bergman relates, that he has sometimes observed beautiful crystallizations or vegetations of metallic silver formed on pieces of iron immersed long in a solution of silver. Mr. Keir observes, he has found, that no time is able to effect this deposition, unless the solution be in a state *nearly* sufficiently disoxigenized to admit of a precipitation by iron, but not disoxigenized enough to effect this purpose immediately.

Experiment X.

Dilution with a great deal of water seemed to dispose the solutions of silver to be precipitated by iron more easily. A solution of silver, which did not act on iron, upon being very much diluted, and having a piece of iron immersed in it during several hours, gave a precipitate of silver in the form of a black powder.

Section II.

On the Alterations which Iron on its Surface undergoes by the Action of a Solution of Silver in Nitric Acid, or of a pure concentrated Nitric Acid.

It has been said, that, when iron is exposed to the action of a disoxigenized solution of silver, it instantly precipitates the silver; is itself acted upon or dissolved by the acid solution, during a certain time, longer or shorter, according to the degree of disoxigenation, quantity of superabundant acid, and other circumstances; and that at length the solution of the iron ceases; the silver precipitate is redissolved, if there be superfluous acid; the liquor becomes clear again, but only rendered a little browner by its having dissolved some iron; while the piece of iron remains bright and undisturbed at the bottom of the liquor, where it is no longer able to affect the solution of silver.

Experiment I.

A part of the disoxigenized solution of silver, which had passed through these changes, and which had ceased to act upon the piece of iron, was poured into another glass, and another piece of fresh iron wire was dropped into the liquor; upon which a precipitation of the silver ensued, a solution of part of the iron, a redissolution of the precipitated silver, and a cessation of all those phænomena, with the iron remaining bright and quiet at the bottom of the liquor, as before. It appeared then, that the liquor had not lost its power of acting on fresh iron, although it ceased to act on that piece which had been exposed to it.

Experiment II.

To one of the pieces of iron, which had been employed in the precipitation of a solution of silver, and from which the solution no longer capable of acting upon it had been poured off, some disoxigenized solution of silver was added, which had never been exposed to the action of iron, but no precipitation happened.

It appeared then, that the iron itself, by having been once employed to precipitate a solution of silver, was rendered incapable of any farther action on any solution of silver. And it is to be observed, that this alteration was produced without the least diminution of its metallic splendour, or change of colour. The alteration, however, was only superficial, as may be supposed; for, by scraping off its altered coat, it was again rendered capable of acting on a solution of silver. Mr. Keir calls iron thus affected *altered* iron; and iron which is clean, and has not been altered, fresh iron.

Experiment III.

To a disoxigenized solution of silver, in which a piece of bright altered iron lay without action, a piece of fresh iron was added, which was instantly enveloped with a mass of precipitated silver, and acted on as usual; but what is very remarkable, in about a quarter of a minute or less the altered iron suddenly was covered with another coat of precipitated silver, and was now acted on by the acid solution like the fresh piece. In a little time the silver precipitate was redissolved, as usual, and the two pieces of iron were reduced to an altered state. When a fresh piece of iron was then held in the liquor, so as not to touch the two pieces of altered iron, they were nevertheless soon acted upon by the acid solution, and suddenly covered with silver precipitate as before; and these phænomena may be repeated with the same solution of silver, till the superfluous acid of the solution becomes saturated by the iron, and then the redissolution of the precipitated silver must cease.

Experiment IV.

Some nitric acid was poured on a piece of altered iron, without any action ensuing, although this acid readily acted on fresh iron; and when to the nitric acid, with a piece of altered iron lying immersed in it, a piece of fresh iron was added, this immediately began to dissolve, and soon afterward the altered iron was acted on also by the acid.

Experiment V.

Upon a piece of altered iron a solution of copper in nitric acid was poured; but the copper was not precipitated by the iron; neither did this iron precipitate copper from a solution of sulphat of copper.

Experiment VI.

Altered iron was acted on by a dilute of nitrous acid; but not by a red concentrated nitrous acid.

Experiment VII.

Some pieces of clean fresh iron wire were put into a concentrated and red fuming nitrous acid. No apparent action ensued; but the iron was found to be altered, in the same manner as it is by a solution of silver, i. e., it was rendered incapable of being attacked either by a disoxigenized solution of silver, or by nitric acid.

Experiment VIII.

Iron was also altered by being immersed some little time in a saturated solution of silver, which did not show any visible action on it.

The alteration thus produced on the iron is very superficial. The least rubbing exposes some of the fresh iron beneath the surface, and thus subjects it to the action of the acid.

It is therefore with difficulty that these pieces of altered iron can be dried, without losing their peculiar property. For this reason Mr. Keir generally transferred them out of the solution of silver, or concentrated nitric acid, into any other liquor, the effects of which he wanted to examine. Or they may be transferred first into a glass of water, and thence into the liquor to be examined. But it is to be observed, that, if they be allowed to remain long in the water, they lose their peculiar property, or alteration. They may be preserved in their altered state, by being kept in ammonia.

Experiment IX.

To a saturated solution of copper in nitrous acid (which was capable of being readily precipitated by fresh iron) some saturated solution of silver was added.—From this mixture, a piece of fresh iron neither precipitated silver nor copper: nor did the addition of some nitric acid effect this precipitation.

Experiment X.

A solution of copper, formed by precipitating silver from nitric acid by means of copper, was very reluctantly and slowly precipitated by a piece of fresh iron; and the iron thus acted on by the acid was changed to an ochre.

Experiment XI.

A saturated solution of silver, having been partly precipitated by copper, acquired the property of acting upon fresh iron, and of being thereby precipitated.

Experiment XII.

Fresh iron, immersed some time in solutions of nitrat of lead, or of nitrat of mercury in water, did not occasion any precipitation of the dissolved metals; but acquired an altered quality. These metals taken in this respect resemble silver.

Experiment XIII.

It is well known, that a solution of sulphat of iron, added to a solution of gold in aqua regis, precipitates the gold in its metallic state. Mr. Keir remarks, he does not recollect, that the precipitation of a solution of silver, by the same sulphat of iron, has been observed. However, upon pouring a solution of sulphat of iron into a nitric solution of silver, a precipitate will be thrown down, which acquires in a few minutes more and more of a metallic appearance, and is indeed perfect silver.—When the two solutions are pretty well concentrated, a bright argentine film swims on the surface of the mixture, or silvers the sides of the glass in which the experiment is made. When a disoxigenized solution of silver is used, the mixture is blackened, as happens generally to a solution of sulphat of iron, when nitrous acid is added to it.

Experiment XIV.

Equal parts of water were added to a mixture of disoxigenized solution of silver and solution of sulphat of iron, in which all the silver had been precipitated, and the dilute mixture was digested with heat; by which means most of the precipitated silver was redissolved. Bergman has observed a similar redissolution of gold, precipitated by sulphat of iron, upon boiling the mixture; but he attributes the redissolution to the concentration of the aqua regis by the evaporation. As this explanation did not accord with Mr. Keir's notions, he diluted the mixture with water, and found that the same redissolution occurred both with the solution of silver and with that of gold. But he did not find, that the redissolution ever took place with either of the metals, unless there had been a superabundant acid in the solutions of gold and silver employed.

Experiment XV.

Mercury is also precipitated in its metallic state, from its solution in nitric acid, by a solution of sulphat of iron. When the liquor is poured off from the precipitate, this may be changed into running mercury, by being dried near the fire.

Experiment XVI.

Mr. Keir found also, that silver may be precipitated in its metallic state, from its solution in sulphuric acid, by addition of a solution of sulphat of iron. A sulphat of mercury may also be decomposed by a solution of sulphat of iron; and the mercurial precipitate, which is a black powder, forms globules, when dried and warmed.

Experiment XVII.

Muriat of silver is not decomposed by sulphat of iron; consequently there is an operation of a double affinity. Nevertheless, this muriat of silver may be decomposed by the elements of sulphat of iron, while they are in the act of dissolution; that is, the silver may be precipitated in its metallic state, by digesting muriat of silver with a dilute sulphuric acid, to which some pieces of iron are added. And it is to be observed, that the reduction of the silver and precipitation takes place while the acid is yet unsaturated. Muriatic acid and iron applied to muriat of silver effect the same reduction of the silver to a metallic state, even when there is more acid than is sufficient for both metals.

Mr. Goettling has given an easy and œconomical method of separating silver from copper. Having ascertained by the touchstone, or in any other way, the proportion of silver in the mixture, take one part of sulphuric acid for every part of silver, and three-fifths for every part of copper. Dilute the acid with half its weight of water, and pour it into a matrass on the alloy reduced into small pieces. To promote the action of the acid, one part more may be added to every sixteen parts of the alloy. Placing the matrass on a sand heat, bring it to boil, and in two or three hours the whole will be united with the acid; particularly if care be taken to stir it occasionally with a glass rod. On this mass, which is thick and frequently hard, pour six or eight times its weight of boiling water, and keep it on the fire some time longer. A plate of copper, or some pieces of copper tied up loosely in a coarse linen cloth, must now be suspended in the mixture, which is to be kept boiling for some hours, and the silver will thus be precipitated in the metallic state. If the silver be not completely separated, a few drops of solution of muriat of soda will show this, by forming in the liquor a cheeselike precipitate.

When the whole of the silver is thrown down, it is to be well washed, till the water that comes off is not rendered at all blue by ammonia. The silver may be kept in the state of powder, or fused with a fourth or at most half its weight of sulphat of potash. The sulphat of copper produced will be at least equal in value to the acid employed.

Mr. Andrew Thomson, of Banchory, has

recommended the following method of purifying silver, which he observes is equally applicable to gold. The impure silver is to be flatted out to the thinness of a shilling, coiled up spirally, and put into a crucible, the bottom of which is covered with black oxide of manganese. More of this oxide is then to be added, till the silver is completely covered, and all the spaces between the coils filled. A cover is then to be luted on, with a small hole for the escape of the gas; and after it has been exposed to a heat sufficient to melt silver for about a quarter of an hour, the whole of the alloy will be oxided. The contents of this crucible are then to be poured into a larger, into which about three times as much powdered green glass has been previously put; a cover luted on as before, to prevent the access of any inflammable matter; and the crucible exposed to a heat sufficiently strong, to melt the glass very fluid. On cooling and breaking the crucible the silver will be found reduced at the bottom, and perfectly pure.

Sulphur combines very easily with silver, if thin plates, imbedded in it, be exposed to a heat sufficient to melt the sulphur. The sulphuret is of a deep violet colour, approaching to black, with a degree of metallic lustre, opake, brittle, and soft. It is more fusible than silver, and this in proportion to the quantity of sulphur combined with it. A strong heat expels part of the sulphur.

Sulphuretted hidrogen soon tarnishes the surface of polished silver, and forms on it a thin layer of sulphuret.

The alkaline sulphurets combine with it by heat, and form a compound soluble in water. Acids precipitate sulphuret of silver from this solution.

Phosphorus, left in a nitric solution of silver, becomes covered with the metal in a dendritic form. By boiling this becomes first white, then a light black mass, and is ultimately converted into a light brown phosphuret. The best method of forming a phosphuret of silver is Pelletier's, which consists in mixing phosphoric acid and charcoal with the metal, and exposing the mixture to heat.

The neutral salts alone do not alter silver either in the moist or dry way; nitre, in particular, does not deflagrate with this metal.

Most metallic substances precipitate silver in the metallic state from its solution. The assayers make use of copper to separate the silver from the nitric acid used in the process of parting. The precipitation of silver by mercury is very slow, and produces a peculiar symmetrical arrangement, called the tree of Diana. In this, as in all precipitations, the peculiar form may be affected by a variety of concomitant circumstances; for which reason one process usually succeeds better than another.

Lemery directs, that an ounce of fine silver be dissolved in a sufficient quantity of very pure and moderately strong nitric acid; that this solution be mixed in a matrass, or bottle, with about twenty ounces of distilled water; and that, after the addition of two ounces of mercury, the whole be suffered to repose. During the space of forty days a kind of tree of silver will be formed on the surface of the mercury, with branches greatly resembling a vegetable substance in its ramifications. The foregoing process is said by Macquer to succeed very well; but the following of Homberg is much quicker in taking effect.

Make an amalgam, without heat, of four drachms of leaf silver with two drachms of mercury. Dissolve this amalgam in four ounces, or a sufficient quantity of pure nitric acid of a moderate strength; dilute this solution in about a pound and a half of distilled water; agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of amalgam of gold, or silver, as soft as butter, is to be added; after which the vessel must be left at rest. Soon afterward small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs.

In the above experiment of Lemery, the nitric acid deposits its silver at the same time that it takes up mercury; and, in consequence of the liquor being so much diluted, the process goes on slowly, and the precipitated silver has time to arrange itself according to the law of its crystallization, whether that depend on the polarity of its particles, or on any other property not yet explained.

In the method of Homberg, there are two circumstances, which appear calculated to forward the process: in the first place, the nitric acid already contains mercury in solution, which may probably render it more disposed to part with the silver; and, in the next place, the mercury is combined with silver or gold in the form of an amalgam. These may perhaps facilitate the precipitation of the silver, by presenting a base for it to combine with; which may be more perfectly at repose, because less agitable than the fluid mercury in the former experiment. After all, however, though the general theory of the experiment is not difficult, yet it does not seem easy to point out the effectual cause of the differences between the two results.

Silver unites with gold by fusion, and forms a pale alloy, as has been already mentioned in treating of that metal. With platina it forms a hard mixture, rather yellower than silver itself, and of difficult fusion. The two metals do not unite well. Silver melted with one tenth part of crude platina, from which the ferruginous particles had been separated by a strong magnet, could not be rendered clear of scabrous parts, though it was repeatedly fused, poured out, and laminated between rollers. It was then fused, and suffered to cool in the crucible, but with no better success. After it had been formed, by rolling and hammering, into a spoon for blowpipe experiments, it was exposed to a low red heat, and became rough, and blistered over its whole surface. The quantities were one hundred grains of silver and ten grains of platina. Nitre was added during the fusions.

Silver very readily combines with mercury. A very sensible degree of heat is produced, when silver leaf and mercury are kneaded together in the palm of the hand. With lead it forms a soft mass, less sonorous than pure silver. With copper it becomes harder and more sonorous, at the same time that it remains sufficiently ductile: this mixture is used in the British coinage. Fifteen parts of silver, alloyed with one of copper, form the compound called standard silver. The mixture of silver and iron has been little examined. With tin it forms a compound, which, like that of gold with the same metal, has been said to be brittle, however small the proportion; though there is probably as little foundation for the assertion in the one case as in the other. With bismuth, arsenic, zinc, and antimony, it forms brittle compounds. It does not unite with nickel. The compound of silver and tungsten, in the proportion of two of the former to one of the latter, was extended under the hammer during a few strokes; but afterward split in pieces.

Silver is found either native or mineralized. The native silver is found in Peru and various parts of Europe; sometimes in considerable masses, and often diffused through sand, ochre, or lime-stone. It is seldom pure, but is generally alloyed with copper, and sometimes with gold, iron, or antimony. The mineralized silver contains sulphur and arsenic, or both, with other admixtures.

Native silver may be purified by pounding or washing, or amalgamation with mercury; and the silver itself is refined by cupellation with lead in the same manner as gold. In the large way, the litharge, or vitrified lead, is blown from the surface of the silver by bellows, instead of soaking into the crucible. Gold may be separated from silver by parting with aqua regia, or treatment with sulphur in the dry way, which combines with the silver, and leaves the gold disengaged.

The vitreous silver ore is one of the richest ores of silver, and contains from seventy to eighty pounds of silver in the hundred weight: the rest being sulphur, with rarely any other metal, except a small portion of iron. It is found either in solid large lumps, or inherent in quartz or spar. Its colour generally resembles that of lead; but it grows dark by exposure to the air. It usually possesses a slight degree of malleability, and is sufficiently soft to be cut by a knife.

To analyse this ore in the moist way, it may be boiled in nitric acid, which acidifies the sulphur, and causes great part to fly off in the form of sulphurous acid gas. Common salt, or muriatic acid, will precipitate the silver in the form of muriat, which may be either reduced, or accounted for by deducting one fourth of its weight when washed and dried, which fourth of its weight is muriatic acid.

In the dry way, it may be reduced by exposing it to a heat not sufficient to melt it. In this way the sulphur is dissipated, and the silver remains usually in a fibrous form. Small portions may be conveniently decomposed in this manner by the blowpipe upon charcoal.

The red silver ore is a heavy shining substance, either transparent or opake; sometimes gray or blackish, but always reddish when powdered: it usually contains more than half, and sometimes three fourths, of its weight of silver, the rest being antimony, oxigen, and sulphur.

In the moist way this ore is analysed by reducing it to fine powder, and boiling it with diluted nitric acid. The residue must be edulcorated with water; and the water added to the solution; from which the silver may be precipitated by muriatic acid, and concentrating the solution. What the nitric acid would not dissolve may be treated with a mixture of one part nitric and five muriatic acid, which will leave the sulphur. And this solution, being poured into a large quantity of water, will let fall the antimony in the state of oxide. On reducing this with black flux, and blowing off the antimony, a little silver will be found: and the sulphur, if deflagrated, will leave behind a little muriat of silver.

Silver united with sulphur, lead, and antimony, is generally called the white ore of silver.

This and the other ores of silver, of which there is considerable variety, may be analysed by varying the processes according to the supposed or known general contents of the ore.

Sulphurous and arsenical silver ores may be assayed by roasting, and subsequent fusion with a greater or less quantity of flux. In the fusion, the silver is obtained alloyed with lead, copper, or iron, which may be separated by cupellation with lead, and the silver left pure.

The fineness of silver is denoted by the assayers by mentioning the number of pennyweights and grains of pure silver contained in the ounce. So that if an ounce of silver be found to lose half a pennyweight by cupellation, it is said to be eleven pennyweights twelve grains fine; if it lose a whole pennyweight, it is said to be eleven pennyweights fine, &c. Silver is likewise tried by the touch, in the same manner as gold. For this purpose the assayers are provided with a set of needles, or small bars; the first of which contains $\frac{1}{16}$ part of its weight of copper, and the rest silver; the second contains $\frac{2}{16}$ parts of copper; the third $\frac{3}{16}$ parts; and so on to the last, which contains 15 parts of copper to one of silver. By the resemblance of colour on the touchstone, an estimate may be made of the fineness of the silver to something nearer than the 30th part of the whole, which is a considerable acquisition in the examination of small articles, such as rings, trinkets and the like. It is true indeed, that the use of the touch supposes the precious metal to be alloyed with copper only, which may not be the case; and consequently the assayer is liable to be deceived in this respect: but he may in this case have recourse to aqua fortis, or the blowpipe, in the same manner as directed in the article gold.

In the large works, where silver is extracted, the processes are grounded on the properties already described. Native silver is triturated with mercury; after which the amalgam is washed, to separate the earthy particles; and the quicksilver separated, partly by pressure in leathern bags, and partly by distillation in iron retorts.

Rich sulphurous ores are roasted, and fused with lead, to refine the silver by cupellation. The poorer ores, which contain copper, are fused with pyrites, which affords a mass consisting of copper, sulphur, and silver. Lead is then added, and the mass treated in the way of eliquation. The lead flows out, carrying the silver with it; and lastly, these two metals are separated by the test, on which the lead is converted into litharge, and the silver remains pure.

The uses of silver are well known: it is chiefly applied to the forming of various utensils for domestic use, and as the medium of exchange in money. Its disposition to assume a black colour by tarnishing, and its softness, appear to be the chief objection to its use in the construction of graduated instruments for astronomical and other purposes, in which a good white metal would be a desirable acquisition. The nitrat of silver, beside its great use as a caustic, has been employed as a medicine, it is said with good success, in epileptic cases, in the dose of $\frac{1}{20}$ of a grain, gradually increased to $\frac{1}{8}$, three times a day. Dr. Cappe gave it in a dose of $\frac{1}{4}$ of a grain three times a day, and afterward four times, in what he supposed to be a case of angina pectoris, in a stout man of sixty, whom it cured. He took it for two or three months. Dr. Cappe imagines, that it has the effect of increasing the nervous power, by which muscular action is excited.—*Journ. de Phys.*—*Phil. Trans.* — *Bergman.* — *Priestley.* — *Murray's Chemistry.*—*Van Mons's Journ.*—*Nich. Journ.* —*Duncan's Med. Annals.*

SILVERING. There are various methods of giving a covering of silver or silvery aspect to the surfaces of bodies. The application of silver leaf is made in the same way as that of gold, for which see GILDING.

Copper may be silvered over by rubbing it with the following powder: Two drachms of tartar, the same quantity of common salt, and half a drachm of alum, are mixed with fifteen or twenty grains of silver precipitated from nitric acid by copper. The surface of the copper becomes white when rubbed with this powder, which may afterward be brushed off and polished with leather.

The sadlers and harness-makers cover their wares with tin for ordinary uses, but a cheap silvering is used for this purpose as follows: Half an ounce of silver, that has been precipitated from aqua fortis by the addition of copper, common salt and muriat of ammonia, of each two ounces, and one drachm of corrosive muriat of mercury, are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed, after which they are made red hot, and then polished. The intention of this process appears to be little more than to apply the silver in a state of minute division to the clean surface of the copper, and afterward to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned, with borax or mercury, and causing it to adhere by fusion.

The dial-plates of clocks, the scales of barometers, and other similar articles are silvered by rubbing upon them a mixture of muriat of silver, sea-salt, and tartar, and afterward carefully washing off the saline matter with water. In this operation, the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick.

The silvering of pins is effected by boiling them with tin filings and tartar. The explanation of this effect is difficult. It should seem as if the order of the affinities was changed by the increase of temperature; so that the tin may be taken up at a lower temperature by the acid, and give place to the brass at a greater heat. But see TINNING.

In the silvering of looking-glasses, as in the preceding operation, no silver is used. A leaf of tin foil, which must be thicker the larger its dimensions, is evenly spread upon a smooth stone table furnished with a rim. Upon this mercury is poured in a small quantity at first, and softly brushed about till the whole surface of the tin appears bright by amalgamation. At this period, the mercury has corroded the upper surface only of the tin; but if the operation were to rest here, its texture would soon be entirely destroyed by a total combination. The workman then pours a considerable quantity of mercury upon the table. A sheet or piece of paper with a neat cut edge is then applied over one of the rims of the table, and upon it the plate of glass intended to be silvered. The plate is then slided onward, and comes in contact with the mercurial surface, so as not only to prevent the interposition of bubbles of air, which would ensue from a perpendicular application, but likewise in a great measure to drive the dust and other impurities before it. As soon as the whole surface of the glass is thus applied to the mercury, the paper is withdrawn, and weights placed on the glass, so as to bring it into close contact with the amalgamated tin foil. The superfluous mercury is then decanted off, and the glass suffered to remain undisturbed for a day or more. During this time, the mercury applied between the surface of the glass and the tin, becomes gradually absorbed by the latter, and forms a hard amalgam, which is not easily injured or removed, and is farther defended by the frame in which looking-glasses are usually set.

The convex surfaces of glass mirrors are silvered in the same manner, but instead of a flat table, a mould of plaster of Paris is made use of. Hollow mirrors or globes are silvered by an amalgam consisting of one part by weight of bismuth, half a part of lead, the same quantity of pure tin, and two parts mercury. The imperfect metals are to be first fused together, and the mercury added when the mixture is almost cold. A very gentle heat is sufficient to fuse this amalgam. In this state it is poured into a clean glass globe intended to be silvered, by means of a paper funnel which reaches to the bottom. At a certain temperature, it will stick to the glass, which by a proper motion may thus be silvered completely, and the superfluous amalgam poured out. The appearance of these toys is varied by using glass of different colours, such as yellow, blue or green.

Sinople is a dark red jasper or flint, which strikes fire with steel, and affords in the dry way 10 per cent. of iron, and melts into a black slag. Specific gravity 2·691. A red hornstone is sometimes called by this name in Hungary.

Sinter. See Stalactites.

Slate. This name is given to argillaceous opake stones, which possess the well known property of breaking or splitting into plates or laminæ.

Of the roof slates, schistus tegularis, there are several varieties. They are generally composed of silex, alumine, lime, magnesia, and iron, with some bituminous particles: their proportions being as a mean in the order here given, but varying considerably in the different varieties. They do not strike fire with steel, and may be lightly scraped with the nail; are very brittle, and of a lamellar texture: specific gravity from 2·5 to 2·88: grain moderately fine: never transparent: slightly effervesce with acids when reduced to powder, otherwise not.

The dark blue slate, schistus tegularis, used for writing on, is one of the varieties.

Other stones are also used for covering houses in various countries, but they are easily distinguished; as their laminæ are much thicker, their surface more uneven, and their texture coarser. They chiefly belong to the class of sand stones, or to the calcareous genus.

The pyritaceous species contains a variable proportion of pyrites. Its colour is gray. brown, blue, or black: it is more or less decomposable by exposure to the air, according to the quantity of the pyritous ingredient and the state of the iron in the pyrites: if the iron be little oxided, it is easily decomposed; but if the iron be already much oxided, it will be decomposed but slowly, if at all. Aluminous schistus is of this species.

The bituminous schistus is intimately mixed with a notable proportion of mineral oil or bitumen. It is generally black, of a lamellar texture, of different degrees of hardness, but never gives fire with steel: it emits a strong smell when heated, and sometimes without heat; and does not show white when scraped.

To these may be added, 1. The argillaceous schistus or flag-stone. It consists of clay mixed with from three to four tenths of its weight of silex, and a little of the yellow or red oxide of iron. It is of a gray, yellowish, or reddish white colour; does not give fire with steel, nor effervesce with acids: its specific gravity is from 2·6 to 2·78: it is in some places used for covering of houses, but mostly for flooring; it is sometimes compact, and sometimes sandy, and then its specific gravity is smaller.

2. The argillaceous grit, free stone, or sand stone. This may be cut easily in all directions: its texture is more or less porous, equable, and rough to the touch: it exhales an earthy smell when fresh broken and breathed upon: it does not give fire with steel, or effervesce with acids. That from Hollington, near Utoxeter, is of a whitish or yellowish gray, and its specific gravity 2·288. That from Knipersly, in Staffordshire, is of a blueish gray, and so infusible as to be used for a fire-stone: its specific gravity is 2·568.

Smalt. See Zaffre.

Smaragdus. See Emerald.

Smectis. See Steatites.

Smell (Principle of). Substances dissolved or suspended in the atmosphere are found to act with peculiar energy on the

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organs of smell. Such permanently elastic fluids as are destructive of animal life, as for example, ammoniacal gas emitted from the concrete alkali commonly called smelling salts, sulphurous acid air formed when sulphur is burning, nitric oxide gas from aqua fortis, and the like, produce effects, to which scarcely any individual is a stranger. Every chemical operation is attended with the extrication of more or less volatile matter. Even the metals and glass affect the organ of smell, probably by some evolution; and the smells emitted by organized substances, in every stage of their existence, are among the most remarkable of their secondary properties.

The principle of smell in plants appears to be of an exceedingly subtile nature. It seems in general to reside in the essential oil, and composes an extremely small part of the weight of vegetables, as may be inferred from the loss of fragrance sustained by essential oils, with little or no loss of their weight. This however does not necessarily show, that the whole principle of smell has flown off; because it may with equal probability be supposed, to have entered into combination with some of the other principles of the substance, which afforded it. Distillation with alcohol is used to extract the fragrant principle from plants. A considerable proportion of this matter may be obtained by distillation with water, in which it comes over probably diffused with a small proportion of essential oil. It has been supposed to consist of an elastic fluid of a peculiar nature.

Smelting of Ores. The separation of metallic substances from their ores in the large way by heat is called smelting. For the processes, see Ores.

Snow. The effect of snow in fertilizing soils has long been an acknowledged fact, but the cause of this property has been disputed; and it is perhaps still to be regretted, that it has never yet been sufficiently examined by chemical analysis. Hassenfratz has lately asserted, that it contains a large quantity of air, and that this air has a large proportion of oxigen. His proofs are, that infusion of litmus dropped into snow-water gives it a redder tinge than it does distilled water; and that much more oxide of iron is precipitated by it from a solution of the sulphat. Dr. Carradori however observes, that fish soon die in snow-water, which he ascribes to its want of oxigen: and that it does not give out oxigen gas, when exposed to the action of light. *Journ. de l'Ecole Polyt.—Journ. de Phys.*

Snow of Antimony. This name has been given to the white oxide obtained by sublimation from the metal.

Soap is a saline compound, formed from fat or inflammable bodies, which not being soluble in water by themselves, compose, by the assistance of salts, a homogeneous mass soluble in water. These substances are slippery to the touch, soluble in water and alcohol, and commonly lather and froth with these fluids, upon being agitated with them; they also render several other substances miscible with water. They are discriminated from each other, not only by the various salts, but likewise by the different sorts of fat substances employed in their preparation. Similar combinations also are found ready formed in nature, though these are less in use and require to be adapted by art to the different purposes to which they may be applied.

Different vegetables very evidently exhibit by nature a saponaceous quality in their composition, of which soap-wort, the soap-berry tree (sapindus saponaria), and the common nightshade, may be adduced as instances. Now since the period that we have been convinced of the presence of alkaline salts in vegetables, nothing is easier than to conceive the origin of a mixture of this kind. In proportion therefore as this salt and the oily parts exceed the rest in quantity, and the force of the alkali is not weakened at the same time by the presence of an acid, such vegetable will be more or less of a saponaceous nature. Sometimes also, though more rarely, a saponaceous compound is met with in vegetables, which consists of oleaginous particles and an acid. For this reason it is necessary in every case, previous to attempting to ascertain the composition of one of these compounds, to see of what kind it is. With this view, the watery extract of the saponaceous plant needs only to be mixed with a solution of fixed alkaline salt, and notice taken, whether any precipitation or separation of the constituent parts ensue or not. If in this operation the mixture be not observed to become turbid, but that an acid, on being added to it, produces this effect, it may reasonably be inferred, that this saponaceous compound has an alkaline salt for its basis. But if upon the addition of an acid to such extract no alteration ensues, and it is, on the contrary, rendered turbid by an alkali, it may be concluded, that the composition is saponaceous with an acid basis.

A perfect soap cannot be produced by art with acids. From the commixture of fluid acids and oily substances no other than greasy, saponaceous masses are produced; which, though they are miscible with water, cannot be brought into a solid and concrete state, and at the same time preserve their saponaceous qualities.

The alkaline salts, on the contrary, are intermediate substances, by which all oleaginous or other inflammable bodies may be brought into a perfectly saponaceous state. But in order to promote the combination proposed, they must necessarily be deprived of carbonic acid, by boiling with quicklime.

With the fixed alkaline salts, soda as well as potash, tallow-soaps are prepared in the following manner: One part of either of these alkaline salts, and about two parts of quick-lime, or as much as is requisite to render them perfectly pure, are to be mixed together, and made into a strong lie, with the necessary quantity of water. This lie is then made to boil with three parts of tallow or fat over a gentle fire, and kept continually stirring till the mixture becomes thick, and ceases to adhere to the hand, when a little is taken out of it for a sample. Toward the end, a proportional quantity of common salt is added, by which the soap acquires a greater degree of hardness. This effect has been accounted for on various suppositions. It has been said, that the quantity of water present is diminished by the abstraction of as much as the salt requires for its solution; a circumstance probably of little consequence. Again, the soap is rendered less soluble in the water by this addition; and therefore more readily separates. But the most important effect seems to be, that the muriatic acid of the salt attracts the potash of the soap, and gives its own soda in return, which is known to afford a much harder soap. The weight of the soap here acquired is commonly, as Wiegleb says, double that of the tallow employed in making it. In the same manner a wax soap may be prepared either of yellow or white wax, which is about three times the weight of the wax, is very hard and firm, and has an agreeable smell of almonds. The Gravenhorsts in Brunswick likwise prepare a soap of cocoa butter for medical uses. Spermaceti also may be made into soap with a caustic lixivium.

Macquer gives us the following process for oil soap: One part of quicklime and two parts of good Spanish soda are boiled together during a short time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phial, which is capable of containing an ounce of water, shall contain an ounce and three eighths of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of sweet almonds, in a glass or stone-ware vessel. The mixture is to be stirred from time to time with an iron spatula, or with a pestle, and it soon becomes thick and white. The combination is gradually completed, and in seven or eight days a very white and firm soap is obtained.

For the coarser sorts of soap cheaper oils are employed, such as oil of nuts, linseed, hempseed, fish, &c. Either of these kinds of soap, to be good, must neither feel greasy or unctuous in water, nor exhibit any vestige of fat upon the water. It ought farther to dissolve easily in water, and lather well, as likewise be easily soluble in alcohol. It must not become moist in the air, or throw out a saline efflorescence on its external surface.

The following methods of making different kinds of soap are given as specimens of those in actual use, in a treatise on soap-making, by a manufacturer, lately printed at Edinburgh.

For making Brown or Yellow Soap.

Let there be weighed 10 cwt. of tallow, and about 3 cwt. of resin; the resin to be broken into small lumps. In the first place, put into the boiler about 150 or 200 gallons of lie, and set the fire; then add the tallow and resin. This done, the pan is said to be charged.

A good fire may be kept up until all is thoroughly melted, and the pan brought to boil; during which time there ought to be constant stirring with the paddle, to prevent the resin from settling to the bottom. If the goods or materials in the pan appear to swell up, damp the fire, which is done by opening the furnace door, and throwing ashes thereon (some have proper dampers), when the whole will boil at leisure. As the caustic alkali immediately grips to the tallow, there is no occasion for long boiling; about two or three hours will be long enough: the fire may then be drawn, and the pan allowed to stand for four or six hours, when the weak lie may be pumped off, and fresh added for a second boil. It may be necessary to mention, that when the pan is wished to be cranned, or pumped off sooner, a few pails of cold lie must be thrown in, a little after the fire is drawn.

Set the fire again for the second boil, and when properly a-boil, two or three hours may be sufficient at any one time to continue the boil: the strength of the lie is often gone before this period arrives. A short experience, however, with attention, will perfectly inform any sagacious person with regard to this particular.

The boilings to be thus continued day after day, until the soap becomes thick, and of a strong consistence. Take then a little upon the forefinger, and after letting it cool a few seconds, press it with the thumb. If it squeeze into a thin, hard scale, the soap is fit, or ready, for finishing: if otherwise it appear greasy, and stick to the finger, and of a soft consistence, more lie must be added; and if this does not harden it, another boil must be given. But, in consequence of the former scaly appearance, give the pan a good hearty boil, and draw the fire. Cool down with two or three pails of lie, and in about two hours thereafter pump off the lie; which should be done at all times as clean as possible. This done, put in six or eight pails of water to the boiler (no lie at finishing being used), set a brisk fire, and keep constantly stirring with hand-stirrer and paddle alternately, until all is melted, and begins to show an appearance something like thin honey. Take now a little from a boiling part, upon the hand-board, and observe, when held up, if any lie runs clearly from it: if it do, more water must be put in, and the boil continued. When, upon the other hand, no lie runs from the soap when held up slanting-ways upon the board; in this case, too much water has already been given. A little strong solution of salt must now be added to open it, technically termed *cutting up*; or, instead of salt brine, a little strong common salt and water; about half a pailful may do. We come now to the most critical part of boiling, that is, the finishing of the soap: and it ought to be particularly attended to, that the soap be brought to such a state, as, when held up upon the hand-board, the lie does not *run* down from the soap, but is seen, as it were, just *starting* from it. The fire may then be drawn away, and the soap declared finished; or, if palm-oil be wished for making it of a beautiful colour, about 20 lbs. may be put into the boiler, after you discover, as above, the soap to be finished; and in about half an hour after the oil is put in, the fire may be drawn, and the whole allowed to stand for 48 hours, when it may be cast into the frames.

In about three days (supposing the frames 30 inches deep), the whole will cut up into bars.

A Charge for pure White Soap.

The boiler being made perfectly clean, put in 10 cwt. of best home melted tallow (no resin is used in white soap), with 200 gallons of lie; melt down with a moderate fire, as the goods now in hand are something similar to milk, exceeding apt to boil over.

Close attention, therefore, is absolutely needful upon this first boil; which may be continued about two hours, with a moderate fire, when it may be drawn away, and the pan allowed to settle about two hours, when the lie may be drawn off. The process to be observed in this soap is exactly similar to the last operation. Two or three boils a day to white soap may be given with great ease; the lie sooner subsiding in the boiler than with yellow soap, and can be cleaner pumped off.

When sufficient boils have been given, and the soap is arrived at perfection, it will assume an appearance something like a curdy mass. Take then a little upon your forefinger (as before directed); and if the same effect seem to attend it, that is, when pressed with the thumb it squeeze into a thin, hard, clear scale, and part freely from the finger, the soap is ready for finishing. Draw the fire cool down with a few pails of lie, and in a short time thereafter pump clean off.

Set the fire, and add to the soap eight or ten pails of water (the pail I suppose to contain about nine or ten English gallons). When this is melted, and properly incorporated with the soap, try, as formerly directed, if the lie run from it when held up upon the hand-board. If it do, more water must be put in. If it do not run, or there be no appearance of it, continue boiling for a short while longer, and then add a pail of salt and water pretty strong, mixed together; about one third salt, and two thirds water. This will have the effect of cutting up the pan, or separating the soap and water completely from one another. When this is apparent, draw the fire; let it stand for half an hour, when the water will pump off, bringing therewith most of the remaining alkaline lie of the former boil.

This I call the first washing; and if kelp lie has been used in the operation, the propriety of this must be conspicuous, for the water pumped off will be of an exceeding dark bottle green colour. The finishing of white soap without this precaution is the sole cause of the blueness, so frequently observed in this article when made and brought to market.

The blue lie being pumped clean off, set again the fire, and put into the boiler six or eight pails of water; and when thoroughly incorporated and boiled some time, try if the water run from the soap: if it do, add water in small quantities at a time, until it is observed not to run, but, as formerly mentioned for yellow soap, to appear as just starting from the soap; in this case, after giving a good boil, and swelling the soap up in the pan to near the brim, draw away all the fire, and spread it about to die away. The pan is now finished, and may stand about twelve or fourteen hours; and if the quantity be large, that is, two, three, or four ton, double this time to stand will be much in favour of the soap, providing always, that it can be kept very close and warm in the boiler. If any blueness still appear, repeat the washing.

Before casting, I would recommend the frames to have a bottom and lining of coarse cloth, for white soap only. After all is cast into the frames, let it be well stirred, or crutched; and it is very proper, that it also be covered close up with old sheets, bass mats, &c., upon the top of the frame and soap, and allowed to cool gradually, and all together.

In about three or four days (supposing, as formerly, the dip 30 inches), the coverings and frames may be taken off, and the whole cut up into such size of bars as may best suit the customers.

To give this white soap the perfume of what is commonly called Windsor soap, a little of the essential oil of caraway seeds mixed with a small portion of alcohol may be incorporated with the soap when putting into the frame, stirring it in by little at a time, so as to diffuse it throughout the whole mass.

For making Black or Green Soft Soap.

The peculiar method pursued in making this soap differs considerably from that of making hard soap. The hard has the whole of the lie totally extracted before finishing: soft soap, on the contrary, retains the whole of the lie used in the making; becoming, with the other materials employed, one compound body, called, *soft soap*. A few examples will clearly explain the nature and practical means made use of in producing this very useful soap.

We shall now commence an operation with a charge for what is called

First Crown Soft Soap, 18 *Barrels*.

The quantity of lie requisite for completion of this charge will be about 400 gallons; about one third of which must be put into the boiler previous to any of the other materials: afterward add, 2 cwt. 2 qrs. of tallow, 2 cwt. 2 qrs. of hogs-lard, and 70 gallons of olive oil. The lie herein to be used is supposed to be from Hungarian and English (Essex) ashes. The proportion is one of the English to eight of the Hungarian. The particular mode of proceeding is thus: After the lie is put in, add the tallow, and light the fire. When all the tallow is melted, put in the oil, and draw the fire a little afterward, and allow the pan to stand about two hours. Light again the fire, and add about 20 gallons more of the lie. After the pan begins to boil, add now and then a little more lie, for the purpose of preventing the soap from boiling over: and this adding of lie is to be continued, until the soap is supposed to be about half boiled; when it will be time to try, whether the soap have got too much, or too little lie.

This trial is called *proving*, and is necessary to be done several times during the operation, and previous to the finishing. The method pf performing it is this: Provide a piece of glazed Dutch delft, and also a clear clean knife: with the knife take up a piece of the soap from the pan, and if it turn whitish thereon, and fall from it in short pieces upon the delft, it is then to be concluded, that too much lie has been put in; to rectify which, a little more oil must be added. On the contrary, if the soap want lie, it will fall from the knife in long, ropy pieces; in consequence of which add some more lie. When, however, it happens to be brought to perfection, neither wanting more lie nor oil, but just in a right state; it will then be observed, when taken upon the knife, to stand the proper colour, not ropy, nor too white, but transparent. The fire may now be drawn, the soap being properly finished, and ought immediately to be cast into the barrels, firkins, &c.

Remember always, after the second time the fire is lighted, to keep the soap boiling briskly, till the pan is nearly ready, when it ought to boil slow, until finishing, and ready to cast.

A Charge for Second Crown Soft Soap.

280 lbs. of tallow.
140 gallons of lie.
82 gallons of whale oil.

Put in 100 gallons of lie, with the tallow, and light the fire. When the tallow is melted, add the oil, and draw the fire. Let all stand for two hours. Again light the fire, and add 20 gallons of lie. With this the boiling is to be continued, until the soap is about half finished, when 10 gallons more of lie are to be added. During the remainder of the boiling, add, at different periods, the other 10 gallons of lie, which will completely finish the soap.

When a solution of soap in alcohol is poured into river or spring water, a precipitation ensues, and a great part of the precipitate is no longer soluble in water. All soaps are decomposed again by acids, and the fat matter separated from them. The alteration however, which the fat and oils undergo on this occasion, is very remarkable. They are now soluble in alcohol, whereas before the case was quite otherwise; the cause of which depends on the action of the caloric upon these bodies; and indeed the naked fire manifestly exerts the same effect upon them in such cases, in which it converts them into empyreumatic oils. In the southern countries, soda, but in the northern countries the common potash, is more commonly employed in the manufacture of soap. With mere lime-water a saponaceous greasy mixture only, but no solid soap, can be obtained. Beside the above-mentioned fat substances, a resinous soap may also be made from the coarser kinds of resin with caustic lie.

Chaptal gives the following classification of matters with which soaps may be made, arranged according to the goodness of the produce.

1. Oil of olives and of almonds.
2. Suet, hogs-lard, butter, and the fat of horses.
3. Rape oil.
4. Oil of beech-mast and poppy seeds.
5. Fish oil.
6. Oil of hempseed, nuts, and linseed.

The compound resulting from this union partakes at the same time of the properties of oil and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap is less combustible than when pure, from its union with the alkali, which is an uninflammable body. It is miscible, or even soluble in water to a certain degree, by means of the alkali. Soap is entirely soluble in alcohol.

When oil unites with alkali in the formation of soap, it is little altered in the connexion of its principles; for it may be separated from the alkali by decomposing soap with any acid, and may be obtained nearly in its original state. By the accurate investigation that Mr. Geoffroy has made of soap, by decomposing it thus by means of an acid, he found that two ounces of this compound consist of one ounce three drachms and one scruple of oil, one drachm and one scruple of soda deprived of all moisture, or twice the quantity of this salt containing the water of its crystallization; and lastly, two drachms and four grains of water. This latter quantity of water is nevertheless variable, according to the condition of the soap; for it may be much more or much less dry.

Concerning the decomposition of soap by means of acids we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting a fixed alkali, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with basis of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acid of these salts, may unite more or less intimately with the substance, which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has shown. When first exposed to fire, it yields a phlegm called by him a spirit; which nevertheless is neither acid nor alkaline, but some water, which enters into the composition of soap. It becomes more and more coloured and empyreumatic as the fire is increased, which shows, that it contains the most subtile part of the oil. It even seems, as Macquer remarks, to raise along with it by help of the oil, and action of the fire, a small part of the alkali of the soap; for, as the same chemist observes, it occasions a precipitate in a solution of corrosive muriat of mercury. But the modern discovery of the composition of ammonia leads us to infer, that the nitrogen of part of the mucilage of the oil formed this salt, by uniting with the hidrogen in the heat of destructive distillation. See AMMONIA. After this phlegm, the oil rises altered, precisely as if it had been distilled from quicklime, that is, empyreumatic, soluble in alcohol, at first sufficiently subtile, and afterward thicker. An alkaline residuous coal remains in the retort, consisting chiefly of the soda contained in the soap, which may be disengaged from the coal by calcination in an open fire, and obtained in its pure state.

As all oils contain an acid more or less combined, which may also be more or less disengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the soap is saturated with the acid of the oil, especially after the distillation of the soap. But this matter has not been so well examined, that we can affirm any thing concerning it.

Fat oils in their natural state have not the least action on asphaltum, jew's pitch, or copal; but if they be reduced to a soap, and afterward separated by any acid, they not only exert a strong solvent power on these substances, but they farther acquire the property of decomposing acetat of lead, as well as other metallic acetats, and of combining readily with their oxides, the acetic acid of which is given out. These oils thus separated would produce the same effect perhaps on other metallic salts. In general all fats, resins, and turpentines combine better with other substances, after they have been reduced to soap and separated by an acid, than in their natural state. Wax comports itself in the same manner. A knowledge of this effect induced Mr. Haussmann to subject to the action of the process for forming oxalic acid a small portion of oil separated from Marseilles soap, which he mixed with sugar previously powdered. At the end of the operation he found, that the oil had acquired the consistence of suet, and that it had assumed a yellowish colour and a rancid smell, retaining the property of swimming on water This grease, having been exposed to the same process a second time, had its rancidity increased, contracting at the same time a little of the smell of wax; and its specific gravity became so great, that after it had been well washed, and perfectly freed from acidity, it sank to the bottom of water, without having lost its property of being soluble in alcohol.

Mr. Berthollet, in the Memoirs of the Academy at Paris for 1780, has given an interesting paper on the decomposition of soap, chiefly by double affinity. It had before been ascertained by others that limewater decomposes common soap; and consequently that the attraction of lime to fat oils is greater than that of fixed alkali, which is thus disengaged in the caustic state. The addition of carbonic acid, or the application of an alkaline carbonat, to calcareous soap, restores the alkali to its original place, by virtue of the strong attraction of the acid for that earth. The caustic volatile alkali was found by our author to have no stronger action upon the calcareous combination than the caustic fixed alkali; but the carbonat of ammonia decomposed it in the same manner as the carbonated fixed alkali. The volatile alkali assumed the appearance of an oil, and the earth remained at the bottom in the state of carbonat.

After having decanted this saponaceous substance, he evaporated the superfluous volatile alkali at a gentle heat, and there remained a soap of a more pungent taste than common soap, and somewhat less consistent. It became decomposed by long exposure to the air. Alcohol dissolves it well, but the quantity taken up by water is extremely small. This last property convinced him that there was no need of so complicated and so long a process to make this soap; and that for this purpose he might make use of the action of double affinities in a different manner.

He therefore mixed a solution of common soap with a solution of muriat of ammonia. Flocks were formed at the same instant, which consisted of the ammoniacal soap, and were retained on the filter; so that the fixed alkali of the soap united with the muriatic acid, while the volatile alkali combined with the oil. Mr. Berthollet recommends this soap as perhaps better for medical uses than the common, possessing over that of Starkey the advantage of a very easy and speedy composition, uniformity of properties, and capability of being preserved in close vessels.

When common soap is mixed with hard water, two decompositions, and two new compositions take place, as Mr. Costel has proved. The alkali of the soap unites with the acid of the sulphat of lime, and the earth of the sulphat combines with the oil of the soap, forming a flocculent insoluble oleo-calcareous matter, which cannot answer the purposes of ordinary soap. Hence the waters containing sulphat of lime have been distinguished by the name of hard water. Sulphat of lime, however, is not the only substance proper to form the oleo-calcareous combination, for every solution of this earth is equally proper. The solution in the muriatic or nitric acid may be used for this purpose. When soap is therefore decomposed in hard waters, the effect depends not only on the sulphát of lime and the calcareous earth held in solution by carbonic acid, but likewise upon all the salts with basis of lime, or even of magnesia, that may exist in the water, as will hereafter be shown.

The mixture of a solution of soap and a solution of sulphat of magnesia afforded a combination of the utmost whiteness. It is unctuous, dries with difficulty, and preserves its white colour after desiccation. It is insoluble in boiling water, but has nevertheless a decided taste of soap. Expressed oil, as well as alcohol, dissolves it in considerable quantity. When water is added to the solution in the latter fluid, it becomes milky. This combination melts with a moderate heat, and forms a transparent mass, slightly yellow, and very brittle. The oleo-calcareous combination cannot be fused but very imperfectly, and at a much stronger heat.

Oil was combined with clay by mixing a solution of alum with a solution of soap. The result of this mixture was a flexible combination, soft to the touch, which preserves its suppleness and tenacity in drying. It appeared to be insoluble in water, alcohol, and oil. It very readily enters into fusion, after which it exhibits a mass of a beautiful transparency, inclined to yellow.

The solution of barytes in muriatic acid afforded with soap a combination nearly the same in appearance and properties as the calcareous compound.

The very simple method used in these experiments to form combinations of oils and earths was attended with equal success, when applied to metallic substances.

When a mixture of the solutions of soap and corrosive muriat of mercury was made, the fluid assumed the appearance of milk, but soon after exhibited small coagula. It is almost impossible to filter this liquor, but the greater part of the mercurial combination is slowly deposited. This deposition may be accelerated by means of alcohol. The same combination may be much more readily effected with the nitric solution of mercury*.

The oleo-mercurial combination is viscid, dries difficultly, dissolves well in oil, and very sparingly in alcohol. It loses its whiteness by exposure to the air, and acquires a slate-colour, which gradually becomes deeper, more especially if it be exposed to the sun or artificial heat. It readily becomes soft and fluid. It must be distinguished from the mercurial ointment used in medicine, in which the mercury retains the metallic state; for in this combination the mercury is in the state of oxide, and forms with the oil a true combination, which perhaps might prove useful in medicine.

The combination of oil and zinc, formed by means of the sulphat of the metal, is of a white colour inclining to yellow. It dries speedily, and becomes friable. The combination of cobalt and oil made by means of the solution of cobalt in aqua fortis, is of a dull leaden colour, and dries with difficulty, though its parts are not connected together. Toward the end of the precipitation, some coagula of a green colour, and much more consistent, fell down. Berthollet apprehends, that this was a combination of oil and nickel; for it is known, that this semi-metal is almost always mixed with the cobalt, and that it forms green solutions with acids, while those of cobalt are red. But he could not establish his conjecture, because he was unable to procure nickel. If it should prove well founded, this process will afford an easy method of separating the two metallic substances.

The combination of oil and tin was made

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* Though probably with different effects accordingly as the solution, supposed to be saturated, is made with or without heat. N.

by means of the solution of this metal in aqua regia. It is white, not fusible when exposed to heat like all the other oleo-metallic combinations, but it is decomposed without any change in the form of its parts. He attributed this circumstance to the great quantity of metal contained in this combination, as we shall see.

The oleo-ferruginous combination is of a reddish brown colour, tenacious, and easily fusible. When spread upon wood it sinks in and dries. It is easily soluble in oil, more particularly oil of turpentine, to which it gives a good colour, which may prove useful as a varnish.

The oleo-cupreous combination made by means of sulphat of copper is resinous to the touch while moist, of a green colour, and becomes dry and brittle. When digested in alcohol its colour becomes deeper, and it liquefies, but does not dissolve in the cold. Ether renders its colour deeper and more beautiful, instantly liquefies it, and dissolves a considerable quantity. This combination is abundantly soluble in oils, to which it communicates a pleasant green colour.

The combination of oil and lead, made by means of the solution of acetat of lead, is white, tenacious, and very adhesive when heated. The union of the oil and the lead is not so intimate in the diachylon, or direct solution of litharge in oil, as in this combination; for this last, when fused, is transparent, and becomes rather yellowish if the heat be somewhat increased; but the diachylon is opake, and the oil which enters into its composition has acquired an acrid property, from the heat to which it has been subjected. It is probable, therefore, that this combination might in some cases be advantageously substituted for that compound. Geoffroy formerly remarked, in the Memoirs of the Academy for 1741, that the combination of oil, which he made in the manner of plasters, formed a kind of soap.

The combination of oil and silver is white when first made; but after a few instants exposure to the air it assumes a red tinge, which no doubt depends on the facility with which this metal yields its oxigen to all combustible matters. The change of colour in the oleo-mercurial combination appeared to depend on the same principle. When the combination of silver is fused, its surface becomes covered with a very brilliant iris; and beneath the superficies it is black.

The combination of gold and oil partly floats on the mixture in the form of a cream, which is at first white, but soon after assumes a dirty purple colour. It dries with difficulty, and adheres to the skin, so that it is difficult to efface the impression.

Manganese was combined with oil by mixing a solution of soap with a solution of manganese in the muriatic acid. This combination is at first white. It assumes in the air a reddish or peach-blossom colour, which becomes more and more deep. It speedily dries to a hard, brittle substance; and by liquefaction it assumes a blackish brown colour.

In order to ascertain whether essential oil had likewise the property of combining with metallic substances, a solution of Starkey's soap, newly made, was mixed with a solution of sulphat of copper. The same thing happened as with the common soap, excepting that the combination was rather a lighter green, and more friable. Black soap, which is said to be made with whale-oil, afforded, with the solution of sulphat of copper, a combination, which, compared with that obtained by means of common soap, is rather of a deeper green, remains somewhat softer, and possesses a very disagreeable smell.

The caustic alkali formed no combination with rectified animal oil.

We have seen, that the calcareous earth (and it is the same with barytes) has more affinity with oil than fixed alkali, and this has more than magnesia; but the combination of magnesia is not decomposed by the caustic volatile alkali, so that magnesia follows the fixed alkalies in the order of affinity. Afterward comes the volatile alkali, which decomposes all the metallic combinations with more or less facility. It totally dissolves the combination of silver, but the mercurial combination is that which appeared most strongly to resist decomposition. With regard to clay, its combination is decomposed by the caustic volatile alkali even more readily than the metallic combinations. Whence it is inferred, that it may be placed after the metallic substances.

Oils by expression did not appear to dissolve the calcareous and argillaceous combinations; oil of turpentine dissolved only a small portion of the calcareous combination, but rather more of that of clay, with which it formed a jelly. Alcohol dissolves some of the oleo-metallic combinations without heat. It requires heat to dissolve some others, though by this means it attacks them all. It nevertheless dissolves much less than the oils, particularly the oil of turpentine.

Part of the combinations here described were calcined, to determine the quantity of earth or metallic oxide they contained. Of each 288 grains were employed. The residue of magnesia amounted to 32 grains, which did not effervesce with an acid; that of lime was 36 grains, which effervesced; that of clay 28 grains; of iron 48 grains; of copper 38; of zinc 42; of manganese 40: the residue of silver amounted to 30 grains in the metallic state; that of tin 79 grains of the reduced metal; that of lead formed by calcination a pyrophorus. When these combinations are to be made, it is proper to use the solutions in a saturated state; for, if there be an excess of acid, part of the soap is decomposed by this excess, and a portion of the oil floats above; but part of the oil enters the combination which is formed, and alters its properties. In whatever acid an earth or a metal may be dissolved, the same combination is always formed by means of soap; nevertheless this combination sometimes exhibits different appearances. Thus the oily compound of mercury is much more tenacious and adhesive, when the corrosive muriat is used, than when the nitric solution of the metal has been employed; doubtless because more oxigen is present in the former than in the latter case.

When the filtered liquor, after forming the oily combination, is evaporated, a salt is obtained, of the particular kind which results from the alkali of the soap, and the acid of the solution made use of.

Fourcroy thinks that some of the metallic soaps might be useful as pigments.

I suppose Mr. Berthollet's experiments were made with soap of vegetable expressed oil. The common soaps of this country contain animal fat.

Alkaline soaps are very useful in many arts and trades, and also in chemistry and medicine. Their principal utility consists in a detersive quality that they receive from their alkali, which, although it is in some measure saturated with oil, is yet capable of acting upon oily matters, and of rendering them saponaceous and miscible with water. Hence soap is very useful to cleanse any substances from all fat matters, with which they happen to be soiled. Soap is therefore daily used for the washing and whitening of linen; for the cleansing of woollen cloths from oil; and for whitening silk, and freeing it from the resinous varnish with which it is naturally covered.

Pure alkaline lixiviums being capable of dissolving oils more effectually than soap, might be employed for the same purposes; but when this activity is not mitigated by oil, as it is in soap, they are capable of altering, and even of destroying entirely, by their causticity, most substances, especially animal matters, as silk, wool, and others: whereas soap cleanses from oil almost as effectually as pure alkali, without danger of altering or destroying; which renders it very useful.

Volatile or essential oils are not united to alkaline salts but with great difficulty. Hence, according to Wiegleb, Starkey's soap is the only soap of this kind known. This soap is prepared by pouring four parts of oil of turpentine upon one of pulverized highly caustic fixed alkali in an alembic, digesting them together for some time in a gentle heat, and lastly, distilling the oil over the helm, and pouring it back again several times, till at length the salt will take up no more of it, and has acquired a saponaceous nature. With empyreumatic oils, a combination of this kind has not as yet succeeded; the formation of a soap of camphor, however, succeeded perfectly well.

Shorter methods have been sought after for the preparation of Starkey's soap, by several chemists; and among these is the illustrious Stahl; who, considering water as part of the combination of every soap, and even that it is a medium by which the salt and oil are united together, directs, that, after having mixed oil of turpentine with very hot alkali, and having shaken them together, this mixture should be exposed in a moist place, that all the portion of alkali which does not unite with the oil may deliquiate, and be separated from the part of the mixture that is combined; that this alkali should then be dried, and new oil poured upon it, as at first; and lastly, that this method should be continued till the whole is reduced into soap; and thus the operation will, as he affirms, be greatly shortened.

Nevertheless, later chemists, not satisfied with this method of Stahl, have endeavoured to simplify still more this operation. Mr. Rouelle the younger has published, in the Journal de Médecine, that he has discovered a more expeditious method than all those hitherto known for the preparation of this soap. Mr. Beaumé has also published in the Gazette de Médecine a method of making it in a few hours. It consists in triturating, during a long time, alkaline salt upon a porphyry, and in adding to this salt, during the trituration, oil of turpentine. According to this able chemist, the thick resinous part only of this oil can truly combine with fixed alkali; and this combination is effected only while the more volatile and attenuated part of the oil is dissipated. For which reason, according to him, a very great quantity of oil of turpentine is requisite for the formation of Starkey's soap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and also the trituration upon the porphyry, by promoting the evaporation of the subtile part of the oil, accelerates considerably the operation of Starkey's soap.

Another artist says, in the Gazette de Médecine, that the operation may be much abridged, by adding to the new mixture a certain quantity of this soap ready made; which corresponds with Beaumé's opinion. Lastly, Beaumé has found, that the addition of a little turpentine, or of ordinary soap, considerably abridges the operation; and this also confirms his opinion, which seems to be very probable. Macquer has made several judicious observations on this compound.

He thinks this preparation seems to be uncertain, and ill chosen. For, beside that the true soap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the usual idea of it, is a thing probably impossible;

it may be affirmed, that the saponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the same state, and by time necessarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only these soaps made by different processes, but also the same soap, a longer or shorter time after it has been made, and we shall find considerable differences in their colour, smell, and consistence. We shall find, that those deliquiate, and are partly resolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of saturating well the fixed alkali; that others acquire by time a pitchy, yellowish, semitransparent, and resinous appearance, which contain too large a quantity of thick residuum of oil of turpentine. Those soaps which seem to be the best made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preserve longer their white colour and the consistence of true soap; but they nevertheless participate more or less in the faults we have mentioned. Lastly, all these soaps are liable to contain a considerable quantity of a sort of neutral salt, formed by the acid of the oil of turpentine united with a part of the alkali of the soap. This salt crystallizes upon the surface, and even within the soap, which in time becomes quite penetrated, and stuck all over with a saline efflorescence.

These bad qualities and alterations of Starkey's soap cannot be avoided by any method, as they depend on the nature of essential oils, which we cannot change. These soaps are known to contain a volatile and superficially combined acid, which unfolds itself more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker consistence. We are no less certain, that the most ethereal part of essential oils, or their spiritus rector, is so volatile, that, however attentive we may be to preserve it, it will gradually dissipate in time: in a word, we know from experience, that all essential oils are drying, and are much more spontaneously alterable than any others; and that these spontaneous alterations cannot be prevented by the imperfect combination, which they are capable of forming with an alkali. On the contrary, this alkali, by absorbing their acid, and by facilitating the dissipation of their ethereal part, with which the alkali is not capable of forming a true union, can only hasten the alterations, to which the oil is naturally disposed.

From all this he concludes, that Starkey's soap is a difficult, uncertain, variable preparation, which is continually changing its nature, and consequently its medicinal virtues. This latter inconvenience, although it were the only one, would be sufficient to make us reject this preparation. And therefore, as is probable, a saponaceous substance, partaking of the properties of fixed alkali and of an essential oil, would be useful in medicine; ordinary soap, incorporated extemporaneously with any quantity of essential oil which shall be judged proper, might be substituted instead of Starkey's soap.

Ammonia is in its nature but ill adapted for remaining fixed in bodies, till a perfect combination can take place with various kinds of fat; though in its caustic state, by bare mixture alone, it imparts a saponaceous quality to lard, butter, and fat oils, insomuch that they become soluble in alcohol. Consequently it is only capable of uniting with volatile ethereal oils, from which concrete and fluid volatile oily salts are compounded. Of the former kind are the smelling salts, or carbonat of ammonia sublimed with the addition of a fragrant or essential oil. Otherwise it may be expeditiously made, indeed extempore, by a mixture of three parts of purified alkali, one part of pure muriat of ammonia, and an addition of one or more parts of scented ethereal oils ad libitum, and kept in a phial well stopped. In the main, too, the salt of hartshorn above described resembles this. Of liquid volatile oily salts, the empyreumatic urinous spirits, Sylvius's volatile spirit (sal volatile oleosum Sylvii), likewise what is called Eau de luce, may be considered as instances. For the latter, Wiegleb directs, that in two drachms of the strongest alcohol be dissolved from six to ten drops of rectified oil of amber, and afterward one scruple of white soap; to this mixture is then to be poured an ounce of pure ammonia, and the whole well shaken together. See Eau de Luce.

Various other saponaceous bodies may be mentioned, which exhibit effects similar to that of soaps upon substances and other bodies insoluble in water, and make them at least miscible with it. This property sugar exhibits with respect to ethereal oils; almonds in substance, the yolk of eggs, thick mucilage of gum arabic, gum tragacanth, the kernels of quinces, and mallow-root, upon camphor, turpentine, wax, and different resins; to effect which purpose, soap itself may be used with advantage.

Soap (Glass-makers'). Oxide of manganese.

Soap of Wool. In the first volume of the Memoirs of the National Institute, Mr. Chaptal has given an account of a new soap, formed by the combination of wool and an alkali. As he has entered into a detail of its uses, as well as its composition, I shall give them nearly in his own words.

In every manufactory of woollen cloths, it is usual to full the cloth immediately after it has passed the loom. This operation is performed not only for the purpose of clearing it of the oil, but to give it the requisite density. For this purpose about thirty pounds of soap are used for every eight pounds of cloth.

Hence it is obvious, how greatly beneficial it must prove to the manufacturer, to be able to substitute without difficulty, instead of the soft soap, another compound of materials, easy to be procured and of moderate cost.

The whole operation consists in making an alkaline lixivium of wood ashes, or potash, and dissolving therein, at the boiling heat, old rags* or clippings of wool to the point of saturation. The product is a soft soap, very soluble in water, of a green grayish colour, well blended, and possessing an animal smell, which the cloths lose by washing and exposure to the air.

The various experiments I have made on this subject have presented the following results:

1. As soon as the wool is plunged into the boiling liquid, the filaments adhere together, and a slight agitation is sufficient to effect the complete solution.

2. The lie becomes coloured, and gradually thickens, in proportion as more wool is added.

3. The soap is more or less coloured, accordingly as the wool is less or more clean and white.

4. The pile, or hairs, which are mixed with the wool, are more difficult of solution.

5. The quantity of wool the alkali is capable of dissolving depends upon the strength of the lixivium, its causticity, and the degree of heat. Two pounds three ounces and six drachms of caustic alkali, at twelve degrees† of concentration, and at the boiling heat, dissolved ten ounces four drachms of wool. The soap when cooled weighed one pound four ounces.

An equal quantity of alkali, at the same degree of causticity, heat, and concentration, in which I dissolved four ounces of wool, did not acquire consistence sufficient to answer several of the purposes required.

An equal quantity of alkali, marking four degrees, dissolved only two ounces seven drachms of wool. The soap when cooled weighed fourteen ounces. It was of a good consistence.

6. In proportion as the wool is dissolved in the lixivium, the solvent power of the alkali decreases, and at last it takes up no more. It is at this period, namely, when the wool being agitated in the fluid is no longer dissolved, that the operation must be terminated.

I. *The Choice and Preparation of Materials.*

The materials required to form this soap are two, alkaline matters and wool.

The alkaline substances may be obtained from the ashes of common culinary fires ‡, and the lie made by the well-known processes. Lime is to be slaked with a small quantity of water: the paste is to be mixed with sifted wood-ashes, in the proportion of one part of quicklime by weight to ten of the ashes. The mixture is to be put into a small stone trough (for wooden vessels colour the lie and become speedily useless), and water is to be poured on to the depth of some inches. After a certain time the solution may be drawn off at an aperture formed in the bottom of the vessel for this purpose. It must not be drawn off till the moment previous to its use, and may be in strength from four to fifteen degrees. But indeed it is of little consequence what the strength may be, because the only difference resulting from the use of a weak or a strong lie is, that the quantities of wool which are dissolved will differ accordingly §.

The potash of commerce may be employed in the same manner, by mixing it with one third of its weight of quicklime.

As to the choice of the wool, every one knows, that in the manufactories of woollen cloths of every kind, there are a number of operations performed, from the first washing of the material to the last package of the finished article, which occasion more or less of loss. The water in which the wool is agitated to cleanse it, the floor on which it is spread out, the warehouse where it is deposited, all afford waste wool; as do the operations of beating, carding, spinning, weaving, shearing, napping, and fulling. In all these several manipulations, we every where see a residue of wool, which, it is true, is collected with some care; but many of these operations are of such a nature, that the remains of wool they afford are solid and

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* Old woollen rags are a very cheap article in this country. But as every other kind of hair must certainly answer, and horns and hoofs probably will, there must be an immense and probably cheaper source in the refuse of the tanners, hog-butchers, horners, and comb-cutters. All these at present are used only as manure. N.

† Qu. By what measure? It is greatly to be wished, that all measures derived from the density of fluids were reduced to the common expression of the tables wherein water is taken as unity, or 1000. N.

‡ Wood being much more usually burned in France than in England, their common ashes are what in London are obtained only from the bakers. The uninstructed workman should be aware, that coal-ashes are unfit for this purpose. N.

§ The weaker the lie, the larger the quantity of it to a given produce, and consequently the more fuel will be consumed in boiling it. C.

mixed with foreign matters, or else cut and rendered too short to enter into other fabrics, so that they are mostly thrown on the dunghill. This manufacture of soap affords the means of converting them all to use. Nothing more is required but to collect them all in those baskets in which the wool is washed, and to wash them with care for the purpose of separating impurities and foreign substances; after which they are to be reserved for this use.

The cuttings of all the woollen stuffs afforded by the shops of manufacturers, dealers, tailors, and the like, may be advantageously collected for this purpose; and the same advantage may be derived from the remains of garments after they are worn out.

II. *Method of making the Soap.*

When the lie and the wool are both ready, it remains only to cause the lie to boil in a vessel of the common form. When it has arrived at this point, the wool is to be added by small quantities at a time, and agitated to cause a more speedy solution. Care must be taken not to add more wool, until the first portions are dissolved. The operation must be stopped the moment the liquor refuses to dissolve more.

From the operations in the large way, made by Michael Fabréguettes, with soaps of his own fabrication after the method I communicated to him, it is certain, that this soap cleans, felts, and supples the cloths perfectly well. But its use requires a few important observations to be made.

1. When the soap is not made with the requisite care, or when dirty or coloured wool has been employed, the cloth receives from the soap a gray tinge, which it is very difficult to eradicate. This tinge is of no consequence when the cloth is intended to be dyed; but it would injure the beauty of that white colour, which in certain goods is intended to be preserved. The remedy consists in employing the most select materials, to form the soap intended for such uses.

2. Cloths fulled with this soap contract an animal odour, which, though not very strong, is nevertheless disagreeable; but water and the air completely remove it.

After having succeeded in the employ of this soap in fulling cloths made of wool, I attempted to substitute soda for potash, and to form, according to the process here described, a solid soap, proper for the operation of dyeing cottons. My experiments have succeeded beyond my hopes.

Forty-six pounds of soda at eight degrees dissolved at the temperature of ebullition five pounds of wool*, and afforded by cooling sixteen pounds fourteen ounces of soap sufficiently solid not to spread (*couler*).

The first wool which is thrown into the soda dissolves readily, but it is afterward seen, that the fluid gradually becomes thicker, and that the dissolution becomes more difficult and slow.

The first solutions render the liquor green, after which it becomes black, and the soap when cooled preserves a blackish green colour.

This soap has been employed in every manner, and under every form, in my manufactory for dyeing cottons; and I am at present convinced, that it may be substituted, instead of the saponaceous liquid we make from the lixivium of soda and oil, to prepare the cottons. I have constantly observed, that by dissolving a sufficient quantity of this soap in cold water to render the fluid milky, and by working the cotton in the manner well known, it is sufficient to pass the cotton three times through, drying it each time, in order that it may be as well disposed to receive the dye, as that which has been passed seven times through the ordinary solution of soap. This will not appear surprising, when it is considered, that animal matters are very proper to dispose thread and cotton to receive the dye, and that some of the operations of our dye-works consist simply in impregnating them with these substances.

It is to be observed, that cotton, which has passed through a solution of this soap, acquires a gray tinge, nearly similar to what it gains by aluming, while the common soap-liquors give it the most beautiful white colour. But this gray colour is not at all prejudicial to the dyeing processes, as we have remarked in speaking of woollens.

I must observe, in confirmation of this last use, which I attribute to the soap of wool, that, after having impregnated cotton with it by the ordinary process, I caused it to pass through all the operations, to which wool is subjected to produce the scarlet dye. The cotton acquired a deep and very agreeable flesh-colour; whereas the cotton, which had not received this preparation, came out of the bath with its natural colour. This

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* It is affirmed, that when common sea-salt is thrown into the combination of oil and vegetable alkali in the process of soap-making, the effect consists not merely in the separation of the soap from the water now rendered salt, but that the alkalis change place; so that the soap obtains the mineral alkali, and the fluid, instead of containing common salt, will be found to contain the combination of marine acid and vegetable alkali. I do not know if this has been shown to be really the case, nor whether this indirect process be of much value. If it be fully as here stated (which I doubt), our soaps must owe their inferiority to those of Spain to the animal oil they contain, and not to their alkali. N.

first essay promises advantageous results, which I mean to pursue.

It may be of some utility to observe, that the soap of wool may be beneficially substituted instead of common soap. In domestic operations I have profitably applied it to wash linen, and particularly woollen garments and other articles. I have no doubt, but the facility and œconomy which it presents in its fabrication* will serve to extend its use still farther; but, in the mean time, I have thought it proper to show, the various objects to which I have applied it.

As the soap of wool gives a gray tinge to piece-goods, which it is difficult to eradicate, it follows, that it cannot be used for bleaching linen, unless it be made of white wool selected and carefully washed.

Soap-stone. See Lapis Ollaris.

Soap-wort. See Saponaria.

Soda. This was formerly called the mineral or fossil alkali, because supposed to belong exclusively to that kingdom: by the London college it is termed natron, as there are sufficient grounds for concluding, that it was the natron, or nitrum, of the ancients, which was long confounded with our nitre; but the French name soda has generally prevailed.

It has been generally considered as a simple substance, and it has never yet been satisfactorily decomposed, though there are reasons for presuming it to be a compound. Magnesia has been supposed to be its base, which is considered as combined in it with nitrogen: and some late experiments seem to show, that it is produced in the decomposition of pure water by galvanism. But, in fact, we know nothing on this head that has the least certainty.

Soda is found native in many hot countries, subsaturated with carbonic acid; and in the water of the sea, in very large quantity, saturated with the muriatic acid. But in Europe it is generally obtained from plants, that grow in the sea or on its shores. In Scotland sea-weeds of different kinds are selected, dried, and burned in pits dug in the sand, or in heaps surrounded with loose stones. Fresh quantities are added, as the first are consumed, the whole being frequently stirred, till it becomes semifluid; and when cold it concretes into hard masses. This impure alkali, which is of a black or blueish colour, is called kelp, and does not contain more than from 2½ lbs. to 5 lbs. of soda in 100.

On the southern coasts of France, and more particularly of Spain, different plants chiefly of the salsola genus are cultivated for the purpose of manufacturing this salt. These are burned in much the same manner, and the saline produce they yield is termed barilla. That of Alicant is in the highest repute. If the plants that thus produce soda be removed to an inland situation, the soda they yield by burning gradually decreases, till at length they afford no other alkali than potash.

From this barilla, or from kelp, the salt is extracted by lixiviation with boiling water, filtration, and crystallization. A pound of barilla will yield from three to five ounces of carbonat of soda. This, being crystallized, is less impure than the carbonat of potash, extracted in a similar manner.

To extract the carbonic acid, and obtain the soda pure, quicklime is used. This, first slaked by the addition of a little water, is mixed with an equal weight of the carbonat of soda, and as much water as will make the whole a thin paste. The mixture being poured into a funnel with a filter of linen cloth, more water is to be added as the solution passes through, till five or six times the weight of the carbonat have been employed. If the soda be required very pure, this solution must be evaporated to the consistence of honey, and about an equal quantity of alcohol added. After these have stood a little time in a close vessel, the lighter fluid on the top is to be poured off from the darker beneath and the solid matter at the bottom, and part of its alcohol abstracted by distillation. The remainder on standing will again separate into two portions; and that which floats like an oil on the surface, being a solution of the pure soda in alcohol, is to be poured off and evaporated in a silver vessel, so as to obtain the alkali in crystals, which are prismatic, but not very regular, or in thin plates.

This soda is white, extremely acrid and caustic, powerfully attractive of water, and capable of being fused and volatilized by heat. With oil it forms soap, and with siliceous earth glass.

From the uses to which soda has been applied in the arts, various modes have been suggested of obtaining it in the large way. Mr. Accum says he has been employed in a soda-manufactory, in which the following method answered exceedingly well: Five hundred pounds of sulphat of soda were introduced into an iron boiler, containing a sufficient quantity of Thames water. Five hundred and sixty pounds of American potash were likewise dissolved in as little water

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* The effect of the excise-laws in Britain confines the manufacture of soap to premises registered in form, and regularly visited. What the general effects of this arrangement may prove on our great national manufacture of woollens, more especially if the present invention should amply come up to the expectations here excited, is a question that well deserves to be investigated. N.

tried, and if indifferent the quantity taken was ten pounds more.

The solution was made with about thirty pails of water to the alkali here mentioned. Both solutions were then made to boil, and as soon as the ebullition took place, the solution of potash was ladled into the boiler containing the sulphat of soda. The mixture was agitated during the transfusion, and the fire raised as expeditiously as possible.

As soon as the fluid boiled, it was ladled into a wooden gutter, which conveyed it into a cistern of wood lined with sheet lead nearly half an inch thick, which was fixed in a cool place. Sticks of wood were then placed across the cistern, from which slips of sheet lead two or three inches wide were hung into the fluid, at four inches distant from each other. When all was cool, which in the winter was generally the case in three days, a plug in the bottom of the cistern was drawn, in order to let off the fluid, and the crystallized salt was taken from the slips of lead. The bottom exhibited a rock of salt, which was detached by chisel and mallet. On this account it is, that the lead which lines the cistern must be thick, in order to guard against accidents. For, if the metal be perforated, the saline solution creeps between it and the wood, and in a very short time detaches the lining; and it is besides extremely difficult to find out the place where the defect really is. The temperature where the soda is left to crystallize ought not to exceed 55° Fahrenheit.

In this stage of the process the whole of the salt is washed in the same cistern with cold water, to clear it of impurities; after which it is transferred again into the boiler, dissolved in clear water, and evaporated by heat. As soon as a strong pellicle is formed, it is suffered to cool so far, that the hand may be dipped in the fluid without injury, and the heat is kept at that temperature as long as effectual pellicles continue to be formed over the whole surface of the boiler, and then fall to the bottom.

When no more pellicles are formed, or at least only by blowing with the mouth upon the surface, the fire is withdrawn, and the fluid is ladled out into the cistern to crystallize. The sulphat of potash, &c., which had been deposited, are then taken out of the boiler, and put aside. If the fluid be suffered to cool pretty low, before it is allowed to run into the cistern, very little sulphat of potash is found in the soda; but in general the rocky masses of soda met with in the market contain a considerable quantity. By this process from 136 to 139 crystallized in large crystals; if small crystallized, it yields less.

We might be inclined to suppose, that the first operation was unnecessary, and that the soda might be separated at once from the sulphat of potash at the instant of the formation; but practice will convince the operator otherwise. A considerable loss is manifested, if the process be not conducted in this manner; though the discovery of the cause may perhaps be not so easily accomplished as the proof of the fact.

Other manufacturers grind together five cwt. of Glauber's salt of the bleachers, and one cwt. of charcoal: they expose this mixture in a reverberatory furnace resembling a baking oven, till the matter, when stirred with a rake, becomes pasty. It is then withdrawn and transferred into large casks, each provided with a double bottom. Water is then suffered to stand one inch high over it for twenty-four hours: the cock is then opened, the solution runs through the perforated bottom, over which a stratum of straw had been previously placed; and is thence conducted into the boiler for evaporation and crystallization *.

It is a curious fact, that iron plates are absolutely necessary to constitute the surface, on which these articles are exposed to heat: fire-bricks do not answer. It seems as if iron assisted the union; though neither iron filings mixed with the articles, nor pyrites, are found of advantage.

This method of making soda is extremely uncertain. If the heat be not raised gradually, or if the mixture be not fused enough, or a little too much, it does not succeed. The worst event is, that when the mixture has been made too hot, sulphuric acid is produced, and sulphat of potash is formed.

The quantity of soda, which may be obtained by this process, is said to be equal to that obtained by any other method.

I have lately been informed, that in Germany soda is made by decomposing the sulphat of soda by means of acetit of lime; the acetic acid is obtained for this purpose from wood, and the charcoal is found to pay the expenses.

The method recommended by several chemists, of obtaining soda by decomposing sulphat of soda by the oxides or acetit of lead, does not answer in this country. The mass is by far too bulky; and requires too much time, attendance, and fuel, to reduce it to a narrow compass. I have been informed by men well skilled in this department, that it is nearly impracticable in the large way. The muriat of lead, which is

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* This was the process at the salt-works. N.

In Prussia they mix muriat of soda and quicklime together; then slake the lime, and form the whole into a thick pulp, which is extended about two inches thick over a large surface, and left in that situation three months. Carbonat of soda is then formed, which is washed out and crystallized in the usual manner. The soda obtained by this process always has a yellowish cast.

The great discovery of the compound nature of the fixed alkalis by Mr. Davy has been mentioned under the article Potash, to which we have nothing at present to add, but that the base of soda is somewhat heavier than that of potash, its specific gravity being 0·9. It remains solid in a temperature not exceeding 150°, but at 180° it is perfectly fluid. Eighty parts of this base appear to combine with twenty of oxigen, to form soda.—*An. de Chimie.—Mem. de l'Ac. des Sciences.—Murray's Chem.—Nich. Journ.*

Soil. The soil, or earth in which vegetables grow, varies considerably in its composition, or in the proportions of the different earths of which it consists; and some plants are found to thrive best in one kind of soil, others in another. Under the heads Arable Land, and Earth (Vegetable), the subject has already been noticed; and the effects of different *manures*, not on the quantity merely but the quality of corn produced, have been mentioned under the article Gluten. See also Manures. Under Analysis the methods of analysing soils, so as to ascertain their composition, will be found, as given by Mr. Davy; and we shall here subjoin the rules he has laid down for their improvement, as connected with the principles of which they consist.

In cases where a barren soil is examined with a view to its improvement, it ought in all cases, if possible, to be compared with an extremely fertile soil in the same neighbourhood, and in a similar situation: the difference given by their analyses would indicate the methods of cultivation, and thus the plan of improvement would be founded upon accurate scientific principles.

If the fertile soil contained a large quantity of sand, in proportion to the barren soil, the process of melioration would depend simply upon a supply of this substance; and the method would be equally simple with regard to soils deficient in clay or calcareous matter.

In the application of clay, sand, loam, marl, or chalk to lands, there are no particular chemical principles to be observed; but when quicklime is used, great care must be taken, that it is not obtained from the magnesian lime-stone; for in this case, as has been shown by Mr. Tennant, it is exceedingly injurious to land. The magnesian limestone may be distinguished from the common limestone by its greater hardness, by the process for carbonat of lime and magnesia.

When the analytical comparison indicates an excess of vegetable matter, as the cause of sterility, it may be destroyed by much pulverization and exposure to air, by paring and burning, or the agency of lately made quicklime. And the defect of animal and vegetable matter must be supplied by animal or vegetable manure.

The general indications of fertility and barrenness, as found by chemical experiments, must necessarily differ in different climates, and under different circumstances. The power of soils to absorb moisture, a principle essential to their productiveness, ought to be much greater in warm and dry countries, than in cold and moist ones; and the quantity of fine aluminous earth they contain should be larger. Soils likewise that are situate on declivities ought to be more absorbent than those in the same climate on plains or in valleys.

The productiveness of soils must likewise be influenced by the nature of the subsoil, or the earthy or stony strata, on which they rest; and this circumstance ought to be particularly attended to, in considering their chemical nature, and the system of improvement. Thus a sandy soil may owe its fertility to the power of the subsoil to retain water; and an absorbent clayey soil may occasionally be prevented from being barren, in a moist climate, by the influence of a substratum of sand or gravel.

Those soils that are most productive of corn, contain always certain proportions of aluminous or calcareous earth in a finely divided state, and a certain quantity of vegetable or animal matter.

The quantity of calcareous earth is however very various, and in some cases exceedingly small. A very fertile corn-soil from Ormiston in East Lothian afforded in a hundred parts only eleven parts of mild calcareous earth; the finely divided clay amounted to forty-five parts. It lost nine in decomposed animal and vegetable matter, and four in water, and exhibited indications of a small quantity of phosphat of lime.

This soil was of a very fine texture, and contained very few stones or vegetable fibres. It is not unlikely, that its fertility was in some measure connected with the phosphat; for this substance is found in wheat, oats, and barley, and may be a part of their food.

A soil from the low lands of Somersetshire, celebrated for producing excellent crops of wheat and beans without manure, I found to consist of one ninth of sand, chiefly siliceous, and eight ninths of calcareous marl tinged with iron, and containing about five parts in the hundred of vegetable matter. I could not detect in it any phosphat or sulphat of lime, so that its fertility must have depended principally upon its power of attracting principles of vegetable nourishment from water and the atmosphere.

Mr. Tillet, in some experiments made on the composition of soils at Paris, found, that a soil composed of three eighths of clay, two eighths of river sand, and three eighths of the parings of limestone, was very proper for wheat.

In general, bulbous roots require a soil much more sandy, and less absorbent, than the grasses. A very good potato-soil, from Varsel in Cornwall, afforded seven eighths of siliceous sand; and its absorbent power was so small, that one hundred parts lost only two by drying at 400° Fahrenheit.

Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almost all common soils that are moderately dry, and do not contain a very great excess of vegetable matter.

The soil taken from a field at Sheffield-place in Sussex, remarkable for producing flourishing oaks, was found to consist of six parts of sand, and one part of clay and finely divided matter. And one hundred parts of the entire soil submitted to analysis produced water 3, silex 54, alumine 28, carbonat of lime 3, oxide of iron 5, decomposing vegetable matter 4, loss 3.

From the great difference of the causes that influence the productiveness of lands, it is obvious, that, in the present state of science, no certain system can be devised for their improvement, independent of experiment; but there are few cases, in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the best methods of melioration; and this will particularly happen, when the defect of composition is found in the proportions of the primitive earths.

In supplying animal or vegetable manure, a temporary food only is provided for plants, which is in all cases exhausted by means of a certain number of crops; but when a soil is rendered of the best possible constitution and texture with regard to its earthy parts, its fertility may be considered as permanently established. It becomes capable of attracting a very large portion of vegetable nourishment from the atmosphere, and of producing its crops with comparatively little labour and expense.

SOLDERS *and* SOLDERING. Solders consist merely of simple or mixed metals, by which alone metallic bodies can be firmly united with each other. In this respect it is a general rule, that the solder should always be easier of fusion than the metal intended to be soldered by it: next to this, care must also be taken, that the solder be as far as is possible of the same colour with the metal that is to be soldered.

For the simple solders, each of the metals may be used according to the nature of that which is to be soldered. For fine steel, copper, and brass work, gold and silver may be employed. In the large way, however, iron is soldered with copper, and copper and brass with tin.

The most usual solders are the compound, which are distinguished into two principal classes, viz. hard and soft solders. The hard solders are ductile, will bear hammering, and are commonly prepared of the same metal with that which is to be soldered, with the addition of some other, by which a greater degree of fusibility is obtained, though the addition is not always required to be itself easier of fusion. Under this head comes the hard solder for gold, which is prepared from gold and silver, or gold and copper, or gold, silver, and copper. The hard solder for silver is prepared from equal parts of silver and brass, but made easier of fusion by the admixture of a sixteenth part of zinc. The hard solder for brass is obtained from brass mixed with a sixth, or an eighth, or even one half of zinc, which may also be used for the hard solder or copper. It is sold in the shops in a granulated form, under the name of Spelter Solder.

The soft solders melt easily, but are partly brittle, and therefore cannot be hammered. Of this kind are the following mixtures: tin and lead in equal parts; of still easier fusion is that consisting of bismuth, tin, and lead, equal parts; or of two parts of bismuth, of tin and lead each one part.

In the operation of soldering, the surfaces of the metal intended to be joined must be made very clean, and applied to each other. It is usual to secure them by a ligature of iron wire, or other similar contrivance. The solder is laid upon the joint, together with sal ammoniac or borax, or common glass, according to the degree of heat intended. These additions defend the metal from oxidation. Glaziers use resin; and pitch is sometimes employed.

Tin foil applied between the joints of fine brass work, first wetted with a strong solution of sal ammoniac, makes an excellent juncture, care being taken to avoid too much heat.

SOLUTION. This word is used by chemists to denote the perfect union of a fluid substance with any other body. It is applied without distinction to the act of union, and to the compound resulting from that act. The fluid is called the solvent, but no particular appellation has been given to the bodies dissolved.

Solution is different from mere mechanical suspension. One of its most distinguishing criterions is transparency in the compound. The act of solution, being performed at the surfaces of bodies, will be more speedy, the smaller the particles. Hence the advantage of pulverizing previous to solution. See ATTRACTION.

SOMMITE. This stone was so called by Delamétherie from the mountain Somma, where it was first found. It is the *hexago-*

It is distinguishable with no great difficulty. When crystallized it appears under the form of hexaëdral prisms, of a grayish white colour, and sufficiently hard for their angles to scratch glass. Their fracture is lamellated in the direction of the axis of the prism, vitreous and conchoidal in the opposite direction.

It melts before the blowpipe, though with difficulty, into a transparent homogeneal glass. Nitric acid renders it cloudy. Its specific gravity is 3·274. Its primitive form is a regular hexaëdral prism.

Phosphat of lime is most liable to be confounded with the sommite, its phosphorescence when thrown on burning coals being almost the only external character that distinguishes it from the sommite, which, however, has a greater degree of hardness.

According to Vauquelin's analysis the sommite is composed of

Alumine	0·49
Silex	0·46
Lime	0·02
Oxide of iron	0·01
	0·98

Hitherto this stone has been found only among volcanic products, and confined to those of Mount Somma, which makes a part of Vesuvius. It lines cavities in the lava, where it is accompanied with mica, hornblende, and vesuvian.—*Thomson.*—*Brongniart.*

Sonorousness. Daily experience shows, that the sounds emitted by various bodies when struck are very different. On the nature of sound, writers upon the mechanical philosophy may be consulted. The sensation is produced by a tremulous or vibratory motion communicated from the sonorous body to the organ of the ear.

The medium of communication seems to admit of no exclusion; but, as far as we yet know, the sound is communicated to greater distances undiminished, the denser and perhaps the more elastic the subject of communication. Thus Dr. Franklin found, that the striking of two stones together under water was audible, with no apparent diminution, at the distance of two miles, by an observer whose head was plunged in the same continued mass of water. And so likewise the scratching of a pin, or the beating of a watch, may be very distinctly heard from one end to the other of a piece of timber of any length, if the ear be applied close to the timber, or if it be pressed between the teeth, even though the ears be closed.

The air of the atmosphere is, however, the common medium of sound. By experiments with stretched strings, bells, and other musical instruments, it is not only found that vibration is the cause of sound, of sound depends on the force of each vibration, and acuteness on their frequency. Hence the sonorous qualities of bodies and other metals must depend in a great measure on their elasticity, and considerably on their figure and density.

Soot is a collection of substances formed by the matter of the flame of inflammable bodies, but which have escaped combustion from not having sufficient contact with the air. This matter, which fixes itself to the internal surface of chimneys, is always of a black colour, more or less brownish. This colour it receives from an oil, that is burnt and half reduced to the state of coal.

As all inflammable bodies undergo a total decomposition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of those which are volatile, are raised in vapours, some part of which burns with flame, is totally dissipated in the elastic state, and another part is sublimed, and adheres to the first cold bodies which it meets.

Soot is, as we have now observed, the portion of fuel, which is reduced to black smoke, and which has not been inflamed from want of sufficient contact with air. For if the vapours exhaling from an inflammable body strongly heated were so rarefied, that each of their parts should be altogether surrounded by air, they would all burn with flame; and then we should have no smoke or soot, or at least this soot would not be black, and would contain nothing inflammable. For which reason the greater the quantity of air admitted among bodies which burn with flame, the less smoke and soot we have; and also, the soot proceeding even from bodies of the same kind must be very different, according to the manner in which they are burnt. See Light. In general, we can say nothing that will be constantly applicable to the nature and principles of soot, as its differences arise not only from the causes above mentioned, but also from the nature of the inflammable substances which produce it. Thus vegetables, from which little or no ammonia is obtained, must furnish a soot different from that of animal matters; and the soot of a pure oil must be different from that of a plant containing all its principles. But these differences have not yet been observed, because chemists have not attended to this subject.

We know only that the ordinary soot of chimneys has an acrid, bitter, empyreumatic and disagreeable taste; that water can extract from it a dusky-coloured matter, which shows, that it contains saline, oily, saponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are set on fire.

If this soot be distilled in a retort, we obtain from it phlegm, ammonia, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid also may possibly be obtainable from certain soots; and generally toward the end of the distillation, when the heat is strong, a little muriat of ammonia is sublimed.

As every soot, even that which proceeds from vegetable matters, contains a good deal of ammonia, Macquer infers, that the principles of vegetables suffer by combustion in an open fire changes similar to those occasioned by putrefaction. Besides, the quantity of fixed coal which remains after the distillation of soot, and which furnishes a fixed alkali, together with much earth, by incineration, shows, that a very considerable quantity of the fixed principles of inflammable bodies is carried off, and even raised to a great height, by means of their combustion with flame: but, as we have said, soots are very different; and the matter is but little known, and requires farther researches.

Sorrel (Salt of). For the purpose of preparing salt of wood-sorrel, oxalis acetosella Linn., the wood-sorrel is bruised in a mortar, and the whole of its juice expressed. After it has stood for some time, the grosser earthy particles subside to the bottom, and the liquor becomes limpid and clear, after which it is filtered. The clear juice is then evaporated to less than one half, and set by in a cool place to crystallize. After some time, the remaining liquor is poured off from the crystals, and then evaporated, filtered, and crystallized afresh. This process is continued till the whole of the salt is extracted from the juice. According to Savary's experiments, fifty pounds of fresh wood-sorrel yielded twenty-five pounds of juice, from which were obtained two ounces and a half of pure salt.

This salt is the Oxalic Acid, which see, combined with a little potash.

Soup. See Gelly.

Sour Water. Water rendered acidulous by fermenting with bran, a preparation much used in dyeing. Twenty-four bushels of bran are put into a tub or vat, that will contain about ten hogsheads: a large boiler is filled with water, which, when just ready to boil, is poured into the vat: the acid fermentation soon commences, and in twenty-four hours the liquor is fit for use.—*Berthollet.*

Sowans. This very nutritious article of food is made in Scotland from the husk of oats, by a process not unlike that by which common starch is made. The husk of the oat, called seeds, is separated from the oatmeal by the sieve; but it still contains a considerable portion of farinaceous matter. It is mixed with water, and allowed to remain for some days, till the water has become sour. The whole is then thrown upon a sieve; and the milky water passes through; but all the husk remains behind.

The water thus obtained is loaded with starchy matter, which soon subsides to the bottom. The sour liquor is decanted off, and about an equal quantity of fresh water is added. This mixture, when boiled, forms a very nutritious article of food; and the portion of the sour water, which still adheres to the starch, gives the whole a pleasant acidity.

It is observable, that the starch-maker's sour water, notwithstanding the great quantity of acid it contains, and the still sourer water of sowans, are swallowed greedily by hogs, and they fatten upon it.—*Thomson.*

Soy. We find in the Memoirs of the Swedish Academy the following account of the mode in which this kind of sauce is prepared.

The ingredients are 50 lbs. of a small, white bean, the fruit of the dolichos soja, 50 lbs. of salt, 60 lbs. of wheat flour, and 250 lbs. of water.

After having well washed the beans, they are boiled in well-water in an open vessel for some hours, or until they have become so soft as to be worked between the fingers. During the boiling they must be kept covered with water, to prevent their burning; and care must be taken not to boil them too much, because in that case too much of their substance would remain in the water of decoction.

The beans, being thus boiled, are taken out, and put into large shallow wooden vessels, which in China are made of thin staves of bamboo, two inches and a half in depth, and five feet in diameter. In these they are spread out to the depth of two inches, and when they are cold enough to be worked with the hand, the wheat flour is gradually thrown in, and mixed with the beans, till the whole of the before-mentioned quantity has been used. When the mass becomes too dry, so that the flour does not mix well with the beans, a little of the hot water of the decoction is added.

The whole being well mixed, the mass is spread abroad in the vessels before mentioned, taking care that its depth shall not be more than an inch or an inch and a half; and it is then covered by a lid, which fits exactly. When the mass begins to grow mouldy, and heat is disengaged, which happens after two or three days, the cover is raised by putting two sticks beneath it, in order that the air may have free access.

During this time a rancid odour exhales; and if the mass become green, it is a sign that the whole goes on properly; but if it begin to be black, which must be carefully noticed, the lid must be raised higher, in order that the mass may have still more air. If it once become black, the whole is spoiled.

As soon as all the surface is covered with green mouldiness, which usually happens in for several days. When it has become as hard as a stone, it is cut into small fragments, which are thrown into an earthen vessel, upon which the 250 lbs. of water, having the 50 lbs. of salt first dissolved in them, are poured. The whole is then well stirred together, and notice is taken of the height at which the water stands. If it be not convenient to put all the mixture into one vessel, a number may be used, taking care that the materials be proportionally distributed in each.

The vessel thus filled is placed in the sun, and its contents stirred up regularly every morning and evening; and a cover is put on at night to defend it from the cold, as well as to prevent any rain from finding entrance either by day or night. The hotter the sun, the sooner will the soy be completed. The process is seldom undertaken but in summer, notwithstanding which it lasts two or three months.

As the mass diminishes by evaporation, well-water is added; and this digestion is continued till the salt water has entirely dissolved the flour and the beans. The vessel is still left for some days in the sun, in order to complete the solution still more effectually, as the good quality of the soy depends upon this circumstance; and the daily stirring or agitation is continued to the very last.

When at length the mass has become very succulent and oily, the whole, as well the thick as the more fluid portions, is poured into bags, through which the soy is pressed, and is then clear and ready for use. It is not afterward boiled, as Mr. Eckeberg pretends. It is to be kept in bottles well corked. The Chinese, who deal in this article, keep it in large pitchers well closed. Before it is strained in the press the soy is of a deep brown colour, but afterward it becomes black.

The Chinese also prepare two kinds of soy from the dregs which remain. The first time they add 150 lbs. of water and 30 lbs. of salt, and after having pressed the mass, they again add 100 lbs. of water and 20 lbs. of salt, always proceeding as before described.

The two last kinds of soy are not strong, but very salt, more especially the latter, which is also lighter coloured. These two kinds are the most common in China, and are used both by natives and Europeans. The differences of price are as 8, 4, and 1.

Spar. The name of spar is given to many stones of different properties and appearances, which do not possess constantly any one common character or mark, by which they may be certainly distinguished from other stones. In general, we may observe, that they are most frequently found in mines, and that they for the most part consist of smooth and shining plates or laminæ; loured; that they are crystallized in various determinate figures, or possess no determinate shape; and lastly, that they differ so much in hardness, density, degree of fusibility, and in their most essential chemical properties, that they cannot be considered as forming a distinct class of fossil substances. We need not wonder therefore that authors, especially those who have not been much accustomed to the examination of fossil bodies, should have given very confused and indistinct descriptions of spars. Many of them have not been sufficiently examined; but those of which we have acquired some knowledge we shall endeavour to distinguish into their several different kinds.

The several stones to which the name of spar has been generally given are, the calcareous, the ponderous, the gypseous, the fluors, and feldt spar.

1. Calcareous spars are soft, heavy stones, which have the common chemical properties of calcareous earth. Their texture is laminated. Some of them have no determinate figure, and others from their form are called rhomboidal. Some spars, called dog's-tooth spar, have a pyramidal figure; but when these are broken, their fragments show, that they also consist of rhomboidal particles.

Some rhomboidal spars are transparent, others are opake; some are colourless, and others are coloured; lastly, some of them have a singular property of refracting doubly the rays of light which pass through them, and thereby of representing any object; as for instance, the letters of a book, seen through it, double. This spar has been called Iceland crystal, or refracting spar. Its figure is that of an oblique parallelopiped, contained within six sides, and eight solid angles. Each of the obtuse angles of the parallelograms is 101 degrees and 52 minutes; and each of the acute angles is 78 degrees and 8 minutes. These are the dimensions given by Sir Isaac Newton of the angles of the sides of the refracting spar.

The satin spar, which is of a pure white, or tinged a little yellow with ochre, and chatoyant, is of this kind. It takes a very high polish, and is then exceedingly beautiful.

Calcareous spars may be distinguished from others by effervescing with acids.

2. Gypseous or selenitic spars. These are sulphated lime, distinctly crystallized. The form of the crystals is rhomboidal. They are also called selenites and glacies Mariæ. Sometimes these spars assume other forms.

3. The ponderous spars are compounds of barytes, either with carbonic or sulphuric acid. The first of these, which was discovered by Dr. Withering, usually resembles alum, and affects a fibrous crystallization diverging from a centre. It has the semi-

78·6 of barytes, and the remainder was sulphat of barytes, without any water. In this last respect it differs much from the carbonat of barytes of Bergman, which he obtained by precipitation from its solvent by mild alkali. This contained 28 parts water, 7 carbonic acid, and 65 barytes. The carbonic acid of the artificial compound could be expelled by heat. But that of the natural spar adhered so strongly, probably on account of the absence of water, that it underwent fusion rather than part with it. This spar, as well as the sulphuric, is eminently distinguishable by its great specific gravity, which amounts to 4·338, and is emulated by no other unmetallic earth but the adamantine spar, which is very scarce, at least in Europe.

The common ponderous spar, or compound of barytes and sulphuric acid, has been called marmor metallicum, spar-like gypsum, Bononian stone, and baroselenite. It is found with various degrees of transparency, from perfect clearness to opacity. Of the regularly crystallized sort, Mr. Thomson showed Magellan some fine specimens, and remarked, that it seems to affect the peculiarity of having its crystals laminated, as radiating from a centre: but this radiation seldom amounts to a whole circle. The corners of these flat crystals are truncated, like those of alum, and are thicker in one side than in the other of each parallelogram, so as to fit one another in the arch of the kind of vault they form together; and have some small ones adhering to their sides, like drusen spars, leaving internal angles, as the macles of the French, or the cruciform crystallizations. In several of the crystals presented to me by that active cultivator of the sciences, the general outline was that of a right-angled parallelogram, and the principal truncatures, namely of the corners, formed angles of 45 degrees. The internal fissures, which resembled those of the common calcareous spar, have likewise this position with respect to each other; which circumstance, joined to that of their great weight, appeared to be distinctive criterions of this substance. The specific gravity of these crystals proved to be 4·75.

The opake crystals are either white, or reddish, from a slight admixture of iron.

The opake fawn-coloured specimens of sulphat of barytes, known by the name of cauk, are common, and affect the peculiar figure of an assemblage of small convex lenses set together edgeways. This is generally distinguished by the name cristated by mineralogists. Its specific gravity is scarcely inferior to that of the transparent specimens.

4. Fluors. These are the fluats of lime. See Acid (Fluoric).

5. Adamantine spar. See the article. Dr. whole figure was such as art had left it. Two sides were flat, apparently from having been sawed with diamond dust. It had the appearance of being part of a larger plate. Its thickness was about a quarter of an inch, the flat sides were unpolished; but a number of small spherical polished concavities had been made in those surfaces, for some use about which I received no information. Its colour was of a dark green, like bottle-glass, so dark as to appear almost opake. When held to the light, some cloudy straight streaks were seen within it, resembling those of certain spars, and some agates. It had one shake or flaw across the direction of the parallel streaks, and on the whole was evidently a natural production. It very easily marked agate, quartz, and other hard stones, and is said to yield in hardness only to the diamond, which I found scratched it without any difficulty. Its weight was 89·2 grains, and it lost by immersion in water 22·25 grains. Whence its specific gravity is deduced 4·09.

6. A milky white spar, in hexahedral crystals, called spar in tablets, by Mr. Stutz, because in its fracture it exhibits a foliated structure, contains according to Klaproth silex 50, lime 43, water 5, and no carbonic acid. Other siliceous spars are found with a yellow, green, or light blue tint, sometimes in hexahedral at others in tetrahedral prisms, with a still larger proportion of silex, and a little alumine, magnesia, and oxide of iron.

7. The compound or magnesian spar, or miemite, is of an asparagus green, or obscure yellow, and contains about 53 carbonat of lime, 43 carbonat of magnesia, and 3 oxide of iron with a little manganese. A variety from Sweden gave Klaproth, in 100 parts, carbonat of lime 73, carbonat of magnesia 25, oxide of iron and manganese 2·25.

SPARGELSTEIN. This stone is so called from its colour, the name translated into English being *asparagus stone*. It is a species of phosphat of lime, and was mistaken for a chrysolite by Romé de Lisle and other French mineralogists.

It is crystallized in equiangular six-sided prisms, terminated by a pyramid with six faces. Its colour is commonly a pale or asparagus green; but sometimes orange, yellowish brown, or greenish blue. It is not phosphorescent on burning coals. It is brittle, and not very hard. Its specific gravity is 3·098.

Vauquelin's analysis gives as its component parts,

Lime	53·32
Phosphoric acid	45·72
	99·04

It appears to be found among volcanic productions, as at Vesuvius, where it occurs mixed with vesuvian. It has been found in the greatest quantity at Mount Caprera, near Cape de Gates, in the kingdom of Grenada, in Spain; where its gangue is a carious stone, greatly resembling a lava.

The brownish and greenish blue crystals have been found in metallic veins in primitive mountains, as in the mine of Marboë or Langloë, near Arandahl, in Norway. These appear to be the *moroxite* of Karsten. —*Thomson.*—*Brongniart.*

Specific Gravity. See **Gravity** (**Specific**).

Specificum Purgans. Sulphat of potash.

Speckstein. The same with **Steatites**, which see.

Specularis Lapis, a name occasionally given to the clear sulphat of lime, or gypseous spar.

Speculum. When tin is melted with copper, it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The uses of this hard, sonorous, and durable composition, in the fabrication of cannon, bells, statues, and other articles, are well known.

Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. The metal required for this purpose ought to be capable of an exquisite polish, hard enough to receive and retain a figure accurately suited to the regular reflection of light, and not subject to become tarnished by the action of the atmosphere. Many excellent telescopes have been made with compositions of pure copper, alloyed with somewhat less than half its weight of tin.

But it appears to be very well ascertained, from the observations of the astronomer royal, that the speculums of Mr. Edwards, whose composition was the result of numerous trials, are much superior to any which have yet been made, and are even equal in light to achromatic telescopes of the same aperture, without altering the colours of objects. He first melts 32 parts of copper as fluid as possible, with one part of brass, and one of silver, together, with the black flux; at the same time that 15 parts of tin are melted in a separate crucible. These being taken from the fire, he pours the tin to the copper; immediately stirs the whole together with a wooden spatula, and pours it out hastily into a large quantity of cold water, which cools and granulates the composition. If the tin were fused together with the copper, or if they were to remain for any length of time in the extreme heat which is necessary to fuse this last metal, a part of the tin would be oxided, and the metal would abound more or less with small microscopic pores. If one of the pieces of the cold metal be broken, it will appear of a most beautiful bright colour, resembling quicksilver. Mr. Edwards affirms, that different kinds of copper require different doses of tin to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the composition will be yellowish; if it be too great, the composition will be of a gray blue colour, and dull appearance. He therefore finds by trial the quantity of tin necessary to be added in the second fusion to render the metal the most perfect. A much less degree of heat is then required to melt the compound. In the second melting he adds one part of arsenic, and immediately stirs the mixture; which he pours into the mould as soon as the fumes of the arsenic have ceased to rise. He casts the speculum in sand, with the face downward; takes it out while red-hot, and places it in hot wood ashes to cool; without which precaution it would break in cooling.

Mr. Little recommends the following proportions: 32 parts of the best bar copper, 4 parts of the brass of pin-wire, 16½ of tin, and 1¼ of arsenic. Silver he rejects, as it has an extraordinary effect of softening the metal; and he found, that the compound was not susceptible of the highest polish, unless it was extremely brittle. He first melts the brass, and adds to it about an equal weight of tin. When this mixture is cold, he puts it into the copper, previously fused with black flux, adds next the remainder of the tin, and lastly the arsenic. This mixture he granulates, by pouring into cold water, as Mr. Edwards did, and fuses it a second time for casting.

As the construction of telescopes is foreign to the immediate purpose of this work, it has not been thought necessary to mention the several precautions of Mr. Edwards in this business; but the curious operator, who may wish to undertake the construction of a reflecting telescope (the better kinds of which are not only difficult to be procured, but of considerable price), may have recourse to Edwards's treatise, annexed to the Nautical Almanack for 1787; where he will find ample instructions for that purpose. He may likewise consult the reverend Mr. James Little's paper, in the 10th volume of the Irish Transactions.

The composition of metal for speculums, previous to the invention of the reflecting telescope, was in the hands of artists, and did not acquire that extreme perfection with regard to density and other properties, which the specula of those instruments demand. Experience showed them, that arsenic is a valuable ingredient in these mixtures; but speculative philosophers, reasoning from the saline property of that substance before it was known that it can be reduced to a metal, were apprehensive that it would increase the disposition to tarnish. I conjecture that Mr. Edwards's composition might be improved by a greater proportion of arsenic, or at least by adding this ingredient in an earlier stage of the process. For this reason, I shall here insert the directions which Blancourt in his Art of Glass gives, as the best of all compositions for whiteness, hardness, and susceptibility of an exceeding fine polish. As I do not answer for the value of this receipt, I shall give it in the author's own words, after remarking, that the oil of tartar is evidently unnecessary; that the gradual management of the heat on a sand bath is probably a useless refinement; that the substitution of orpiment for arsenic, as he recommends, must be noxious; that by latten I understand common brass, of which there are various kinds; and that the addition of the tin should be made in the fused state.

Take plates of copper, one pound, mince them, that they may be put into a crucible, imbibing them with oil of tartar; then powder a quarter of a pound of white arsenic, and put these stratum super stratum until you fill the crucible; pour on them afterward linseed oil to cover the arsenic and the copper; head and lute your crucible; and when the lute is dry, set it on a sand furnace, letting the sand arise no higher than the head; heat the furnace gently till it arrives at a just degree, and the oil begins to evaporate; by this time the oil will prepare the copper for retaining the arsenic, which must enter the copper as easily as oil does leather; set it again on fresh sand, and increase the heat of the furnace, giving it the same degree as before, until the oil evaporates and boils up; then take off the crucible, let it cool, and break it, you will find your copper of several colours. It would be much better, if instead of arsenic you made use of orpiment.

Take of this copper one part, of latten two parts, melt the latten on a smart fire, and so put in the copper; when they are well melted, cast the metal drop by drop into a glazed earthen vessel full of water, over which lay a bush or broom for the stuff to go through; thus you will have a metal not to be touched with a file, nor brittle, as good as any steel for all uses whatever.

Take of this hard metal, three parts, and best tin of Cornwall, which has no lead in it, one part; melt the metal before you put in the tin; after these are well incorporated, you may fill your moulds, &c.

Speiss. The Bohemian name for mispickel, which see.

Spelter. Zinc is called spelter in commerce. The soft brass, containing a redundant proportion of zinc, and sold in the granulated form for the use of artists in soldering, is called spelter solder, and frequently spelter only.

Spermaceti. The brain of a species of whale, purified from the oily matter, affords a fat of a singular kind, known in the shops by the improper name of spermaceti.

The spermaceti whale, physeter, called by the English sailors employed in the Greenland-fishery, torump, jubart, or gibbart, is smaller than the common whale, but the head is proportionably much larger, amounting to above one third the bulk of the whole body. He is furnished with teeth, which the other is not; and wants the flexible bones in the mouth, called whale-bone, which the other has. The throat is also remarkably wider.

One of these fishes affords some tons of brains, which are first grossly freed from the oil by draining and pressing, and afterward more perfectly purified by steeping them in a ley of alkaline salt and quicklime, which dissolves the remains of the oily matter into a saponaceous liquid. The brains, being then washed with water, appear of a silver whiteness; and nothing more is required to complete the preparation, than to cut them in shivers with wooden knives, and spread them abroad to dry. Such is the simple process, by which this profitable commodity is prepared. It has been said, that spermaceti is a natural concrete, found floating on the surface of the northern seas: but this is plainly a false report, perhaps intended to prevent inquiry into the manner of its preparation.

Good spermaceti is in fine white flakes, glossy and semi-transparent, soft and unctuous to the touch, yet dry and easily friable, in taste somewhat like butter, of a faint smell like that of tallow.

It is apt in keeping, if not carefully secured from the air, to grow yellowish, and contract a rancid fishy smell. The more perfectly it has been purified at first, the less susceptible it is of these alterations; and after it has been so changed, it may be rendered white and sweet again, by steeping it afresh in a ley of alkaline salt and quicklime.

It melts in a small degree of heat, about 113° F., and congeals again as it cools. Laid on burning coals, it emits a fetid smell, like that of the snuff of a candle. The contact of flame does not set it on fire, but with a wick it burns equally with common tallow candles.

In distillation it totally rises, leaving no coal or caput mortuum behind; from four ounces were obtained three ounces and a half of oil, and a drachm and a half of phlegm; the other two drachms and a half having been wasted or dissipated in the process. The oil is not a brown or black fetid empyreumatic oil, like those of other animal substances; but clear, yellowish, of a butyraceous consistence, in smell like oil of wax, like which also it coagulates in the cold.

Alcohol, digested and boiled with spermaceti, takes up about half a drachm out of half an ounce; the greater part settles to the bottom, and the finer particles float in the liquor, in appearance like flowers of benzoin. To dissolve this quantity requires at least nine ounces of alcohol.

Warm ether dissolves it rapidly, but it is precipitated so plentifully by cooling, as in appearance to convert the whole into a solid crystallized mass.

Water long digested or boiled with it extracts nothing. By grinding it with sugar or almonds it becomes miscible with water, but not near so perfectly as the vegetable resins do by the same treatment: on standing for a little time the spermaceti separates and floats on the surface. Yolks of eggs unite it more thoroughly with watery liquors; but when dissolved by these also it separates on standing.

Pure potash forms with it a compound perfectly soluble. Ammonia does not act upon it without the assistance of a boiling heat, when it readily forms an emulsion, which is not decomposed by cooling, but is by the addition of water.

With fat oils, wax, resins, &c. it easily unites. Oil of turpentine dissolves it in a gentle heat, but deposits it on cooling. It combines with sulphur like fat oils.

Neither nitric nor muriatic acid acts on it, but the concentrated sulphuric dissolves it, and changes its colour.

Beside the use of spermaceti in medicine, it is employed for making candles, which are of a beautiful colour, and appear to be a medium between wax and tallow with respect to the advantages derived from a slender wick. See Light.

Sphene. The reddish brown ore of titanium was thus called by Haüy.

Spikenard. Nardus Indica, quæ spica, spica nardi, et spica Indica officinarum C. B. Andropogon nardus Lin. Indian nard, brought from the East Indies.

It consists of a number of slender brittle filaments, of a reddish brown colour, cohering together so as to form a bunch or spike about the size of a finger. They are the stalks of a plant of the gramineous kind.

Spikenard has a very strong, not disagreeable, smell and taste, scarce to be concealed or overpowered by a large admixture of other substances. It contains only a small portion of essential oil: on distilling an ounce, there was only an appearance of some oily particles on the water. Alcohol brings over nothing. The spirituous extract possesses much more of the smell and taste than the watery. An ounce yields a drachm of extract with alcohol, and afterward forty-six grains with water. Water applied first extracted four scruples, and alcohol afterward twenty-five grains. In each case the residuum was six drachms ten grains. It is said to be used in the East as a spice. —*Neumann.*—*Lewis.*

Spinel. See Ruby.

Spirit. This name was formerly given by chemists to all volatile substances collected by distillation. Three principal kinds were distinguished: inflammable or ardent spirits, acid spirits, and alkaline spirits. In the first class were included not only the product known by the common name of spirit of wine, and its compounds, but the light volatile oils, ethers, and the aromatic principle. The contents of the latter classes need no enumeration.

The word spirit is now almost exclusively confined to alcohol; and the other substances formerly arranged under the classes here mentioned are distinguished respectively by their peculiar names, without reference to any general arrangement grounded on a property of so indistinct a nature as that of their being separated from other bodies by distillation. See Alcohol.

Spirit of Libavius. The same thing as the smoking liquor of Libavius; for which see the article Tin.

Spirit of Mindererus. A solution of acetat of ammonia, made by adding concrete carbonat of ammonia to distilled vinegar till saturation takes place.

Spirit of Nitre. See Acid (Nitric). In the shops the purer nitric acid is called spirit of nitre, and the less pure used by artisans, is called aqua fortis. Some authors assert that the common aqua fortis, being distilled from impure nitre, and containing muriatic acid, has in many cases the effect of an aqua regia. We have already remarked, that the refiners purify their aqua fortis by adding a small portion of the nitric solution of silver, the metallic part of which combining with the muriatic acid falls down in the form of muriat of silver.

Spirit of Salt. See Acid (Muriatic).

Spirit of Sulphur. See Acid (Sulphuric).

Spirit of Urine. Liquid ammonia, formerly so called when distilled from urine.

Spirit of Venus. The acetic acid distilled from the crystals of verdigrise without addition.

Spirit of Vinegar. The common acetous acid, or distilled vinegar.

Spirit of Vitriol. This name has been given to the first portions of acid which come over in a diluted state, when sulphuric acid is distilled or concentrated. It has also been applied to every other weak sulphuric acid.

Spirit (Volatile) of Sal Ammoniac. See Ammonia.

Spirit of Wine. See Alcohol.

Spiritus Rector. Boerhaave and other chemists give this name to a very attenuated principle, in which the smell of odorant bodies peculiarly resides, now called Aroma. See Smell.

Spodumene. This mineral, the *triphane*

of Haüy, is but little known. It has the pearly appearance of the adularia or moonstone, but it differs from it essentially in its mechanical division, which exhibits characters easily observable. The spodumene is divisible into prisms with a rhombic base, the angles of which are 80° and 100°. These prisms admit of a section in the direction of the shorter diagonal of their base, so that we may say this stone is divisible into triedral prisms, the sides of which are equally brilliant, while their bases are dull. The adularia feldtspar, on the contrary, divides into oblique quadrilateral prisms.

Thus the spodumene exhibits a smooth and shining fracture in a direction parallel to the sides of a quadrilateral or trihedral prism, and a dull, rough, or scaly fracture in a direction perpendicular to the axis of the prism.

It is found in the iron mine of Utoe, in Sudermania, in Sweden, and also in Norway. Its gangue is a reddish feldtspar with greasy quartz and black mica. Dandrada first described it. It is in masses, of a pale green, or greenish white, and transparent. It scratches glass, and strikes fire with steel. Its specific gravity is from 3·1923 to 3·218.

Before the blowpipe it first splits into small yellowish or grayish scales, which afterward unite and melt into a transparent grayish globule. The division into scales, however, is not always very obvious. If heated in a crucible it splits into similar scales, many of which appear of a golden yellow colour, like some varieties of mica, and others are of a dark gray; but in a few days they all lose their lustre, and become of a dark gray alike.

Vauquelin analysed it; but he operated on a very small quantity, and experienced a loss of near one tenth of the whole. He obtained from one hundred parts of the stone,

Silex - - -	56·5
Alumine - -	24·0
Lime - - -	5·0
Oxide of iron -	5·0
	90·5

Thomson.—Brongniart.

Sponge. A soft, light, very porous, and compressible substance, readily imbibing water, and distending thereby. It is found adhering to rocks, particularly in the Mediterranean sea, about the islands of the Archipelago. It was formerly supposed to be a vegetable production; but is now classed among the zoophytes, and analysed it yields the same principles with animal substances in general. Lewis says, that the volatile salt is in larger quantity than he obtained from any animal matter, except the bags of the silk-worm. On this salt seem to depend the virtues of the officinal Spongia usta. Crude sponge, from its property of imbibing and distending by moisture, is sometimes made use of as a tent for dilating wounds and ulcers.

It adheres strongly to the mouths of wounded vessels; and when retained by proper compression, it has prevented considerable bleedings, preferable to agaric, puff-ball, &c. On account of the saline matter contained in burnt sponge, it has been used in scrofulous and other cutaneous affections, and in bronchocele.

Spuma-maris. See Keffekil.

Squill. The bulbous root of the scilla maritima Lin., or sea onion. It is employed in medicine as a diuretic, and to excite nausea and vomiting. We do not know of any chemical analysis of it, but it is supposed to contain resin, extractive matter, mucilage, and the bitter principle. If, when fresh, it be rubbed on the skin, it excites considerable itching.

Staining of Wood and other Substances. The practice of staining chiefly takes place in solid and inflexible bodies; and as it is performed with different views, it is also different in its nature. Here this kind only will be considered, in which a body is dyed on its surface, or the colour which it has already is changed. It has commonly this peculiarity, that the penetrating materials are only laid on the bodies with a brush; though the latter may also sometimes be boiled or steeped in the former without receiving any detriment. It is used for wood, leather, horn, ivory, and various kinds of stones. In all these cases attention ought to be paid to the natural composition of the bodies and their properties, as well as to the nature of the staining materials.

For the staining of wood, sharp corrosive fluids must be used, such as sulphuric acid, aqua fortis, or a solution of sulphat of iron or copper, according to the nature of the wood, or to the state into which it has been put by means of art. Otherwise wood may be stained red, by previously soaking it in alum water, and then putting it into a decoction of brazil wood, in lime-water. It may be made blue with a somewhat diluted solution of indigo in sulphuric acid. It assumes a green colour in a decoction of verdigrise, sal ammoniac, and vinegar; black in a decoction of galls, logwood, sulphat of iron, filings of iron, and vinegar.

Quicklime slaked on common deal gives it a brown hue, more or less deep, according to the quantity and time it lies on; and this may be so managed as to make it finely veined. If after this it be well rubbed with linseed oil in which alkanet has been boiled, and lastly varnished, it will make a very good imitation of mahogany. A solution of iron in aqua fortis likewise makes a good stain for wood. So do gamboge and dragon's blood dissolved in oil of turpentine.

For leather, on the contrary, these sharp corrosive substances must be avoided; because its durability will be destroyed by them. To give it a red colour, the skins, after being properly prepared, are dipped into a solution of tartar and common salt, then put into a bath of madder, tartar, alum, and calcined oyster-shells, and sometimes also at last into a simple decoction of brazil wood. Or the skins are steeped in alum water, and afterward stained with a decoction of gum, lac, brazil wood, alum, and sal ammoniac. They acquire a blue colour by being rubbed over with a solution of indigo and alum water. They become yellow in a decoction of turmeric in lime-water; and green with sap green dissolved in lime water.

The above-mentioned baths may in like manner be used for horn and ivory; beside which the diluted solutions of mercury, iron, copper, and silver may also be employed.

These latter liquors may likewise be laid upon all kinds of trinkets and toys made of agate. For the staining of marble, coloured resinous solutions in alcohol, or in ethereal oils, must be used; and, to promote the penetration of them into its substance, a little heat must be had recourse to. In the same manner, alabaster also may be stained with various colours, in particular red, with a decoction of brazil wood and alum; blue with elder-berries and alum; yellow with saffron or turmeric, and other liquid colours of this kind. It is in a similar kind of staining, that the effects of common writing-ink consist. See Ink.

Stalactites. These are found suspended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving those particles behind: this deposition can scarce be called a crystallization, as the earthy particles scarcely appear to have been dissolved, nor even very minutely divided, though this sometimes happens; whereas transparent spars appear to have been formed from a solution in water, by means of the carbonic acid. Stalactites are of a lamellar or granular texture, and either in a branchy form, or in that of perforated cones, or globular, and then called stalagmites, oolithes, pisolites, &c. Most of these stones contain a slight mixture of clay and oxide of iron: and hence, they are of a gray, brown, yellow, or blackish colour.

Starch. This is a white, insipid, combustible substance, insoluble in cold water, but forming a jelly with boiling water. It exists chiefly in the white and brittle parts of vegetables, particularly in tuberose roots, and the seeds of the gramineous plants. It may be extracted by pounding these parts, and agitating them in cold water; when the parenchyma, or fibrous parts, will first subside; and these being removed, a fine, white powder, diffused through the water, will gradually subside, which is the starch. Or the pounded or grated substance, as the roots of arum, potatoes, acorns, or horse-chestnuts, for instance, may be put into a hair sieve, and the starch washed through with cold water, leaving the grosser matters behind. Farinaceous seeds may be ground and treated in a similar manner. Oily seeds require to have the oil expressed from them before the farina is extracted.

If starch be subjected to distillation, it gives out water impregnated with empyreumatic acetous acid, a little red or brown oil, a great deal of carbonic acid, and carburetted hidrogen gas. Its coal is bulky, easily burned, and leaves a very small quantity of potash and phosphat of lime. If when diffused in water it be exposed to a heat of 66° F., or upward, it will ferment, and turn sour; but much more so if it be not freed from the gluten, extract, and colouring matter. Thus in starch-making the farina ferments and becomes sour, but the starch that does not undergo fermentation is rendered the more pure by this process. Some water already soured is mixed with the flour and water, which regulates the fermentation, and prevents the mixture from becoming putrid; and in this state it is left about ten days in summer and fifteen in winter, before the scum is removed, and the water poured off. The starch is then washed out from the bran, and dried, first in the open air, and finally in an oven.

With boiling water starch forms a nearly transparent mucilage, emitting a peculiar smell, neither disagreeable nor very powerful. This mucilage may be dried, and will then be semitransparent, and much resembling gum, all the products of which it affords. When dissolved it is much more easily digested and nutritious than before it has undergone this operation.

Both acids and alkalis combined with water dissolve it. It separates the oxides of several metals from their solutions, and takes oxigen from many of them. It is found naturally combined with all the immediate principles of vegetables, and may easily be united with most of them by art.—*Fourcroy.*—*Chaptal.*

Staurolite. Cross-stone. *Harmotome* of Haüy, *white cruciform hyacinth*, variety 9, of Romé de Lisle, *andreolite* of Delamétherie.

This stone has been found at Andreasberg, in the Hartz, and at Strontian, in Argyleshire, in veins. At Oberstein it occurs crystallized in agate balls. The general form of its crystals has induced mineralogists to give it the name of staurolite, or cross stone, they being two four-sided flattened prisms, terminated by tetrahedral pyramids, and intersecting each other at right angles, the plane of intersection passing longitudinally through the prisms. Sometimes these prisms occur solitary. Their primitive form is an octahedron with isosceles triangular faces. The faces of the crystals are striated longitudinally.

The colour of the staurolite is a grayish white. Its longitudinal fracture, foliated; cross fracture, uneven, sometimes small conchoidal. Its specific gravity is from 2·333 to 2·361. It scratches glass, but not very easily. When heated slowly it loses 0·15 or 0·16 of its weight, and falls into powder. It effervesces with borax and with microcosmic salt, and is reduced to a greenish opake mass. With soda it melts into a frothy white enamel. When its powder is thrown on a hot coal, it emits a greenish yellow phosphorescent light.

This stone has been analysed by four different chemists, whose analyses agree sufficiently in their results. The following is Klaproth's.

Silex - - -	49
Barytes - - -	18
Alumine - -	16
Water - - -	15
	98

This stone must not be confounded with the *staurolitte* of Delamétherie, *staurotide* of Haüy, for which see the following article.—*Thomson.—Brongniart.*

Staurotide. This stone, the *staurolitte* of Delamètherie, *cruciform schoerl* of Romé de Lisle, *granatite* of Werner, Brochant, and others, is likewise a cross-stone, but differs from the preceding in this particular, that its prisms decussate each other longitudinally. Sometimes they cross each other at right angles; at others obliquely, so as to form angles of 60° and 120°; and sometimes, though rarely, three prisms unite, making a cross with six arms.

Frequently, however, the staurotide occurs in single prisms; and hence Brongniart makes two varieties of it: the *staurotide grenatite*, in simple prisms; and the *staurotide croisette*, with cruciform crystals.

The staurotides belong to the class of primitive stones. The granatite, or single crystal, is found more particularly in micaceous rocks. That of St. Gothard is generally accompanied by cyanite.

The cruciform variety is more common. It has been found principally in the department of Morbihan in France, near Quimper, in the communes of Baud and Corray. It occurs in scattered crystals in a micaceous clay, which appears to have been produced by the decomposition of a primitive rock. It has likewise been found in a primitive rock near St. James of Compostella in Spain; in the Alps, toward Nice; and by Mr. Dupuget in Cayenne.

Mr. Haüy has shown in a very ingenious manner, that the primitive form of the staurotide is a rectangular prism, the bases of which are rhombs with angles of 129° 30′ and 50° 30′; that the height of the prism is to the greater diagonal of the rhomb as one to six; and that its integrant molecules are triangular prisms, similar to what would be obtained by cutting the primitive crystal in two by a plane passing vertically through the shorter diagonal of the rhomboidal base. From this structure he has deduced the law of the formation of the cruciform varieties.

The staurotide is of a reddish brown colour, and commonly in the form of a flattened prism with four or six sides, either single, or united in the form of a cross. Its fracture is uneven. It is infusible by the blowpipe; but, when exposed to its flame powerfully urged, becomes coated with a black frit.

It is harder than quartz, yet does not easily give fire with steel. Its specific gravity is 3·286. It is never perfectly transparent; and scarcely ever homogeneous, so that it cannot be analysed with precision. The single crystals are commonly of a brown garnet red, and frequently translucid: the cruciform are more opake, their surface dull and sometimes uneven, and their colour a dull brown.

Vauquelin gives the following results of his analysis of the two varieties. Of the first,

Alumine - - -	44
Silex - - -	33
Lime - - -	3·84
Oxide of iron - -	13
Oxide of manganese -	1
	94·84

Of the second,

Alumine - - -	47
Silex - - -	30·6
Lime - - -	3
Oxide of iron -	15·3
	95·9

Thomson.—Brongniart.

Steatites. Soap rock, French chalk, smectis, speckstein. A stone of the magnesian kind, of a green or greenish colour, and so soft as to be scraped by the nail; of a soft soapy feel; specific gravity from 2·433 to 2·78. It is not easily diffusible in water, nor rendered ductile by mixture with it.

It does not effervesce with acids, and is very slowly and only partially soluble in the three mineral acids.

In fire it hardens, but is infusible per se, and becomes whiter. It is imperfectly melted by soda and microcosmic salt, but more perfectly by borax. It is apt to corrode the crucibles.

A steatites analysed by Bergman gave in 100 parts, silex 80, magnesia 17, alumine 2, iron 1. A specimen from Cornwall afforded Klaproth silex 48, magnesia 20·5, alumine 14, oxide of iron 1, water 15·5: and another from Bayreuth, silex 59·5, magnesia 30·5, oxide of iron 2·5, water 5·5.

The steatites in its natural state may be cut or turned with great ease, and if it be afterward burned in a close vessel it will be rendered so hard as to resist the file. It may likewise be stained so as to imitate the most beautiful stones; and in its hardened state is susceptible of a higher polish than agate.

French chalk is used to extract grease from clothes, and is said by Brisson to form the basis of the *rouge* termed vegetable.

Steel. See Iron.

Stilbite. Foliated or pearly zeolite. See Zeolite.

Stinkstein. See Swinestone.

Stone. An indurated hard mass of earth. Stones were formerly distinguished from earths in classification. It does not seem, however, that any useful purpose is likely to be answered by this distinction. For a stone is a mass of earth of considerable magnitude, sand is a collection of small stones, and earth in the pulverulent state may be considered as a fine sand. To the chemist, whose attention is chiefly taken up with the component parts of bodies, these variations of dimension are comparatively of little consequence.

Stones (Precious). See Precious Stones.

Stones *or* Calculi, *found in the bodies of animals.* See Calculus.

Storax. The most fragrant of the solid resins, and indeed of all the known vegetable substances, is storax or styrax, obtained from a tree of the same name, said to grow most plentifully in Syria, Cilicia, and Pamphilia. America likewise produces storax-trees, but not that particular species which affords the officinal resin. The true storax-tree has leaves like those of the quince, and hence is named by Caspar Bauhin and Tournefort, Styrax folio mali cotonei: its flowers are white, in shape somewhat like a funnel, divided into several segments about the edges: the fruit is about the size of a hazel-nut.

The fine storax, called red storax, or storax in the tear, is the pure native juice, flowing from incisions made in the trunk of the tree. This is very rarely to be met with. The common storax is supposed to be in part an artificial composition, mixed with a considerable portion of the genuine resin. Of the production however of this concrete we have no satisfactory account. That it is not an artificial composition may be judged from this; that, notwithstanding its large admixture of saw-dust, it is more fragrant than the pure storax in the tear, and its fragrance is exactly of the same kind. Some resinous bodies indeed discover a greater degree both of smell and taste, when diluted with other substances of themselves inodorous and insipid, than in their pure state: but the pure resin extracted from common storax by alcohol, is still more fragrant than the storax itself, or the resin prepared by the same means from storax in the tear.

It seems probable, that the pure storax is the juice which concretes upon the tree, and which has lost in the drying its more subtle odoriferous parts; and that the common storax is the juice received immediately in vessels, and mixed with saw-dust enough to thicken it; the shops requiring under the name of storax a solid or consistent mass, and evaporation being found to dissipate its fragrance. Neumann observes, that he cannot conceive for what other purpose the woody matter could be added; for it is too easily distinguishable to have been intended as an imposition.

The storax-tree is said to grow spontaneously, not only in the eastern countries, but in Italy: whether it yields any resin there, we have no account. It scarcely bears the winters of our climate without shelter.

The common storax was formerly brought to us enclosed in reeds or canes, whence its name styrax calamita: at present we meet with it in large cakes or loaves, of a reddish brown colour, softish, and as it were unctuous to the touch, yet brittle and friable, and of an extremely pleasant sweet smell.

Out of an ounce of common storax, alcohol dissolved six drachms; from the residuum, water extracted half a drachm of gummy matter; the rest was almost mere saw-dust. Another ounce of the same storax, treated with water at first, gave two drachms of extract; after which it yielded with alcohol four drachms of resin, the saw-dust remaining as before.

Alcohol elevates in distillation very little of the smell of the storax: the distilled water is notably impregnated with its fine flavour, but no separable oil is obtained. To determine this last point more fully, Neuman distilled eight ounces of storax with sixteen ounces of water in a glass retort. No appearance of oil could be perceived till the water was almost all drawn off, and the remaining storax began to grow dry and scorched: then arose a fine subtle oil, weighing two scruples, together with nine drachms of an empyreumatic liquor: presently succeeded two drachms and a scruple of thick butyraceous oil, and afterward two ounces one drachm of an empyreumatic oil, which had nothing of the smell of the storax, along with five drachms of an acid spirit: the residuum weighed two ounces and seven drachms. The butyraceous oil being washed with warm water, and the water set by in a cold place, a small portion of saline matter separated, similar in appearance to the flowers of benzoin.

Though alcohol distilled from storax brings over little or nothing of its smell; we may nevertheless obtain a spirit pretty strongly impregnated both with the smell and taste of the storax, by previously mixing the resin with twice its weight of salt of tartar, and drawing over the alcohol from this mixture. The strongest and most fragrant principle, separable from storax, is the subtile, slightly empyreumatic oil, which arises first in the distillation of it.

In the shops, we meet with a fluid resinous substance, called styrax liquida.

composition of turpentine, oil, wine, and a little solid storax. This last account is the most probable. Neumann informs us, there was a person in his neighbourhood (Berlin), who prepared some hundred weights every year, and was said to employ chiefly common resin.

Lewis in a note on this passage observes, that the genuine liquid storax is obtained not from the tree which yields the solid storax, but from one of a different genus, though usually called by the same name. That which yields the solid is distinguished by the epithet quince-leaved, and that which yields the liquid by that of maple-leaved storax.

The maple-leaved storax-tree is a native of Virginia, Mexico, and some other parts of America, and is easily naturalized to our own climate. A resinous juice approaching in fragrance to storax exudes upon the surface of the leaves, and may be extracted more perfectly by alcohol: the process by which the juice is procured abroad has not been tried with the trees raised here.

Liquid storax and liquid amber are said to be both obtained from this one tree, the first by boiling the bark or branches in water, the latter by making incisions in the trunk. Mr. Petiver gives an account, in the Philosophical Transactions, of the preparation of liquid storax, as practised in the island Cobros in the Red-Sea, from a tree (which probably is no other than this) called by the Turks and Persians, rosa millos. The bark is annually cleared off, and boiled in sea water to the consistence of bird-lime. The resinous matter, which floats upon the surface, and contains a considerable portion of the substance of the bark, is taken off, liquefied again in boiling water, and passed through a strainer. The purer part which passes through, and the more impure which remains on the strainer, are both sent to Mocca, from whence they are sometimes, but very rarely, brought to us. The first is of the consistence of honey, tenacious like turpentine, of a brownish colour, an acrid aromatic unctuous taste, and a smell approaching to that of solid storax, but so strong as to be disagreeable. The impure sort is full of woody matter, and much weaker in smell.

The liquid amber, or juice which issues from incisions in the trunk, is at first of the consistence of thin turpentine, but by long keeping grows hard and brittle. It is of a yellow colour, inclining to red, of a hot aromatic taste, and a fragrant smell, not unlike that of storax heightened with a little ambergris. It was formerly much used as a perfume, but is at present scarcely known in the shops.

Four drachms of liquid storax yielded,

the resin. In distillation with water, an essential oil arose, similar in flavour to oil of turpentine, or the oleum pini. By distillation in a stronger fire, instead of a clear empyreumatic oil, what came over was almost mere pitch. These experiments are a sufficient proof, that the common liquid storax is an artificial compound.

STRAHLSTEIN. *Actinote* of Haüy, *rayonnante* of Brochant. Of this mineral there are three subspecies, the common, asbestose or fibrous, and glassy. Haüy indeed and Brongniart make five, chiefly from the shape of the crystals.

1. The common strahlstein, *actinolyte* of Kirwan, *zillerthite* of Delamétherie, is usually of a leek green, sometimes pistachio, olive, or blackish green. It is found either massive, or crystallized in very oblique hexahedral prisms. The primitive form of its crystals, according to Haüy, is a quadrilateral prism with rhombic bases, which he presumes to be the same with that of hornblende. The crystals are often longitudinally streaked, large, and not unfrequently acicular. Their fracture is commonly radiated, sometimes foliated. Specific gravity from 3·000 to 3·310.

This subspecies is chiefly found in the Zillerthal in Tyrol, and on St. Gothard. It likewise occurs in Saxony, in the country of Salzburg; in Norway; in Piedmont; in the glacier of Bossons, between Mont Blanc and l'Aiguille du Midi; &c.

2. The asbestose strahlstein, *amyanthinite* of Kirwan, is of a greenish gray, mountain green, smalt blue, olive green, yellowish, or liver brown. It occurs massive, and in capillary crystals, which are sometimes a little flexible and elastic. It melts before the blowpipe into a black or gray scoria. Specific gravity from 2·584 to 2·916.

3. The principal colour of the glassy strahlstein is mountain green, passing to greenish gray, and emerald green. It is found massive, and in thin six-sided acicular crystals. Specific gravity from 2·950 to 3·903.

Brongniart says, that the green colour of the strahlstein is owing to chrome. The following is the result of the analysis of one hundred parts, it does not appear of which subspecies, by Mr. Laugier.

Silex	50
Magnesia	19
Lime	10
Alumine (at most)	1
Oxide of iron	11
Chrome	3
Water and loss	6
	100.

Thomson.—Brongniart.

STRONTIANITE. In the second part of

the Philosophical Transactions for 1794, there is an account, by Mr. Schmeisser, of a mineral substance thus denominated from the place, Strontian in Scotland, where it is found in granite rocks, accompanied by galena and carbonat of barytes.

In all the specimens this author had seen, he could not discover any regular crystallized figure. The specimen which he submitted to experiment was in solid masses, apparently composed of long fibres, closely adhering together and disposed in radiations; its colour was an asparagus green, deeper towards the centre of the mass; when broken, the surface was a little shining in certain directions, the fragments rather bar-like, and somewhat brittle.

Some specimens exhibit only light shades of this colour, and appear to be composed of long thin bars, which are often separated from each other towards the extremity.

The specimen examined was semitransparent, but the most of it rather inclining to opake. A hard knife scratched it, but it could not be scraped. Its specific gravity was 3·586 at 60° of temperature.

The first experiments, which pointed out a distinction between the basis of this stone and the ponderous earth of Scheele, were made by Dr. Crawford's desire, by his assistant Mr. Cruikshank, and were afterward repeated by himself. See Earth (Strontian).

Stucco. A very fine-grained parget, susceptible of a good polish, and capable of being variously coloured, is made of plaster of Paris, and called stucco. Gypsum carefully selected and well burnt is taken for this purpose, and a suitable proportion of joiner's glue is added in beating it up into mortar, with the colour intended to be given it previously ground with water. When the coating of plaster laid on in the usual way is dry, it may be polished, by rubbing first with pumice-stone, then with a whetstone, and afterward with tripoli. The last polish is given it by rubbing it with a piece of felt, or old hat, wetted with soapsuds, and afterward with oil.

Stucco is likewise made with pure lime, beaten into mortar with water alone, or with various admixtures.

Mr. B. Higgins's patent stucco is a compound of fourteen or fifteen pounds of choice lime, fourteen pounds of bone-ashes finely powdered, and ninety eight pounds of clean sand, fine or coarse according to the work intended, mixed up into mortar as quickly as possibly with lime-water, and used as soon as made.

Sublimate (Corrosive). See Mercury.

Sublimate (Red). If the red nitrat of mercury be suddenly exposed to a strong heat, most of it will be sublimed, without decomposition, and was then known by this name.

Sublimate (Sweet). The mild muriat of mercury, or calomel.

Sublimation is a process by which volatile substances are raised by heat, and again condensed in the solid form.

This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all that has been said on the article Distillation is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile.

Sublimation is also used in other cases: for instance, to combine volatile matters together, as in the operation of the sublimates of mercury; or to collect some volatile substances, as sulphur, the acid of borax, and all the preparations called flowers.

The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire vary according to the nature of the matters which are to be sublimed, and according to the form which is to be given to the sublimate.

The beauty of some sublimates consists in their being composed of very fine, light parts, such as almost all those called flowers; as flowers of sulphur, of benzoin, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbit, to which is adapted a capital, and even several capitals placed one upon another, are employed. The sublimation is performed in a sand-bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed, and the capitals are to be guarded as much as possible from heat. The height of the cucurbit and of the capitals seems well contrived to accomplish this intention.

When along with the dry matter which is to be collected in these sublimations a certain quantity of some liquor is raised, as happens in the sublimation of acid of borax, and in the rectification of volatile concrete alkali, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordinary capital of the alembic, furnished with a beak and a receiver.

Some sublimates are required to be in masses as solid and compact as their natures allow. Of this number are camphor, muriat of ammonia, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art, therefore, of conducting these sublimations consists in applying such a degree of heat, or in so disposing the sand (that is, making it cover more or less the matrass), that the heat in the upper part of the matrass shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily to be attained, especially in great works.

Many substances may be reduced into flowers, and sublimed, which require for this purpose a very great heat, with the access of free air, and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most soots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air; and the flowers are collected in the chimney of the furnace in which the operation is performed. The tutty, calamine, or pompholix, collected in the upper part of furnaces in which ores are smelted, are sublimates of this kind.

Subsalt. A salt having an excess of base beyond what is requisite for saturating the acid, as *supersalt* is one with an excess of the acid. Thus sulphat of potash is the neutral compound of sulphuric acid and potash; subsulphat of potash, a compound of the same ingredients, in which there is an excess of base; supersulphat of potash, a compound of the same acid and the same base, in which there is an excess of acid. The term was introduced by Dr. Pearson.

Succinat. A saline compound of the acid of amber, or succinic acid. See Acid (Succinic).

Succinic Acid. The acid obtained from amber. See Acid (Succinic).

Sugar is a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, skirret, parsneps, and dried grapes. The process of this chemist consisted in digesting these roots, rasped or finely divided, in alcohol. This fluid dissolves the sugar; and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract sugar from the maple. At the commencement of spring they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice afford by evaporation fifteen of a brownish sugar. The quantity prepared annually amounts to fifteen thousand weight.

Dr. Rush, in the Transactions of the American Philosophical Society, vol. iii. has given an account at length of the sugar maple tree, of which the following is a short abstract:

The acer saccharinum of Linnæus, or sugar maple-tree, grows in great quantities in the western counties of all the middle states of the American union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white blossom in the spring, before any appearance of leaves: its small branches afford sustenance for cattle, and its ashes afford a large quantity of excellent potash. Twenty years are required for it to attain its full growth. Tapping does not injure it; but on the contrary it affords more sirup, and of a better quality, the oftener it is tapped. A single tree has not only survived, but flourished, after tapping, for forty years. Five or six pounds of sugar are usually afforded by the sap of one tree; though there are instances of the quantity exceeding twenty pounds. The sugar is separated from the sap either by freezing, by spontaneous evaporation, or by boiling. The latter method is the most used. Dr. Rush describes the process; which is simple, and practised without any difficulty by the farmers.

From frequent trials of this sugar, it does not appear to be in any respect inferior to that of the West Indies. It is prepared at a time of the year when neither insect, nor the pollen of plants, exists to vitiate it, as is the case with common sugar. From calculations grounded on facts, it is ascertained, that America is now capable of producing a surplus of one eighth more than its own consumption; that is, on the whole, about 135,000,000 pounds; which in the country may be valued at fifteen pounds weight for one dollar.

The Indians likewise extract sugar from the pith of the bamboo.

The beet has lately been much cultivated in Germany, for the purpose of extracting sugar from its root. For this the roots are taken up in autumn, washed clean, wiped, sliced lengthwise, strung on threads, and hung up to dry. From these the sugar is extracted by maceration in a small quantity of water; drawing off this upon fresh roots, and adding fresh water to the first roots, which is again to be employed the same way, so as to get out all their sugar, and saturate the water as much as possible with it. This water is to be strained and boiled down for the sugar.

Some merely express the juice from the fresh roots, and boil this down; others boil the roots: but the sugar extracted in either of these ways is not equal in quality to the first.

Prof. Lampadius obtained from 110lbs. of the roots, 4lbs. of well grained white powder sugar; and the residuums afforded 7 pints of a spirit resembling rum. Achard says that about a ton of roots produced him a hundred pounds of raw sugar, which is afforded by the sugar-cane (arundo saccharifera), which is raised in our colonies. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called in the French sugar-colonies vesou; and the cane, after having undergone this pressure, is called begasse. The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the scum as it rises. In this state it is called sirup; and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the cooler. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterward poured into casks, to accelerate its cooling; and while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottom with several holes stopped with cane. The sirup which is not condensed filters through these canes into the cistern beneath; and leaves the sugar in the state called coarse sugar, or muscovado. This sugar is yellow and fat, and is purified in the islands in the following manner: The sirup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The sirup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure sirup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the sirup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called fine sirup. Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterward taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed,

iners consists in dissolving the cassonade, or clayed sugar, in lime water. Bullocks' blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminished, and the scum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in, to moderate its agitation. When the boiling is sufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the sirup together with the grain sugar already formed. When the whole is cold, the moulds are opened, and the loaves are covered with moistened clay, which is renewed from time to time till the sugar is well cleansed from its sirup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to 145° F. They remain in this stove eight days, after which they are wrapped in blue paper for sale.

The several sirups, treated by the same methods, afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of melasses. The Spaniards use this melasses in the preparation of sweet-meats.

A solution of sugar, much less concentrated than that we have just been speaking of, lets fall by repose crystals, which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of sugar-candy.

The preceding account of the manufacture of sugar in the colonies is chiefly extracted from Chaptal. The following more ample account is taken from Edwards's History of the West Indies, the authority of which is indubitable.

The sugar-cane is a jointed reed, which terminates in leaves or blades, the edges of which are finely and sharply serrated. The body of the cane, though brittle, is strong, and, when ripe, is of a fine straw colour inclinable to yellow. It likewise contains a soft pithy substance, which is replete with juice of a very agreeable taste. The general distance between each joint of the cane is from one to three inches in length, and from half an inch to an inch in diameter; and the general height (the flag part being excluded) is from three feet and a half to seven feet. In very rich lands, too, the stool or root has been known to put forth upward of one hundred suckers or shoots.

To bring a plant of this rank and succulent nature to perfection, no land can be too rich; and the ashy loam of St. Christopher's appears to be the best soil hitherto known, for the production of sugar of the finest quality, and in the largest proportion. The next to this in excellence is the soil which in Jamaica is called brick-mould. It is a deep, warm, and mellow, hazel earth, which is easily worked, and which in the wettest season seldom requires trenching. In a very fine season, plant-canes (which are those of the first growth) have been known, in this soil, to yield two tons and a half of sugar per acre. The black mould of several varieties may be reckoned after this. The best is the deep black earth of Barbadoes, Antigua, and some other of the windward islands; but there is a species of this mould in Jamaica, that is perhaps not in the least inferior to it, which abounds with lime stone and flint, on a substratum of soapy marle. Black mould on clay is more common; and, when properly pulverized and manured, becomes very productive, and may be said to be inexhaustible. But there are few soils, that produce a greater return of refined sugar, than a peculiar sort of land on the north side of Jamaica, and particularly in the parish of Trelawney. This land is generally of a red colour, is every where remarkable when first turned up for a glossy surface, and, when wetted, stains the fingers like paint. It appears to consist of a native earth or pure loam, with a mixture of clay and sand; and though deep, it is by no means heavy, and is naturally dry. Hence, as its fertility is destroyed when too much exposed to the burning influence of a tropical sun, the system of husbandry, where this soil abounds, chiefly depends on what is called ratoon canes. Ratoons are the suckers, that spring from the roots or stools of the canes that have been previously cut for sugar, and are generally ripe in twelve months. Plant-canes, or canes of the first growth, are the immediate produce of the original germes placed in the ground, and require from fifteen to seventeen months to bring them to maturity. The first yearly returns from their roots are called first ratoons, the second year's growth second ratoons, and so on, according to their age. The common yielding too of this cane-land, on an average, is seven hogsheads of 16 cwt. to ten acres, which are cut every year.

The crop time in the sugar islands is the season of festivity, both to man and beast; for so agreeable to the taste, and so nourishing to the corporeal frame, is the juice of the cane, that every animal derives health and vigour from its use. Such of the negroes as were meagre and sickly become surprisingly altered for the better in a few weeks after the mill is set in action. The labouring horses, oxen, and mules, though almost constantly at work during this season, yet, in consequence of eating plentifully of the green tops of this invigorating plant, and being indulged with some of the scummings from the boiling-house, improve more than at any other period of the year. Even pigs and poultry fatten on the refuse. In short, during crop-time, plenty and industrious cheerfulness every where prevail in such a high degree on a well-regulated plantation, as considerably to soften the hardships of slavery, and induce an impartial spectator to conclude, that the miseries of life are sometimes exaggerated through the delusive medium of fancy.

Such planters, as are not fortunately furnished with the means of grinding their canes by water, are at this season frequently impeded by the failure or insufficiency of their mills; for though a sugar mill is a very simple contrivance, yet great force is requisite to make it vanquish the resistance which it necessarily meets with. It principally consists of three upright iron rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one, to which the moving power is applied, turns the other two by means of cogs. The canes, which are previously cut short and tied into bundles, are twice compressed between these rollers; for after they have passed through the first and second rollers, they are turned round the middle one by a piece of frame work of a circular form, which is called in Jamaica the dumb-returner, and forced back through the second and third. By this operation they are squeezed completely dry, and sometimes even reduced to powder. The cane-juice is received in a leaden-bed, and thence conveyed into a vessel called the receiver. The refuse, or macerated rind of the cane, which is called cane-trash, serves for fuel to boil the liquor.

The juice from the mill usually contains eight parts of pure water, one part of sugar, and one part made up of gross oil, and mucilage, with a portion of essential oil. The proportions are taken at a medium; for some juice has been so rich as to make a hogshead or sixteen hundred weight of sugar from thirteen hundred gallons, and some is so watery as to require more than double that quantity. The richer the juice is, the less it abounds with redundant oil and gum; so that very little knowledge of the contents of any other quantity can be obtained by the most exact analysis of any one quantity of juice.

The following matters are likewise usually contained in cane-juice. Some of the green tops, which serve to tie the canes in bundles, are often ground in, and yield a raw acid juice exceedingly disposed to ferment and render the whole liquor sour. Beside these they grind in some pieces of the ligneous part of the cane, some dirt, and lastly, a substance of some importance, which may be called the crust. This substance is a thin black coat of matter that surrounds the cane between the joints, beginning at each joint, and gradually growing thinner the farther from the joint upwards, till the upper part between the joints appears entirely free from it, and resumes its bright yellow colour. It is a fine black powder, that mixes with the clammy exudations from the cane; and as the fairness of the sugar is one symptom of its goodness, a small quantity of this crust must very much prejudice the commodity.

The sugar is obtained by the following process: The juice or liquor runs from the receiver to the boiling-house, along a wooden gutter lined with lead. In the boiling-house, it is received into one of the copper pans or caldrons called clarifiers. Of these there are generally three; and their dimensions are determined by the power of supplying them with liquor. There are water mills, that will grind with great facility sufficient for thirty hogsheads of sugar in a week. Methods of quick boiling cannot be dispensed with on plantations thus fortunately provided; for otherwise the cane liquor would unavoidably become tainted before it could be exposed to the fire. The purest cane-juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are sometimes seen of one thousand gallons each. But on plantations that during crop time make from fifteen to twenty hogsheads of sugar a week, three clarifiers of three or four hundred gallons each are sufficient. The liquor, when clarified, may be drawn off at once, with pans of this size, and there is leisure to cleanse the vessels every time they are used. Each clarifier is furnished either with a siphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a separate fire, each chimney having an iron slider, which, when shut, causes the fire to be extinguished through want of air*.

As soon as the stream from the receiver has filled the clarifier with fresh liquor, and the fire is lighted, the temper, which is generally Bristol white-lime in powder, is stirred into it. This is done, in order to neutralize the superabundant acid, and to get rid of which is the great difficulty in sugar-making. Alkali, or lime, generally effects this; and at the same time part of it is said to become the basis of the sugar. Mr. Edwards affirms, that it affects both the smell and taste of the sugar. It falls to the bottom of the pans in a black insoluble matter, which scorches the bottom of the vessels, and cannot without difficulty be detached from them. But in order that less of the lime may be precipitated to the bottom, little more than half a pint of Bristol lime should be allowed to every hundred gallons of liquor, and Mr. Bousie's method of dissolving it in boiling water previous to mixing it with the cane-juice should be adopted†.

As the force of the fire increases, and the liquor grows hot, a scum is thrown up, which is formed of the gummy matter of the cane, with some of the oil, and such impurities as the mucilage is able to entangle. The heat is now suffered to increase gradually till it nearly rises to the heat of boiling water. The liquor, however, must by no means be suffered to boil. When the scum begins to rise into blisters, which break into white froth, and generally appear in about forty minutes, it is known to be sufficiently heated. Then the damper is applied, and the fire extinguished; and if circumstances will admit, the liquor after this is suffered to remain a full hour undisturbed. In the next place, it is carefully drawn off, either by a siphon, which draws up the clear fluid through the scum, or by means of a cock at the bottom. In either case, the scum sinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper; and if produced at first from good and untainted canes, it will then appear almost transparent.

In the grand or evaporating copper, which should be sufficiently large to re-

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* The clarifiers are generally placed in the middle or at one end of the boiling-house. When they are placed at one end, the boiler called the teache is placed at the other, and three boilers are usually ranged between them. The teache commonly holds from 70 to 100 gallons, and the boilers between the clarifiers and teache diminish in size from the first to the last. But when the clarifiers are in the middle, there is generally a set of three boilers on each side, which in effect form a double boiling-house. This arrangement is very necessary on large estates.

† Mr. Bousie, to whom, for his improvements in the art of sugar-boiling, the Assembly of Jamaica gave 1,000*l*, in a paper which he distributed among the members recommends the use of vegetable alkali, or ashes of wood, such as pimento tree, dumb cane, fern tree, cashew, or logwood, as affording a better temper than quick-lime. Afterward, however, he was convinced, that sugar formed on the basis of fixed alkaline salts never stands the sea, unless some earth is united to the salts. Such earth as approaches nearest to the basis of alum, Mr. Edwards thinks, would be most proper; and it deserves to be inquired how far a proper mixture of vegetable alkaline salts and lime might prove a better temper than either lime or alkaline salts alone. In some parts of Jamaica, where the cane-liquor was exceedingly rich, Mr. Bousie made very good sugar without a particle of temper.

ceive the net contents of one of the clarifiers, the liquor is suffered to boil, and the scum, as it rises, is continually taken off by large scummers, till the liquor becomes finer and somewhat thicker. This operation is continued till the subject is so reduced in quantity, that it may be contained in the next or second copper, into which it is then ladled. The liquor is now almost of the colour of Madeira wine. In the second copper the boiling and scumming are continued; and if the subject be not so clean as is expected, lime-water is thrown into it. This addition not only serves to give more temper, but likewise to dilute the liquor, which sometimes thickens too fast to permit the feculencies to rise in the scum. When the froth in boiling arises in large bubbles, and is not much discoloured, the liquor is said to have a favourable appearance in the second copper. When in consequence of such scumming and evaporation the liquor is again so reduced, that it may be contained in the third copper, it is ladled into it, and so on to the last copper, which is called the teache. This arrangement supposes four boilers or coppers, beside the three clarifiers.

In the teache the subject undergoes another evaporation, till it is supposed boiled enough to be removed from the fire. This operation is usually called striking, *i. e.* lading the liquor, which is now exceeding thick, into the cooler.

The cooler, of which there are generally six, is a shallow wooden vessel, about eleven inches deep, seven feet in length, and from five to six feet wide. A cooler of this size holds a hogshead of sugar. Here the sugar grains, *i. e.* as it cools, it runs into a coarse irregular mass of imperfect crystals, separating itself from the melasses. From the cooler it is taken to the curing-house, where the melasses drains from it*.

But here it may be proper to notice the rule for knowing when the subject is fit to be ladled from the teache to the cooler. Many of the negro boilers, from long habit, guess accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted is to judge by what is called the touch, *i. e.* taking up with the thumb a small portion of the hot liquor from the ladle, and, as the heat diminishes, drawing with the forefinger the liquid into a thread. This thread will suddenly break and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. A thread of a quarter of an inch long generally determines the proper boiling height for strong muscovado sugar†.

The curing-house is a large airy building, provided with a capacious melasses cistern, the sides of which are sloped and lined with terras, or boards. A frame of massy joist-work without boarding is placed over this cistern; and empty hogsheads without headings are ranged on the joists of this frame. Eight or ten holes are bored in the bottoms of these hogsheads, and through each of the holes the stalk of a plantain leaf is thrust six or eight inches below the joists, and long enough to stand upright above the top of the hogshead. Into these hogsheads the mass from the cooler is put, which is called potting; and the melasses drains through the spungy stalk, and drops into the cistern, whence it is occasionally taken for distillation. In the space of three weeks, the sugar becomes tolerably dry and fair. It is then said to be cured, and the process is finished.

Sugar thus obtained is called muscovado, and is the raw material whence the British sugar-bakers chiefly make their loaf or refined lump. There is another sort, which was formerly much used in Great Britain for domestic purposes, and was generally known by the name of Lisbon sugar. In the West Indies it is called clayed sugar; and the process of making it is as follows:

A quantity of sugar from the cooler is put into conical pots or pans, which the French call formes, with the points downward, having a hole about half an inch in diameter at the bottom, for the melasses to drain through, but which at first is closed with a plug. As soon as the sugar in these

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* It is necessary to observe in this place, that, in order to obtain a large-grained sugar, it must be suffered to cool slowly and gradually. If the coolers be too shallow, the grain is injured in a surprising manner.

† The vessel called the teache probably derived its name from this practice of trying by the touch (tactio). Some years ago, John Proculus Baker, esq., barrister at law, recommended to the public a method more scientific and certain, in a treatise which he published in 1775, entitled An Essay on the Art of making Muscovado Sugar. It is as follows: "Provide a small thin pane of clear crown glass, set in a frame, which I would call a tryer; on this drop two or three drops of the subject, one on the other, and carry your tryer out of the boiling-house into the air. Observe your subject, and more particularly whether it grain freely, and whether a small edge of melasses separate at the bottom. I am well satisfied, that a little experience will enable you to judge what appearance the whole skip will put on when cold, by this specimen, which is also cold. This method is used by chemists, to try evaporated solutions of all other salts: it may seem therefore somewhat strange, it has not been long adopted in the boiling-house."

pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the sirup or melasses that drains from it. In this state it is left as long as the melasses continues to drop, when a stratum of clay is spread on the sugar, and moistened with water. This, imperceptibly oozing through the pores of the clay, dilutes the melasses, in consequence of which more of it comes away than from sugar cured in the hogshead, and the sugar of course becomes so much whiter and purer. According to Sloane, the process was first discovered in Brasil, by accident: "A hen," says he, "having her feet dirty, going over a pot of sugar, it was found under her feet to be whiter than elsewhere." The reason assigned why this process is not universally adopted in the British sugar islands is this, that the water which dilutes and carries away the melasses, dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. It is probable, however, that the French planters are of a different opinion; for upwards of four hundred of the plantations of St. Domingo have the necessary apparatus for claying, and actually carry on the system.

Sugar is very soluble in water, and is a good medium for uniting that fluid with oily matters. It is much used for domestic purposes, and appears upon the whole to be a valuable and wholesome article of food, the uses of which are most probably restricted by its high price. This price may in a certain degree arise from the nature of the article, and its original cost; but is no doubt in a great measure owing to the inhuman and wasteful culture by slaves, and the absurd principles of European colonization, duties, draw-backs, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the case with regard to our West-India islands, and their produce.

One very extensive use of sugar and saccharine juices consists in the formation of ardent spirit, an article which, all things considered, is perhaps a curse to society. The wines or beers of pure sugar ferment so rapidly, that they can scarcely be kept, but are for the most part made for immediate use. I do not know of any beer of pure sugar, which is stored and kept for sale; though it is said to enter largely into the composition of porter; and a kind of beer for present use is made by fermenting treacle and water in many country places. See Alcohol; also Acid (Oxalic).

Mr. Haussman says, that when he used nitric acid of 40° to convert sugar into oxalic acid, either of its full strength or diluted with equal parts of water, he constantly obtained a little greasy matter, when he conducted the process in the large way on a vapour bath.

On treating the same sugar three times successively with equal portions of this acid, either concentrated or diluted, the first portion occasions a brown colour, and produces the smell of burnt sugar: and when the action of the nitric acid has ceased, some of this grease is perceived swimming at the top; and it appears to be farther increased by the successive addition of the other two portions of acid, which cause the brown colour and smell of burnt sugar to disappear, forming a great abundance of oxalic acid, and a small quantity of the malic and citric acids. He adds, that, perhaps, if the gasses were collected, we should find a little acetic acid also.

To satisfy himself whether the sugar gave rise to the formation of the grease, he examined one of the largest sized sugar-loaves, which he commonly used. He divided it into two equal portions, the first consisting of the outer part of the loaf, the second of the inner. Each of these portions he boiled for a few minutes in three times its weight of water. No grease swam on either of these solutions of sugar, after they were cold; but as they were not very clear, he began to suspect, that, the sirup for common sugar being clarified with bullocks' blood by the sugar-bakers, the gelatinous part of this animal substance unites in some measure with the particles of sugar by a forced and confused crystallization, and when acted upon by nitric acid may give rise to the separation of grease. He was not long before he satisfied himself, that his suspicion was just; for, on making oxalic acid with some fine white sugar-candy, and at the same time with the finest loaf-sugar he could procure, neither of these showed any signs of grease

It appears, that sugar has the property of rendering some of the earths soluble in water. This property was accidentally discovered by Mr. Wm. Ramsay, of Glasgow

Being employed in making experiments on sugar, and happening to put some quicklime into a cold solution of it, he noticed, that it had acquired an uncommon caustic taste.

Uncertain whether sugar dissolved in common lime water might not have the same taste, I prepared a small quantity, and added sugar to it; but the taste of the solution was very little different from that of sugar dissolved in water. On adding diluted sulphuric acid to the former, a copious precipitation of sulphat of lime took place, while the latter scarcely showed any traces of the presence of lime by the same agent.

Hence he concluded, that sugar possesses the property of dissolving a certain proportion of lime; and in order to ascertain its capacity in this respect, the following experiments were made upon this earth, together with barytes, stronites, magnesia, &c.

One pound avoirdupois of common unrefined sugar was dissolved in rain water, and the solution filtered; the specific gravity at the temperature of 50° of Fahrenheit's thermometer was found to be 1040. This solution was used in all the following experiments as a standard, to which the earths were added at first at the temperature of 50°.

A portion of the saccharine solution was taken, quicklime was added to it in superabundance, repeatedly filtered, and fresh portions of the earth given to it, until the solution was evidently saturated; when the specific gravity was found to be

Solution of sugar . .	1020
Increased specific gravity from lime in solution .	40
	1060

Consequently sugar dissolved in water at the temperature of 50° is capable of dissolving one half of its weight of lime.

As most salts combine with greater facility, and in general in larger proportion, by the medium of heat, it was thought, that the action of the sugar on the lime might be increased, and a greater quantity of it dissolved, at a higher temperature. Fresh quicklime was boiled in the solution of sugar. On filtering and cooling the liquid, it was found, that very little of the earth was dissolved. On the addition of dilute sulphuric acid, a slight cloudiness only appeared; but by the addition of oxalic acid to another portion of the liquid, a precipitation of oxalat of lime took place, which was estimated at about twice the quantity of lime that would have been precipitated from common lime-water by the same agent.

The solution of lime in sugar is of a beautiful white-wine colour, and has the smell of fresh slaked quicklime.

It is precipitated from the solution, by the carbonic, citric, tartarous, sulphuric, and oxalic acids; and it is decomposed, by double affinity, by caustic and carbonated potash and soda, the citrat, tartrit, and oxalat of potash, &c.

Having ascertained the quantity of lime that is dissolved in a given quantity of sugar, he next tried it as a solvent of strontia. Two ounces of this earth were taken, and the carbonic acid expelled by dilute nitric acid; the mixture was evaporated to dryness, and then put into a crucible in a red heat, until the nitric acid was decomposed. A portion of the solution of sugar was taken, and the earth added to it in the cold state: the specific gravity was increased to 1060. This solution was boiled on a fresh tion of earth, and the liquid immediately d; for some time it remained of a ite-wine colour, but as the liquid gradually deposited a number of gray-coloured crystals, which are soluble in water, and have the same taste as the saccharine solution of strontia. At the temperature of 50°, the specific gravity of this solution was as under:

Solution of sugar . .	1040
Increased specific gravity from strontia in solution .	40
	1080

Consequently an equal weight of strontia with the sugar employed, is capable of being dissolved at the temperature of 212°, and of being retained in solution by the sugar at 50° of Fahrenheit. On exposing the crystals, which had fallen down during the cooling of the liquid, to the air of the atmosphere, they attracted carbonic acid, and effloresced.

The solution of strontia in sugar is of a fine white-wine colour, and like that of lime has a peculiar caustic smell. This earth is precipitated by caustic and carbonated potash and soda; also by the carbonic, citric, tartarous, sulphuric, and oxalic acids: and it is decomposed, by compound affinity, by the carbonats of potash and soda; also by the citrat, tartrit, and oxalat of potash.

Judging from the greater solubility of strontia when compared with lime in the saccharine solution, that this might proceed from its superior affinity for this substance; it was thought, that a greater proportion of barytes would be dissolved than of either of the former earths. Two ounces of the carbonat of barytes were taken, and treated in the same manner as had been narrated in the preparation of the strontian earth, by expelling the carbonic acid by dilute nitric acid, evaporating to dryness, and then igniting the mixture until the nitric acid was destroyed. The prepared earth was put into the saccharine solution in the cold state, and frequently agitated: the liquid assumed a dull greenish appearance, and the smell of carbonated hidrogen gas was sensibly felt. After twenty-four hours rest the solution had lost its green colour, and was of the same colour as the original solution of sugar; and a black matter was found precipitated to the bottom of the glass jar. On trying the specific gravity of the solution it was not increased. The liquid was taken and boiled on a fresh portion of the barytic earth, then filtered; on being cooled to the temperature of 50°, the specific gravity was

Solution of sugar .	1040
Barytes in solution .	6
	1046

From the result of this experiment being so very different from those preceding it on lime and strontia, I supposed that some change had taken place either in the sugar or barytes: the experiment was therefore repeated several times, but always with the same result. The barytic earth, which was left on the filtering paper, was put into dilute nitric acid, and a violent disengagement of carbonic acid gas took place, although the whole of this gas was apparently expelled before the earth was introduced into the saccharine solution. The same portion of earth was treated in the same manner thrice, and on expelling the carbonic acid and introducing it into the saccharine liquor, the specific gravity was not farther increased: the liquid always assumed the greenish appearance before noticed, and when in this state carbonated hidrogen gas was evidently disengaged, and a black flocculent matter always subsided before the liquid became transparent.

From these appearances one would be almost ready to conclude, that barytes, by its superior affinity with the carbon of the sugar, is capable of decomposing it; that part of the carbon, in union with the barytes, is precipitated along with the earth in its carbonated state; and that the oxigen of the sugar, being set at liberty, unites with the hidrogen and another portion of the carbon, and is disengaged in the state of carbonated hidrogen gas. But as I cannot say that the earth and the nitric acid were in a state of absolute purity, on this account I dare not trust entirely to this explanation, and only state what took place during the course of making these experiments.

I next tried the power of the solution of sugar on magnesia. One half ounce of this earth calcined was added to the saccharine solution in the cold state, without the specific gravity being perceptibly increased: the mixture was then boiled, when on filtering and cooling the liquid to 50°, the specific gravity was

Solution of sugar .	1040·000
Magnesia in solution .	3·050
	1043·050

The solution of magnesia, like those of lime and strontia, was of a pure white colour, and had no sensible variation in smell or taste from the common solution of sugar; farther than that the sweet seemed much improved, and was softer and more agreeable to the palate, as if it were entirely freed from the earthy taste, which unrefined sugar frequently has. On its remaining at rest for some months in a bottle well corked, the magnesia appears to be entirely separated.

Very little alumine is dissolved by a solution of sugar, when fresh precipitated earth is presented to it either in the cold or hot state. Neither does it seem capable of holding it in solution, when sulphat of alumine is decomposed by saccharit of lime in the way of double decomposition: both the lime and alumine are precipitated together. But when fresh precipitated earth of alum is boiled for some time in the saccharine solution, it seems capable of attracting the colouring matter of the sugar, and the liquid, when the earth has precipitated, is in a purer state than before. Perhaps with certain modifications this agent might be of service in the refining of sugar.

The union of sugar with the alkalis has been long known; but this is rendered more strikingly evident, by carbonated potash or soda, for instance, decomposing the solutions of lime and strontia in sugar by double affinity.

In making solutions of unrefined sugar for culinary purposes, a gray-coloured substance is found frequently precipitated. It is probable, that this proceeds from a superabundance of lime, which has been used in clarifying the juice of the sugar-cane at the plantations abroad. Sugar with this imperfection is known among the refiners of this article by the name of *weak*. And it is justly termed so, the precipitated matter being nothing but lime which has attracted carbonic acid from the sugar (of which there is a great probability) or from the air of the atmosphere. A bottle in which I had kept a solution of lime in sugar for at least four years closely corked, was entirely encrusted with a yellowish-coloured matter, which on examination was found to be entirely carbonat of lime.

SUGAR OF LEAD. See LEAD.

SUGAR OF MILK. See MILK.

SULPHUR, or brimstone, is a well known, hard, brittle, inflammable substance, of an opake yellow colour. It is found more or less pure in the neighbourhood of volcanoes; where most probably it is always expelled from some previous state of combination, by the heat of subterraneous fires. It is a very common ingredient in a great variety of minerals and ores; but it is extracted for sale chiefly from a stone called pyrites.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distil in vessels, which must be close to prevent its burning.

Sulphur is extracted from pyrites at a work at Schwartzemberg, in Saxony, in the high country of the mines, and in Bohemia, at a place called Alten-Sattel.

The furnaces employed for this operation are described by Macquer. They are oblong, like vaulted galleries; and in the vaulted roofs are made several openings. These are called furnaces for extracting sulphur.

In these furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the size of small nuts. Each of these tubes contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a star, at the place where it begins to be-is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place. From this residuum, which is called burnings of sulphur, sulphat of iron is extracted. See Acid (Sulphuric).

The eleven tubes into which are put, at three several distillations, in all nine quintals, or nine hundred pounds of pyrites, yield from one hundred to one hundred and fifty pounds of crude sulphur, which is so impure as to require to be purified by a second distillation.

This purification of crude sulphur is also done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the forerunner. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated as soon as the sulphur begins to distil. At three o'clock in the morning, the wooden pegs, which stop the lower holes of the forerunners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it would also be of a gray colour, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech-tree, which have been previously dipped in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called roll-brimstone.

As sulphur exists not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the large way from the different ores which

of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expel it. This operation is called torrefaction, or roasting of ores. See Ores.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of Ramelsberg, in the county of Hartz.

This ore, which is of lead containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher, so that the whole mass shall be a quadrangular pyramid truncated above, the base of which is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the centre of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladlefulls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for this purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes or hollows are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur, to be purified in the manner above related.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain have not fallen, or if the operation have not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur is burnt and consumed, from ten to twenty quintals of crude sulphur are by this method collected.

The sulphur of this ore, like that of most others, was formerly neglected, till in the year 1570 a person employed in the mines, called Christopher Sauder, discovered the method of collecting it, nearly as it is done at present.

Metallic minerals are not the only substances from which sulphur is extracted; this matter is diffused in the earth in such quantities, that the metals cannot absorb it all. Some sulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanoes, in caverns, and in mineral waters. Such are the opake kind, called virgin-sulphur; the transparent kind, called sulphur of Quito; and the native flowers of sulphur, as those of the waters of Aix-la-Chapelle. It is also found mixed with different earths. Here we may observe, that all those kinds of sulphur which are not mineralized by metallic substances, are found near volcanoes, or hot mineral waters, and consequently in places where nature seems to have formed great subterranean laboratories, in which sulphureous minerals may be analysed and decomposed, and the sulphur separated in the manner in which it is done in the small way in our works and laboratories. However this may be, certainly one of the best and most famous sulphur-mines in the world is that called Solfatara. The Abbé Nollet has published, in the Memoirs of the Academy, some interesting observations upon this subject, of which Macquer gives the following abridgment:

Near Puzzoli, in Italy, is that great and famous mine of sulphur and alum, called at present Solfatara. It is a small oval plain, the greatest diameter of which is about 400 yards, raised about 300 yards above the level of the sea. It is surrounded by high hills and great rocks, which fall to pieces, and the fragments of which form very steep banks. Almost all the ground is bare and white, like marl; and is every where sensibly warmer than the atmosphere in the greatest heat of summer; so that the feet of persons walking there are burnt through their shoes. It is impossible not to observe the sulphur there; for every where may be perceived by the smell a sulphureous vapour, which rises to a considerable height, and gives reason to believe, that there is a subterraneous fire below, from which that vapour proceeds.

Near the middle of this field there is a kind of basin three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, the waters of which seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapours rising from the bottom of the lake, which, being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapours are exhaled. Persons who have the itch come to these pits, and receive the vapours, in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured, which yields sulphur. From these cavities vapours exhale, and issue out with noise, which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapours may be evidently seen to rise twenty-five or thirty feet from the surface of the earth.

These vapours, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, supported by a wall behind, open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow colour; but the workmen say they have lost their strength, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground.

These last-mentioned stones are broken into lumps, and put into pots of earthen ware, containing each about twenty quarts. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the centre of each pot is in the centre of the thickness of the wall, and one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls which form the two sides of the furnace. Betwixt these walls there is a space of fifteen or eighteen inches; which space is covered by a vault resting on the two walls. The whole forms a furnace seven feet long, two feet and a half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter, and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base of fifteen or eighteen

Four or five of these furnaces are built under one shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuums may be more easily taken out.

The fire, being kindled in the furnace, heats the first pots containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pot, whence it passes through the pipe of communication into the external vessel. There the vapours are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel is that of a truncated cone, the narrower end of which is placed below; and because the hoops of the tub are so fastened, that they may be occasionally loosened. The mass of sulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and cast into rolls, as we receive it.

For accurate purposes, sublimation is necessary to deprive sulphur of the accidental impurities it may contain. This may be done in an earthen cucurbit set on a sand-bath, with a head properly adapted. The sulphur rises by a very gentle heat, little more than is sufficient to melt it; and the fine sublimate thus obtained is called flowers of brimstone or of sulphur.

Water has no immediate action on sulphur. It is said, however, to soften the outside by long contact with it; and if sulphur be heated nearly to such a degree as to set it on fire, and then poured into water, it becomes soft, and partly transparent. In process of time it recovers its original hardness and opacity. If steam of water be passed over sulphur contained in a heated earthen tube, hidrogen is extricated, and comes out at the end of the tube. The experiment is troublesome, on account of the sulphur subliming.

Sulphur is soluble in alcohol. An ounce digested over a gentle fire for twelve hours with two drachms of flowers of sulphur took up 23 grains. A similar mixture being exposed a month to the rays of the sun, 16 grains were dissolved; while another being kept a like time in a dark place, only 13 grains were taken up. The alcohol must be very highly rectified, otherwise the proportions dissolved are much less.

Sulphuric ether by long digestion takes up about one thirteenth of its weight in the light, and only a seventeenth in the dark.

The combinations of sulphur with earths or alkalis were formerly called hepars, or livers of sulphur, from their colour; a name which has been changed for that of sulphurets. There is no perceptible action between sulphur and silex. Alumine has very little action upon it in the direct way; but the lime will be sufficient to produce the combination. On addition of more water it becomes reddish, and emits a fœtid smell of rotten eggs, which is common to all the sulphurets. The more caustic the lime, the deeper the colour of the sulphuret. The pure fixed alkalis decompose sulphuret of lime, by virtue of their stronger affinity to the sulphur; and any acid whatever decomposes it, by attracting the lime, the sulphur at the same time falling to the bottom in the form of a subtile white powder, formerly called magistery of sulphur.

Pure barytes boiled in water with sulphur has but little action upon it; but in the dry way, when sulphat of barytes is strongly heated in a crucible with charcoal, a coherent mass is formed, which is soluble in water, with the smell and other characters of a sulphuret.

If a small quantity of magnesia, and an equal quantity of flowers of sulphur, be enclosed in a vessel perfectly filled up with distilled water, and well stopped, and then exposed to heat by immersion in boiling water for several hours, a combination will take place; and the water will contain a sulphuret of magnesia.

The fixed alkalis combine very readily with sulphur, either in the moist or dry way, whether they be in a caustic state, or combined with carbonic acid; though more strongly in the former than the latter case. If a solution of fixed alkali in water be boiled with half its weight of powdered sulphur, a combination takes place, and a sulphuret is formed. Or if equal parts of dry alkali and powdered sulphur be melted in a crucible, and poured out on a flat polished stone, as soon as the fusion is complete the combination will be of a liver colour, and is the solid sulphuret. If it be made with a caustic alkali, its colour is deeper, and its characteristic properties more intense, than when a mild alkali is used. A solution of the solid sulphuret in water forms precisely the same substance as the preparation made in the moist way.

The peculiar fœtid smell of the solid sulphuret when moistened, or of its solution, is produced by the emission of a permanently elastic fluid, called sulphuretted hidrogen. See the article Gas.

All the sulphurets are decomposable by acids, which precipitate the sulphur in a white powder, formerly called milk of sulphur. This, according to Dr. Thomson, is a compound of sulphur and water, which may be rendered yellow like the sublimed sulphur, by expelling its water by means of heat.

The modes of separating the sulphur from the native sulphurets of different metals have already been given, either under the metals themselves or the article Ores; but gineer of mines, since that part of this Dictionary was printed off, I shall avail myself of this opportunity of introducing his observations.

Among the great number of metallic sulphurets, with which nature presents us, the decomposition of many is of much importance in the arts. The sulphurets of iron, copper, lead, and mercury, and some others, give rise to metallurgical processes, that particularly claim the attention of those, who are addicted to the study of chemistry. The nature and properties of these have been well known, since chemistry has made them an object of her labours: but as the facts collected in laboratories have never been carefully compared with those that extensive works furnish, though we are well aware, that this would be the best way of attaining useful results, the theory of the various operations to which sulphurets are subjected has not yet been improved by the progress of that science. My object is to supply this defect; and to accomplish it I have collected a great many experiments and observations that have been long known: I have added some researches of my own; and from their examination I have deduced consequences, that must make some alteration in the ideas generally entertained respecting the treatment of metallic sulphurets.

Section I.

Of the Action of Heat on metallic Sulphurets.

The action of heat on metallic sulphurets requires first to be examined, because it occurs in all the processes employed for their decomposition. To appreciate this with accuracy, I have chosen experiments and observations in which this action is completely distinct, which it is of importance to remark; for it is owing to not having analysed the effects produced by various causes, that metallurgists have ascribed to caloric alone a desulphurating power, which it does not appear to me to possess in any very high degree.

The sulphurets of mercury and arsenic are volatilized in close vessels, when exposed to a temperature a little elevated. The sublimed sulphuret has frequently a different colour from that which has not been sublimed; and the experiments of Proust and Thenard demonstrate, that this change is the consequence of an alteration in the proportions of the elements of the compound.

The native sulphuret of iron experiences but a partial decomposition by means of caloric. By distillation in a retort, we cannot extract half the sulphur it contains. In Saxony, the distillation of pyrites in the large way never yields more than 13 or 14 per cent of their weight of sulphur. come to my knowledge were made at no very high temperature, I put into a crucible lined with charcoal some powdered pyrites, covered it with charcoal powder, and exposed it for an hour to the heat of a forge. The result was a mass still retaining all the characters of pyrites. It appeared to have been completely melted, and retains two thirds of the sulphur originally belonging to it. This experiment, having been repeated, left me no doubt of the effects of heat alone on sulphuret of iron; and I think I may conclude from it, that, whatever may be the temperature, only a partial decomposition can be produced by it.

On sulphuretted copper and pyritous copper, heat produces effects analogous to those observed with iron. The distillation of pyritous copper afforded me but very little sulphur. These two ores, however, may be considered as mixtures of the sulphurets of copper and of iron, and the sulphur separated by heat comes from that of iron almost wholly.

The sulphuret of lead, or galena, is one of those minerals, the treatment of which is most varied. All chemists agree in considering it as a compound of sulphur and lead only, in the proportion of 15 parts sulphur to 85 of lead. I was the more careful in observing the effects of caloric on galena, as in separating the sulphur by its means I might hope to obtain metallic lead, the weight and fusibility of which would render its union very easy. I could likewise, without difficulty, exclude the air in the process.

Into a retort I put 30 grammes (463 grains) of powdered galena, which I heated for two hours so gently as not to agglutinate it. Only a little sulphurous acid produced by the action of the air of the vessels was evolved, and I perceived no sulphur sublime in the neck of the retort. I then increased the fire, and kept it thus two hours more, till both the galena and the retort experienced a commencement of fusion. The sulphur volatilized in this second stage of the operation was so little, that I could not detach it from the vessel and weigh it. The residuum had the metallic brilliancy, was agglutinated, and did not contain an atom of ductile lead.

As the heat in this experiment was not very great, I subjected to a forge fire some powdered galena in a crucible lined and covered with charcoal powder. The result was a mass that had been well fused, and resembled what metallurgists call lead matt. There was in it no lead united together, but some parts of the button were merely a little ductile. By analysis I found, that about three fifths of the sulphur still remained. Part of the loss it had experienced by the action of the fire, which was 27 per cent, I ascribed to the volatilization of a portion of the sulphuret; for that owing to the separation of the sulphur could not have exceeded 6 per cent at most.

Galena then is but very imperfectly decomposed by heat.

I shall not speak particularly of the sulphurets of zinc, antimony, &c., because I am not acquainted with any experiments sufficient to determine with certainty the effects that heat produces on them; but I am led to believe, from analogy, that it does not decompose them completely.

All the facts I have adduced appear to me to evince, that the action of caloric alone on metallic sulphurets, and particularly on those of iron, copper, and lead, is limited to the taking from them a small portion of the sulphur contained, and afterward fusing and even volatilizing them.

SECTION II.

Of the simultaneous Action of Heat and Air on metallic Sulphurets.

That metallurgical process, the object of which is the desulphuration of metals, is known by the name of roasting. Most authors, who have treated of it, seem to consider caloric as the sole agent in the decomposition; and even those who have remarked the influence of the air, since the establishment of the new chemical theory, have not considered it as essential. The experiments I have collected having shown the insufficiency of heat alone to decompose a metallic sulphuret, the oxigen of the air must be considered as having a greater share in the desulphuration of metals by roasting. The affinities both of sulphur and metallic substances for this principle render it very probable; and it is likewise proved by the chemical examination of the products of all roastings, as well as by the manner in which the process is conducted. In the roasting of sulphurets, instead of seeing the volatilization of the sulphur effected by a moderate and long-continued heat, we find a sulphuret decomposed by the simultaneous action of caloric and air: and the acknowledged necessity of not fusing the ore, instead of arising from the fear of communicating to it by liquefaction a cohesive force capable of resisting the separation of the sulphur, will be ascribed more simply to this circumstance, that such a state will confine the action of the air to a surface that cannot be renewed, and will soon be covered with a metallic oxide. The combination of oxigen with the elements of sulphurets gives rise to oxides and acids, the affinities of which have great influence on the separation of the sulphur, and the results of roasting; which are commonly a mixture of an oxide, a sulphat, and undecomposed sulphuret. I shall now examine more particularly and separately the roasting of several kinds of sulphurets, because the nature of the metal greatly modifies the results; and I shall afterward point out how the sulphur is separated, and in what form.

Roasting of Copper Pyrites.

Pieces of pyritous copper are laid on billets of wood in the most convenient manner for the combustion to continue a long time. The first heat separates part of the sulphur, which is in some degree sublimed, and may be collected; but afterward it becomes the combustible, that serves by burning to continue the operation; and sulphurous acid is disengaged, the elasticity of which, being augmented by the increase of temperature, prevents its combination with the metallic oxides. The sulphuric acid, that is formed notwithstanding the care taken to moderate the combustion, unites with the oxides of iron and copper, but the sulphat of iron is in part decomposed by the superoxidation of the metal.

Iron pyrites subjected to the same operation will undergo similar decompositions in the same order.

The roasting of cupreous pyrites in the reverberatory furnace gives rise to the same phænomena, and might be supposed to allow a much more complete separation of the sulphur than that conducted in the open air. If it do not, this no doubt is owing to the difficulty of preventing the agglutination of the sulphuret produced by the elevation of temperature arising from the rapid and unavoidable combustion of a large quantity of sulphur.

It remains for me to speak of a furnace, in which both the smelting and roasting of the pyritous copper, to a certain point, are effected at the same time. It is used at Fahlun in Sweden. This has an interior crucible, which receives the product of a smelting of 24 or 48 hours, and in which a separation, or rather combustion, of the sulphur is effected. A stream of air from the bellows is made to blow on the melted mass with such force, as to drive off the scoriæ, and burn a part of the sulphur that is found on the surface. The iron is thus oxided, and quartz is added to vitrify it in proportion as the roasting goes on. This process is perhaps the only one, in which sulphur and iron are separated in so large a quantity at the same time.

The desulphuration of pyritous copper by roasting appears to me to be effected, 1st, By the sublimation of a small portion of sulphur, which may either be collected, or burned in the air: 2dly, By the disengagement of sulphurous acid, which is the more abundant in proportion as the process is well managed: 3dly, By the vaporization of a little sulphuric acid, the greater part of which, however, remains united with the copper.

Roasting of Galena.

Galena is very difficult to desulphurate completely by roasting. The affinity of its component parts for oxigen, it is true, renders their separation sufficiently speedy; but that of the new compounds, sulphuric acid and oxide of lead, gives rise to a new combination, which retains the sulphur, and thus forms an obstacle to the desulphuration. To this affinity of the oxide of lead for sulphuric acid must be ascribed the facility with which this acid is formed in the roasting of galena.

I shall analyse in detail the various processes, to which this important decomposition has given birth, because I conceive I can account for the numerous and complicated phænomena they exhibit.

Whatever care be taken to roast galena in a roasting test, it is impossible to convert the whole of the sulphur into sulphurous acid, and avoid the formation of sulphuric. The result always exhibits a mixture of oxide and sulphat of lead.

In roastings in the large way, on hearths prepared for the purpose, the proportion of sulphat of lead is still more considerable, being in the ratio of the temperature, and the facility with which the air pervades the ore. Numerous analyses made in the School of Mines lead me to believe, that the roasted ore of the mines at Pezey contains from a third to half its weight of sulphat of lead; whence it follows, that, even supposing the whole of the galena to have been decomposed, the roasting has not separated half the sulphur it contained.

The reverberatory furnace is employed with great success to roast ores of sulphuretted lead. In some works indeed, as at Poullaouen, such a complete separation of the sulphur is accomplished in this furnace, that, when the roasting is judged to be finished, nothing more than the addition of charcoal is requisite, to obtain directly a large quantity of metallic lead. It cannot be doubted, however, but a great deal of sulphat of lead is formed, which, as we have seen, is a necessary result of the action of air on galena subjected to a high temperature: besides, the chimneys of the furnaces are filled with it. The decomposition of this sulphat by the charcoal produces a sulphuret, or lead matt, and though sulphurous acid may be evolved, it is very difficult to explain how the addition of charcoal causes the lead to flow immediately in considerable quantity. I have imagined that the sulphat of lead was decomposed during the roasting; and that after this operation nothing remained but an oxide very little mixed: and I think I have found the cause of this decomposition in the action of the galena still undecomposed on the sulphat formed. The following experiments will make known the nature and result of this action:

Into a retort I put a mixture of one part of powdered sulphuret of lead and three of sulphat; which at first I heated slowly. When the retort was redhot, a pretty considerable quantity of sulphurous acid gas was evolved; and this continued for an hour, at the expiration of which the retort began to melt. The residuum had been fused, and was found to be a mixture of oxide and sulphat of lead. I satisfied myself, that the sulphurous acid, which had been received into water, was not mixed with any sulphuric.

This experiment proves the possibility of the decomposition of the sulphat of lead by the sulphuret; or rather that of the sulphuric acid it contains by the sulphur and lead of the galena. The sulphurous acid arises no doubt equally from the oxigenation of the sulphur, and the semidecomposition of the acid; for I convinced myself, that the residuum contains no sulphat. I repeated the process with equal parts of galena in sulphat, when the evolution of sulphurous acid was still more abundant, and what remained in the retort was a mixture of oxide and sulphuret. Hence I concluded, that, if the proportion of sulphuret of lead were too small in the former experiment, it was too large in this. I made also an attempt to ascertain more nearly the proportions that would exactly effect the mutual decomposition; and at the same time I endeavoured to satisfy myself of the oxidation of the lead contained in the galena in the metallic state.

With this view I put 14 gram. of sulphat and 8 of sulphuret, well mixed together, into a crucible, not lined, which I suffered to grow redhot undisturbed. I observed that a considerable ebullition took place, occasioned by the evolution of sulphurous acid; and I did not withdraw the crucible till the matter was in quiet fusion. When cold I found two distinct substances; one, which was at the bottom, consisted entirely of sulphuret of lead, that had been fused, without any mixture of ductile lead; the other exhibited all the characters of the oxide called glass of lead, and was a compound of oxide and silex from the crucible, without any indication of sulphat of lead.

This experiment convinced me, that the lead of the galena had been oxided at the expense of the sulphuric acid: but it did not show the quantity of galena necessary for the complete decomposition of the sulphat. I believe, however, that the proportion of one part of galena to two of sulphat will be very near the mark; and besides, it differs little from what a calculation of their component parts would indicate.

The following are the natural consequences of these facts: 1. Galena and sulphat of lead mutually decompose each other at a high heat. 2. This decomposition gives rise to the formation and evolution of a large quantity of sulphurous acid, and consequently to the separation of a considerable and galena.

The application of these consequences to the roasting of sulphuret of lead in the reverberatory furnace is easy. I shall explain the theory of this process in the manner in which I conceive it. The powdered galena, or washed ore of lead, spread on the bottom of the furnace to the thickness of a few inches, the upper part of which is exposed to the action of the air, gives rise to the phænomena we have observed in ordinary roastings. The heat vaporises a little sulphur: the air converts part of that on which it acts into sulphurous acid which is evolved, and another more considerable into sulphuric acid, which combines with the lead oxided at the same time The ore is stirred: the sulphate of lead mixes with that which is not decomposed, and their mutual decomposition produces sulphurous acid: the fresh surface reproduces sulphate, which serves to occasion a fresh extrication of gas, and thus to continue the desulphuration, which is limited only by the complete decomposition of the galena. If the process have been well managed, and too much sulphat of lead has not been formed, the result of the roasting will be almost pure oxide of lead: if the contrary, some sulphat may remain, which the charcoal will reduce to the state of sulphuret, and the decomposition of which will be effected in the same way as that of so much galena. Hence we may learn the importance of not fusing the sulphuret of lead subjected to the process of roasting; for the action of the air on the fused ore would soon be rendered null by the formation of oxide of lead which would cover it; and as the sulphat of lead could no longer mix with the galena, there would be no way of desulphurating it.

The roasting of galena in the reverberatory furnace then is reduced to the conversion of the sulphur it contains into sulphurous acid; and as this is in great measure effected by the intervention of the sulphat of lead, which is continually forming, it admits a more complete desulphuration than other processes.

A similar decomposition of the sulphuret of lead by the sulphat appears to me also to take place in the treatment of lead ores in the Scotch furnace. In Scotland galena is roasted and smelted in an uninterrupted process by means of coal and turf.

The same furnace is employed with success at Pezey for fusing roasted galena containing at least one third of its weight of sulphat of lead. Its final result gives no matts; which proves, that it permits the decomposition of the sulphat, and the separation of the sulphur it contains. I conceive, that the action of the part reduced

Some furnaces have been mentioned, as that of Fahlun and the Scotch, in which metallic sulphurets undergo a real roasting; but there are others in which this effect is scarcely sensible. Some reflections on their differences in this respect will probably not be out of place here; and they will be the more interesting, as they are intimately connected with our subject, and account for phænomena, which are inexplicable according to the idea generally entertained of roasting.

It is a fact well known in smelting-houses, that the highest furnaces are least favourable to desulphuration, or in the language of metallurgists produce the most matts. If an indisputable proof of this were required, I need only say, that at Pezey I have seen roasted lead ores containing a great deal of sulphat of lead, which smelted in the Scotch furnace yielded not matts as the ultimate result, but produced a large quantity in the *fourneau à manche* (a kind of high furnace).

If heat alone could easily and completely decompose metallic sulphurets, the upper part of high furnaces would be well adapted to the roasting of ores; for, beside that the temperature there is not too great, the air that comes thither, being deprived of part of its oxigen, scarcely forms any of those sulphats, that oppose the separation of the sulphur. But the fact is the reverse of this; which is to me an additional proof of the little effect of the action of caloric alone on these substances. The sulphur is separated from the sulphurets, and has been seen in the state of sulphurous acid, and oxigen is indispensable to its formation. In furnaces of no great height the air that comes into contact with the fresh charge of ore still contains a great deal of oxigen, and the sulphurous acid formed is soon withdrawn from the disoxiding action of the charcoal: but if a small portion be decomposed, a fresh sulphuret is formed, which is afterward roasted in the same manner as the ore. In the Scotch furnace for instance, when any matts flow from it, they are immediately thrown into the furnace again, and what escaped decomposition in the first process is decomposed in a second. In high furnaces, on the contrary, the ore placed in the upper part undergoes a very incomplete desulphuration, because the air coming into contact with it contains but very little free oxigen; the sulphurous acid formed in the interior is far the greater part decomposed in traversing all the height of the furnace filled with coals, and a sulphuret is recomposed; this by its gravity tends to descend into the basin, which it does not reach till after a succession of decompositions; and the consequence must be a considerable loss of metal, as in fact is observed.

All these facts together seem to me to place it beyond doubt, that the decomposition of metallic sulphurets in roasting is produced by the oxigenation of their component parts, and the sulphur is separated more or less completely in the state of sulphurous acid.

SECTON III.

Desulphuration of Metals independently of the Action of the Air.

The various affinities of sulphur for different mineral substances afford means of decomposing certain sulphurets, and metallurgists have already availed themselves of several with success. In order that the decomposition of a metallic sulphuret by any mineral may constitute the basis of a metallurgical process, it is not sufficient, that the affinity of this mineral for sulphur be greater than that of the metal: it is farther necessary, besides the conditions œconomy requires, that several others indispensable to the success of the process be satisfied, which greatly diminishes the number of agents indicated by chemistry. For example, if the sulphuret resulting from the decomposition be infusible, or nearly so; or if it have the property of combining with the metal to be separated, or with the sulphuret yet undecomposed; it is obvious, that the object sought, which is the separation of the metal, will not be obtained. Hitherto scarcely any thing but lime and iron has been employed.

Desulphuration of Mercury.

The sulphuret of mercury is easily decomposed. It is sufficient to present to the sulphur a substance capable of retaining it, and the mercury may be volatilized alone. Thus iron and lime are employed singly or conjointly in the treatment of cinnabarine ores.

Desulphuration of Copper.

Copper pyrites are smelted in some works with lime, either in the *fourneau à manche*, or the reverberatory furnace; but this process is not sufficiently known in detail, to enable us to judge of the efficacy of this agent.

I had thought with some metallurgists, that the acknowledged greater affinity of iron than of copper for sulphur might occasion the decomposition of sulphuret of copper by this metal, at least in some cases: but the experiments I am about to give induced me to relinquish this opinion.

1st *Exp.* I mixed 10 gram. (155 grs.) of pyritous copper, the composition of which I knew, with 4·3 gram. (66 grs.) of iron filings; put the mixture into a crucible; covered it with charcoal powder; and heated it in a forge fire three quarters of an hour. The proportion of iron was calculated so as to be sufficient for taking up all the sulphur combined with the copper in the ore employed. In the crucible I found a perfectly homogeneous mass, weighing 13·1 gram. (202 grs.), which did not contain the least globule of metallic copper, or any sign of separation between the sulphuret of iron and that of copper*.

2d *Exp.* Another trial was made with 10 gram. (155 grs.) of pyritous copper and 5 gram. (77 grs.) of the same mineral roasted, which is nearly the state of the product when the ore or matts have not been completely desulphurated. The proportion of iron was still insufficient to separate any copper, of which there was abundance in the mixture. I heated it three quarters of an hour, and found, as in the preceding experiment, a homogeneous mass, without any sign of metallic copper, or pure sulphuret of copper: it was a true copper matt.

3d *Exp.* Equal parts of crude and roasted copper pyrites were mixed, moistened with olive oil, and heated strongly for half an hour in a crucible lined with charcoal. The product was nothing but a powder, that had not undergone any fusion, no doubt owing to the superabundance of iron.

These few trials I conceive are sufficient to prove, that the desulphuration of copper by means of iron will always be very difficult to effect, because a triple compound of sulphur, iron, and copper, is formed, or a combination takes place between the sulphurets of copper and iron, which obstructs the separation of the copper.

Desulphuration of Galena.

Galena is one of those sulphurets in which this decomposition is most readily effected. The fusibility of lead, which facilitates the union of its particles, as well as the little affinity it has for sulphur, are the causes of the success of the attempts of this kind. Lime and iron are employed in different circumstances for the desulphuration of galena. The use of lime is not very general, and it is impossible to judge of its effects from what is known of the properties of sulphuret of lime. The treatment of galena by malleable or cast iron in small pieces is more in use, and appears very advantageous.

At the School of Mines of Montblanc a great many experiments have been made on the desulphuration of galena by iron, the results of which were of sufficient importance to render the publication of them desirable.

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* In the decomposition of galena by iron, when the latter is in too small quantity, three distinct substances may be observed: lead, sulphuret of lead, and lastly sulphuret of iron at the upper part.

The present paper contains several facts applicable to the art of metallurgy, and capable of suggesting different experiments to those who cultivate it. I have not pointed out any, because they will readily suggest themselves to those, who are capable of conducting them.

All the experimental researches here given were made in the laboratory of the Council of Mines, and under the eye of Mr. Descotils, whose advice was of great advantage to me, in giving them that accuracy, which he is accustomed to observe even in the least operations.

Sulphur is capable of combining with carbon. Some years ago prof. Lampadius, distilling some substances in which charcoal and sulphur were contained, obtained a liquid of a penetrating smell; highly volatile; producing a great degree of cold by its evaporation; boiling at 104°, yet heavier than water, its spec. grav. being 1·3; burning away entirely with a blue flame, and without smoke; abundantly soluble in alcohol, and but very sparingly in water; and dissolving phosphorus readily without the assistance of heat. Its products when burned were sulphuric acid and water. This liquor, which he called sulphur-alcohol, he repeatedly endeavoured in vain to procure again

Clement and Desormes, too, once obtained a similar fluid by chance, but could not succeed in subsequent attempts to form it. Some time after, prof. Lampadius, in distilling pyritized wood, met with this product again, and had an opportunity of noticing the phænomena of its formation.

His general process for obtaining it, consists in exposing pyritized wood, or a mixture of pyrites with common or bituminous wood, fossil wood, or anthracite, to a strong heat, in an earthen retort, connected with an adopter, the extremity of which is immersed in water. A large quantity of sulphuretted hidrogen gas is evolved, except when anthracite is used, with a little empyreumatic oil; and as soon as the retort is at a full red heat, this peculiar product passes over in small drops, that sink to the bottom of the water.

The process given by Clement and Desormes for obtaining their carburetted sulphur is to fill an earthenware tube with charcoal broken small and partly reduced to powder, fix it in a sloping position in a furnace, and lute to the lower end a glass tube the extremity of which is immersed in water. To the upper end is to be luted another glass tube, filled with short cylindrical pieces of sulphur, and closed with a cork, through the centre of which passes a wire, to push the sulphur nearer to the earthen tube when requisite. The earthen tube is to be heated very gradually; and when the gas usually contained in the charcoal is expelled, the sulphur is to be pushed down so far as to melt, but as slowly as possible, and run down among the charcoal. With these precautions an oily liquid will be observed to flow down the lower tube, and drop into the water in the receiver. It is colourless when pure, but has generally a greenish yellow tinge.

This liquid is capable of combining with more sulphur, which renders it deeper coloured, but does not act on charcoal. It unites with the alkalis, and also with oil, depositing a little charcoal. It is partially oxidized by the oxigenized muriatic acid, as it is by the nitric when assisted by heat. When burned it gives out a smell of sulphurous acid, deposits sulphur, and leaves a residuum of charcoal; agreeing in every other respect with the liquid obtained by Lampadius.

Sulphur forms a combination with phosphorus, for the properties of which see PHOSPHORUS.

With fixed oil sulphur unites by boiling in a large proportion, so as to form a balsam of a thick consistence. With the essential oils it unites likewise, but not in so large a quantity. These compounds, which are of a very dark red colour, were formerly called balsams of sulphur, and distinguished by the terms terebinthinated, anisated, &c., from the oil that entered into them.

Dr. Thomson combined oxigenized muriatic acid with sulphur, by passing the gas into a bottle containing it in the state of pure dry flowers. The sulphur soon became moist and doughy, the particles that adhered to the sides trickled down in drops, its colour changed to orange, and at last a fine red liquor made its appearance. This liquor was more than double the weight of the sulphur, though a little had been volatilized during the process. Its spec. grav. was 1·623. Its colour was between scarlet and crimson; but when streaks of it ran down the sides of the phial, they appeared green by transmitted light. Exposed to the air, it fumes at first almost as much as the liquor of Libavius, but the fume gradually diminishes, and at last resembles that of concentrated muriatic acid a little heated.

It is very volatile, disappearing rapidly in a moderate heat. Its smell resembles that of seaweeds, but is much stronger. The eyes exposed to its fumes are soon filled with tears, and acquire the same painful feeling as when exposed to the smoke of wood or peat. Its taste is strongly acid, hot, and bitter, affecting the throat with a painful tickling. It tinges vegetable blues red; but the change takes place slowly, unless the paper be dipped into water; and the paper is corroded if heat be applied. When brought near a phial of ammonia, dense white fumes of muriat of ammonia make their appearance. If it be held above a solution of nitrat of silver, yellow flakes precipitate in abundance.

If a drop of sulphuretted muriatic acid be let fall into a glass of water, the surface is immediately covered with a film of sulphur; and a greenish red globule falls to the bottom, which remains for some time like a drop of oil, but at last is converted into yellow flakes. These flakes have an acid taste, which they do not lose though allowed to remain in water for several days; and continue very ductile, though left exposed to the air.

The sulphuretted muriatic acid dissolves phosphorus cold with great facility. No effervescence takes place; and the solution, which has a fine amber colour, is permanent. On evaporation the phosphorus remains behind with a little sulphur, and at last takes fire. If the solution be mixed with liquid potash, the whole becomes beautifully luminous, and phosphuret of sulphur is precipitated.

If the sulphuretted acid be mixed with alcohol, a violent effervescence is produced, ether is immediately disengaged, and this ether is mixed with sulphurous acid. All the acids decompose it, sulphur usually precipitating, except liquid sulphurous acid, which produces in it no change. The nitrous acid dissolves and decomposes it at the same time. The dry fixed alkalis produce with it a violent effervescence, and a very high degree of heat. When ammoniacal gas is passed through it, the vessel is filled with a fine purple smoke, and the whole becomes solid, and of a deep red colour; but when mixed with water sulphur is immediately precipitated. It precipitates silver of a yellow colour mixed with white. The white is muriat of silver: the yellow is a compound of the oxides of silver and of sulphur, which becomes brown when dry, and is decomposed by the nitric acid, this acid dissolving the silver and acidifying the sulphur.

Sulphur forms with oxygen two different acids, the sulphuric and sulphurous, for which see Acid. The French chemists, too, speak of an oxide of sulphur, but the existence of such a compound is very questionable. If, when sulphur is in perfect fusion, the heat be increased, instead of remaining so, or becoming thinner till it rises in vapour, it begins to thicken again at 320°, and continues to do so from this point to 530° or 550°, at which temperature copious fumes arise. This thickening has been ascribed to oxigen: but the fluidity returns if the heat be lowered, which certainly would not abstract the oxigen; and thus it may be rendered alternately fluid and viscid any number of times, without any other circumstance than merely diminishing and augmenting the heat. This result, too, as Dr. Irvine observes, is not affected by the free or difficult access of air to it. The thickening does not appear to be attended with contraction; for on cooling the sulphur from the temperature of 400° it continues to contract till it reaches 226°, when in congealing it expands considerably.

If this viscid matter, which is of a dark reddish colour, and has somewhat of a pitchy appearance, be poured into water, it remains for a while soft and tough, and when solid retains a certain degree of tenacity. It is with this sulphur casts are made. —*Journ. de Phys.—Ann. de Chim.—Nich. Journ.—Van Mons's Journ.—Murray's Chem.*

Sulphuret. A compound of sulphur with some other substance, as alkalis, earths, metals, &c., in which the sulphur is not in the acid state. *See the preceding article.*

Sulphuret (Hidroguretted). A name given by Mr. Chenevix to those sulphurets which are formed by the compound of sulphur and hidrogen, in which sulphur predominates; those which are formed by a compound in which the hidrogen is in its full proportion being denominated by him *sulphuretted hidrogurets.*

Sulphuretted Hidrogen Gas. See the article Gas (Hidrogen, Sulphuretted). It is the same as what was formerly called hepatic air.

Sulphuric Acid. The vitriolic acid of the old chemists. See Acid (Sulphuric).

Sulphurous Acid. The volatile or phlogisticated vitriolic acid of old chemists. See Acid (Sulphurous).

Sumach. Common sumach (rhus coriaria) is a shrub that grows naturally in Syria, Palestine, Spain, and Portugal; in the two last it is cultivated with great care: its shoots are cut down every year quite to the root; and, after being dried, they are reduced to powder by a mill, and thus prepared for the purposes of dyeing and tanning. The sumach cultivated in the neighbourhood of Montpellier is called rédoul or roudou.

The infusion of sumach, which is of a greenish fawn colour, soon becomes brown by exposure to the air: a solution of potash produces but little change on it while recent; acids brighten its colour, and turn it yellow; solution of alum renders it turbid, and produces in it a small quantity of yellow precipitate; the liquor remains yellow.

Acetat of lead produced immediately a considerable quantity of yellowish precipitate, the surface of which was brown; the liquor remained of a clear yellow.

Sulphat of copper produced a copious precipitate of a yellowish green, which after some hours changed to a brownish green; the liquor remained clear and slightly yellow

Common sulphat of zinc rendered the liquor turbid, darkened its colour, and produced a deep blue precipitate.

Pure sulphat of zinc did not deepen the colour nearly so much; only a small quantity of a brownish fawn-coloured precipitate was produced.

Sea salt at first produced no sensible change; but after some hours the liquor became somewhat turbid, and its colour was rendered a little more clear.

kalis.

Mr. Hatchett found, that an ounce contains about 78 or 79 grains of tannin.

Sumach acts on a solution of silver just as galls do; it reduces the silver to its metallic state, and the reduction is favoured by the action of light.

Of all astringents, sumach bears the greatest resemblance to galls: the precipitate, however, produced in solutions of iron by an infusion of it, is less in quantity than what is obtained by an equal weight of galls; so that in most cases it may be substituted for galls, the price of which is considerable, provided we proportionally increase its quantity.

Sumach alone gives a fawn colour inclining to green; but cotton stuffs, which have been impregnated with printer's mordant, that is, acetat of alumine, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass, so that it becomes necessary to impregnate all the stuff with different mordants to vary the colours, without leaving any part of it white.

Supersalt. A compound of an acid and base, in which the acid is in excess. See Subsalt.

Sweat. When the temperature of the body is much increased, either by being exposed to a hot atmosphere, or by violent exercise, the perspired vapour not only increases in quantity, but even appears in a liquid form. This is known by the name of *sweat*.

In what manner sweat is produced is not at present known; but we can see a very important service, which it performs to the animal. No sooner is it thrown upon the surface of the skin than it begins to evaporate. But the change into vapour requires heat; accordingly a quantity of heat is absorbed, and the temperature of the animal is lowered. This is the reason, that animals can endure to remain for some time in a much higher temperature without injury, than could have been supposed.

The experiments of Tillet, and the still more decisive experiments of Dr. Fordyce and his associates, are well known. These gentlemen remained a considerable time in a temperature exceeding the boiling point of water.

Beside water, it cannot be doubted, that *carbon* is also emitted from the skin; but in what state, the experiments hitherto made do not enable us to decide. Mr. Cruickshanks found, that the air of the glass vessel in which his hand and foot had been confined for an hour contained carbonic acid

almost entirely of carbonic acid gas. The same conclusion may be drawn from the experiments of Ingenhousz and Milly. Trousset has lately observed, that air was separated copiously from a patient of his while bathing.

Now it is evident, that the carbonic acid gas, which appeared during the experiment of Mr. Cruickshanks, did not previously exist in the glass vessel; consequently it must either have been transmitted ready formed through the skin, or have been formed during the experiment by the absorption of oxigen gas, and the consequent emission of carbonic acid gas. The experiments of Mr. Jurine do not allow us to suppose the first of these to be true; for he found, that the quantity of air allowed to remain in contact with the skin did not increase. Consequently the appearance of the carbonic acid gas must be owing either to the emission of carbon, which forms carbonic acid gas by combining with the oxygen gas of the air, or to the absorption of oxigen gas, and the subsequent emission of carbonic acid gas; precisely in the same manner, and for the same reason, that these substances are emitted by the lungs. The last is the more probable opinion; but the experiments hitherto made do not enable us to decide between them.

Beside water and carbon, or carbonic acid gas, the skin emits also a particular odorous substance. That every animal has a peculiar smell, is well known: the dog can discover his master, and even trace him to a distance, by the scent. A dog, chained up several hours after his master had set out on a journey of some hundred miles, followed his footsteps by the smell. But it is needless to multiply instances of this fact; they are too well known to every one. Now this smell must be owing to some peculiar matter, which is constantly emitted; and this matter must differ somewhat either in quantity or some other property, as we see, that the dog easily distinguishes the individual by means of it. Mr. Cruickshanks has made it probable, that this matter is an oily substance; or at least, that there is an oily substance emitted by the skin. He wore repeatedly, night and day for a month, the same under-waistcoat of fleecy hosiery, during the hottest part of the summer. At the end of this time he always found an oily substance accumulated in considerable masses on the nap of the inner surface of the waistcoat, in the form of black tears. When rubbed on paper it rendered it transparent, and hardened on it like grease. It burned with a white flame, and left behind it a charry residuum.

Berthollet has observed the perspiration acid; and he has concluded, that the acid which is present is the phosphoric: but this has not been proved. Fourcroy and Vauquelin have ascertained, that the scurf which collects upon the skins of horses consists chiefly of phosphat of lime, and urea is even sometimes mixed with it.

According to Thenard, however, who has lately endeavoured more particularly to ascertain this point, the acid contained in sweat is the acetous: which, he likewise observes, is the only free acid contained in urine and in milk, this acid existing in both of them when quite fresh. His account of his examination of it is as follows:

The sweat is more or less copious in different individuals; and its quantity is perceptibly in the inverse ratio of that of the urine. All other circumstances being similar, much more is produced during digestion, than during repose. The maximum of its production appears to be twenty-six grains and two thirds in a minute, the minimum nine grains, troy weight. It is much inferior, however, to the pulmonary transpiration: and there is likewise a great difference between their nature and manner of formation. The one is the product of a particular secretion, similar in some sort to that of the urine: the other, composed of a great deal of water and carbonic acid, is the product of a combustion gradually effected by the atmospheric air.

The sweat, in a healthy state, very sensibly reddens litmus paper or infusion. In certain diseases, and particularly in putrid fevers, it is alkaline: yet its taste is always rather saline, and more similar to that of salt, than acid. Though colourless, it stains linen. Its smell is peculiar, and insupportable when it is concentrated, which is the case in particular during distillation. But before I speak of the trials to which I subjected it, and for which I had occasion of a great quantity, I ought to mention the method I adopted for procuring it.

I applied to persons who are in the habit of wearing flannel waistcoats next the skin. To avoid every source of error, the waistcoats, before they were put on, were first washed with soap; then rinsed in a stream of water, and afterward in diluted muriatic acid several times; and lastly they were immersed and wrung out of a large tub of water. The persons who were so obliging as to submit to the experiment, went into the bath before they began it, and were particularly careful to rub every part of the body well. The sweat that was collected uninterruptedly in the flannel during the course of ten days I separated by means of hot distilled water; and this I boiled down to the consistence of a sirup in a retort, to the neck of which a receiver was adapted. The product of this distillation emitted a nauseous smell, which diminished as the liquor cooled. It caused no alteration in sirup of violets, but it evidently reddened infusion of litmus. Left for some time exposed to the air, it retained the transparency it had at first, and underwent no remarkable change, unless with respect to its smell, which entirely vanished: in a close vessel probably it would have putrefied, like the product of distillation of all other animal fluids.

The residuum was not very copious, and evidently void of smell; though pretty strongly acid, the agreeable taste of sea salt predominated in it, yet with this taste something acrid and pungent was perceptible; it was slightly deliquescent, requiring some days to resolve into a liquid; and it was completely soluble in water. Lime, barytes, ammonia, the acidulous oxalat of potash, the carbonats of potash and soda, most acids, and acetat of lead, gave no precipitate with this solution, and disengaged nothing from it. Nutgalls occasioned a slight precipitate in it, but the nitrat of silver rendered it very turbid.

Calcined by itself it was decomposed, emitting vapours that had nothing of the fetid smell of animal matter, and was converted into a black substance, that was composed simply of a great deal of common salt, charcoal, and scarcely perceptible quantities of lime and oxide of iron.

Finally, when subjected to calcination after the acid had been saturated with potash, this base was obtained in the state of carbonat, beside the preceding matters, in the black substance remaining.

These trials already convinced me, that sweat contains muriat of soda, traces of phosphat of lime and oxide of iron, very little animal matter, no sulphat, no soluble phosphat, and in addition an acid, the nature of which I already suspected.

In fact, this acid combined with a base, giving rise to a carbonat, by its calcination, must belong to the vegetable or animal kingdom; and as besides it was volatile, and formed soluble salts with the different salifiable bases, it became very probable, that it was the acetous acid.

Led by this reasoning to suppose the existence of acetous acid in sweat, I still required positive experiments, to convince myself of it; for though the properties I have mentioned belong only to the acetous, of all the known acids, yet they might equally belong to an unknown acid. Thus nitrogen is far from being sufficiently characterized by the properties with which we usually content ourselves as denoting its presence; namely, its being without smell, without colour, and without action on blue colours or solution of lime; all negative properties, and far from being as characteristic as those, which, being founded on combinations, may be termed positive. Farther, to give certainty, there must be a combination of these positive properties, unless some one, which happens in certain instances, be so decisive as to suffice of itself.

Thus though every thing apparently tended to show me, that the acid of sweat was the acetous, it was necessary for me to obtain it separate, and combine it with different substances, before I would pronounce definitively on its nature. This I effected easily, by distilling with another acid the residuum, which a certain quantity of sweat collected in a flannel waistcoat slightly alkaline afforded by evaporation. In this distillation I preferred the phosphoric acid; on one hand, because it is fixed; and on the other, because, as it is very difficult to decompose, it acts less on organic matters than many others. I farther took every precaution, to condense the product of distillation in the receiver. This product strongly reddened infusion of litmus: its taste was that of a weak acid: its smell that of vinegar: combined with potash it formed a salt, which by evaporation was reduced to little shining scales, micaceous as it were, acrid, and very deliquescent: on the addition of sulphuric or phosphoric acid this salt evolved a strong smell of acetic acid; and, poured into a solution of nitrat of mercury, it precipitated crystalline scales, similar to acetit of mercury.

This acid therefore was the acetous, and consequently human sweat is formed of a great deal of water; free acetous acid; muriat of soda; an atom of phosphat of lime and oxide of iron; and an inappreciable quantity of animal matter, which approaches much nearer to gelatine than to any other substance.—*Annales de Chimie.*—*Thomson.*

Sylvanite. Native tellurium.

Sylvius (Salt of), or Febrifuge (Salt of). Muriat of potash.

Synovia. Within the capsular ligament of the different joints of the body there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of *synovia.*

Whether it be the same in different animals, or even in all the different joints of the same animal, has not been determined, as no accurate analysis of the synovia of different animals has been attempted. The only analysis of synovia, which has hitherto appeared, is that by Mr. Margueron, which was published in the 14th volume of the *Annales de Chimie.* He made use of synovia obtained from the joints of the lower extremities of oxen.

The synovia of the ox, when it has just flowed from the joint, is a viscid semitransparent fluid, of a greenish white colour, and of a smell not unlike frog-spawn. It very soon acquires the consistence of jelly; and this happens equally whether it be kept in a cold or hot temperature, whether it be exposed to the air, or excluded from it. This consistence does not continue long; the synovia soon recovers again its fluidity, and at the same time deposits a matter like threads.

Synovia mixes readily with water, and imparts to that liquid a great deal of viscidity. The mixture froths when agitated; becomes milky when boiled, and deposits some pellicles on the sides of the disk; but its viscidity is not diminished.

When alcohol is poured into synovia, a white substance precipitates, which has all the properties of albumen. One hundred parts of synovia contain 4·52 of albumen. The liquid still continues as viscid as ever; but if acetic acid be poured into it, the viscidity disappears altogether, the liquid becomes transparent, and deposits a quantity of matter in white threads, which possess the following properties:

1. It has the colour, smell, taste, and elasticity of vegetable gluten.

2. It is soluble in concentrated acids and pure alkalis.

3. It is soluble in cold water. the solution froths. Acids and alcohol precipitate the fibrous matter in flakes. One hundred parts of synovia contain 11·86 of this matter.

When the liquid, after these substances have been separated from it, is concentrated by evaporation, it deposits crystals of acetat of soda. Synovia, therefore, contains soda. Margueron found, that 100 parts of synovia contained 0·71 of soda.

When strong sulphuric, muriatic, nitric, or acetic, or sulphurous acid is poured into synovia, a number of white flakes precipitate at first, but they are soon redissolved, and the viscidity of the liquid continues. When these acids are diluted with five times their weight of water, they diminish the transparency of synovia, but not its viscidity; but when they are so much diluted, that their acid taste is just perceptible, they precipitate the peculiar thready matter, and the viscidity of the synovia disappears.

When synovia is exposed to a dry atmosphere, it gradually evaporates, and a scaly residuum remains, in which cubic crystals, and a white saline efflorescence, are apparent. The cubic crystals are muriat of soda. One hundred parts of synovia contain about 1·75 of this salt. The saline efflorescence is carbonat of soda.

Synovia soon putrefies in a moist atmosphere, and during the putrefaction ammonia is exhaled. When it is distilled in a retort, there comes over, first water, which soon putrefies; then water containing ammonia; then empyreumatic oil and carbonat of ammonia. From the residuum muriat and carbonat of soda may be extracted by lixiviation. The coal contains some phosphat of lime.

From the analysis of Mr. Margueron it appears, that synovia is composed of the following ingredients:

11·86	fibrous matter
4·52	albumen
1·75	muriat of soda
·71	soda
·70	phosphat of lime[*]
80·46	water
100·00	

How far the synovia of the human body resembles that of oxen it is impossible to say. The following fact renders it probable, that it either contains different ingredients, or is liable to alteration from disease. Concretions often form in the joints of gouty people, and make their way through the skin. These, in common language, are called *chalkstones*. Dr. Wollaston, Dr. Pearson, and Mr. Tennant analysed some of them, and found them composed of *lithat of soda*. This analysis has been repeated by Fourcroy, and confirmed. Doubtless this fact has induced Fourcroy to conjecture, that lithic acid forms a constituent part of synovia.—*Thomson*.

T.

TALC. Magnesia ·44, silex ·50, and alumine ·06, according to the analysis of Mr. Hœpfner, constitute Venetian talc.

Its colour is white, gray, yellowish, or greenish; it is soft and soapy to the touch, and in thin pieces semitransparent; it is composed of very thin plates, disposed in a laminar or filamentous form, much tenderer and more brittle than those of mica, but like this it has a metallic lustre; its hardness is so inconsiderable, that it may be scratched with the nail; and its specific gravity is 2·729.

It does not effervesce with acids; and is soluble therein very difficultly, by particular management, and only in part.

In fire it becomes more brittle and whiter, but is infusible per se by the blowpipe, and scarcely fusible by fixed alkalis, but more completely and with little effervescence by borax or microcosmic salt.

Muscovy talc consists of broad, elastic, flexible, transparent leaves; and differs externally from mica only in being softer and more soapy to the touch. Its analysis by Vauquelin gave silex ·62, magnesia ·27, oxide of iron ·035, alumine ·015, water ·06.

It abounds in the hills of Bahar, and other parts of India, where its market price, split into sheets about 2 lines thick, is at the rate of 24 lbs. avoirdupois for a rupee (2*s*. 6*d*.). The natives, as well as the Chinese, make very splendid lanterns, shades, and ornaments of it, tinged of various colours. They likewise use it in medicine, considering it when calcined a specific in obstinate coughs and consumptions. Powdered it makes a silver sand for writing.

Talcite. *Nacrite* of Brongniart, *talc granuleux* of Haüy, *erdigter talk*, earthy talc, or scaly talc. This mineral appears in the form of slightly agglutinated earthy particles; of a silvery white, or shining pearl gray; friable and greasy to the touch, and covering the skin with a pearly coat. It is very light, swells a little in water, and fuses easily before the blowpipe.

Talcite differs from talc by its great fusibility, and its turning sirup of violets green; for both which properties it is indebted to its chemical composition. Mr. Vauquelin obtained on analysing it,

Silex - - -	50
Alumine - - -	26
Potash - - -	17
A little iron	
Some lime	
And even muriatic acid	
	93.

It is found disseminated in scales, or little kidney-shaped masses, in the cavities of primitive rocks, and particularly in the interstices of quartz crystals.

It is brought from Sylva in Piedmont, the neighbourhood of Freyberg in Saxony, Meronitz in Bohemia, and other places.—*Brongniart*.

Tallow. I do not know of any experiments, which ascertain a chemical difference between this concrete animal fat, which is chiefly taken from the intestines of animals, and other fat oils of the same nature. The most valuable property of tallow is the considerable heat it requires to fuse it, which is commonly distinguished by the term hardness. The quantity of soot and fetid exhalation emitted from the various kinds of tallow candles brought to market also forms a distinguishing characteristic in the use of this article, and is accompanied with notable variations in the quantities of light afforded by each.

It is an object of no small importance to purify or improve tallow. The tallow-chandlers clear it of fibrous matter and other gross impurities by careful melting, straining, and the like mechanical management. It is said also, that they improve its whiteness by the addition of alum, the efficacy of

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[*] Mr. Hatchett found only 0·208 of phosphat of lime in the synovia which he examined. He observed however traces of some other phosphat; probably phosphat of soda.

ness; but these slow operations are ill calculated for a manufactory, in which the greatest part of the capital is vested in the raw material and duty, and very little in the manufacturing process: and if they increase the hardness of the tallow, they injure its colour, and candles kept too long do not burn so well.

The oxigenized muriatic acid produces a state in tallow, which is somewhat nearer to that of wax than before, and a thin stratum of tallow exposed upon an extended surface of water becomes likewise harder; but the indications these processes might afford to the manufacturer have not yet been applied to any extended purposes of utility.

Tallow (Mineral). See Mumia.

Tamarinds. The fruit of the tamarindus indica L. It is a pod resembling a bean-cod, including several hard seeds, together with a dark-coloured viscid pulp, of a pleasant acid taste: the East India tamarinds are longer than the West India sort; the former containing six or seven seeds each, the latter rarely above three or four.

Tannin. This, which is one of the immediate principles of vegetables, was first distinguished by Seguin from the gallic acid, with which it had been confounded under the name of the *astringent principle.* He gave it the name of tannin, from its use in the tanning of leather; which it effects by its characteristic property, that of forming with gelatine a tough insoluble matter.

It may be obtained from vegetables by macerating them in cold water; and precipitated from this solution, which contains likewise gallic acid and extractive matter, by hyperoxigenized muriat of tin. From this precipitate, immediately diffused in a large quantity of water, the oxide of tin may be separated by sulphuretted hidrogen gas, leaving the tannin in solution.

Prof. Proust has since recommended another method, the precipitation of a decoction of galls by powdered carbonat of potash, washing well the greenish-gray flakes, that fall down, with cold water, and drying them in a stove. The precipitate grows brown in the air, becomes brittle and shining like a resin, and yet remains soluble in hot water. The tannin in this state, he says, is very pure.

Mr. Davy, after making several experiments on different methods of ascertaining the quantity of tannin in astringent infusions, prefers for this purpose the common process of precipitating the tannin by gelatine: but he remarks, that the tannin of different vegetables requires different proportions of gelatine for its saturation; and that the quantity of precipitate obtained is influenced by the degree in which the solutions are concentrated.

Mr. Hatchett has made a number of experiments, which show, that an artificial tannin, or substance having its chief property, may be formed by treating with nitric acid matters containing charcoal. It is remarkable that this tannin, when prepared from vegetable substances, as dry charcoal of wood, yields on combustion products analogous to those of animal matters. From his experiments it would seem, that tannin is in reality carbonaceous matter combined with oxigen; and the difference in the proportion of oxigen may occasion the differences in the tannin procured from different substances, that from catechu appearing to contain most.

Bouillon Lagrange asserts, that tannin by absorbing oxigen is converted into gallic acid.

It is not an unfrequent practice, to administer medicines containing tannin in cases of debility, and at the same time to prescribe gelatinous food as nutritious. But this is evidently improper, as the tannin, from its chemical properties, must render the gelatine indigestible. For the chief use of tannin, see the following article.—*Phil. Trans.*—*Ann. de Chim.*—*Mem. de l'Institut.*

Tanning. The several kinds of leather are prepared from the skins of animals macerated for a long time with lime and water, to promote the separation of the hair and wool, and of the fat and fleshy parts, in which recourse is also had to the assistance of mechanical pressure, scraping, and the like. The skin, when thus deprived of its more putrescible part, and brought considerably toward the state of mere fibre, is tanned by maceration with certain astringent substances, particularly the bark of the oak-tree. Neumann affirms, that prepared leather, as well as skins, affords a large quantity of glue by boiling in water. The Chevalier de St. Real, in a memoir inserted among those of the Royal Academy of Sciences at Turin, for the years 1788 and 1789, of which an extract by Berthollet is given in the 10th volume of the *Annales de Chimie*, p. 44, gives a number of interesting experiments respecting the tanning of skins, to the following effect:

After having exhausted the skin by infusion and a subsequent strong boiling with water, and separating the products obtained by this means, the author has observed, that the skin then consists of nothing but the mere fibres. In the next place he examined the state of tanned leather by the same means. It afforded neither lymph nor jelly, but merely an astringent extract, which gave a black precipitate when applied to a solution of iron. The astringent principle of tanned leather could not be exhausted by long boiling with water, for it at last became black when moistened with a solution of sulphat of iron.

The author shows, that all the operations performed upon skins preliminary to tanning them consist in separating such matters as are of a different nature from the epidermis and the fibres which constitute the skin, in order that the astringent principle may afterward be combined with these animal fibres. He next examines the different processes of the art of tanning, analyses their advantages and imperfections, and has succeeded in simplifying and abridging them, and by these means accelerating the return of capital, of which the investment constitutes a large part of the price of leather. With this view, his inquiries were directed to ascertain what degree of heat is sufficient to extract the animal jelly, and also at what temperature the fibrous texture of the skin begins to suffer alteration.

He ascertained, that the heat proper to dissolve the animal jelly commences at 140° F. and that the fibrous texture is capable of sustaining a degree of heat beyond 167° F., without undergoing any alteration in places where the mean temperature of the barometer is 26 inches and 4 lines, I suppose French measure. See MEASURE.

In consequence of his researches and observations, the author proposes to reduce the practice of the art of tanning to the following particulars:

1. The skins are to be kept separately immersed in running water, for a time sufficient to extract the lymph or serum. This period is easily ascertained, by putting a piece of the skin into a small quantity of water, and gradually heating it. If it contain serum, this matter will be first extracted, and afterward coagulated in the form of scum on the surface. If therefore no scum appear, the skins may be considered as purified from lymphatic matter.

2. These washed and rinced skins are then to be transferred into boilers properly adapted for the purpose; water is then to be added, and heat applied, so that the temperature of the water may not exceed 60°. The skins are to remain in this situation for an hour.

3. The skins are then to be taken out, and worked in the usual manner, to clear them of their impurities.

4. After this process they are again to be placed in the boiler, which must be so disposed, that a constant stream of water at the temperature of 167° F. shall enter by one cock, and pass off by another on the opposite side beneath.

5. The skins are to remain in this situation, until the water that comes off exhibits no vestige of animal jelly. This is easily ascertained by evaporating a small quantity.

6. The skins are then to be taken out, and cleared in the usual manner of the cellular membrane, and fleshy parts.

7. Lastly, they are to be washed in a running stream, and replaced in a boiler, similar to that just mentioned, which is to be filled with the saturated decoction of tan, or oak bark. The same degree of heat is to be applied, as in the preceding operation, and the skins are to remain until they are perfectly tanned. Fresh decoction of tan must be substituted from time to time in the room of that which is exhausted. The exhausted state is shown by its not having power to afford a black, when a few drops of solution of sulphat of iron are added.

The operations which are chiefly practised for strong leather constitute the first part of Mr. de St. Real's memoir: his second part is employed on the currying, which is performed upon the soft or flexible leathers.

This leather is most commonly made of calf's skin. It is not exposed for so long a time to the action of the tan as the strong leather. The intention of the art of the currier is to supple the leather, and to render it uniformly compact and dense. The most remarkable defect in the ordinary preparations is, that the leather is more or less penetrable by water. This defect is more especially observable in the leather commonly used for the soles of women's shoes, and may evidently be of great prejudice to the health of the wearer. The author proposes, beside the common operations of currying, that the skin should be impregnated with tallow, by keeping them for a certain time in a bath of this melted substance, and afterward passing them between rollers. Experience convinced him, that, after these two operations, which add but little to the price of the leather, it much more effectually resists the action of water, without having suffered any diminution of strength.

It is obvious, that there is one defect in Mr. St. Real's theory at least; for if he deprived the skins of all gelatinous matter, they would never constitute leather. But the hide consists almost wholly of gelatine, and all that is necessary is, to divest it of the hair, epidermis, and any flesh or fat adhering to it. This is commonly done, after they have been soaked in water some time, and handled or trodden to cleanse them from filth, by immersing them in milk of lime. Some instead of lime use an acescent infusion of barley or rye meal, or spent tan; and others recommend water acidulated with sulphuric acid. Similar acidulous waters are afterward employed for raising, or swelling the hide, when this is necessary.

The skins thus prepared are finally to undergo what is properly called the tanning. This is usually done by throwing into a pit, or cistern made in the ground, a quantity of ground oak bark that has already been used, and on this the skins and fresh bark in alternate layers, covering the whole with half a foot of tan, and treading it well down. The tanning may be accelerated by adding a little water.

newed three or four times; Mr. Seguin adopted the latter part of the Chev. de St. Real's process, or steeping the skins in a strong infusion of tan, and assisting its action by heat. Chaptal observes however, that this requires an extensive apparatus, for preparing the liquor, and the skins: the leather imbibes so much water, that it remains spongy a long time, and wrinkles in drying: and it is extremely difficult so to arrange the hides in a copper, as to keep them apart from each other, and free of the sides of the vessel.

The following account of Mr. Seguin's practice was transmitted to England in the year 1796.

To tan a skin is to take away its putrescent quality, preserving however a certain degree of pliability. This is effected by incorporating with the skin particles of a substance, which destroys their tendency to putrefaction.

The operations relating to tanning are therefore of two kinds: the first is merely depriving the skin of those parts, which would oppose its preservation, or which adhere to it but little, such as hair and flesh; the other consists in incorporating with it a substance, which shall prevent its putrefying.

The operations of the first kind are technically termed unhairing and fleshing; the operations of the second kind belong to tanning properly so called.

Fleshing is an operation merely mechanical: unhairing is a mechanical operation if performed by shaving; or a chemical operation, if effected by dissolution or decomposition of the substance, which connects the hair with the skin.

According to the ancient method, the dissolution of this substance was effected by means of lime; the decomposition either by the vinous fermentation of barley, by the acetous fermentation of oak bark, or by the putrid fermentation produced by piling the hides one upon another.

Unhairing by means of lime would often take twelve or fifteen months; this operation with barley, or the acetous part of tan, could not be performed in less than two months.

The slowness of these operations, which the experiments of Seguin have shown may be finished in a few days, and in a more advantageous manner by means of the same substances, proves, that the nature of those operations was not understood by those who performed them. Those of tanning properly so called were as little known, as the details we are about giving will prove, which we compare with the least improved routine now in practice.

Whatever the method of unhairing was, the mode of tanning was always the same, eighteen months or two years, often three years when it was wished to tan the hides thoroughly.

Among the substances for tanning, gallnut, sumach, and the bark of oak, to which may be added catechu, appear the most proper, at least in the present state of our knowledge. In the middle departments of France, oak bark is preferred, because it is the cheapest and most abundant substance. To use it, it is first ground to powder; then, according to the old mode, it is put into large holes dug in the ground, which are filled by alternate layers of ground bark and unhaired hides.

As the principle which effects the tanning cannot act in the interior of the skin, unless carried in by some liquid in which it is first dissolved, tanning is not produced by the immediate action of the powdered bark upon the skin, but only by the action of the dissolution of the tanning principle originally contained in the bark. The tan therefore has the tanning property only when wetted so much as not to absorb all the water thrown on it. But as tanners put in their vats only a small portion of water compared to what would be necessary to deprive the bark of all the tanning principle which it contains, the bark put into the vats preserves when taken out a portion of its tanning principle.

This waste is not the only disadvantage of the old modes of proceeding; they are besides liable never to produce in the skins a complete saturation with the tanning principle. For as the property of attraction is common to all bodies according to the different degree of saturation, the water containing in solution a certain quantity of the tanning principle will not part to a fixed weight of skins with as much as the same quantity of water will, in which a greater quantity of the principle is dissolved.

As the water, which in the old manner of proceeding is in the vats, can contain but a small portion of the tanning principle, owing to the nature of the operation, it can give but a small portion of it to the skin, and even this it parts with by slow degrees. Hence the slowness in the tanning of skins according to the old method, which required two whole years, and sometimes three, before a skin was well tanned to the centre. Hence also the imperfection of skins tanned by that method, an imperfection resulting from the non-saturation of the tanning principle, even when it had penetrated the centre.

The important desideratum was therefore, to get together within a small compass the tanning principle, to increase its action, and produce in the hide a complete saturation in a much shorter time than that ne-and analyse the oak bark. The principles of these three substances were to be insulated, and their action upon one another determined the influence of their combination upon that action known, and the circumstances most productive of its greatest action found out

Seguin, by following this method, has determined,

1. That the skin deprived of flesh and hair is a substance, which can easily, by a proper process, be entirely converted into an animal jelly (glue).

2. That a solution of this last-mentioned substance, mixed with a solution of tan, forms immediately an imputrescible and indissoluble compound.

3. That the solution of tan is composed of two very distinct substances; one of which precipitates the solution of glue, and which is the true tanning substance; the other, which precipitates sulphat of iron, without precipitating the solution of glue, and which produces only the necessary disoxigenation of the skin, and of the substance which connects the hair to the skin.

4. That the operation of tanning is not a simple combination of the skin with the principle which precipitates the glue, but a combination of that principle with the skin disoxigenized by the substance which in the dissolution of tan is found to precipitate the sulphat of iron; so that every substance proper for tanning should possess the properties of precipitating the solution of glue, and of precipitating the sulphat of iron.

5. That the operation of tanning consists in swelling the skins by means of an acidulous principle; to disoxigenize, by means of the principle which in the solution of bark precipitates the solution of sulphat of iron, that substance which connects the hair to the skin, and thus produce an easy unhairing; to disoxigenize the skin by means of the same principle, and to bring it by this disoxigenation to the middle state between glue and skin; and then to combine with it, after this disoxigenation, and while it is in this middle state, that particular substance in oak bark, as well as in many other vegetables, which is found to precipitate the solution of glue, and which is not, as has been hitherto conceived, an astringent substance.

Agreeably to these discoveries, there only remains, in order to tan speedily and completely, to condense the tanning principle so as to accelerate its action. Seguin, to effect this, follows a very simple process. He pours water upon the powdered tan contained in an apparatus nearly similar to that made use of in salt-petre works. This water, by going through the tan, takes from it a portion of its tanning principle, and by than to give up more. Seguin succeeds in bringing these solutions to such a degree of strength, that, he says, he can, by taking proper measure, tan calf-skin in 24 hours, and the strongest ox-hides in seven or eight days. These solutions, containing a great quantity of the tanning principle, impart to the skin as much of it as it can absorb, so that it can then easily attain a complete saturation of the principle, and produce leather of a quality much superior to that of most countries famous for their leather.

On the above I have only to remark, that every new art or considerable improvement must unavoidably be attended with many difficulties in the establishment of a manufactory in the large way. From private inquiry I find, that this also has its difficulties, which have hitherto prevented its being carried into full effect in this country. Of what nature these may be I am not decidedly informed, and mention them in this place only to prevent manufacturers from engaging in an undertaking of this kind, without cautious inquiry.

Mr. Desmond has recommended, to saturate water with tannin, by affusion on successive portions of oak bark, or whatever may be used; and when the bark will give out no more tannin, to extract what gallic acid still remains in it, by pouring on fresh water. To the latter, or acidulous liquor, he adds one thousandth part by measure of sulphuric acid; and in this steeps the hide, till the hair will come off easily by scraping. When raising is necessary, he steeps the hide ten or twelve hours in water acidulated with a five-hundredth part by measure of sulphuric acid: after which they are to be washed repeatedly, and scraped with the round knife. Lastly, the hides are to be steeped some hours in a weak solution of tannin, then a few days in a stronger, and this must be renewed as the tannin is exhausted, till the leather is fully tanned.

For the softer skins, as calves', goats', &c., he does not use the acid mixture, but milk of lime.

Of substances used for tanning Mr. Davy observes, that 1lb. of catechu is nearly equal to 2¼ of galls, 3 of sumach, 7½ of the bark of the Leicester willow, 8¼ of oak bark, 11 of the bark of the Spanish chesnut, 18 of elm bark, and 21 of common willow bark, with respect to the tannin contained in them. He observes too, that leather slowly tanned in weak infusions of barks appears to be better in quality, being both softer and stronger than when tanned by strong infusions; and he ascribes this to the extractive matter they imbibe. This principle therefore affects the quality of the material employed in tanning; and galls, which contain a great deal of tannin, make

Tantalite. An ore of tantalium. See the following article.

Tantalium. This is a new metal, discovered by Mr. Eckeberg of Sweden, as he was examining a fossil containing yttria, with a view to ascertain the difference or identity of this earth and glucine. Beside this fossil, which he calls yttrotantalite, he has found another ore of tantalium, in which this metal is mixed with iron and manganese, and which he calls tantalite.

Tantalite is in detached crystals, of the size of a nut, approaching the octaëdral form. It contains particles of feldtspar and mica. Its surface even, polished and blackish. Fracture compact, of a metallic brilliancy, and not alike in colour all through, varying from a grayish blue to the black of iron. Powdered it is of a blackish gray, approaching to brown. It gives sparks with steel. Specific gravity 7·953. Its gangue is composed of white quartz and mica, with veins of red feldtspar. These crystals had been considered as a variety of the garnet-shaped tin ore.

The yttrotantalite was found in the same place and gangue as gadolinite; in small nodules, not so large as a nut, thinly encrusted with feldtspar. Its fracture is granulated, of the black colour of iron, with a metallic brilliancy. When in powder it is grayish. It is not attracted by the magnet. It may be scraped with a knife, though with difficulty. Specific gravity 5·13; though no doubt it would be more, if totally free from feldtspar.

Tantalium is characterized by its insolubility in all the acids. The only reagent that has any action on it is caustic fixed alkali. When exposed to the fire with this, and the mass afterward lixiviated, it partly dissolves in water, and may be precipitated by means of an acid; but the precipitate is not in the least attacked, whatever the quantity of acid employed. Separated by filtration and dried, it is an extremely white powder, the colour of which is not changed by a red heat. The remainder of the mass, being treated with acids, affords the same powder. Specific gravity after ignition 6·5. It is fusible with the blowpipe by the addition of an alkaline phosphat and borat of soda, but it does not impart any colour to the flux.

Exposed to a strong heat in a crucible with powdered charcoal, it is reduced to a moderately hard button, having a metallic brilliancy at its surface; but its fracture is dull and blackish. The acids have no other action on it than converting it to a white oxide. This might be confounded with the oxide of tin, tungsten, or titanium: but the oxide of tin is easy to be dissolved and reduced; that of tungsten is soluble in am-

of potash.—*Journ. de Physique.*

Tar. If the wood of the turpentine trees be exposed to the fire, in a vessel every where closed except an aperture at the bottom, as for example in a retort with the neck placed lowermost, the resinous juice melts out by the heat, and at the same time contracts an empyreumatic smell and taste: in this state it is tar. Tar is prepared in different parts of Germany, Norway, Sweden, &c., from the pine and the fir-trees, and in some places from the larch and the terebinth. The wood is enclosed in a large oven, to the quantity of ten or more loads at a time: this stands within another oven called the mantle, the space betwixt them receiving the fire: from the bottom of the inner oven runs a gutter, by which the tar is conveyed off in proportion as it melts out from the wood.

The above account is from Neumann. Chaptal informs us, that tar is obtained from the wood of the trunk, branches, and roots of the pine, which are heaped together, covered with turf, and set on fire to produce a close combustion, in the same manner as for making charcoal. The oily parts, which are disengaged, trickle down, and are received in a gutter, which serves to convey them to a tub. The most fluid part is sold under the name of huile de cade; and the thicker part is the tar used for paying or painting the parts of shipping and other vessels.

Tarras, *or* **Terras.** A volcanic earth used as a cement. It does not differ much in its principles from pouzzolana; but it is much more compact, hard, porous, and spongy. It is generally of a whitish-yellow colour, and contains more heterogeneous particles, as spar, quartz, schoerl, &c., and something more of a calcareous earth. It effervesces with acids, is magnetic, and fusible per se. When pulverized, it serves as a cement, like pouzzolana. It is found in Germany and Sweden.

Tartar is deposited on the sides of casks during the fermentation of wine: it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from 10 to 15 livres the quintal.

All wines do not afford the same quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar is distinguished from its colour into red and white: the first is afforded by red wine.

Tartar is purified from an abundant extractive principle, by processes which are executed at Montpellier and at Venice.

The following is the process used at

of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrite of potash.

Mr. Desmaretz has informed us, that the process used at Venice consists,

1. In drying the tartar in iron boilers.
2. Pounding it, and dissolving it in hot water, which by cooling affords purer crystals.
3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product. See Acid (Tartarous).

Tartar (Chalybeated). This is prepared by boiling three parts of the supertartrit of potash and two of iron filings in forty-six parts of water, till the tartarous acidule appears to be dissolved. The liquor is then filtered, and crystals are deposited on cooling, more of which are obtained by continuing the evaporation.

Tartar (Cream of). The popular name of the purified supertartrit of potash.

Tartar (Crude). The supertartrit of potash in its natural state, before it has been purified.

Tartar (Emetic). The tartrit of potash and antimony. See Antimony.

Tartar of the Teeth. The popular name for the concretion that so frequently encrusts the teeth, and consists apparently of phosphat of lime.

Tartar (Regenerated). Acetat of potash.

Tartar (Salt of). The subcarbonat of potash.

Tartar (Secret Foliated Earth of). Acetat of potash.

Tartar (Soluble). Neutral tartrit of potash.

Tartar (Vitriolated). Sulphat of potash.

Tartarin. The name given by Kirwan to the vegetable alkali, or potash.

Tartarous Acid. See Acid (Tartarous).

Tartrit. A neutral compound of the tartarous acid with a base.

Tears. That peculiar fluid which is employed in lubricating the eye, and which is emitted in considerable quantities when we express grief by weeping, is known by the name of *tears*. For an accurate analysis of this fluid we are indebted to Messrs. Fourcroy and Vauquelin. Before their dissertation, which was published in 1791, ap-

smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper stained with the juice of the petals of mallows or violets a permanently green colour, and therefore contains a fixed alkali. It unites with water, whether cold or hot, in all proportions. Alkalis unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it. Exposed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriat of soda: but they tinge vegetable blues green, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries.

This liquid boils like water, excepting that a considerable froth collects on its surface. If it be kept a sufficient time at the boiling temperature, $\frac{96}{100}$ parts of it evaporate in water, and there remain about ·04 parts of a yellowish matter, which by distillation in a strong heat yields water and a little oil; the residuum consists of different saline matters.

When alcohol is poured into this liquid, a mucilaginous matter is precipitated in the form of large white flakes. The alcohol leaves behind it, when evaporated, traces of muriat of soda and soda. The residuum which remains behind, when inspissated tears are burnt in the open air, exhibits some traces of phosphat of lime, and phosphat of soda.

Thus it appears, that tears are composed of the following ingredients:

1. Water,
2. Mucus,
3. Muriat of soda,
4. Soda,
5. Phosphat of lime,
6. Phosphat of soda.

The saline parts amount only to about 0·01 of the whole, or probably not so much.

The mucus contained in the tears has the property of absorbing oxigen gradually from the atmosphere, of becoming thick and viscid, and acquiring a yellow colour. It is then insoluble in water, and remains long suspended in it without alteration. When a sufficient quantity of oximuriatic acid is poured into tears, a yellow flaky precipitate appears, absolutely similar to this inspissated mucilage. The oximuriatic acid loses its peculiar colour; hence it is evident, that it has given out oxigen to the mucilage. The property which this mucilage has of absorbing oxigen, and of acquiring new qualities, explains the changes that take place in tears, when they are exposed a long time to the action of the atmosphere, as is the case in those persons who labour under a fistula lachrymalis.

The mucus of the nose has also been examined by Fourcroy and Vauquelin. They found it composed of precisely the same ingredients with the tears. As this fluid is more exposed to the action of the air than the tears, in most cases its mucilage has undergone less or more of that change, which is the consequence of the absorption of oxigen. Hence the reason of the greater viscidity of the mucus of the nose; hence also the great consistence which it acquires during colds, where the action of the atmosphere is assisted by the increased action of the parts.

As to the mucus which lubricates the alimentary canal, the trachea, the bronchiæ, the urethra, and all the different cavities of the body, nobody has hitherto subjected it to analysis, because it cannot be obtained in sufficient quantity. It is viscid, and no doubt contains a mucilaginous substance, similar to that contained in the saliva, the tears, and the mucus of the nose; as, like these liquids, it is liable to become much more thick by exposure to the air.—*Thomson.*

Teeth. The basis of the substance that forms the teeth, like that of other bones (see Bone), appears to be phosphat of lime. The enamel, however, according to Mr. Hatchett, differs from other bony substances in being destitute of cartilage: for raspings of enamel, when macerated in diluted acids, he found, were wholly dissolved; while raspings of bone, treated in the same manner, always left a cartilaginous substance untouched.

Mr. Pepys, who has made the most complete analysis of teeth, agrees with Mr. Hatchett. He obtained from one hundred parts of enamel,

Phosphat of lime	78
Carbonat of lime	6
	84;

the remaining sixteen parts he reckons as water and loss.

Fourcroy and Vauquelin, on the contrary, assert, that teeth are composed of

Phosphat of lime	72·9
Gelatin and water	27·1
	100.

Mr. Pepys gives the following as the results of his analyses of the body of the teeth themselves. In the teeth of adults,

Phosphat of lime	64
Carbonat of lime	6
Cartilage . .	20
Loss . .	10
	100

In the first teeth of children,

Phosphat of lime	62
Carbonat of lime	6
Cartilage . .	20
Loss . .	12
	100.

In the roots of the teeth,

Phosphat of lime	58
Carbonat of lime	4
Cartilage . .	28
Loss . .	10
	100.

Fossil teeth and fossil ivory have been found sometimes at least to contain fluat of lime; and Morichini, an Italian chemist, asserted, that recent enamel of teeth contained the same substance.

Mr. Brande, in consequence, examined it very carefully, with a view to ascertain this point, but he could find no trace of the fluoric acid. He kept a hundred grains of the enamel of tooth for a few minutes in a red heat, reduced the whole to powder, and put it into a platina crucible, in which a piece of glass rod was placed horizontally, so as to be about an inch and a half above the enamel. He then added half an ounce of sulphuric acid, covered the crucible with a plate of clear glass, applied the heat of a lamp, and carried on the distillation for half an hour. During the process white suffocating fumes were extricated; but on removing the glass which closed the top of the crucible, neither this, nor the rod below it, was in the least acted upon; which must have been the case, had fluoric acid been extricated.

After this he introduced fifty grains of the same enamel into a small glass retort; and a little sulphuric acid being added, distillation was carried on nearly to dryness, but in such a manner, that the gaseous products might be received over mercury. A small quantity of sulphurous acid gas was disengaged; and what remained in the retort consisted, as far as Mr. Brande could ascertain, of a mixture of sulphat of lime, phosphoric acid, and a small portion of sulphur, arising from a decomposition of a small part of the sulphuric acid by the animal matter existing in the enamel.

A letter from Mr. Gehlen, however, to the editor of the *Journal de Physique*, says, the very extensive and accurate experiments of Mr. Berzelius of Stockholm have proved, that the enamel and the bony part of the teeth of man and of the ox, as well as their bones themselves, contain fluoric acid. The following are the results of the analyses:

Enamel of Human Teeth.

Phosphat of lime . . .	85·3
Fluat of lime . . .	3·2
Carbonat of lime . .	8·0
Phosphat of magnesia .	1·5
Soda, combustible animal matter, and water . .	2
	100.

Enamel of the Teeth of the Ox.

Phosphat of lime	81
Fluat of lime	4
Carbonat of lime	7·1
Phosphat of magnesia	3
Natron	1·34
Animal matter	3·56
	100.

Osseous Part of the Human Teeth.

Phosphat of lime	61·95
Fluat of lime	2·10
Carbonat of lime	5·50
Phosphat of magnesia	1·05
Soda, with a little muriat of soda	1·40
Gelatine, veins, and water	28·00
	100.

Osseous Part of the Teeth of the Ox.

Phosphat of lime	57·46
Fluat of lime	5·69
Carbonat of lime	1·38
Phosphat of magnesia	2·07
Soda, with a little muriat of soda	2·40
Gelatine, veins, and water	31·00
	100.

Dry fresh Human Bones.

Gelatine	32·17
Veins belonging to their organization	1·13
Phosphat of lime	51·04
Fluat of lime	2·00
Carbonat of lime	11·30
Phosphat of magnesia	1·16
Soda, with a small quantity of muriat	1·20
	100.

Dry fresh Ox-bones.

Gelatine Veins belonging to their organization	33·30
Phosphat of lime	55·45
Fluat of lime	2·90
Carbonat of lime	3·85
Phosphat of magnesia	2·05
Soda, with a small quantity of muriat	2·45
	100.

Phil. Trans.—Mem. de l'Instit.—Journ. de Phys.—Nich. Journ.

Telesia. The name by which Haüy distinguished the precious stones called oriental rubies, sapphires, &c. See Ruby.

Tellurium. Mueller first suspected the existence of a new metal in the aurum paradoxicum, or problematicum, which has the appearance of an ore of gold, though very little can be extracted from it. Klaproth afterward established its existence, not only in this but in some other Transylvanian ores, and named it tellurium.

According to his analysis, what has been called white gold ore contains in 100 parts, 92·55 of tellurium, 7·2 of iron, and 0·25 of gold; though according to Raab the gold sometimes amounts to more than 12 per cent: the graphic gold ore, tellurium 60, gold 30, silver 10: the yellow gold ore of Nagyag, tellurium 45, gold 27, lead 19·5, silver 8·5, and a minute quantity of sulphur: foliated gray ore of Nagyag, tellurium 33, gold 8·5, lead 50, sulphur 7·5, silver and copper 1.

Pure tellurium is of a tin-white colour, verging to lead-gray, with a high metallic lustre; of a foliated fracture; and very brittle, so as to be easily pulverized. It melts before ignition, requiring a little higher heat than lead, and less than antimony; and according to Gmelin is as volatile as arsenic. When cooled without agitation, its surface has a crystallized appearance. Before the blowpipe on charcoal it burns with a vivid blue light, greenish on the edges; and is dissipated in grayish white vapours, of a pungent smell, which condense into a white oxide. This oxide heated on charcoal is reduced with a kind of explosion, and soon again volatilized. Heated in a glass retort it fuses into a straw-coloured, striated mass. It appears to contain about 16 per cent of oxigen.

Tellurium is oxidized and dissolved by the principal acids. To sulphuric acid it gives a deep purple colour. Water separates it in black flocculi, and heat throws it down in a white precipitate.

With nitric acid it forms a colourless solution, which remains so when diluted, and affords slender, dendritic crystals by evaporation.

The muriatic acid, with a small portion of nitric, forms a transparent solution, from which water throws down a white submuriat. This may be redissolved almost wholly by repeated affusions of water. Alcohol likewise precipitates it.

Sulphuric acid, diluted with two or three parts of water, to which a little nitric acid has been added, dissolves a large portion of the metal, and the solution is not decomposed by water.

The alkalis throw down from its solutions a white precipitate, which is soluble in all the acids, and by an excess of the alkalis or their carbonats. They are not precipitated by prussiat of potash. Tincture of galls gives a yellow flocculent precipitate with them. Tellurium is precipitated from them in a metallic state by zinc, iron, tin, and antimony.

Tellurium fused with an equal weight of sulphur, in a gentle heat, forms a lead-coloured striated sulphuret. Alkaline sulphurets precipitate it from its solutions of a brown or black colour. In this precipitate either the metal or its oxide is combined with sulphur. Each of these sulphurets burns with a pale blue flame, and white smoke. Heated in a retort, part of the sulphur is sublimed, carrying up a little of the metal with it. It does not easily amalgamate with quicksilver.—*Klaproth*.—*Murray*.

Terra Foliata Crystallizata. Acetat of soda.

Terra Japonica. Catechu.

Terra Lemnia. A red bolar earth formerly esteemed in medicine.

Terra Merita. Turmeric.

Terra Ponderosa. Barytes. See Earths.

Terra Sienna. A brown bole, or ochre, with an orange cast, brought from Sienna in Italy, and used in painting, both raw and burnt. When burnt it becomes of a darker brown. It resists the fire a long time without fusing. It adheres to the tongue very forcibly.

Terra Sigillata. When the boles were much more esteemed for medicinal purposes than they are at present, and supposed to differ considerably in their virtues, some of them were impressed with a seal, as of particular excellence, and hence called *sealed earths*.

Terras. See Tarras.

Terra Foliata Tartari. Acetat of potash.

Terre Verte. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites; alum and sulphat of lime are also accidentally found with it. It is difficultly soluble in acids, is not magnetic before calcination, and becomes of a coffee-colour when heated. It is said to afford about 40 per cent of iron.

Thallite. The name given by Delamétherie to the green schoerl of Dauphiny of Romé de Lisle, the pistazite of Werner.

Thermantide Porcellanite of Haüy. Porcelain jasper.

Thermantide Tripoleenne of Haüy. Tripoli.

Thermometer. In the present cultivated state of philosophical knowledge, it can hardly be supposed that the reader has not seen a thermometer. Minute description is therefore unnecessary. But as the accurate construction and subsequent improvement of this instrument must greatly depend on the knowledge which those who use it may possess of the method of making it; and as we have no perfect account of this, there can be no doubt but a short relation of the whole process, from experimental knowledge, will be acceptable.

The tubes may be had at the glass-house; and the first care of the artist must consist in examining whether their cavities be equal or cylindrical throughout. This is done by immersing one end into mercury, and withdrawing it, after closing the other end with the finger. By this means a small quantity of mercury will enter the tube, which will occupy a longer space the deeper the tube is immersed. Lay the tube horizontally upon a graduated rule, and observe the length of the mercurial column in different parts of the tube, to which it may be made to run by inclining it more or less. If the length continue invariably the same, it is a proof that the tube is uniformly cylindrical; but if otherwise, the diameter varies, and the tube cannot be used to make a good thermometer, unless the graduations in the different parts of the tube be lengthened or shortened, in proportion to the measures of the mercurial column.

Direct the flame of a large candle, a watch-maker's lamp, or, which is cleanliest and best of all, a lamp with alcohol, upon one end of the glass tube, by means of the blowpipe. The extremity will soon become red-hot, and in a state of imperfect fusion. Remove the tube from the flame, and blow into its other end, and the heated part will be inflated so as to form a bulb. This last inflation is the most difficult and laborious part of the business; but it may be performed with great ease and advantage, by previously fastening the neck of one of the small bottles of elastic gum, or India rubber, about the end of the tube; which, when the other end is ignited, may be pressed by the hand, so as to blow the bulb very commodiously, and without the introduction of any moist air.

Immerse the open end of the thermometer tube into some very clean dry mercury, that has been boiled, and warm the bulb with a candle; part of the air will be immediately heard rushing through the mercury; withdraw the candle, and as the bulb cools, the mercury will rise in the tube. This will be facilitated by holding the tube as near a horizontal position as can be done, without raising its lower end above the surface of the mercury. In this way the bulb will be nearly half filled, Without altering the position of the apparatus, move the whole so that the bulb may be held over a candle. A small candle newly snuffed is best, because of the steadiness of its flame; and it will be necessary to wrap a piece of paper round the tube, to defend the finger and thumb from its heat. The mercury will soon boil, and most of the remaining air will be heard escaping from the bulb. As soon as this escape has ceased, remove the bulb from the candle, and it will be suddenly filled with mercury from the vessel.

Take the thermometer thus filled out of the mercury, and wrap round its open end a piece of thin paper, in such a manner as to leave a cavity beyond the tube, at least sufficient to hold as much mercury as the bulb contains; secure this by wrapping it tight with packthread about the tube; then put a drop of mercury into the proper cavity, and apply the bulb again over the snuffed candle, holding the tube upright between the finger and thumb, or a pair of small pincers, at the part wrapped with paper and packthread; the mercury will soon boil, and about half the contents of the bulb will rush violently up the tube into the paper. Remove the bulb from the candle, and the mercury will suddenly return; then boil it again, and repeat the operation till the speedy boiling of the mercury, when placed over the candle, and the diminished noise and agitation, show, that the whole has been well heated, and deprived of the air or moisture, which might have adhered to it.

The operation of boiling will fail, if the mercury or the inside of the bulb be moist; for in this case the bulb is usually burst by the mercurial vapour: the explosion, however, is not dangerous: it is very likely to happen with bulbs blown by the mouth, unless they be kept some weeks in a dry place before they are filled. The same danger makes it prudent not to boil the mercury strongly the first or second time; and it is likewise of importance, to keep the bulb clear of the flame, as the contact of this last against the empty part of the bulb would melt it, and a hole would be immediately made by the excluded vapour.

After the boiling is completed, plunge the bulb into cold water, the temperature of which is known. Melting ice or snow (or snow and water) always has the temperature of 32° of Fahrenheit's scale. Then take off the paper, and put the bulb into the hand, and afterward into the mouth; this heating will cause some of the mercury to drop out of the tube. Cool it again to 32°, by immersing it in the cold water, and mark where the mercury stands. The distance between this station and the top of the tube measures the interval between freezing and blood heat, or 32 and 95, which makes 63 degrees; and will consequently show whether the degrees will be large or small, and what extent the scale is capable of; that is to say, it will show whether the bulb be of the proper size. This last, supposing the judgment of the operator not sufficient to proportion the bulb nearly to the tube and the intended scale, might however have been more conveniently ascertained after the first filling, before the boiling had been undertaken.

When the number of degrees to which the length of the tube will extend is thus known, the operator must settle whereabouts he will have the freezing point, which may be nearer or farther from the bulb, accordingly as he intends the instrument to be used, more particularly to ascertain great degrees of heat or of cold. At this stage of the business, likewise, he may heat the upper part of the tube with the blowpipe, and draw it out to a fine capillary tube ready for sealing. The bulb must then be heated in the candle, till a few particles of mercury have fallen off the top of the tube; and notice must then be taken how much nearer the freezing point is to the bulb than before; which may be done by immersing it in the melting snow as before. If it be not as low as desired, the heating must be repeated, carefully observing not to throw out too much mercury at a time.

When the due quantity of mercury is thus adjusted, two candles must be prepared, the one to heat the bulb, and the other to close the tube. The blowpipe being in readiness, the upper part of the tube near the flame of one candle, and the bulb near the flame of the other, the mercury will rise, and at last begin to form a globule at the point of the capillary tube. At this instant the bulb must be withdrawn from the lower candle, at the same time that the flame of the upper is directed by the blowpipe upon the point of the tube. This last will be immediately ignited, and will close by the melting of its parts, before the mercury has perceptibly subsided. When the mercury has fallen, this closure may be rendered more secure from accidental breaking, by fusing the whole point of the tube till it becomes round.

If this business be properly done, the mercury in the instrument thus filled will run backwards and forwards in the tube, immediately upon inverting its situation.

In the original graduation of thermometers, two fixed points of temperature are necessary. These are the freezing point of water, or temperature of ice or snow, at the instant of formation, or rather when it is just beginning to liquefy; and the boiling point of water, or temperature at which, under a known pressure, it is plentifully converted into steam. For the settling of the freezing point, nothing more is necessary than to immerse the thermometer so deep in melting snow or ice, as that the mercury may be barely visible above its surface, and carefully mark the place at which it stands. The boiling point is not quite so easily ascertained; crude, hard, or saline waters acquire a greater heat in boiling than such as are purer; and the same water will acquire a greater heat under a greater pressure. For this last reason, the boiling point should be fixed according to the decision of the committee of the Royal Society; namely, when the barometer stands at 29·8 inches.

The best method is to provide a vessel somewhat longer than the thermometer, with a cover, and two holes in it; one about an inch in diameter, for the steam to escape; and the other smaller, for the thermometer-tube to be fastened in it. When this is used, the thermometer must be fastened in the cover, so that the estimated place of the boiling point may be just above the hole. Water must be put into the vessel, not sufficient to touch the bulb of the thermometer when the cover shall be put on. The vessel must then be covered, a thin plate of metal laid on the steam-hole, and the water made to boil by heat applied to the bottom only. The thermometer will be then surrounded with steam, which will more convenient to those who are not provided with such a vessel: Wrap several folds of linen rags or flannel round the tube, nearly as high as the supposed boiling point; hold the ball of the thermometer in the ascending current of boiling rain-water, about two or three inches below the surface; pour boiling water on the rags three or four times, waiting a few seconds between each time; and wait some seconds after the last time of pouring on water, in order that the water may recover its full strength of boiling, which is considerably checked by the pouring on the rags. The place where the mercury stands is the boiling-water point.

Notwithstanding the accurate adjustment of the fixed points of a thermometer, yet, if the tube be not truly cylindrical, or if the divisions be not adjusted to the inequalities of its diameter, the errors at the middle, between the two fixed points, may amount to more than a whole degree. A small error in the standing of thermometers may be occasioned by the varying pressure of the atmosphere, which alters the capacity of the glass; but it never amounts to so much as the tenth part of a degree. Spherical bulbs are least subject to this.

Thermometers, which from the great length of their degrees, or for any other reason, are made to take in but a small part of the interval between the two fixed points, are usually graduated by comparison with a standard thermometer.

The very careful boiling of the mercury, as above described, is absolutely necessary for such thermometers as are to be sealed when full; for if there were any air or moisture left in the bulb, it would prevent the mercury in the tube from descending into the bulb, so that the tube would continue always full. These thermometers are undoubtedly the best; but the vacuum above the mercury does not seem to be an indispensable requisite. If a clean dry tube be filled with pure boiled mercury, and a small bulb be left at the top of the tube, to contain common air, in order that its expansion or condensation, produced by the change in the mercurial surface, may be inconsiderable; there will be few practical objections against such a thermometer, more especially if it be a secondary instrument, graduated by means of a standard. There are some thermometers made with tubes so very small, and bulbs so large in proportion to them, that they will not admit of boiling the mercury in them, but are filled with boiled mercury by means of a condenser. These are necessarily of the kind here mentioned.

The thermometers most in use at present are Fahrenheit's, Reaumur's, and Celsius's. The centigrade thermometer of the modern scale the number of degrees between the freezing and boiling-water point is 180; the freezing point being at 32°, and the boiling-water point at 212°, both above 0°, or the part from which the degrees are reckoned both ways. In Reaumur's scale, the number of degrees between these two points is 80, and the freezing point is called 0°, from which the degrees are reckoned both ways. In Celsius's thermometer, the interval is divided into 100°, and the freezing point is called 0°, as in Reaumur's. To reduce these scales to each other, it must be observed, that one degree of Fahrenheit's is equal to four ninths of a degree of Reaumur, and to five ninths of a degree of Celsius. Therefore, if the number of degrees of Fahrenheit, reckoned above or below the freezing point, be multiplied by 4, and divided by 9, the quotient will be the corresponding number on Reaumur's scale. Or if the multiplier 5 and the divisor 9 be used, the quotient will give the degrees of Celsius's scale. And, contrariwise, if any number of degrees, either of Reaumur or Celsius, be multiplied by 9, and divided by 4 if of Reaumur, or by 5 if of Celsius, the quotient will give the degrees of Fahrenheit, reckoned either above or below the freezing point as the case may be.

THUMMERSTONE. *Axinite* of Haüy, *yanolite* of Delamétherie, *tumite* of Napione. This stone was first described by Mr. Schreber, who found it near Balme d'Auris in Dauphiny, and called it *violet schoerl*. It was afterward found near Thun in Saxony, whence Werner gave it the name of *thummerstein*.

This stone is sometimes found massive, but more frequently crystallized. It is difficult to get at its primitive form, which, according to Haüy, is a rectangular quadrilateral prism, the bases of which are oblique-angled parallelograms. The greater angle is 101° 32′.

The secondary forms are so much the more difficult to determine, as they have likewise for their type a quadrangular prism, but oblique, and differing from that of the primitive form. If we leave out of consideration the facets, which alter their figure a little, the general form of the crystals is a quadrangular prism, oblique and flattened to such a degree, that their edges are thin and cutting like those of an axe. This is the first character that strikes the eye on looking at them.

Thummerstone is not so hard as quartz, but harder than feldspar. It strikes fire with steel, emitting a smell resembling that of the common gun-flint. Its appearance and fracture are glassy; but sometimes its fracture is a little rough, or even scaly.

Before the blowpipe it froths and melts into a grayish enamel, but with borax it assumes a fine olive-green colour. Though most commonly of a dirty violet colour, it is sometimes as transparent as glass. Its specific gravity varies from 3·213 to 3·300.

The violet crystals are rendered electric by heat; and are not symmetrical, as is common to all that possess this property.

Klaproth and Vauquelin have both given analyses of this stone, between which there is a considerable difference. Klaproth found in a hundred parts,

Silex	52·7
Alumine	25·6
Lime	9·4
Oxide of iron	9·6
	97·3

Vauquelin's analysis gave

Silex	44
Alumine	18
Lime	19
Oxide of iron	14
Oxide of manganese	4
	99.

Though it is most commonly of a violet colour, it is sometimes green and transparent, or even opake; this opacity being produced by a mixture of chlorite. It has been remarked, that the crystals with this mixture were more regular and better defined. When massive it is of a dirty violet, and composed of a mulitude of laminæ, crossing each other in all directions, and leaving in some places cavities between them. They are likewise intermixed with sulphuret of iron. In this state it is found at Ehrenfriedersdorf in Saxony.

It does not form large masses, or enter into the composition of rocks; but it is found in the veins and clefts of primitive rocks, particularly in those with base of serpentine. The insides of these clefts are lined with its crystals.

It has been found in France, in the neighbourhood of Oysans, in the department of the Isère: in the Pyrenees, at the peak of Eredlitz, on a gangue of quartz, and accompanied with carbonat of lime; in the environs of Alençon, in the midst of granites: at Thum, near Ehrenfriedersdorf: in Mount Atlas, in Africa: near Kongberg, in Norway, in a white foliaceous limestone, accompanied with black mica, quartz, and sometimes native silver: in the mine of Torbiorns-begrube, at Arendahl, accompanied with feldspath, strahlstein, &c.: and in Cornwall.—*Thomson.—Brongniart.*

THUS. Frankincense. See OLIBANUM.

TIN is a metal of a yellowish white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious. Wires cannot be made of it; but under the hammer it is extended into leaves, called tin foil, which are about one thousandth of an inch thick, and might easily be beaten to less than half that thickness, if the purposes of trade required it. The process for making tin-foil consists simply in hammering out a number of plates of this metal, laid together upon a smooth block or plate of iron. The smallest sheets are the thinnest. Its specific gravity is less than that of any other malleable metal. Long before ignition, it melts at about the 410th degree of Fahrenheit's thermometer, and by a continuance of the heat it is slowly converted into a white powder by oxidation. Like lead, it is brittle when heated almost to fusion, and exhibits a grained or fibrous texture, if broken by the blow of a hammer; it may also be granulated by agitation at the time of its transition from the fluid to the solid state. The oxide of tin resists fusion more strongly than that of any other metal; from which property it is useful, to form an opake white enamel when mixed with pure glass in fusion. The brightness of its surface when scraped soon goes off by exposure to the air; but it is not subject to rust or corrosion by exposure to the weather.

Concentrated sulphuric acid, assisted by heat, dissolves half its weight of tin, at the same time that sulphureous gas escapes in great plenty. By the addition of water an oxide of tin is precipitated. Sulphuric acid, slightly diluted, likewise acts upon this metal; but if much water be present, the solution does not take place. In the sulphuric solution of tin, there is an actual formation or extrication of sulphur, which renders the fluid of a brown colour while it continues heated, but subsides by cooling. The tin is likewise precipitated in the form of a white oxide by a continuance of the heat, or by long standing without heat. This solution affords needle-formed crystals by cooling.

Nitric acid and tin combine together very rapidly, without the assistance of heat. Most of the metal falls down in the form of a white oxide, extremely difficult of reduction; and the small portion of tin, which remains suspended, does not afford crystals, but falls down, for the most part, upon the application of heat to inspissate the fluid. The strong action of the nitric acid upon tin produces a singular phænomenon, which is happily accounted for by the modern discoveries in chemistry. Mr. de Morveau has observed, that, in a solution of tin by the nitric acid, no elastic fluid is disengaged, but ammonia is formed. This alkali must have been produced by the nitrogen of that part of the nitric acid which was employed in affording oxigen to oxide the tin.

The muriatic acid dissolves tin very readily, at the same time that it becomes of a darker colour, and ceases to emit fumes. A slight effervescence takes place with the disengagement of a fetid inflammable gas. Muriatic acid suspends half its weight of tin, and does not let it fall by repose. It affords permanent crystals by evaporation. If the tin contain arsenic, it remains undissolved at the bottom of the fluid. Recent muriat of tin is a very delicate test of mercury. Mr. Chenevix says, if a single drop of a saturated solution of neutralised nitrat or muriat of mercury be put into 500 grains of water, a few drops of solution of muriat of tin will render it a little turbid, and of a smoke gray. He adds, that the effect is perceptible, if ten times as much water be added.

Oxigenized muriatic acid dissolves tin very readily, and without sensible effervescence. The solution itself does not appear to differ from the foregoing.

A muriat of tin at a much higher degree of oxidizement, and very different in its properties, may be formed by an indirect process.

When equal parts of an amalgam of tin and mercury, and of corrosive muriat of mercury, are triturated together, and the mixture exposed to distillation in a retort, by a very gentle heat, a colourless fluid first comes over. This is followed by a thick white fume, which becomes condensed into a transparent liquor, called the fuming liquor of Libavius, on account of the copious fumes it emits when the vessel that contains it is opened. On account of the considerable volatility of this liquid, it rises partly in the form of flowers to the top of the bottle into which it is put; so that, in the course of several months, it becomes entirely closed.

The composition and effects of this liquid were but imperfectly known until lately, when Mr. Adet made several ingenious experiments upon it. By exposing this liquid under receivers containing dry air, over mercury, he found that the volatile fluid arose, and lined the vessel with crystals, when water was present, though very few crystals were formed, when the air was as dry as it could be made. He observed likewise, that when water was added to the fuming liquor of Libavius, it became solid, and ceased to emit fumes. A precise quantity of water is required to produce this effect in the most perfect manner. If the quantity of water be too small, the liquor retains more or less of its disposition for the fluid state; and if it be too considerable, the fluidity of the water prevails. By several trials he found, that the due proportion of water to be added to the fuming liquor of Libavius was 7 to 22. A kind of ebullition, or escape of bubbles, was produced during the combination; which, on examination, was found to arise from the escape of the air previously contained in the fluid water. He found likewise, that this concrete substance, when rendered fluid by an increase of temperature, was capable of dissolving more tin, without the disengagement of hidrogen. After the concrete substance was saturated with tin, it could no longer be sublimed, but might be made to undergo a red heat, during which time there was an escape of vapours, consisting of tin combined with the muriatic acid; and after a strong heat, the residue was a white oxide of tin. It appeared therefore, that the liquor of Libavius, rendered concrete by water, and saturated with tin, resembles in its properties the common solution of tin in the muriatic acid.

From these circumstances Mr. Adet concludes, that the tin, by stronger affinity, combines with the oxigenized muriatic acid of the corrosive muriat of mercury with which it is heated; that this combination contains no water; and that, as it abounds with a substance of such extreme volatility as that oxigenized acid, its freezing point is very low, insomuch that it is habitually fluid; that the addition of water, in a due proportion, alters the freezing point, and renders it concrete at a common temperature; and lastly, that the state of the muriatic acid in this substance is that which is called oxigenized; which is proved, as well from the experiments which ascertain that state in corrosive muriat of mercury, as from similar experiments with the fuming liquor, which, as has been observed, is capable of dissolving more tin without disengaging hidrogen; the fuming liquor of Libavius has therefore the same relation to the common solution of tin as corrosive sublimate has to calomel. Proust however considers it as a combination of tin highly oxidized with the common muriatic acid.

The residue, after the distillation by which the fuming liquor of Libavius is produced, consists of tin combined with the muriatic acid, calomel, and running mercury, which sublime into the roof and neck of the retort; and at the bottom is found an amalgam of mercury and tin, covered with a saline combination of muriatic acid with tin, and such other metals as the tin may have been adulterated with. Much information may be derived from the foregoing experiments of Mr. Adet respecting the phænomena produced when tin is dissolved in aqua regia.

Proust makes this fuming liquor without any amalgama. He mixed 24 oz. of corrosive muriat of mercury with 8 oz. of powdered tin, and from these obtained 9 oz. of the liquor of Libavius. As a great excess of pure and oxided tin was found in the residuum, he tried the proportion of 32 oz. to 8, but this gave him only 10 oz. of the liquor.

Pelletier prepared it by passing oxigenized muriatic acid gas through a solution of muriat of tin, and expelling the excess of muriatic acid by heat.

Aqua regia, consisting of two parts nitric and one muriatic acid, combines with tin with effervescence, and the development of much heat. In order to obtain a permanent solution of tin in this acid, it is necessary to add the metal by small portions at a time; so that the one portion may be entirely dissolved before the next piece is added. Aqua regia, in this manner, dissolves half its weight of tin. The solution is of a reddish brown, and in many instances assumes the form of a concrete gelatinous substance. The addition of water sometimes produces the concrete form in this solution, which is then of an opal colour, on account of the oxide of tin diffused through its substance.

The uncertainty attending these experiments with the solution of tin in aqua regia seems to depend upon the want of a sufficient degree of accuracy in ascertaining the specific gravities of the two acids which are mixed, the quantities of each, and of the tin, together with that of the water added. It is probable, that the spontaneous assumption of the concrete state depends upon water imbibed from the atmosphere. The solution of tin in aqua regia is used by dyers to heighten the colours of cochineal, gum lac, and some other red tinctures, from crimson to a bright scarlet, in the dyeing of woollens.

The acetous acid scarcely acts upon tin. The operation of other acids upon this metal has been little inquired into. Phosphat, fluat, and borat of tin have been formed by precipitating the muriat with the respective neutral salts.

Earthy substances do not appear to affect this metal in the dry way. It detonates very rapidly with nitre, and becomes converted into an oxide, which partly combines with the alkali. All the sulphats are decomposed by tin. The tin becomes oxided, and the sulphuric acid converted into sulphur, which forms a sulphuret with the alkali, or earth of the salt, and dissolves part of the oxide.

Sal ammoniac is very readily decomposed by tin. Ammonia and hidrogen are disengaged, and a concrete muriatic salt remains behind, which in some measure resembles the fuming liquor of Libavius. Notwithstanding the facility with which this metal decomposes sal ammoniac, there is an inconvenience resulting from its use, which depends on the great fusibility of this metal; in consequence of which, it cannot be intimately mixed with the sal ammoniac, but remains at the bottom of the vessel in the fluid state, while part of the sal ammoniac eludes its action, and is sublimed entire.

If the crystals of the saline combination of copper with the nitric acid be grossly powdered, moistened, and rolled up in tinfoil, the salt deliquesces, nitrous fumes are emitted, the mass becomes hot, and suddenly takes fire. In this experiment the rapid transition of the nitric acid to the tin, is supposed to produce or develop heat enough to set fire to the nitric salts; but by what particular changes of capacity has not been shown.

If sulphur, in powder, be added to about five times its weight of melted tin, the two substances combine, and form a black compound, which takes fire, and is much less easily fused than tin itself. The mass is brittle, and of a needled texture.

The combination of oxide of tin and sulphur forms a compound called *aurum musivum*; which see.

When tin is heated with phosphoric acid and charcoal, the metal appears to be very little changed. A combination, however, seems to take place; for the phosphorus burns on the surface of the metal when heated by the blow-pipe. If small pieces of phosphorus be thrown on tin in fusion, it will take up from 15 to 20 per cent, and form a silvery white phosphuret of a foliated texture, and soft enough to be cut with a knife, though but little malleable. This phosphuret may be formed likewise by fusing tin filings with concrete phosphoric acid.

Tin unites with bismuth by fusion, and becomes harder and more brittle in proportion to the quantity of semimetal added. With nickel it forms a white brilliant mass. It cannot easily be united in the direct way with arsenic, on account of the volatility of this semimetal; but by heating it with the combination of the arsenical acid and potash, the salt is partly decomposed; and the tin combining with the acid becomes converted into a brilliant brittle compound, of a plaited texture. It has been said, that all tin contains arsenic; and that the crackling noise, which is heard upon bending pieces of tin, is produced by this impurity; but from the experiment of Bayen this appears not to be the fact. Cobalt unites with tin by fusion; and forms a grained mixture of a colour slightly inclining to violet. Zinc unites very well with tin, increasing its hardness, and diminishing its ductility, in proportion as the quantity of zinc is greater.

This is one of the principal additions used in making pewter, which consists for the most part of tin. The best pewter does not contain above one twentieth part of admixture, which consists of zinc, copper, bismuth, or such other metallic substances as experience has shown to be most conducive to the improvement of its hardness and colour. The inferior sorts of pewter, more especially those used abroad, contain much lead, have a blueish colour, and are soft. The tin usually met with in commerce in this country, has no admixture to impair its purity, except such as may accidentally elude the workmen at the mines. But the tin met with in foreign countries is so much debased by the dealers in that article, especially the Dutch, that pewter and tin are considered abroad as the same substance.

Antimony forms a very brittle, hard

by computation from the specific gravities and quantities of each, separately taken. Tungsten fused with twice its weight of tin affords a brown spongy mass, which is somewhat ductile.

Tin is scarcely ever found native. Native tin may be analysed in the moist way, by the application of nitric acid, which oxides the tin, and dissolves the other metals it may contain. One hundred and forty grains of the washed and dried oxide are equivalent to one hundred grains of metallic tin. The metallic admixtures may be separated from the nitric acid, by methods adapted to their respective properties; which may be easily gathered from what has been observed in the humid analysis of the metals before treated of.

The calciform ores of tin are—wood-tin, hitherto found only in Cornwall and Mexico, in fragments generally rounded, of a brown colour, specific gravity from 6·450 to 6·738, and containing 0·91 oxide of tin, 0·09 oxide of iron—tin spar, which is generally of a whitish or gray colour, sometimes greenish or yellowish, semitransparent, and crystallized in a pyramidal form, or irregularly—opake brown or black tin ore, crystallized and embodied in quartz, fluor, or mica, or mixed with white and yellow pyrites; these ores contain a mixture of iron—the reddish-yellow, or garnet ore, which contains more of iron than tin—and the tin-stones, vulgarly called lode-stones, which contain still less tin. See Ores of Tin.

It was formerly supposed, that tin was frequently mineralized by arsenic; but it is now admitted, that the arsenic which may be contained in tin is afforded by the matrix.

The scarcity of sulphureous tin ores was likewise considered, till lately, as a very singular fact, on account of the facility with which that substance unites to tin: such combinations however have since been found. The native aurum musivum, from Siberia, is of this kind: and a very considerable vein of tin in combination with sulphur, and an admixture of copper and iron, has been found in Cornwall.

The analysis of tin ores in the humid way is an object of some difficulty; because they are not acted upon effectually either by the sulphuric, nitric, or muriatic acid, or by aqua regia. The method of Bergman is as follows: The ore must be reduced to a very subtile powder by levigation and elutriation. This last process consists in agitating any powder in water, which is heavy enough to sink in that fluid. The particles will be resisted in their descent, according to the surfaces they oppose against the fluid. It is scarcely necessary to observe, that a larger body vided into parts. For this reason, when a powder consisting of particles of the same density, but different magnitudes, is agitated in a slighter fluid, the largest pieces come first to the bottom: and hence the method of elutriation enables us to assort the various particles of a powder according to their magnitudes, by first agitating the fluid, and successively decanting it into different vessels. Thus, for example, if the water be decanted five seconds after the agitation, it will leave a powder behind it; if it be again decanted at the end of five seconds more, the second vessel will contain a much finer powder than the foregoing; and, by a third decantation, a still more subtile powder will be obtained. This is the method applied in the preparation of the white oxide of tin, called putty, and used for polishing fine metallic speculums, and the object lenses of telescopes; and in this way the tin ore to be analysed may be reduced to a very subtile powder, by levigating and again washing the coarse residue, which subsides in the first vessel. It may be observed, that the successive decantations are unnecessary where the very finest powder only is wanting; because this may be as well obtained by suffering the water to stand a sufficient time before it is decanted off at first.

To the very subtile powder of tin ore, thus afforded, a quantity of concentrated sulphuric acid must be added, and kept in a strong digesting heat for several hours. A small portion of concentrated muriatic acid must be poured into this when cold. A strong effervescence takes place with considerable heat, and the escape of muriatic acid air, which has been deprived of its water by the sulphuric acid. After the expiration of an hour or two, some water must be added, and the clear liquor decanted. The same operation must be repeated with the residuum, until the acids can dissolve no more: and nothing will then remain but the stony matrix. The solution, when precipitated by means of mild alkali, will afford 100 grains of metallic tin for each 132 grains of precipitate, when washed and dried. If the precipitate do not consist of pure tin, but contain copper or iron, it must be oxided for an hour in a red heat; then digested in nitric acid, which will take up the copper; and afterward in muriatic acid, which will dissolve the iron.

In the dry way, after pulverization, and separation of the stony matter by washing, the tin ores may be hastily fused with twice their weight of a mixture of pitch and oxided borax, in a crucible lined with charcoal, and covered; or the ore may be mixed with twice its weight of tartar, one part of black flux, and half a part of resin.

This mixture being then divided into three parts, each part must be successively projected into a crucible ignited to whiteness, which must be immediately covered as soon as the portion thrown in ceases to flame.

The operation of reducing tin ores in the large way is conducted upon similar principles. When impure, they are cleansed from foreign admixtures, by sorting, pounding, and washing. A slight previous roasting renders the stony parts more friable; and when arsenic is contained in the matrix, it is driven off by a strong heat, continued for a short time; the ore being frequently stirred, to prevent its running together by fusion. In the smelting of the ore, care is taken to add a larger quantity of fuel than is usual in the reviving of other metals; and to avoid a greater heat than is necessary to reduce the ore, in order that the loss by oxidation may be prevented as much as possible. See Ores.

Tin is a metal which, as far as our present information extends, is not very much diffused. It is found in Bohemia and Saxony, and on the island of Malacca in the East Indies. But the largest quantities, at least for the European consumption, are found in England; particularly in the county of Cornwall. This island has been famous for its tin mines from the remotest periods of history; and would not, probably, have been frequented by the ancient Phœnician navigators, if they had not been attracted hither by the great plenty of tin, with which it abounds. Several etymologists have endeavoured to show, that the name of Britain is derived from a word common to the Syrian and Chaldæan languages, denoting tin; but on this no great stress can be laid.

The uses of tin are very numerous, and so well known, that they scarcely need be pointed out. Several of them have been already mentioned. The tinning of iron and copper, the silvering of looking-glasses, and the fabrication of a great variety of vessels and utensils for domestic and other uses, are among the advantages derived from this metal. See Tinning.

Tincal. Crude borax, as it is imported from the East Indies in yellow greasy crystals, is called tincal.

Tinctures *of vegetable and animal substances.* Many medicinal preparations are called tinctures, because they are made by digesting certain vegetable and animal substances in alcohol, either pure, or diluted with an equal quantity of water, to which they communicate different colours according to their nature.

Some of these tinctures are made with one vegetable or animal substance only. These are called simple tinctures, and they are distinguished by the name of the vegetable or animal matter employed; such are the tinctures of myrrh, of aloes, of saffron, of castor, and many others.

Others contain a greater or less number of different vegetable and animal substances, which are digested in the menstruum, according to the several receipts. These have the general name of compound tinctures, and have also been distinguished by the names of their particular authors and qualities.

These several tinctures are rather objects of pharmacy than of chemistry. Macquer makes the following general observations upon them:

First, as vegetables and animals are composed of several principles, which are not all soluble, or not equally soluble in alcohol, we cannot consider spirituous tinctures as complete extracts of the vegetable and animal substances employed in their preparation.

Secondly, the principles of those substances, upon which alcohol can act, are volatile essential oils, and others of the same nature; resins, properly so called; any oils that are in a saponaceous state, and soluble in water by means of some saline matter; acids; and lastly, several kinds of neutral salts. And the principles which alcohol cannot dissolve directly, are sweet oils and oily concretions that are neither volatile nor saline; substances purely gelatinous and gummy; earthy matters neither saline nor soluble in water; and lastly, many neutral salts, which are insoluble in alcohol, the various kinds of which have not yet been determined.

Thirdly, many of the vegetable and animal principles, that are essentially insoluble in alcohol, particularly gums, jellies, and neutral salts, are soluble in water.

Fourthly, from the last observation we may perceive, that tinctures drawn from the same vegetable or animal substance must differ considerably, according to the state of dryness of these substances, and the dilution of the alcohol employed. For a tincture made from moist plants, and with a weak spirit, must contain some gummy and saline principles, which could not be contained in a tincture made with the plants perfectly dried and a spirit perfectly rectified.

Fifthly, as many chemical experiments show, that substances naturally insoluble in any certain menstruum may be rendered soluble in that menstruum by some other intermediate substance; and as among the vegetable and animal principles, some such intermediate substances may exist; it cannot therefore be affirmed, that spirituous tinctures contain no other of these principles, than such as are naturally soluble in alcohol; but it seems more probable that they contain other principles. As this subject has not been sufficiently examined, it is impossible to speak upon it in any other than a vague and general manner.

Tinglass. Bismuth.

Tinning *of copper and of iron.* Tinning is an operation, by which a very thin layer of tin is applied to the surface of some metals, and especially of copper and of iron. The methods of tinning these two metals are different. Copper is tinned after it has been formed into utensils, and by the copper smiths who form these utensils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, England, Germany, and in some other places.

The several operations for tinning of copper and iron are founded, first, on the facility with which tin unites with these metals, which is so great, that when either of these metals is tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheless, the tin incorporates with these metals, dissolves in some measure their surface, and forms a kind of alloy, at least when the tinning is well performed.

Secondly, the foundation of all the parts of the operation used to make the tinning succeed is, that metals cannot perfectly unite with each other but when they are in a metallic state; and that they cannot unite with any earthy matter, or even with their own oxides.

Hence the whole art of tinning consists in employing melted tin, the surface of which shall be very clean, metallic, and not covered with any oxide of tin, to the surface of iron or of copper, which must also be very clean, and free from all rust or oxide.

To attain these purposes the following method is used: As the surface of copper is continually altered merely by the action of air, the workmen before the tinning of any vessel scrape its surface with a steel instrument till it is clean and bright; then they place the vessel upon kindled coals, and heat it to a certain degree: as soon as it is hot, they rub it with pitch; and then apply the melted tin, which they spread upon the surface of the copper by means of hards, or balls of flax. Pure tin is seldom used for this purpose; but generally two parts of tin are alloyed with one part of lead.

The pitch used in this operation is quite necessary, because the degree of heat given to the copper is sufficient to oxide its surface in some measure; and this alteration, however slight, would prevent the perfect adhesion of the tin. This pitch prevents also the slight oxidation which would happen on the surface of the tin, or revives the small particles of oxide, which are formed during the operation.

When plates of iron are to be tinned, they must be perfectly well cleansed, which is done by scouring them with sand, and steeping them some time in an acid liquor; then they are to be wiped, and dried quickly and perfectly. Lastly, they are to be plunged vertically into a vessel containing melted tin, the surface of which is covered with fat and pitch. These substances covering the surface of the tin prevent its oxidation, by which its adhesion to the iron would be impeded; and also render the surface of the iron, while it passes through them, fitter to receive the tin. By thus plunging plates of iron into melted tin, they are covered over with this metal, or are tinned.

Sal ammoniac is also used successfully in the tinning of iron and copper, and for the same reason. The acid of this salt perfectly cleans the surface of the metals to be tinned; and the alkali contained in sal ammoniac prevents the oxidation. Thus by heating these metals to a certain degree, and rubbing them with sal ammoniac, the tin may be applied immediately afterward.

The art of tinning is kept a great secret by the workmen, but does not appear to be in any respect difficult to an ingenious contriver. Thus iron tacks, which cannot be conveniently tinned in a bath, are easily covered with tin by including the nails, with a due proportion of tin and sal ammoniac, in a stone bottle, and agitating them while heating and cooling.

The advantages received from tinning are very considerable. As tin is a soft and fusible metal, vessels formed of it alone would not have sufficient strength and hardness to keep their shape in common use, and would also be liable to be melted by a small heat; but when it is applied to the surface of hard and difficultly fusible metals, as copper and iron, many vessels may be fabricated, which have the advantage of being preserved by means of the tin from rust, to which the copper and iron are very subject. It has been nevertheless justly alleged, that copper vessels are not perfectly prevented from rust or verdigrise by tinning; and this fault is so much more important, as tinned copper vessels are used in the preparation of food. These vessels, therefore, even when tinned, ought not to be employed for this purpose: especially as lead, a very hurtful metal, is used in tinning. Nevertheless, tinned copper vessels may be used for many other purposes. Besides, the tinning of copper and iron vessels may be improved by attending to the fundamental principles of this art delivered in the present article.

Mr. Malouin has proposed in his Memoirs on Zinc (Mem. de l'Acad. des Sciences, 1742) to substitute that semimetal in place of lead and tin, for the tinning of iron and copper vessels The greater hardness of the zinc, it is thought, would render it less liable to be worn; and the dangerous effects of lead and tin would be avoided. But whether it might not be attended with other inconveniences must be submitted to farther experience.

Mr. Buschendorf, of Leipsic, has proposed the following compound; which, though more expensive than tin itself, is much more durable. Tin one pound, malleable iron 1½ ounce, platina 1 drachm, silver 24 grains, gold 3 grains. In this however the gold can have little effect. He likewise recommends a second coat, formed of a mixture of 3 parts of tin and 2 of zinc, to be applied over the first coating of copper vessels tinned in the common way.

For the tinning of looking-glasses, see Silvering.

The tinning of pins has been the object of a considerable series of investigations by Mr. Gadolin. In the Journal de Physique for May and June 1789, there is a translation of his Memoir by Dolfuss, of which the following is an abstract. It is a generally admitted fact, that copper dissolved in any acid whatever is always totally precipitated by the addition of tin. The experiment of whitening pins shows nevertheless, that tin is really precipitated in the metallic form by copper, if both be boiled in a solution of tartar. Mr. Gadolin, in the presence of Mr. Gahn, found, that the remaining fluid contained no copper; whence these chemists concluded, that the precipitation must be effected in some way different from that of the ordinary elective attraction. He therefore instituted the following experiments:

1. A leaf of tin was kept some days in a solution of half a loth of cream of tartar, after which it was found to have lost 0·005 loth of its weight. A plate of copper, by digestion for six hours in the fluid, after the tin was taken out, lost 0·0006 loth of its weight, but was not visibly altered, excepting that its surface was slightly oxided. The solution was then boiled with polished iron, and both the tin and the copper were precipitated on the iron.

2. The results were nearly the same when acid of tartar was used instead of the cream of tartar.

3. To a solution of tin in aqua regia neutral tartrit of potash was added: the tin fell down in combination with the acid of tartar. Of this precipitate, first edulcorated and dried, half a loth was boiled with water and a polished copper-plate for three hours. No remarkable change happened to the copper.

4. The last experiment was repeated with one tenth of a loth of the precipitate, and 0·07 loth of crystallized acid of tartar. The result was as before.

5. Tin foil was then added along with the polished copper in the last-mentioned solution. After three hours boiling the copper became covered with a pellicle of tin, which was rather dull, and had increased in weight 0·0002 loth. The tin lost 0·001 loth.

6. One tenth of a loth of the precipitate N° 3, was boiled for three hours on a plate of copper, with the addition of tin foil. The tin became of a blackish yellow dull colour, with the loss of 0·0009 loth; but the copper was not at all changed.

7. The last-mentioned experiment was made, with the addition of half a loth of cream of tartar to the solution. The tin lost 0·0009 loth of its weight; the copper became covered with a very slight pellicle, and had lost 0·0004 of its weight.

8. Half a loth of cream of tartar, dissolved in water, was boiled with leaves of tin and a plate of polished copper. The copper became covered with a pellicle of tin, and had gained in weight 0·0001 loth. The tin had lost 0·0004 loth.

9. One sixth of a loth of crystallized acid of tartar was dissolved in water, and boiled with leaves of tin and polished copper for three hours: the tin lost 0·0004 loth; but the copper was not changed either in colour or weight.

10. To the last-mentioned solution a quantity of potash was added, sufficient to saturate the tartar. A plate of copper and leaves of tin were again added, and the whole boiled a little. The tin thus added lost 0·0005 loth of its weight. The copper was covered with a pellicle of tin, but did not acquire any perceptible increase of weight.

11. One loth of cream of tartar was dissolved in water, and saturated with potash. In this solution leaves of tin and polished copper were boiled for three hours, at the end of which time the copper was not changed, but the tin had lost 0·0014 of its weight. A few drops of solution of the acid of tartar were then added, and the boiling repeated. The copper became covered with tin.

12. Two thirds of a loth of cream of tartar were dissolved in water, and boiled with a plate of polished copper, the surface of which was covered with a slight pellicle of tin: the copper had lost by that means 0·0062 loth of its weight, in the form of a detached scoria. One part was dissolved, and the rest lay at the bottom of the phial. Into this solution a plate of polished copper was put, with leaves of tin. After three hours the tin and the copper were found covered with a black thick crust, which might have been scaled off. The tin had lost 0·007 loth of its weight by this operation. But the copper had lost nothing, and was covered with an unequal tarnished film of tin. On those parts from which the black pellicle was removed, a slight scale of tin might be perceived.

13. Two thirds of a loth of cream of tartar were dissolved in water, and to this were added 0·005 loth of oxide of copper, precipitated from sulphat of copper by potash. After having boiled in this solution a piece of tin in leaves and polished copper for the space of three hours, the tin became covered with an entire crust, but detached as in the last experiment. After the separa-

tion of this crust, the tin weighed 0·0071 loth less than before. The copper was covered with a blackish pellicle, and had gained 0·004 loth of weight.

14. One sixteenth of a loth of crystallized acid of tartar, and 0·0028 loth of precipitated oxide of copper. In this solution a plate of polished copper and tin in leaves were boiled for three hours. It was then found that the tin, cleared of its black crust, had lost 0·0056 loth. The copper, which was covered with a black pellicle not detached, had gained 0·0004 loth.

15. In a solution of one sixth of a loth of crystallized acid of tartar in water, a piece of iron was boiled during half an hour, and lost 0·002 by solution. Into this clear solution a piece of polished copper and leaves of tin were put, and boiled for three hours. The copper became covered with a bright pellicle of tin, without any remarkable acquisition of weight. The tin had lost 0·0004 loth.

The reasoning of Mr. Gadolin on these experiments is premised by two observations: 1. That in all oxidation of metals, a common substance unites with and becomes a component part of the oxide. 2. That a metal is oxidable in different degrees, and is disposed to combine with a greater portion of oxigen, or to part with some of that which it already holds, accordingly as that quantity is less or greater. He then proceeds to infer,

That copper can never separate metallic tin from a solution of tin in tartar, or its acid, if metallic tin itself be not at the same time present.

That the solution of tin is made in the acid of tartar by an oxidation of that metal; that the copper tends to attract and combine with the dissolved metal, but cannot separate it from the oxigen; but that the oxigen having a tendency to unite with the metallic tin already present in the mass, is by this means solicited to quit the dissolved tin, which it does in part. The consequence is, that a small portion of the tin combines with the copper in the metallic state, and another portoin of tin is taken up, accurately sufficient to set the several tendencies in equilibrio.

This precipitation does not take place when the acid of tartar predominates greatly, and still less if the solution be saturated with an oxide of tin in a higher state of oxidation. For in the first case the unsaturated acid retains the tin by a power too strong to be overcome by the attraction of the copper, and in the latter case the oxigen acts on the tin nearly in the same way.

The precipitation of the tin takes place, if the acid of tartar have recently dissolved a small portion of iron in the metallic state. For iron recently dissolved is very strongly disposed to combine with the oxigen; and by this means favours the reduction of the tin.

Mr. Gadolin farther remarks, that tin is more abundantly dissolved in tartar, or its acid, if tin in a state of higher oxidation be previously dissolved; and that the action of the acid is still more effectual, if the oxide of copper be previously dissolved in it. And in this case the metallic copper presented is covered with a dirty pellicle. In these experiments (13, 14, 15) the metals previously dissolved are precipitated in the metallic state. And hence it is seen, that those who are engaged in this business ought to be careful to avoid any impurity or scoria of copper in their mixtures.

From the ingenious solution this chemist affords to the difficulty attending the precipitation of tin by copper in this process, by the attraction existing between the two metals and the different degrees of oxidation, it is evident how important it is to pay a due attention to all the circumstances of chemical operations, and particularly this last. The Baron de Gedda on this occasion made several experiments, which led to a closer investigation on the part of professor Gadolin.

The Baron whitened copper by boiling it with tartar and tin. He also tried alum and common salt, together and separately. The alum answered particularly well. His remarks on the theory of the Professor were, in short, that the subject did not appear to be sufficiently mature to admit of a clear explanation, particularly as the effect is attributed to a simple attraction, and ought to succeed with an addition of iron, after taking out the metallic tin, which he tried in various ways without success.

In his second set of experiments, Mr. Gadolin shows more strongly, that the copper need not be acted on by the acid in the process, by repeating the experiments with cream of tartar, tin, and a piece of fine gold. The gold was well tinned, though the acid of tartar had assuredly no action on it.

With regard to the precipitation of the tin upon the copper by the addition of iron, after the leaves of tin were taken out, he did not indeed find it take place in trials with the acid of tartar, which he attributed to the slight action of this acid. And accordingly he found, that it succeeded when tin and alum were boiled together; the tin then taken out, and a plate of copper boiled in the solution, with a few filings of iron. The iron was strongly acted on, and the copper in a few minutes covered with a pellicle of tin.

The following experiments tend also to throw farther light on the subject. One part of tin in leaves was added to two parts of sulphat of copper dissolved in water. The mixture was kept in a close phial for several days, in a moderate heat and occasionally agitated. After some days the green colour had disappeared, the copper had fallen down, and the solution by the test of ammonia gave an abundant precipitate of oxide of tin, but no trace of copper. Of this sulphuric solution of tin one part was added to a plate of copper and leaves of tin; a second part was added to a plate of copper and another of iron; and the third was added to a plate of copper alone. These three mixtures, in separate phials, quite full and well closed, were kept in a moderate heat for some hours; after which the copper in the first was found to be covered with an even polished pellicle of tin, but a little dull and blueish. In the second the copper was also tinned, but less uniformly; and the iron was every where well covered. In the third the copper was not at all changed.

The solutions in the first set of experiments, which contained copper, and were unfit for this operation, were rendered fit for the purpose by first precipitating the copper by ebullition with tin. The same effect took place with the aluminous solution of tin contaminated with copper.

Unequal proportions of tartar, alum, and common salt, are used in the arts for whitening copper. When a bright and shining surface is required rather than a high degree of whiteness, the solution of tartar is to be preferred. The solution of alum gives merely an exquisite whiteness, and is to be preferred where a clear dead white, as it is called, is wanted. Tartar and common salt are added to diminish the appearance of want of polish the solution of alum gives to the blanched metal. Gadolin found, that a mixture of one part of white tartar or cream of tartar, two of alum, and two of common salt, is the most useful solvent for this purpose, and very well calculated to succeed.

Titanites. This name has been given to certain ores of titanium, containing that metal in the state of oxide. See the following article.

Titanium. About twenty years ago the Rev. Mr. Gregor discovered in a kind of ferrugineous sand, found in the vale of Menachan in Cornwall, what he supposed to be the oxide of a new metal, but was unable to reduce.

Klaproth, afterward analysing what was called the red schoerl of Hungary, found it to be the pure oxide of a new metal, which he named titanium, and the same with the menachanite of Mr. Gregor. Since that oxide of titanium has been discovered in several fossils.

The red schoerl, titanite of Kirwan, rutile of Werner, is crystallized in prisms of four or six sides, frequently capillary, penetrating quartz. Its colour has frequently a shade of brown. It is shining and slightly translucent; hard, brittle, and of a foliated fracture. It does not melt before the blowpipe, but with borax fuses into a red, transparent glass. Its spec. grav. is 4·18.

Another titanite from Spain, of a light reddish brown internally, and externally coated with white clay, is in hexahedral columns, with a flat six-sided pyramidal termination, ending in a hexahedral cavity instead of a point.

Another from Aschaffenburg is of a deep reddish brown, in rounded prisms, apparently quadrilateral. Its spec. grav. only 4·065.

The blue schoerl, oisanite, anatase, or octahedrite, is an oxide of titanium mixed with silex.

A variety of corundum, of a mottled colour, the prevailing tint in which is lilac, analysed by Mr. Gregor, gave in 100 parts, alumine 81·75, silex 12·125, oxide of titanium 4, water 0·937.

In the menachanite, nigrine, and iserine, the oxide of titanium is mixed with that of iron; beside which in the first there is a little silex, and sometimes a minute portion of oxide of manganese; in the second, a little oxide of manganese; and in the third, about 10 per cent of oxide of uranium.

We do not know that titanium has been completely reduced, except by Lampadius, who effected it by means of charcoal only. The oxide he employed was obtained from the decomposition of gallat of titanium by fixed alkali. The metal was of a dark copper colour, with much metallic brilliancy, brittle, and in small scales considerably elastic. It tarnishes in the air, and is easily oxided by heat. It then acquires a blueish aspect. It detonates with nitre, and is highly infusible. All the dense acids act upon it with considerable energy. According to Vanquelin it is volatilized by intense heat.

The native red oxide is insoluble in the sulphuric, nitric, muriatic, and nitro-muriatic acids: but if it be fused with six parts of carbonat of potash, the oxide is dissolved with effervescence. The sulphuric solution when evaporated becomes gelatinous: the nitric affords rhomboidal crystals by spontaneous evaporation, but is rendered turbid by ebullition: the muriatic becomes gelatinous, or flocculent, by heat, and transparent crystals form in it when cooled; but if it be boiled, oxigenized muriatic acid gas is evolved, and a white oxide thrown down. Phosphoric and arsenic acids take it from the others, and form with it a white precipitate. These precipitates are soluble in muriatic acid, but in no other.

The solutions of titanium give white precipitates with the alkalis, or their carbonats; tincture of galls gives a brownish red; and prussiat of potash a brownish yellow. If the prussiat produce a green precipitate, this according to Lowitz is owing to the presence of iron. Zinc immersed in the solutions changes their colour from yellow to violet, and ultimately to an indigo: tin produces in them a pale red tint, which deepens to a bright purple red. Hidrosulphuret of potash throws down a brownish red precipitate, but they are not decomposed by sulphuretted hidrogen.

some lustre, brittle, of a granular texture, and not very fusible.

The oxides of iron and titanium, exposed to heat with a little oil and charcoal, produce an alloy of a gray colour, intermixed with brilliant metallic particles of a golden yellow.

Oxide of titanium was used to give a brown or yellow colour in painting on porcelain, before its nature was known: but it was found difficult to obtain from it an uniform tint, probably from its not being in a state of purity.—*Journ. de Phys.*—*Nich. Journ.*—*Scherer's Journ.*—*Kirwan.*—*Klaproth.*—*Murray.*

TOBACCO (Petum, Nicotiana, herba medicea, &c.) was first discovered in the island Tobago; brought into Europe in the year 1559 or 1560, by Mr. Nicot the French ambassador in Portugal, and presented to queen Catherine de Medicis. It is now become the object of very extensive manufactures, and cultivated in large quantity by the European colonies in America, as also in some parts of Europe. There are different species of the plant, and great differences also in the qualities of one species according to the soil and climate: still farther differences are occasioned in the prepared tobaccos and snuffs from the manner of preparation, and the additions made use of for communicating colour, flavour, &c.

The leaves of this plant, taken internally, prove virulently emetic, cathartic, and narcotic: even in the common forms, in which they are employed in such immense quantities, they generally at first disorder the constitution, till habitual use, which subdues many noxious things, has rendered them perhaps innocent, and perhaps even necessary. Distilled in a retort without addition, they yield an acrid empyreumatic oil, which has been found from repeated trials to be poisonous to sundry animals: it is probably on this oil that the effects of the smoke of tobacco depend, for when the plant is set on fire, its native qualities are destroyed.

Tobacco loses its virulence by long coction in water. Though all the active parts of the herb are extracted by the water, yet the extract left upon evaporating the liquor, taken in doses of four or five grains, is said to prove mildly aperient and anodyne, and to be of great service in disorders of the breast: the longer the coction is continued, a suitable quantity of water being added for this purpose, the milder is the extract. The late Dr. Fowler gave the infusion with success in dropsy.

Neumann analysed three sorts of tobacco; the American canister tobacco, the Dutch leaf, and the dried leaves of our own growth. An ounce of the canister, treated first with water, gave four drachms thirty grains of that of the second, sixty; and from that of the third, thirty. An ounce of the canister sort, treated first with alcohol, yielded one drachm thirty grains; the same quantity of the Dutch, two drachms twenty grains; and an ounce of ours, two drachms thirty grains. From the residuum of the first, water extracted three drachms thirty grains: from that of the second, two drachms forty grains; of the third, two drachms thirty grains; the indissoluble earthy matter amounted in each of the experiments to three drachms.

The spirituous extracts made from all the sorts were stronger than the watery; that of the canister sort was notably pungent on the tongue; of the Dutch, only bitterish, without any acrimony; the spirituous extract of ours tasted somewhat pungent, but the watery only bitter. The spirituous extracts of all the sorts are of a fine green colour, the watery of a yellowish brown. The distilled waters and spirits have no taste or smell. Bohn, however, pretends, that the distilled water, especially if drawn from the juice of the herb, will occasion vomiting, if taken to the quantity of an ounce or two.

TOLU (**BALSAM OF.**) This substance is obtained from the toluifera balsamum, a tree which grows in South America. The balsam flows from incisions made in the bark. It comes to Europe in small gourd shells. It is of a reddish brown colour and considerable consistence; and when exposed to the air, it becomes solid and brittle. Its smell is fragrant, and continues so even after the balsam has become thick by age. When distilled with water, it yields very little volatile oil, but impregnates the water strongly with its taste and smell. A quantity of benzoic acid sublimes, if the distillation be continued.

Mr. Hatchett found it soluble in the alkalis, like the rest of the balsams. When he dissolved it in the smallest possible quantity of lixivium of potash, it completely lost its own odour, and assumed a fragrant smell, somewhat resembling that of the clove pink. "This smell," Mr. Hatchett observes, "is not fugitive, for it is still retained by a solution, which was prepared in June, and has remained in an open glass during four months."

When digested in sulphuric acid, a considerable quantity of pure benzoic acid sublimes. When the solution of it in this acid is evaporated to dryness, and the residuum treated with alchol, a portion of artificial tannin is obtained; the residual charcoal amounts to 0·54 of the original balsam.

Mr. Hatchett found, that it dissolved in nitric acid with nearly the same phenomena as the resins; but it assumed the smell of bitter almonds, which led him to suspect the formation of prussic acid. During the solution in nitric acid, a portion of benzoic acid sublimes. By repeated digestions it is converted into artificial tannin.

It is totally soluble in alcohol, from which water separates the whole of it, except the benzoic acid.

A simple tincture of it is directed by the London College, and it enters into their compound tincture of benzoin, as it did into the once celebrated friar's balsam. A fragrant sirup, bearing its name, is likewise made by boiling it in water, which takes up from it some benzoic acid, of which it contains a considerable portion.—*Thomson.*—*Lewis.*

Tombac. A white alloy of copper with arsenic, commonly brittle, though if the quantity of arsenic be small it is both ductile and malleable in a certain degree. It is sometimes called white copper.

Topaz. All the known varieties of the topaz have the prismatic form. The prism has a perceptibly rhomboidal base, and is striated longitudinally, by which marks the topazes may be distinguished at first sight. In hardness it comes next to the spinel ruby. Spec. grav. from 3·464 to 3·564. Its fracture in the direction of the axis of the prism is vitreous, and perpendicularly to it lamellated. It is infusible by the blowpipe. Its primitive form is a rectangular prism, with a rhombic base, the greater angle of which is 124° 22′.

Among the varieties of the topaz some are rendered electric by heat, others by friction alone, but they possess this property in a more marked degree than other stones. The Brasil and Siberian topazes, when heated, become positively electrified on the one side, and negatively on the other.

Lowitz was the first who analysed the topaz with any accuracy, but he had a loss of 7 per cent, for which he could not account. Klaproth found, that this was owing to the escape of fluoric acid. His analysis, however, gave only 5 per cent of this acid from a Siberian topaz, and 7 from a Brasilian: while Vauquelin, who examined it afterward, obtained from 17 to 20 per cent of this acid, from 47 to 50 of alumine, and from 28 to 30 of silex. In the Siberian topaz he found 2 per cent of oxide of iron, and in the Brasilian 4. He says its powder turns the sirup of violets green.

Brongniart divides the topazes into, 1. The crystallized, of which there are six variations from the primitive form. Haüy observes, that the two summits of the prism of such as acquire opposite electricities are different; and this he adds is common to all crystals, which heat renders positively electric at one end, and negatively at the other. 2. The colourless. Most of these come from Siberia. 3. The yellow. This is the prevailing colour of the topaz: it is sometimes pale, as in the Saxon, which are electric by friction, and grow white in the fire: sometimes saffron-coloured, as in the oriental: sometimes russet, reddish, or even rose-coloured, as in those of Brasil. 4. The greenish. This, when of a greenishyellow, has been called Saxon chrysolite by some; and when the green inclines to a blue, Brasilian sapphire, or oriental aqua marina.

The topaz belongs to the primitive stones, even of the earliest formation, since it is found in the granites of tin-mines, either crystallized with the quartz and tin, or embedded in the granite itself. When of a very pure yellow, and free from flaws, it is of some value; but in general is not much prized.

It is sometimes of considerable size. Sir John St. Aubyn has one in his collection as big as a man's fist; and there was one in the cabinet of the prince of Orange at the Hague, of the shape of an egg, and upwards of seven inches in length. This, which I saw many years ago, had the appearance of a pebble rounded by water. Its surface and colour resembled resin. A considerable piece had been broken from one end, where the fracture appeared vitreous, and the stone clear. I suppose it must have been from trials with this piece, that its claim to the character of a topaz was ascertained.—*Brongniart.*—*Thomson.*

Topazolite. Dr. Bonvoisin has called by this name some dodecahedral crystals, with rhomboidal faces, of a very pale topaz yellow, and sometimes of a green approaching to that of the peridot, which he found in the valley of Lans, in Piedmont. They are, however, in fact garnets.—*Brongniart.*

Tophi. Duckstein of the Germans, Pori. Kirwan says that these differ from the calcareous stalactites, not only in shape, but principally in this, that they have been formed by a gradual deposition of earths, chiefly of the calcareous kind, barely diffused through water itself, and not in air. Hence they are of a soft and porous texture, and of the same colour as the stalactites.

The word tophi is also used as synonymous with tufa or tarras, which is a volcanic product. Great heaps of tufa, or tophi, are found in Italy, forming various hills, and covering large tracts of land, whence it is cut and carried for making the walls, vaults, and upper cielings of houses; it is a very soft kind of stone, extremely advantageous for these purposes, on account of its small weight, and being easily cut into any form. The inhabitants of Umbria and other parts of Italy dig with very little labour various subterraneous galleries and large excavations under earth, where they keep wines and many kinds of provision quite free from the irregularities and excesses of temperature.

Torrefaction. This name is given to a kind of calcination, by which ores are deprived of the volatile mineralising sub-rhubarb, &c.

Torsten. An iron ore of a bright blueish black, or yellowish gray colour, and fibrous texture, shows a red trace when scratched, and is weakly magnetic before calcination. According to Rinman, it is less oxided than hæmatites.

Touchstone. The black basaltes is used for examining the precious metals by the touch, and is commonly distinguished by this name. See Assay.

Tourmalin. This is one of the most strikingly characterized stones, notwithstanding the very different colours it is liable to exhibit, and which tend to disguise it. It is almost always in the form of long, and canulated prisms, the fracture of which is always vitreous, and sometimes articulated, that is, convex on one surface and concave on the other. The prism has commonly from six to twelve sides, and is terminated by unequal summits with three principal faces: but sometimes it is so short, that the summits unite, and form what is generally called a lenticular crystal. It is less hard than quartz. All its varieties, except the red, are easily fused by the blowpipe, and reduced to a whitish enamel with ebullition.

Most of the tourmalins are of a shining black. They are commonly more or less transparent, but have this peculiarity, that they are so only at right angles to the axis of the prism; so that when this is very short, they are transparent through their greater thickness, and opake through their less. They are likewise found colourless, of a honey yellow, emerald green, greenish blue, indigo blue, and red. The yellow has been called peridot; the green, emerald; and the blue, sapphire, of Brasil: and the red, rubellite, daourite, siberite, apyrous tourmaline, and red schoerl of Siberia; but it must not be confounded with the titanite, which also has borne the latter name.

A green tourmalin, analysed by Vauquelin, gave in 100 parts, silex 40, alumine 39, water 4, iron 12½, manganese 2: a violet red, the *siberite* of Lermina, silex 42, alumine 40, manganese 7, and soda 10: and a blackish violet, silex 45, alumine 30, oxide of manganese 13, soda 10. The last two were from Siberia.

The electricity of the tourmalin is its most remarkable property, and is in some respects singular. If a prismatic crystal be slightly heated, it will attract light bodies, and cause the electrometer to diverge. If a brass needle balanced on a pivot, and insulated, be electrified negatively, the extremity of the prism that has the greater number of faces will repel, and the other attract it. If a filament of silk be fixed to the end of a stick of sealing-wax, and electrified nega-

little below the summit. It appears, therefore, that the poles are confined to the neighbourhood of the extremities, the space between attracting any electrical body, whichever kind of electricity it may possess; unless indeed the electricity be distributed in alternate zones throughout. If the tourmalin be broken when electric, each of the fragments will exhibit electrical poles in the same direction as before.

The most advantageous degree of heat for exciting the electricity of the tourmalin is from 100° to 212°. If it be carried beyond this, it loses its electricity, and resumes it only on cooling: but by continuing to raise the temperature, we shall come to a point at which the tourmalin will be again electric, but the electricity of its poles will be reversed. Mr. Haüy observes, that the poles may be equally reversed by heating it unequally by means of a burning glass.

The tourmalin was the first stone in which the property of becoming electric by heat was discovered, at least in modern times, Lemery noticing it in 1719. Pliny, however, speaks of a reddish or purple stone that possessed this property, which was probably the rubellite tourmalin from Ceylon.—*Brongniart.*

Traass. See Tarras.

Tragacanth (Gum). This substance, which is vulgarly called gum dragon, exudes from a prickly bush, the *astragalus tragacantha* Lin., which grows wild in the warmer climates, and endures the cold of our own, but does not here yield any gum. This commodity is brought chiefly from Turkey, in irregular lumps, or long vermicular pieces bent into a variety of shapes; the best sort is white, semitransparent, dry, yet somewhat soft to the touch.

Gum tragacanth differs from all the other known gums, in giving a thick consistence to a much larger quantity of water; and in being much more difficultly soluble, or rather dissolving only imperfectly. Put into water it slowly imbibes a great quantity of the liquid, swells into a large volume, and forms a soft but not fluid mucilage: if more water be added, a fluid solution may be obtained by agitation; but the liquor looks turbid and wheyish, and on standing the mucilage subsides, the limpid water on the surface retaining little of the gum. Nor does the admixture of the preceding more soluble gums promote its union with the water, or render its dissolution more durable: when gum tragacanth and gum arabic are dissolved together in water, the tragacanth seems to separate from the mixture more speedily than when dissolved by itself.

Vauquelin has lately instituted an examination of this gum, of which he has given

Ten grammes (154·5 gr.) of red gum dragon produced on combustion three decigrammes and a half (5·4 gr.) of white ashes. These ashes dissolved in muriatic acid with effervescence, and gave forth an odour of sulphurated hidrogen. Their solution deposited a precipitate by ammonia, which was phosphat of lime and oxide of iron. The oxalat of ammonia precipitated from it much lime. Thus red gum dragon contains in 100 parts about 3½ of ashes, which was composed for the most part of carbonat of lime, a small quantity of iron, of phosphat of lime, and perhaps of a very minute portion of alkali.

Ten grammes (154·5 gr.) of white gum dragon submitted to the same proofs, gave three decigrammes (4·6 gr.) of ashes, which were composed of the same principles as the red kind, with the addition of a little potash.

Ten grammes (154·5 gr.) of gum arabic burnt as the others, left three decigrammes (4·6 gr.) of ashes, which were composed of the same elements as the preceding, except that they gave no sign of the presence of alkali or sulphur.

Mr. Vauquelin formerly thought that the opacity of gum dragon, and the difficulty of its solution in water might be occasioned by a greater proportion of earthy matter; but from these experiments he supposed, that they are due to another cause.

The lime which he found in the gum, was doubtless neither in the state of carbonat, and still less in that of quicklime; for the solutions of the gum were not in the least alkaline; but on the contrary, slightly acid; at least a bit of the gum rubbed on some paper well moistened (with blue vegetable juice) made it sensibly red. It is also certain, that oxalat of ammonia and carbonat of potash occasion precipitates in the solution of gum arabic, and that acetit of lead does not form any. It follows from this, that the lime is most probably united to some acid in the gums, which doubtless is a vegetable acid; for in being decomposed they leave their bases combined with carbonic acid; but can be neither the oxalic, the tartarous, or the citric, because their combinations are insoluble in water, and that besides they exist but in a small number of vegetables; still less can it be the benzoic, the gallic, the moroxalic, or the melitic, which are very rarely found in it naturally, and of which the three last also form insoluble compounds.

There only remains to decide between the acetous and the malic acids, which are the most abundant in the vegetable kingdom. The first forms, as is well known, soluble combinations with all the substances with which they are capable of union; some of them are even deliquescent. It is besides the most frequent result of the operations

fermentation, the action of the more powerful acids, and by the influence of heat.

The combinations of the second are for the most part insoluble in water; that which it forms with lime particularly, is not sensibly soluble, but when there is an excess of acid; and its existence in nature is by no means so frequent as that of the acetous acid; and as the lime which is found in the transparent gums has been incontestably dissolved in the juices of the vegetables which produce these substances, it is much more probable, that this earth is in them combined with acetous acid than with any other.

It is also probable that the small quantity of potash which he found in the ashes of the burnt gums, is united to the same acid; which explains why these substances are so sensible to humidity, and soften so much more as to prevent their pulverization.

He is, however, much inclined to think, that in certain opake dragon gums, which are of difficult solution, and yield much lime on incineration, this earth is combined with malic acid. He has had occasion lately to examine a gum gathered by Mr. Paliss of Beauvois, from the cochineal nopal, which was opake, swelled with water, did not dissolve uniformly, and which yielded 8 per cent of lime. And as the sap of every cactus which I have analysed, yielded more or less acidulous malat of lime, there is great reason to believe, that the species of it which nourishes the cochineal contains it likewise: and that it is the presence of this salt proceeding from the vegetable, and dissolved in the sap along with the gum, which causes its opacity, and obstructs its solution in water. It results at least from these experiments, that the gums contain, first a calcareous salt, most commonly acetat of lime; secondly, sometimes a malat of lime with an excess of acid; thirdly, phosphat of lime; fourthly and lastly, some iron, which is probably also united to phosphoric acid.

Tragacanth is usually preferred to the other gums for making up troches, and other like purposes, and is supposed likewise to be the most effectual as a medicine; but on account of its imperfect solubility is unfit for liquid forms. It is commonly given in powder with the addition of other materials of similar intention: thus to one part of gum tragacanth, are added one of gum arabic, one of starch, and six of sugar.—*Annales de Chimie.—Lewis.*

TRANSMUTATION. See **METALS.**

TRAPP. A dark gray or black stone, generally invested with a ferruginous crust, and crystallized in opake triangular or polyangular columns, is called basaltes; that which is irregular, or breaks in large thick square pieces, is called trapp, from its resemblance to stairs, of which trapp is the Swedish name. Their constituent principles and relation to acids and fluxes are exactly the same. The texture of this stone is either coarse, rough, and distinct, or fine and indiscernible. This latter sort is often reddish; it is always opake, and moulders by exposure to the air; some specimens give fire with steel very difficultly, though it is always very compact; sometimes it is sprinkled over with a few minute shining particles: its specific gravity is 3·000.

When heated red hot, and quenched in water, it becomes by degrees of a reddish brown colour: it melts per se in a strong heat into a compact slag. Borax also dissolves it in fusion, but soda not entirely.

Tremolite. Grammatite of Haüy. There are three sub-species of this stone, the common, glassy, and asbestous. All of them have a fibrous or radiated texture, with a certain glassy lustre, by which they are easily known. They present themselves in the form of long flattened bundles of slender parallel fibres, or that of flattened prismatic crystals, the sides of which are furrowed longitudinally.

The only stone from which it is difficult to distinguish it is the asbestus, the asbestous tremolite differing from this scarcely in any external character except hardness. The asbestous tremolite is always stiff; its filaments are hard and rough to the touch; and rubbed on glass with a little water they wear its surface, and destroy its polish, which asbestus never does, unless it be mixed with some harder stone.

The fracture of the tremolite is radiated and fibrous in the direction of its length, uneven transversely. Before the blowpipe it fuses into a white glass full of blebs. Its specific gravity varies from 2·9 to 3·2.

The general form of the crystals of tremolite is a very flat prism, with a rhomboidal base, and terminating in two culminating faces. The longitudinal edges of the prism sometimes have their place supplied by slender facets.

The primitive form likewise is an oblique prism with a rhomboidal base, the sides of which are inclined to each other in angles of 126° 52′ 12″ and 53° 7′ 48″.

Tremolite scarcely ever occurs pure, almost always including within its crystals part of the rock, which has served as its bed. Hence it is, that its analyses teach us nothing certain respecting its true nature, and that they differ greatly from each other, as may be seen by the following.

A glassy tremolite analysed by Klaproth gave from one hundred parts,

Silex - - -	65
Lime - - -	18
Magnesia - -	10·33
Oxide of iron -	0·16
Water - -	6·50
	99·99.

A gray tremolite by
Silex -
Magnesia
Lime -
Carbonic acid a

Different white trem
Silex - -
Magnesia -
Lime - -
Carbonic acid and
Dr. Kennedy found
Silex -
Lime -
Alumine
Soda -
Oxide of iron
Carbonic acid

The colours of the t
striking: they vary
pearly white to yello
and occasionally reddi
It is commonly op
translucid, or even tra
is the case it has a vitr
The fibres of whic
sometimes parallel, so
Tremolite is most
that compound carbo
distinguished by the r
is found in it mixed
forms. This tremoli
both by friction and b
de Bournon has show
for this property to
tains, since, if it be fr
of an acid, it loses its p
says too, that he has f
argillaceous gangue, t
14 per cent of alumin
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This stone is said t
covered by Pini in th
in Saint Gothard, wh
Wyttenbach however
never found in the va
at Campo Longo, ab
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was discovered by Ho
even been called Hoep
It has since been fo
in Hungary, Carinth
Kalkberg, near Rasp
Corsica it occurs in
filaments of a gray c
posed of laminæ of a g
talc. Near Nantes it
fibres on a granite ab
It is found in the fibro
in the granulous carbo
ma: in Bengal, in pre
greenish gray: on Vesu
It has likewise been
on the borders of lak
stellated masses, in a

lime. This has been called *baikalite*. Mr. Patrin found it on the Upper Irtisch in Chinese Tartary; and in the mine of Kadainsk, near the river Amoor. The gangue of the first of these was a coarse grained dolomite of a reddish white colour with blue stripes; that of the second a very white fine-grained dolomite.—*Brongn.*—*Thomson.*

Tria Prima. The three elements of the alchemists, their salt, sulphur, and mercury: the first of which appears to have denoted whatever remained fixed in the fire; the second, whatever was inflammable; and the third, whatever was neither fixed, nor inflammable, but rose in vapour without being burned.

Trip. The same with *Tripoli*, or rotten stone.

Triphane. See Spodumene.

Tripoli. See Rotten Stone.

Trisule. A salt in which two bases are combined with the same acid.

Tritorium. A vessel generally made of glass, used for the separation of liquors of different densities, as oil and water. Its largest diameter is the middle, and it terminates with an aperture at each of the two extremities. The lower extremity, the aperture of which is very narrow, is dipped into the mixed liquor; and when it is sufficiently filled, the upper orifice is to be stopped close, by pressing the thumb upon it, by which means the liquor contained will not run out at the lower aperture when the vessel is raised from the mixed liquor. When the fluids, of which this liquor consists, have perfectly separated according to their respective densities, by removing the thumb the heavier fluid will run out at the lower extremity, and the separation will be thus effected.

Trituration is an operation which consists in the mechanical division of bodies, and is executed by the same methods, and by the same instruments that are employed for other divisions of this kind; that is to say, in mortars, upon porphyries, and in mills. This word is generally applied to denote the grinding of several bodies together, to unite them with each other; as for instance, the extinction of mercury in the operation of ethiops mineral, and others of a similar kind.

*Trompe. The trompe, or blowing machine, is formed of a hollow tree which rests upon a cask whose lower head is knocked out, and the open part of the cask itself plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a stone which is erected in the middle of the cask. The air becomes disengaged, and is obliged to pass out at a collateral aperture in the cask, by means of a tube which carries it to the lower part of the furnace. This air is afforded, 1. by that air which the water carries along with it: 2. by a current which passes through apertures made at the distance of six feet from the summit of the tree, and called trompilles. I use the French names, because I do not know of any appropriated English terms.

The dimensions of a good trompe, according to Chaptal, are the following:

Length of the tree or wooden trunk, from its summit to the side apertures or trompilles, six feet.

Length of the tree from the trompilles to the cask, eight feet.

Height of the cask, five feet.

Diameter of the cask, four feet six inches.

The form of the internal part of the trunk, above the trompilles, is that of a funnel, whose superior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is six in.

Dr. Lewis, in his Philosophical Commerce of Arts, treats expressly on this simple and useful instrument, on which he made many experiments. The following remarks, references, and investigations, are abridged from his work.

The earliest method of animating the large fires of the furnaces for smelting ores, appears to have been by exposing them to the wind. Such was the practice of the Peruvians before the arrival of the Spaniards in that country. Alonso Barba relates, that their furnaces, called guairas, were built on eminences, where the air was freest; that they were perforated on all sides with holes, through which the air was driven in when the wind blew, which was the only time the work could be carried on; that under each hole was made a projection of the stone work on the outside, and that on these projections were laid burning coals to heat the air before its entrance into the furnace. Some authors speak of several thousands of these guairas burning at once on the sides and tops of the hills of Potosi.

It is said that several remains of a like rude process are to be seen in some parts of our own country. The old blomery hearths, as they are called, for the running down of iron ore, are all on the tops of hills; a situation which can scarcely be supposed to have been chosen on any other account than for the conveniency of the wind, being in other respects extremely incommodious.

The gradual succession of bellows to this insufficient mode of supplying air, cannot perhaps be traced. It appears, that at some of our iron-furnaces, and others, the bellows were formerly moved by a handle, as those of the smith's forge, or by the pressure of the foot upon a treadle, or by other means requiring the strength of men; and that since the force of water has been called in aid to move them, the quantity of ore run down has not only been far greater, but the separation of the metal more complete.

The first account that is to be met with of a machine for propelling air into furnaces, by a fall of water carrying down air and open at both ends, is placed upright. A stream of water runs in at the top, and is discharged at the bottom; and about the middle of the height of the pipe a smaller horizontal one is inserted, which reaches to the furnace, and is said to convey to it a strong blast of air.

According to Mr. Bélidor, a pipe with air holes, inserted into an air vessel, is used for this purpose in some parts of France.

Mr. Mariotte gives an account of a contrivance for blowing fire by a fall of water, which consists of a funnel and pipe, without air holes, inserted into an air vessel.

Mr. Stirling describes a machine erected in Scotland, for blowing air into the furnaces in which lead ores are smelted, and for conveying fresh air into the works. This machine consists of a funnel and pipe, with air holes, inserted into an air vessel.

The blowing machines used in Dauphiny for the forges and smelting furnaces, have a great resemblance in their general structure to the foregoing.

In the county of Foix, the blowing machines, as described by Reaumur, are considerably different from the foregoing. The pipe is rectangular, and the part above the choak divides into three funnel-shaped partitions. On the top is a reservoir or cistern of water: and two of the partitions, close on all sides, pass up above the surface of the water, for carrying down air, and thus supplying the place of the lateral air holes: the water enters into the third partition, which is only the space between the two foregoing, and which has but two sides, formed by the two opposite sides of the others.

Mr. Barthes gives a minute description of a blowing machine at the forge of St. Pierre, on the river Obriou. Its general structure is nearly the same with that of Foix, but the height of water above the choak much less.

Dr. Lewis's trials, though not carried to such a length as he could have wished, satisfied him and those who assisted at them, that much more air is to be obtained by dividing the stream by means of a cullender, than by any other methods that have been tried; and that with such a machine as that of St. Pierre above described, a stream of a hundred and fifty gallons at most in a minute is sufficient to produce a continued blast from a pipe of three quarters of an inch bore, of such strength as to support a column of water of three feet or more.

His summary view of the most material particulars which his experiments have discovered, with regard to the perfection of the structure of blowing machines, and his description from them of such a machine as promises to be the most effectual, are as follow:

solicitous about procuring a greater height; for though a greater would be of some advantage, yet this advantage appears to be much less considerable than has been commonly imagined. In the channel by which the water is conveyed, are to be placed gratings of different sizes; and before the aperture a finer grating, which may be either a perforated iron plate or a wire sieve, to serve as strainers for keeping back such matters as would obstruct the apertures which the water is afterwards to pass through. The stream should enter at one side, or be so managed, that the water in the reservoir or funnel may not be agitated by it, or put into a spiral motion, which Dr. Lewis's experiments showed to be very injurious.

In the bottom of the reservoir is to be made a round hole, for admitting the upper end of a cylindrical pipe of copper or cast iron, five or six inches in the bore, and seven feet long. To the end of this pipe is to be fitted a cullender about a foot long, with the holes triangular, of half an inch each side; and six or seven spaces from top to bottom, at equal distances, must be left without holes, for admitting air to pass down to the lower streams. All the holes should be directed downwards, that the streams may not be forcibly projected against the sides of the pipe which is to receive them, so as to have their velocity too much diminished.

If there are six of the perforated spaces in the cullender, the number of holes in each may be twenty; so that the whole number will be one hundred and twenty. The side of each of the triangular holes being half an inch, the area of each will be the eighth part of a square inch, and the sum of their areas will be fifteen square inches. The quantity of water running through one aperture of such an area, at the depth of seven feet and a half under the surface, comes out on calculation about six hundred and twenty-two gallons in a minute; but the real quantity will doubtless be much less than this, on account of the great friction of the water in passing through a number of small holes, and of the resistance of the air, which increases in a very high ratio according to the increase of the velocity and enlargement of the surface: it is in part to make up for these retardations, that the pipe is directed to be made so high. The surface of the water is here above thirteen times greater than if it passed all through one circular aperture.

Both the pipe and the cullender should have a flanch or rim round their orifices, and be secured to one another by screws passing through the rims of both, with a plate of lead between them to make the juncture tight, as commonly practised in joining iron pipes for water works. This way of joining them admits the cullender to be taken off and cleaned, when a diminution of the effect of the machine shows the holes to be choked up; which, however, it is apprehended, will seldom if ever happen.

As the holes will permit more water to run through than may at all times be wanted, it is proper to have some contrivance for occasionally closing a part of them. This may be effected by means of a thin copper pipe, open at both ends, as high as the cullender, and of such width as just to drop into it. It will be easily conceived, that when this register is let entirely down, the lateral holes will be covered, and the water admitted only to those in the bottom; and that by raising it farther and farther, more and more of the lateral holes will be uncovered. The register is to be hung by a wire to a cross-bar over the reservoir, by which it may be raised or lowered; and a scale or divided board may be adjusted against the upper part of the wire, for showing the height of the register, or the number of holes closed by it.

The most commodious and effectual way of admitting air to the water appears to be that of hanging the throat of the funnel, in this case the cullender, within the wider receiving pipe; for by this means the air is admitted freely and uniformly all round. This last pipe should likewise be of iron or copper, twelve inches in diameter, and spread out at top to the width of sixteen or eighteen inches, that a large space may be left round the cullender: this space should reach three or four inches above the uppermost perforations of the cullender, to prevent any of the water from being dashed over the top.

A pit is to be sunk in the ground, not less than six feet deep. In this is to be placed an air vessel, made of wood lined with lead, without a bottom, three or four feet in width, and ten or eleven high. The vessel should be supported on feet of a proper strength, with sufficient spaces between them for the water to pass freely out: this way is preferable to the common one of placing the lower edge of the vessel on the bottom of the pit, and cutting an aperture in the side, because the height of the aperture is so much taken off from that of the vessel. The reservoir being fourteen feet above the ground, and the upper pipe and cullender reaching down eight feet, only six feet remain below the cullender; so that the air vessel having six feet sunk, the ground will reach nearly up to the cullender, and almost the whole height of the undermost pipe will be included within the vessel. This pipe may be above nine feet long, three feet or more of it going down into the pit; which three feet are here an entire gain in the height of the fall, for the pipe in the other machines comes at most no lower than the level of the ground where the water runs off on the outside. This height is gained in virtue of the compressed air in the vessel pushing down the water below: it may be always as great as the height to which the water is intended to rise in the gage. At the distance of five or six inches under the orifice of the pipe is to be placed the concave iron plate or stone for the water to fall on. In the top of the air vessel is to be fixed the gage and the blowing pipe.

Such is the general construction of the blowing machine, which (says Dr. Lewis) promises to be particularly useful in cases where water is scarce, or where the want of a natural fall renders it necessary to raise, by very expensive means, the great quantities requisite for working the common bellows. Dr. Lewis thinks too, that one of these machines will be sufficient for the iron forge, and for sundry other purposes where the quantity of air is not required to be very great; that it will be less expensive, on account of the durability of its materials and the simplicity of its structure, than any kind of bellows now in use; and what is of principal importance, that much less water will serve for working it. He adds, in cases where one of the machines cannot supply air enough, as for the large iron smelting furnace, two pipes may be used, both fed by one reservoir, and entering into one air vessel. The using of two pipes appears more eligible than enlarging the bore of one: for air cannot be so freely introduced into a large body of water, though divided into streams by the cullender, as into two smaller ones of equal quantity.

It may be observed, that the blast will be stronger in a dense state of the atmosphere than when it is more rare or expanded, a greater quantity of air being then introduced under an equal volume. If therefore the quantity of water has been adjusted so as to raise the gage to a proper height when the air was light, it will frequently happen that the same quantity of water shall raise it higher, and consequently, if no greater height is required, that a part of the water may be saved. As the gage of the machine discovers by inspection the variations in its effect, the register affords convenient means of regulating its power, and increasing or diminishing the quantity of water.

The method of blowing in our large furnaces is by iron bellows or machines, worked by a steam engine. Some years ago I had a conversation on this subject with one of our most eminent iron-masters, whose name I should be glad to mention as a credit to myself, if I had at this time an opportunity of asking his permission.

The air machines are iron cylinders six feet in diameter, in which a piston works with a stroke of seven feet in length. Each stroke therefore protrudes 198 cubic feet of air. At best the rate of working is sixteen strokes in a minute. The density of the air is such that it will raise three pounds

The reservoir, called the regulating belly, is a large close chamber open below, and surrounded with a sufficient mass of water to rise within it, and by its reaction keep up the density of the air with which its upper part is supplied from the cylinder. The difference of height between the surfaces of the water within and without the reservoir is between six and seven feet, and the rise and fall at each stroke of the piston is about four or five inches on the outer surface. I think he afterward said two or three. From this last datum we may deduce the size of the regulating belly or its horizontal section. For its surface will be to that of the piston, inversely as this rise is to the length of the stroke. If the medium of the first numbers be taken, its surface will be 19 times that of the piston, which is 28¼ square feet, that is to say, 536 square feet, or a square whose side is 23 feet. But if the medium of the second numbers be taken, the surface will be 45 times that of the piston, that is 1271 square feet, or a square whose side is about 36½ feet. The larger this surface, the steadier the blast. From the regulating belly proceeds the nozle or twyer (tuyere) as it is called. Its diameter at the aperture is one, two, or three inches. They have sometimes enlarged them for experiment as far as five; but they then found the apparatus not to supply the air quickly enough, or at least not with the same advantage as when a smaller aperture was used.

If we attend to the height of the water on the outside of the reservoir, we shall find the force of this apparatus to be greatly beyond that of the other bellows in use. Six or seven feet of water upon the base of a square inch will give 72 or 84 solid inches, and those at 1000 ounces to the cubic foot, or 1728 inches, will give 41 ounces, or two pounds nine ounces for the pressure upon a square inch, represented by the first of these numbers. The second number will give near 48 ounces, or three pounds. These pressures referred to a column of mercury, which is a very usual and convenient method of admeasurement, will correspond to 5·3 and 6·2 inches elevation of that fluid; that is to say, at most not one fifth of an atmosphere.

In some of the early volumes of the Abridgment of the Transactions, there is an account of a method of conveying air to vast distances, through pipes for the purpose of blowing, and, as I think, speaking from recollection, for the communication of mechanic effect. This scheme was put in practice by the father of the iron-master from whom the preceding information was received. The project, which did not succeed, cost four thousand pounds. was intended to be conveyed. A pipe ten inches diameter conveyed the air from the engine to the works, and the stream of air was never so strong as to blow out a candle. So I find it in my notes; but I think, from recollection, the expression was, to affect the flame of a candle, and certainly a very gentle breath of air was meant. The engine worked but a few strokes before it stopped. The proprietor concluded, that the pipe was in some part designedly obstructed; but upon advice, he put a cat into the pipe, which walked through it and came out at the other end.

It remained, therefore, to ascertain whether the obstruction of the air arose merely from the length of the pipe. For this purpose holes were cut in the pipe at various distances from the end at which the air entered, and proper coverings prepared, that each might be opened at pleasure. It was found, that the engine worked slower, the remoter the hole which was opened, the wind issuing of course with less strength; and when the hole was made at a certain distance, it stopped. I did not ask the distance. It is said, that the passage of air from a blowing machine to its place of escape is considerably impeded through pipes of the length of 40 or 50 feet. The fact, which is perfectly authentic, is certainly very curious. Whether it is to be ascribed to the loss by friction of a momentum, in which the velocity is so great and the mass so small; or whether there be any effect similar to that stickage which takes place when wool, or other elastic bodies are rammed into a tube, must be determined from a numerical estimate of all the facts, and may perhaps require new experiments. I cannot help, however, entertaining the opinion, that the former cause is the most effectual in this business; and that the undertaking here described might have been made to answer, by enlarging the diameter of the tube. For if the impediment be friction arising from the velocity of the mass, that element will diminish in proportion as the diameter of the tube is increased, and the quantity of surface rubbed against by the same mass of air will not alter. Hence, it should follow, that if a tube, of an inch diameter and three feet long, do not perceptibly resist the passage of the air, another tube thirty feet long will afford no more resistance, provided its diameter be ten inches, that is to say, proportional to its length.—*Phil. Trans.*—*Journ. des Sçavan.*—*Belidor's Arch. Hydr.*—*Mariotte du Mouvem. des Eaux.*—*Reaumur Art des Forges.*—*Mem. of the French Ac.*

TRUFFLE. See LYCOPERDON (TUBER).

TUBE OF SAFETY. A tube open at both ends, inserted into a receiver, the upper end communicating with the external air, and the lower being immersed in water. Its intention is to prevent injury from too sudden condensation or rarefaction taking place during an operation. For, if a vacuum be produced within the vessels, the external air will enter through the tube: and if air be generated, the water will yield to the pressure, being forced up the tube. Thus too the height of the water in the tube indicates the degree of pressure from the confined gas or gasses. See Pl. VII. fig. 3, *h*. It is now more frequently used in a curved form, *ib*. fig. 1; and is commonly called a welter's tube.

Tufa. See Tophi.

Tumite. See Thummerstone.

Tungstat. This name has been applied, though improperly, to the compounds of oxide of tungsten with some base, when that oxide was supposed to be an acid. See the following article.

Tungsten. This name, signifying heavy stone, was given by the Swedes to a mineral, which Scheele found to contain a peculiar metal, as he supposed in the state of an acid, united with lime. The same metallic substance was afterward found by the Don D'Elhuyarts united with iron and manganese in wolfram.

The tungstat of lime, as it was called, is of a yellowish or grayish white, changing sometimes superficially to pearl gray, or yellowish brown. It is generally found in masses or disseminated; but sometimes in octaëdral crystals. It is semitransparent; its fracture foliated inclining to the conchoidal, with an unctuous or vitreous splendour; seldom hard enough to give fire with steel; and brittle. Specific gravity from 5 to 6. Before the blowpipe it decrepitates and is infusible; but with microcosmic salt effervesces, and melts into a blueish globule.

From Scheele's analysis it would appear to consist of oxide of tungsten 44, lime 56: D'Elhuyarts, on the contrary, give 68 oxide of tungsten, and 30 of lime for its component parts: and Klaproth obtained from a transparent crytallized specimen, oxide of tungsten 78, lime 18, silex 3. It is found at Pengilly in Cornwall, contaminated with a little iron and manganese.

Wolfram is of a black, or dark brownish black colour. It is found in lumps, or crystallized in broad hexaëdral prisms, or rectangular four-sided tables. It is always opake; externally dull; internally of a metallic lustre. Its fracture lengthwise is foliated; transverse, uneven. Specific gravity from 6·8 to 7·333. It yields to the file.

Don D'Elhuyarts obtained by analysis from 100 parts oxide of tungsten 64, of manganese 22, of iron 13, silex and tin 2: Vauquelin, oxide of tungsten 67, of iron 18, of manganese 6·25, silex 1·5: Klaproth, from that of Poldice in Cornwall, oxide of tungsten 46·9, of iron 31·2, and some arsenic. This ore is much more common than the preceding.

From the first of these the oxide may be obtained by digesting its powder in thrice its weight of nitric acid; washing the yellow powder that remains, and digesting it in ammonia, by which a portion of it is dissolved. These alternate digestions are to be repeated, and the tungstic oxide precipitated from the ammoniacal solutions by nitric acid. The precipitate is to be washed with water, and exposed to a moderate heat, to expel any ammonia that may adhere to it. Or the mixture may be evaporated to a dry mass, which is to be calcined under a muffle, to dissipate the nitrat of ammonia. From wolfram it may be obtained by the same process, after the iron and manganese have been dissolved by muriatic acid.

The Spanish chemists reduced the oxide of tungsten to the metallic state by exposing it moistened with oil, in a crucible lined with charcoal, to an intense heat. After two hours a piece of metal weighing 40 grains, but slightly agglutinated, was found at the bottom of the crucible. Some have attempted its reduction in vain, but Guyton, Ruprecht, and Messrs. Aikin and Allen have been more successful. The latter gentlemen produced it from the ammoniuret. From 240 grs. of this substance, in acicular crystals, exposed for two hours to a powerful wind furnace, in a crucible lined with charcoal, they obtained a slightly cohering mass of roundish grains, about the size of a pin's head, with a very brilliant metallic lustre, and weighing in the whole 161 grains.

Richter has recommended, to expose equal parts of the oxide and dried blood to a red heat in a crucible for some time; transfer the black powder thus formed to a smaller crucible, and expose this to a violent heat in a forge for at least an hour.

Tungsten is said to be of a grayish white or iron-colour, with considerable brilliancy, very hard, and brittle. Its specific gravity Don D'Elhuyarts found to be 17·6; Messrs. Aikin and Allen, above 17·22; Guyton, but 8·3406; and Ruprecht, only 6·823.

Scheele supposed the white powder obtained by digesting the ore in an acid, adding ammonia to the residuum, and neutralizing it by nitric acid, to be pure acid of tungsten. In fact it has a sour taste, reddens litmus, forms neutral crystallizable salts with alkalis, and is soluble in 20 parts of boiling water. It appears however to be a triple salt, composed of nitric acid, ammonia, and oxide of tungsten; from which the oxide may be obtained in a yellow powder by boiling with a pure concentrated acid. In this state it contains about 20 per cent of oxigen; part of which may be expelled by a red heat, when it assumes a green colour.

Tungsten is insoluble in the acids; and

that the oxide gives great permanence to vegetable colours.—*Scheele's Essays.—Brongniart's Min.—Nich. Journ.—Phil. Mag.—Murray's Chemistry.*

Tungsten of Bastnas, or False Tungsten. See Cerium.

Turbith Mineral. Yellow subsulphat of mercury. See Mercury.

Turbith (Nitrous). The yellow suboxynitrat of mercury, precipitated by hot water from a solution of oxynitrat of mercury. See Mercury.

Turnsole. See Heliotropium.

Turkey Stone. Cos Turcica. This stone is of a dull white colour, and often of an uneven texture, some parts appearing more compact than others, so that it is in some measure shattery. It is used as a whetstone: and those of the finest grain are the best hones for the most delicate cutting tools, and even for razors, lancets, &c. Its specific gravity is 2·598. It gives fire with steel, yet effervesces with acids. Kirwan found, that 100 parts of it contain 25 of carbonat of lime, and no iron.

There probably are two sorts of stones known by this name, as Wallerius affirms that which he describes neither to give fire with steel, nor effervesce with acids. Workmen affirm, that this stone hardens with oil. The value of such specimens as contain a very fine grit, or siliceous part, is much greater than that of the common samples. Artists select them by trial; but it is not generally known, that most of these stones have a fine and a coarse side, and ought therefore to be sawed with an attention to this circumstance. It naturally arises from the stone having been formed from subsidence in water.

Turmeric (terra merita), curcuma longa, is a root brought to us from the East Indies. Berthollet had an opportunity of examining some turmeric that came from Tobago, which was superior to that which is met with in commerce, both in the size of the roots and the abundance of the colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness; but it possesses no durability, nor can mordants give it a sufficient degree. Common salt and sal ammoniac are those which fix the colour best, but they render it deeper, and make it incline to brown; some recommend a small quantity of muriatic acid. The root must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts soon disappears in the air.

Mr. Guhliche gives two processes for fixing the colour of turmeric on silk. The first consists in aluming in the cold for two ounces of turmeric and

sure) of aceto-citric acid, mixed with three quarts of water. The second process consists in extracting the colouring particles from the turmeric by aceto-citric acid, in the way described for brazil wood, and in dyeing the silk alumed as already mentioned in this liquor, either cold or only moderately warm. The colour is rendered more durable by this than by the former process. The first parcel immersed acquires a gold yellow; the colour of the second and third parcels is lighter, but of the same kind; that of the fourth is a straw colour. Mr. Guhliche employs the same process to extract fine and durable colours from fustic, broom, and French berries: he prepares the wool by a slight aluming, to which he adds a little muriatic acid. He seems to content himself in these cases with vinegar or some other vegetable acid, instead of his aceto-citric acid, for the extraction of the colour; he directs that a very small quantity of solution of tin should be put into the dye-bath.

Turpentine is a resinous juice extracted from several trees. Sixteen ounces of Venice turpentine, being distilled with water, yielded four ounces and three drachms of essential oil; and the same quantity, distilled without water, yielded with the heat of a water-bath two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is farther continued, it acquires a reddish brown colour. On distilling sixteen ounces in a retort with an open fire increased by degrees, Neumann obtained, first, four ounces of a limpid colourless oil; then two ounces and a drachm of a dark brownish red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name.

The essential oil, commonly called spirit of turpentine, cannot without singular difficulty be dissolved in alcohol, though turpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of alcohol; but on standing a while, the greatest part of the oil separates and falls to the bottom.

Turpeth. See Turbith.

Turquois. This was formerly ranked among the gems, and employed in various articles of jewellery; but, though it has been considered as of some value, of late years it is little esteemed. Probably this has been chiefly owing to its exclusion from the rank of a stone; for it has long been considered as the tooth of an unknown animal, coloured by an oxide of copper. It appears however, that the opinion of its colouring matter was not founded on any accurate analysis: but it remained till lately unquestioned, because it was supposed, that no substance but copper could impart the colour by which it is distinguished. Bouillon Lagrange has lately examined it, and found it to be tinged by phosphat of iron. The following is his account of it.

The turquois comes chiefly from Persia. Its specific gravity is 3·127. Colour light green or blue: surface smooth and polished; hardness such as slightly to scratch glass: difficult to pulverize, and of a greenish-gray when reduced to powder: its fracture polished.

Before the blowpipe it loses its colour, and becomes of a grayish-white, but does not melt.

Heated in a crucible of platina, it acquires the same colour, but becomes friable, and is easily reduced to powder. In this experiment it loses 6 per cent of its weight.

The nitric and muriatic acids totally dissolve the turquois. The solution, in the latter acid, is yellow; and that in the nitric, is colourless.

The nitric solution presented the following phænomena:—1. with lime-water, a white flaky precipitate;—2. by ammonia in excess, a precipitate of the same colour, but more abundant: the supernatant fluid did not acquire any blueish tinge;—3. carbonat of ammonia likewise gave a precipitate;—4. with the oxalat of ammonia, the precipitate was a fine very light powder;—5. prussiat of potash gave a deep blue precipitate.

These preliminary experiments already afford an approximation to a knowledge of the constituent parts of the turquois; though they are not sufficient to lead to a regular classification. I therefore chose out of a certain quantity of turquois, those which were the hardest and deepest coloured, and I subjected them to the following experiments:

A.—100 parts of turquois, reduced to powder, were introduced into a small retort: and 300 parts of nitric acid, at 36 degrees, were poured in. After some time, a slight effervescence appeared, which lasted till the solution was complete. The gas, being collected in the pneumatic apparatus over mercury, presented all the characters of carbonic acid gas.

B.—This nitric solution was white, and of the consistence of sirup. It was evaporated to dryness, and the remaining matter made red-hot in a crucible of platina.

C.—The calcination having scarcely changed its colour, this substance was again dissolved in water, acidulated with nitric acid, with the intention of separating the iron, which might exist in the state of oxide. But the whole was entirely dissolved; which evidently proves, that the iron was neither in the state of red oxide, nor in that of nitrat, but in that of phosphat.

D.—Ammonia in excess was poured on the liquor C, which gave a white precipitate of considerable bulk. This precipitate, after washing and drying, was treated with concentrated liquid potash, which dissolved a certain portion. The solution being separated, muriat of ammonia was added to it, which threw down a white substance, possessing all the properties of alumine. This substance, after the calcination, weighed one part and a half.

E.—The portion dissolved by the potash was also calcined, and its weight proved to be 82 parts.

F.—Being desirous of ascertaining whether the liquor, from experiment D, did not contain lime in solution, carbonat of ammonia was poured on the fluid, and a precipitate was obtained, which, being slightly dried and heated, was found to be carbonat of lime. Its weight was 8 parts.

G.—The supernatant liquor was afterward evaporated, but it afforded no precipitate; whence it may be concluded, that it contained no magnesia.

H.—Being persuaded beforehand, that the precipitate E contained phosphats, it was treated with sulphuric acid. The matter was afterward washed, and the waters being mixed together, prussiat of potash was poured on, which formed a precipitate of a fine deep blue, the weight of which after calcination was found to be one part and a half. It was red oxide of iron. Care must be taken to heat the liquor, in order to separate the precipitate entirely.

The supernatant liquor held in solution the acid phosphat of lime, which was proved by the phosphorus it afforded, when treated with charcoal.

I.—This oxide of iron was heated again with a little potash. When the whole was in fusion, the matter assumed a deep green colour; and when the cold mass was afterward dissolved in water, it gave the same colour to the fluid. Upon adding a small quantity of muriatic acid it became of a fine rose colour. This experiment was repeated on a number of turquoises, and the phænomenon always took place; which evidently shows the presence of a very small quantity of magnesia.

K.—Being desirous of ascertaining whether the turquois contained phosphat of magnesia, as the experiments of Fourcroy and Vauquelin upon bones would lead us to suspect, I treated this substance according to the method indicated by those chemists, in the 47th volume of the *Annales de Chimie*, and found, that 100 parts of the turquois contained two parts of the phosphat of magnesia.

From the preceding experiments it follows, that 100 parts of turquois contain phosphat of lime 80, instead of 82, found in experiment E, deducting the quantity of phosphat of magnesia before mentioned; carbonat of lime 8; phosphat of iron 2;

phosphat of magnesia 2; phosphat of manganese an inappreciable quantity; alumine 1·5; water and loss 6·5.

Though I obtained similar products in the examination of several turquoises, it cannot yet be decided whether they be identical. The turquoises used in my experiments are perfectly similar to those in the Cabinet of the Museum of Natural History; and Mr. Haüy, whom I consulted, could not affirm whether they were truly from Persia. Mr. Guyton thinks, that there is a difference between the turquoises of Persia and the Occidental.

This philosopher has announced, for several years, in his course of mineralogy at the Polytechnic School, that the former contained silex. It is possible, that turquoises may contain this earth accidentally; but I have not found it in any of those which I examined. This difference ought not, I think, to suspend the classification of this substance by mineralogists. Mr. Guyton himself has already placed it among fossil bones. This celebrated chemist has likewise made some comparative experiments. He has found, that fossil bones assume, in the fire, a colour similar to that of the turquois; that, when digested in water containing potash, they turn blue; and that this blue varies in its shape, by passing from greenish-blue to deep blue; and, lastly, that bones, exposed to the air, become white.

Messrs. Fourcroy and Vauquelin have likewise observed, that bones, strongly calcined, often assume a blueish tinge: this colour appeared to them to be owing to the presence of a small quantity of phosphat of iron.

There cannot, therefore, any longer exist a doubt respecting the matter which colours the turquois. If it were necessary to add any thing more to the facts announced, I should observe that, having put the same turquoises which I analysed into the hands of Mr. Vauquelin, he did not find a particle of copper in them; and, lastly, I have ascertained, that, by pouring into a solution of muriat of lime, phosphat of soda and some drops of muriat of iron at a maximum, the phosphat of lime and of iron is obtained, of which the colour is a greenish blue. We may, likewise, by decomposing the phosphat of soda by muriat of iron at a maximum, obtain a phosphat of iron, which is not white, as some chemists have asserted, but of a green-blueish colour.

These reflections, without doubt, are not very important; but I present them as tending to show the possibility of imitating the colour of turquois; and at the same time to show, that iron can, in various circumstances, afford colours similar to those of copper.—*Annales de Chimie.*

Tutenag. This name is given in India to the semimetal zinc. It is sometimes applied to denote a white metallic compound brought from China, called also Chinese copper, the art of making which is not known in Europe. It is very tough, strong, malleable, may be easily cast, hammered, and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is. Three ingredients of this compound may be discovered by analysis; namely, copper, zinc, and iron.

Some of the Chinese white copper is said to be merely copper and arsenic.

Mr. Engestrom, in the Memoirs of Stockholm for the year 1775, quoted by Kirwan, has given us an analysis of a tutenag ore from China. It was of a white colour, interspersed with red streaks of oxide of iron, and so brittle as to be easily broken betwixt the fingers. In the dry way it exhibited the same appearances as zinc spar, except that it lost no part of its weight. It was soluble in the mineral acids, particularly with the assistance of heat, and with the sulphuric afforded sulphats both of zinc and iron. The quantity of carbonic acid was so small as to be absorbed by solution. It contained in various specimens from 60 to 90 per cent of zinc; the remainder was iron, and a small proportion of clay. This variety of calciform ores, which was mixed with a notable proportion of iron, was also discovered in Germany by Mr. Bindheim, who found it to consist of zinc, a little iron, and silex.—4 *Berl. Schrift.* 400.

Tutty. A metallic substance, various in its composition and properties, which nevertheless appear to depend on the presence of zinc. The better sorts of tutty, according to Neumann, are in semicylindrical concave pieces, like the bark of a tree; ponderous and somewhat sonorous; moderately compact, and generally not easy to break; of an ash- or mouse-gray colour, often with yellow or green variegations; pretty smooth on the inside, full of cavities or protuberances on the outside. The entire, compact, gray pieces are preferred; the broken, powdery, crumbly, yellow, or reddish, rejected. Boecler relates, that tutty has a sharp taste, but no such taste is perceptible in ours.

Wiegleb affirms, that the matter which in the fusion of brass is deposited over the melted metal is called tutty; but Neumann made various unsuccessful inquiries relative to its origin, and the place where it may be produced. That it is not produced at Goslar, or Schneeberg, or at any of the considerable founderies of brass, bronze, bell-metal, &c., in Germany, Holland, France, Italy, and England, he affirms from his own experience. He therefore concludes, that it is an artificial production, expressly made up of the oxide of zinc with clay and other matters.

Type Metal. The basis of type metal

for printers is lead, and the principal article used in communicating hardness is antimony, to which copper and brass in various proportions are added. The properties of a good type metal are, that it should run freely into the mould, and possess hardness without being excessively brittle. The smaller letters are made of a harder composition than those of a larger size. It does not appear, that our type founders are in possession of a good composition for this purpose. The principal defect of their composition appears to be, that the metals do not uniformly unite. In a piece of casting performed at one of our principal founderies, the thickness of which was two inches, I found one side hard and brittle when scraped, and the other side, consisting of nearly half the piece, was soft like lead. The transition from soft to hard was sudden, not gradual. If a parcel of letter of the same size and casting be examined, some of them are brittle and hard, and resist the knife, but others may be bent and cut into shavings. It may easily be imagined, that the duration and neatness of these types must considerably vary. I have been informed, but do not know the fact from trial, that the types cast in Scotland are harder and more uniform in their qualities.

U.

ULMIN. Dr. Thomson has given this temporary name to a very singular substance lately examined by Klaproth. It differs essentially from every other known body, and must therefore constitute a new and peculiar vegetable principle. It exuded spontaneously from the trunk of a species of elm, which Klaproth conjectures to be the *ulmus nigra*, and was sent to him from Palermo in 1802.

1. In its external characters it resembles gum. It was solid, hard, of a black colour, and had considerable lustre. Its powder was brown. It dissolved readily in the mouth, and was insipid.

2. It dissolved speedily in a small quantity of water. The solution was transparent, of a blackish brown colour, and, even when very much concentrated by evaporation, was not in the least mucilaginous or ropy; nor did it answer as a paste. In this respect ulmin differs essentially from gum.

3. It was completely insoluble both in alcohol and ether. When alcohol was poured into the aqueous solution, the greater part of the ulmin precipitated in light brown flakes. The remainder was obtained by evaporation, and was not sensibly soluble in alcohol. The alcohol by this treatment acquired a sharpish taste.

4. When a few drops of nitric acid were added to the aqueous solution, it became gelatinous, lost its blackish brown colour, and a light brown substance precipitated. The whole solution was slowly evaporated to dryness, and the reddish brown powder, which remained, was treated with alcohol. The alcohol assumed a golden yellow colour; and when evaporated left a light brown, bitter, and sharp, resinous substance.

5. Oxymuriatic acid produced precisely the same effects as nitric. Thus it appears, that ulmin, by the addition of a little oxigen, is converted into a resinous substance. In this new state it is insoluble in water. This property is very singular. Hitherto the volatile oils were the only substances known to assume the form of resins. That a substance soluble in water should assume the resinous form with such facility is very remarkable.

6. Ulmin when burnt emitted little smoke or flame, and left a spongy but firm charcoal, which, when burnt in the open air, left only a little carbonat of potash behind.

Such are the properties of this curious substance, as far as they have been examined by Klaproth.—*Thomson.*

Ultramarine. A blue colour, made from lapis lazuli. The manipulations for making it are variously described by authors, and consist in pulverizing the stone very finely, by ignition, quenching it in water or strong vinegar, and subsequent levigation. This powder is then carefully stirred by small portions at a time into a mass of resinous composition, from which it is again extracted by washing and kneading in hot water. Cleanliness of the hands, and of all the vessels and materials made use of, is of the utmost consequence in the manufacture. Some artists use the mere powder of lapis lazuli without any subsequent management.

The following detailed account is given by Messrs. Clement and Desormes in the *Annales de Chimie.*

To extract the ultramarine from its ore, a process is employed, to which art offers nothing analogous, and of the theory of which we are totally ignorant. This process consists in levigating the lapis lazuli, and mixing it well with a melted composition of resin, wax, and linseed oil. When these are thoroughly mixed, the compound is suffered to cool, and then well ground with a pestle, or a roller, in warm water. This water becoming turbid is thrown away, and fresh substituted, which is soon perceived to acquire a fine blue tint. When this is sufficiently loaded with the colouring matter, it is put by to settle, and more wa-quires only a dirty gray hue. From these waters a powder is deposited, which is so much the more beautiful, in proportion as the lapis lazuli was more rich, and according to the order in which the water affording it was employed. The gangue of the ultramarine remains behind in the cement.

We employed in our researches ultramarine of various qualities, but that used in the experiments from which we have deduced the approximate proportions of its constituent principles was of the greatest beauty. Only two or three per cent of this was obtained from a very fine lapis lazuli; yet still it was not perfectly pure, though it was at least fifteen or twenty times as pure as the stone from which it was taken.

The following are the results of our labours:

1. The specific gravity of ultramarine is to that of water as 2·360 to 1·000.

2. This substance, as afforded by the preceding process, contains oily or resinous matters decomposable by fire: their coal burns completely in contact with air: the ultramarine grows red, and as it cools resumes its former beautiful colour. In this operation it loses a little in quality, and requires levigation to reduce it to the state of fineness and softness it at first possessed.

3. With a more violent fire, perhaps of 1500° of the centigrade thermometer (2732° F. 13° W.) the ultramarine fuses into a black enamel, if the cement mixed with it have not been completely burnt away; but, if this have been done, into a transparent and almost colourless glass. In this fusion it loses twelve per cent of its weight.

4. Treated in the fire with borax, it readily gives a very transparent glass; and sulphur is evolved, with a little carbonic acid, the quantity of which varies according to the quality of the ultramarine.

5. Exposed to the action of the galvanic pile, the oxigenating end completely deprives it of colour, but the hidrogenating extremity occasions no change.

6. Oxigen gas changes the colour of ultramarine exposed to a red heat, causing it to assume a dirty green hue, with an augmentation of weight of one per cent, owing probably to the formation of sulphurous acid, which adheres to it.

7. Hidrogen gas in the same circumstances changes the colour of ultramarine completely, imparts to it a reddish colour, and takes from it sulphur. There does not appear to be any water formed, but there is a loss of weight somewhat exceeding that of the sulphur.

8. Sulphur in fusion does not rob it of colour, and after being driven off by volatilization, leaves the ultramarine as beautiful as before.

11. Water of barytes, assisted by heat, deprives it of colour, and it is afterward found to contain silex and alumine.

12. The sulphuric, nitric, muriatic, and oxigenated muriatic acids presently deprive ultramarine of its colour. The first three in a concentrated state form with it a very thick jelly, the fourth dissolves it almost entirely.

If the sulphuric and muriatic acids be diluted with water, sulphuretted hidrogen is evolved. The action of nitric acid produces nitrous gas and sulphuric acid.

13. The acetous acid acts upon it in a similar manner, but more weakly.

14. Potash and soda in solution heated with ultramarine diminish its weight, and are found to contain alumine. They do not alter its colour.

If pure potash be heated strongly on ultramarine, its colour is destroyed, the result of the fusion is reddish, and comports itself nearly as if the ultramarine were an argil, or a stone composed of silex and alumine.

15. Ammonia has no action upon it.

16. If oil be heated with ultramarine, the weight of the latter is diminished after being washed in an alkaline solution.

17. The analysis of ultramarine appeared to us more difficult than that of a stone of an analogous composition would be, though it is very readily attacked both by acids and alkalis. The disunion of its principles is not complete till after the most decided action of each of the reagents employed.

The quality of the ultramarine we used, which we cannot consider as perfectly pure, and the variation that must occur in the proportions of its constituent principles, induced us to study their nature rather than their quantities. To the knowledge of each of these principles we devoted a separate portion of ultramarine; and it is from these results united, that we conclude a hundred parts of ultramarine to be composed of silex 35·8, alumine 34·8, soda 23·2, sulphur 3·1, carbonat of lime 3·1.

We always experienced a loss of about five per cent, sometimes more.

The carbonat of lime we discovered is not essential to the composition of ultramarine, any more than the iron, which we did not meet with in ultramarine of the first quality procured from a lazulite little charged with sulphuretted iron. It is not the same with sulphur, which always occurs.

The following is the mode in which we ascertained the nature of the four substances that appear to us essential to ultramarine:

Thirty grammes (an ounce) of fine ultramarine, heated with sulphuric acid, left a residuum weighing 14 grammes. The liquor on evaporation exhibited a few crystals of alum*, and a great deal of sulphat of soda, in long needles.

All these crystals and the remaining liquor afforded by means of ammonia 6·85 of dry alumine, and 9·60 of sulphat of soda fused by fire.

We found by other experiments, that the alumine and soda were commonly in greater quantity than the action of sulphuric acid indicated.

By passing oxigenated muriatic acid gas into water in which 20 grammes of ultramarine were kept in constant agitation, 18·48 were dissolved. The remaining 1·52 had all the characters of silex. From the solution we obtained 4·6 of dry alumine, as much muriat of soda as contained about 4 grammes of alkali, and a portion of sulphat of barytes containing six tenths of a gramme of sulphur, supposing it to be composed of 33 per cent of sulphuric acid, and this acid of 52 per cent of sulphur. The quantity of silex was not well ascertained.

If 5 grammes of ultramarine be fused with 20 grammes of potash, and the compound be treated with alcohol, its weight is diminished one gramme, and the alcohol contains very little silex and alumine. This loss is evidently owing to the soda of the ultramarine, which quits the other principles, because their combination has been broken by the action of the potash in the fire.

On treating ultramarine with carbonated soda, we obtained from 10 grammes 3·3 of silex, possessing all its peculiar characters in a manner less equivocal than was sometimes the case, when it had been procured from ultramarine treated by acids or caustic alkalis. We had supposed, that this was owing to a mixture of some foreign substance, but we were unable to detect any. To ascertain this silex we had employed the ordinary means, and among the rest volatilization by the fluoric acid, which deposited a jelly in the water it was passed through.

Thus the ultramarine afforded on decomposition silex, alumine, soda, and sulphur.

If we bear in mind, that this valuable substance, as furnished by the process of its extraction, contains oleaginous particles; that soda is one of its constituent principles; that the first waters used for washing away the ultramarine from the cement, with which its ore had been incorporated, are soft to the touch like an alkaline lixivium, and that they leave an alkaline residuum on evaporation; it will be easy to deduce the following theory:

The cement with which the lapis lazuli is mixed is intended to impart oil to the ultramarine, to form a kind of soap, which the warm water carries away, rendering it a little soluble; while the gangue remains united to the cement, in the midst of which it is far from being so easily wetted as the ultramarine, because of its want of soda; in consequence of which it cannot slip like the ultramarine from the fatty, resinous substance, that forms a kind of net for it. In short, the process of extraction of ultramarine is a real *saponation* (*savonnage*); an expression in which we hope we may be indulged on account of its fitness.

These are the conclusions that the French chemists think may be drawn from their labours; and they express a hope, that their inquiry into a substance so little known, and so singular, may be followed by its artificial production.

It has already been observed, under the head Lapis Lazuli, that the blue colour of the stone has been ascribed to iron, either in the state of oxide or of sulphuret; but we here find it asserted, that the iron is accidental, and has nothing to do with the colour. On a subject so interesting, therefore, it may not be superfluous to add the following analysis of a lazulite by Trommsdorff and Bernhardi, from Gehlen's Journal.

The lazulite was found at first near Waldbach, in Stiria, and afterward in the environs of Wienerisch-Neustadt. It is sufficiently known from the works of various mineralogists. Some time after, a mineral was discovered in the country of Salzburg, which was called mollite; but baron Moll has given it the name of siderite, on account of its acknowledged identity with this fossil according to the researches of Mr. Mohs.

Though Klaproth found in the lazulite of Vorau silex, alumine, and iron, he could not ascertain their proportions, from the smallness of the quantity he had to examine. An analysis of the siderite by Heim gave 0·65 alumine, and 0·30 iron.

It is strange, that Messrs. Klaproth, Estner, and Mohs, should fancy there was a great analogy between the lazulite and feldtspar, as analysis shows this analogy to be very slight; and that between their crystallization and contexture is equally so.

The most usual form of the lazulite is a regular octaëdron with truncated edges, passing to the regular rhomboidal dodecaëdron. The faces of the octaëdron make an angle of 109° 28′ 16″: those of the dodecaëdron an angle of 120°: and the former cut these at an angle of 144° 44′ 8″. Beside these, several smaller faces were observed, which were not easy to determine, because the specimens were not very distinct.

It is not uncommon to meet with flattened

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* It is probable that the alkali, which occasioned the crystallization of this sulphat of alumine, was potash proceeding from the ultramarine: we do not affirm this, however, because we had not secured the salt from the ammoniacal vapours, that might have existed in the laboratory.

quadrilateral prisms, the faces of which form angles of 101° 32′ and 78° 28′; angles that occur in several minerals, particularly in the calcareous spar. At the extremities of these prisms were faces in greater or less number, which we could not ascertain.

As to its contexture, we could not find it split decisively in any direction.

With respect to its crystallization, it can be compared only with the spinelle, with which Mr. Haüy classes the ceylanite or pleonast. As analysis informs us too, that it resembles it in its constituent parts, we must consider them as similar.

The following is a comparative analysis of them:

	Of the spinelle by Vauquelin.		*Of the spinelle by Klaproth.*	*Of the ceylanite by Collet-Descotils.*	*Of the siderite by Trommsdorff.*
Alumine	86·0	82·47	74·5	68	66
Magnesia	8·5	8·78	8·25	12	18
Silex			15·5	2	10
Lime			0·75		2
Oxide of iron			1·5	16	2·5
Oxide of chrome	5·25	6·18			

We find that alumine united with magnesia must be considered as the essential part of the mineral.

As Mr. Bernhardi took upon himself to describe the characters of the lazulite, Mr. Trommsdorff attended more particularly to the analysis. He proceeded as follows:

A. A hundred grains of siderite strongly calcined in a covered crucible lost five grains of their weight. The fine blue colour had disappeared, and was changed to a yellowish white.

B. The calcined mineral was easily ground, and did not scratch the agate mortar. One hundred grains were urged to a red heat with four hundred of caustic soda; and after a pasty fusion there remained a mass, which, diffused in water, afforded a turbid solution void of colour. This was supersaturated with muriatic acid, evaporated and redissolved in boiling water; when silex was precipitated from it, which weighed ten grains after calcination.

C. The boiling liquor was precipitated by carbonat of soda.

D. The precipitate, containing neither glucine nor yttria, was boiled in a lixivium of caustic soda, which effected a partial solution. The spongy, insoluble, brownish-red residuum was set apart.

E. The soda-lixivium (D) was supersaturated with muriatic acid, and the boiling liquor precipitated by carbonat of soda. The white precipitate, after sufficient elutriation, and being strongly calcined, left 66 grains of pure alumine.

F. The reddish-brown residuum (D) dissolved entirely in muriatic acid. The solution was concentrated, and the excess of muriatic acid saturated with ammonia. A little concentrated sulphuric acid was then poured in, which threw down a white precipitate. This was washed several times in cold water, and calcined, after which six grains of sulphat of lime, being equivalent to two grains of lime, remained.

G. Into the liquor from which the lime had been precipitated prussiat of potash was poured, and the precipitate produced contained 2·5 grains of oxide of iron.

H. The liquor decanted from the prussiat of potash was mixed with carbonat of soda, and kept some time boiling. A white substance fell down, which, after calcination, consisted of 18 grains of magnesia.

One hundred grains of the calcined fossil, therefore, contained

Silex	10	(B)
Alumine	66	(E)
Magnesia	18	(H)
Lime	2	(F)
Oxide of iron	2·5	(G)
Loss	1·5	
	100.	

The blue colour of the fossil appears to be owing to the degree of oxidation of the iron; and this is so much the more probable, as Mr. Ritter has announced the existence of a blue oxide of iron.

It is true Mr. Guyton has discovered also a blue sulphuret of iron, to which he ascribes the colour of lapis lazuli: but in this case perhaps the sulphur may serve to produce this minimum of oxidation. Besides, direct experiments on the lazulite have convinced the author of this memoir, that it does not contain the least trace of sulphur or sulphuric acid.—*Annales de Chimie.*—*Gehlen's Journal.*

Umber. A brown ochreous earth used as a pigment. It acquires a reddish colour when slightly heated, but in a stronger heat becomes again brown, and magnetic, and in a still stronger is fused into a black glass. It does not effervesce with acids before roasting, but after that process the iron it contains is soluble. According to Klaproth's analysis it consists of oxide of iron 48, oxide of manganese 20, silex 13, alumine 5, water 14.

Kirwan also mentions under this name, in his Argillaceous Genus, a brown or blackish substance which stains the fingers, and is very light. This was long supposed to be a clay; but Mr. Hupsch, in the Berlin Memoirs for 1777, shows, that it consists of particles of decayed wood mixed with bitumen.

Union. This word is often used by

compound. Thus it is said, that the parts of a mere mixture are united mechanically; but in an actual combination they are said to be chemically united.

Uran-glimmer. An ore of uranium, formerly called *green mica*, and by Werner *chalcolite*. See the following article.

Uranite, *or* **Uranium.** A new metallic substance discovered by the celebrated Klaproth in the mineral called *Pech blende*. In this it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uran-glimmer, and in the uran-ochre.

The uran-glimmer is in thin leaves, or small quadrangular tables; of an emerald green, lemon-yellow, and sometimes silver-white colour; more or less transparent; soft and easily broken; specific gravity from 2·19 to 3·1. This is nearly pure oxide of uranium, but sometimes contaminated with a little copper, which appears to give it the green colour. The reverend Mr. Gregor found oxide of lead, lime, and silex, in some Cornish specimens.

The uran-ochre is generally an incrustation or efflorescence, of a light yellow colour, sometimes tinged green, brown, or red. Specific gravity 3·2. This too is nearly pure oxide of uranium, mixed with a little oxide of iron when of a red or green colour.

By treating the ores of the metal with the nitric or nitromuriatic acid, the oxide will be dissolved; and may be precipitated by the addition of a caustic alkali. It is insoluble in water, and of a yellow colour; but a strong heat renders it of a brownish gray.

To obtain it pure, the ore should be treated with nitric acid, the solution evaporated to dryness, and the residuum heated, so as to render any iron it may contain insoluble. This being treated with distilled water, ammonia is to be poured into the solution, and digested with it for some time, which will precipitate the uranium and retain the copper. The precipitate, well washed with ammonia, is to be dissolved in nitric acid, and crystallized. The green crystals, dried on blotting paper, are to be dissolved in water, and recrystallized, so as to get rid of the lime. Lastly, the nitrat, being exposed to a red heat, will be converted into the yellow oxide of uranium.

It is very difficult of reduction. Fifty grains, after being ignited, were formed into a ball with wax, and exposed, in a well-closed charcoal crucible, to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgwood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark gray colour, hard, firmly cohering, fine-grained, of very minute pores, and externally glittering. On filing it, or rubbing it with another hard body, it verges to a brown. Its specific gravity was 8·1. Bucholz, however, obtained it as high as 9·0.

When heated to redness in an open vessel, it undergoes a species of combustion, and is soon converted into a grayish black powder, containing about 5 per cent of oxigen. According to Bucholz it forms six distinct oxides, in the following order of succession, as marked by their colours: grayish black, dark gray inclining to violet, greenish brown, grayish green, orange, lemon-yellow.

The oxide is soluble in dilute sulphuric acid gently heated, and affords lemon-coloured prismatic crystals. Its solution in muriatic acid, in which it is but imperfectly soluble, affords yellowish green rhomboidal tablets. Phosphoric acid dissolves it, but after some time the phosphat falls down in a flocculent form, and of a pale yellow colour.

It combines with vitrifiable substances, and gives them a brown or green colour. On porcelain, with the usual flux, it produces an orange.—*Klaproth's Essays.*—*Gehlen's Journ.*—*Nich Journ.*—*Thomson.*—*Murray.*

Uranochre. An ore of uranium, containing this metal in the oxided state. See the preceding article.

Uree. If human urine be evaporated to the consistence of a thick sirup, and set by to cool, it concretes into a crystalline mass. If this be treated with four times its weight of alcohol, at different times, assisted by a gentle heat, the greater part will be dissolved; and by evaporating to a sirupy consistence, a crystalline matter will be obtained, which Rouelle jun., who first mentioned it in 1773, called *saponaceous extract of urine*. Little, however, was known concerning it till 1799, when Fourcroy and Vauquelin examined it, and distinguished it by the name of *uree*, or *urea*.

This substance is in micaceous shining laminæ, grouped together, pressed against each other, and always incomplete. It exhales a strong, fetid, alliaceous smell, offensive to animals, and affecting the brain and nerves in an unpleasant manner. It adheres to the vessel; is difficult to cut or break; and is hard, granulous, and consistent at the centre. It is deliquescent, becomes soft like honey at the surface, separates in parts from the sides of the vessel, and a thick brown liquid flows round it.

If cautiously introduced into a retort with a wide, short neck, it fuses with a gentle heat: a white fume rises, which is benzoic acid, and condenses on the sides of the receiver: crystallized carbonat of ammonia succeeds, and continues to the end: neither water nor oil rises, but the sublimate is turned brown: the air expelled from the apparatus is impregnated with a smell of ish, and covered with a raised white crust, which rises at length in a heavy vapour, and attaches itself to the lower part of the retort. This is muriat of ammonia.

If water be poured on the residuum, it emits a smell of prussic acid. Burned on an open fire it exhales the same smell, gives out ammonia, and leaves one hundredth of its weight of acrid white ashes, which turn sirup of violets green, and contain a small quantity of carbonat of soda.

The aqueous solution, distilled by a gentle fire, and carried to ebullition, affords very clear water loaded with ammonia. By adding more water, as the liquor became inspissated, Fourcroy and Vauquelin obtained nearly two thirds of the weight of the urea in carbonat of ammonia, and the residuum was not then exhausted of it. The latter portions, however, were more and more coloured.

This decomposition of an animal substance at the low heat of boiling water is very remarkable, particularly with respect to the carbonic acid. Indeed it appears, that a very slight change of equilibrium is sufficient, to cause its constituent principles to pass into the state of ammonia, and carbonic, prussic, and acetous acids.

The muriatic, phosphoric, fluoric, and carbonic acids effect no change in uree. Concentrated sulphuric acid burns it. Oxigenized muriatic acid decomposes it; separates it in part from the water, in which it is dissolved, in the form of yellow flakes; precipitates carbon; disengages carbonic acid and nitrogen gas; reduces a small portion of it to the state of oil; and decomposes the ammonia, which it at first forms.

If highly concentrated nitric acid be poured on uree in its solid state, a considerable ebullition is excited; it swells up greatly, and emits a thick vapour, without taking fire; and it is afterward found in the state of solid yellowish crystals and a bright red fluid. The action is so violent, that it is impossible to collect the gas.

If a somewhat weaker acid be poured on a thick solution of uree in water, radiated and lamellated crystals are immediately formed, of a yellowish white colour, smooth and unctuous to the touch, almost filling the vessel, and apparently a combination of the uree little or not at all changed with the nitric acid.

When urine considerably evaporated is treated with nitric acid but little diluted, the same result is obtained, as Cruickshank observed.

If nitric acid be distilled upon the uree dissolved in water, an effervescence takes place, which continues for several days, and a large quantity of carbonic acid gas and azotic gas is given out. Prussic acid gas too is disengaged. The products received into and there remains only a light, fat residuum, the lixivium of which precipitates sulphat of iron blue.

Caustic alkalis dissolve and soften the crystallized uree, and decompose the muriat of ammonia in it. Barytes, strontian, lime, and magnesia, likewise extricate ammonia from it.

Uree has a singular effect on the crystallization of some salts. If muriat of soda be dissolved in a solution of uree, it will crystallize by evaporation, not in cubes, but in octaëdra: muriat of ammonia, on the contrary, treated in the same way, instead of crystallizing in octaëdra, will assume the cubic form. The same effect is produced, if fresh urine be employed, instead of a solution of uree. This is apparently owing to the interposition of some carbonaceous colouring matter, from which the salts may be freed by repeated solution and recrystallization, when they will recover their natural form. Possibly it may affect the appearance of other salts in a similar way.

Proust says, that the uree of Fourcroy and Vauquelin is a saline substance saturated with ammonia; and that sulphuric acid, carrying off this ammonia, will leave the uree pure, except that it is coloured with a resin, from which he could not free it.—*Annales de Chim.*—*Journ. de Phys.*—*Fourcroy.*—*Thomson.*

Uric Acid. See Acid (Lithic).

Urine. This excrementitious fluid, in its natural state, is transparent, of a yellow colour, a peculiar smell and saline taste. Its production as to quantity, and in some measure quality, depends on the seasons and the peculiar constitution of the individual, and is likewise modified by disease. It is observed, that perspiration carries off more or less of the fluid, which would else have passed off by urine; so that the profusion of the former is attended with a diminution of the latter.

From the alkaline smell of urine kept for a certain time, and other circumstances, it was formerly supposed to be an alkaline fluid; but by its reddening paper stained blue with litmus or the juice of radishes, it appears to contain an excess of acid.

The numerous researches made concerning urine have given the following as its component parts: 1. Water. 2. Uree. 3. Phosphoric acid. 4, 5, 6, 7. Phosphats of lime, magnesia, soda, and ammonia. 8, 9, 10, 11. Lithic, rosacic, benzoic, and carbonic acid. 12. Carbonat of lime. 13, 14. Muriats of soda and ammonia. 15. Gelatine. 16. Albumen. 17. Resin. 18. Sulphur.

Muriat of potash may sometimes be detected in urine, by cautiously dropping into it some tartarous acid. As may sulphat of soda, or of lime, by a solution of muriat of barytes, which will throw down sulphat of

Urine soon undergoes spontaneous changes, which are more or less speedy and extensive, according to its state, as well as the temperature of the air. Its smell, when fresh made, and healthy, is somewhat fragrant; but this presently goes off, and is succeeded by a peculiar odour termed urinous. As it begins to be decomposed, its smell is not very unlike that of sour milk; but this soon changes to a fetid, alkaline odour. It must be observed, however, that turpentine, asparagus, and many other vegetable substances, taken as medicine, or used as food, have a very powerful effect on the smell of the urine. Its tendency to putrefaction depends almost wholly on the quantity of gelatine and albumen it contains; in many cases, where these are abundant, it coming on very quickly indeed.

Thenard has lately examined urine with considerable minuteness, chiefly to ascertain what was the free acid, that appeared to exist in it.

The acids in urine, he says, are

1st. The uric acid, which frequently gives rise to the stone in the bladder:

2dly. The benzoic acid, which exists very rarely in that of adults or old persons, and is more frequent in that of infants:

3dly. We are obliged to admit another acid, since the urine strongly and constantly reddens tincture of litmus, an action which cannot be ascribed either to the uric acid, that does not alter its colour, nor to the benzoic acid, that is found in the urine only under certain circumstances, which are not yet well known.

What is this new acid? This is the second question that I shall attempt to discuss. At present it is generally supposed to be the phosphoric acid. This opinion is grounded on the presence of a pretty large quantity of phosphat of lime in urine, which, being itself insoluble when neutral, becomes very soluble and even deliquescent, when it is with an excess of acid: and at the same time it is strengthened by the consideration, that beside the phosphats of lime, soda, ammonia, and magnesia, we find nothing in urine but the sulphats of potash and soda, and muriats of soda and ammonia, neither of which salts is decomposed by the acidulous phosphat of lime: their acids, therefore, that is the sulphuric and muriatic, cannot exist in the urine, since, as is well known, they would convert the phosphat of lime into acidulous phosphat of lime. If then the phosphoric acid be not the solvent of the phosphat of lime in urine, it must undoubtedly be some other weak acid, and probably an acid of the nature of the vegetable and animal acids.

Nothing in fact proves, that this is not

must suppose, that a portion of one of the phosphats of the blood is decomposed in the kidneys, when it reaches them: that the phosphoric acid be free, or at least constitute an acidulous phosphat with the phosphat of lime, though present with the soda of the blood, and with the base of the phosphat decomposed, both of which appear not to enter into any new combination at the time, and which are taken up with the residuum of the secretion by the venous system, to be returned into the circulation.

It is true, it may be said, that bodies under the influence of life act in a different manner from what they do when deprived of it; and that consequently decompositions may take place in the animal œconomy contrary to all that we are acquainted with. But, beside that this answer, though accurate, proves little in favour of the case in question, it may be employed in a certain degree to retort the argument, as thus: We have no avowed instance of salts being decomposed in the animal œconomy so that their alkali and acid remain present together without combining, while on the other hand it is demonstrated, that animal substances, particularly those that exist in the blood, as the fibrine and albumen, are transformed into some other in passing through this or that organ; thus in the mammary glands they are converted into sugar of milk, and the caseous, butyraceous, and extractive matters; and in the kidneys they form uree, uric acid, and sometimes benzoic acid. Now if they constantly form one of these acids, and sometimes the other likewise, it is possible they may form a third, which combines with the phosphat of lime, and holds it in solution. Such were the reflections that have led me to examine the acid of urine; and I shall proceed to relate the experiments, that I have made to discover its nature.

After having employed several means, which I shall pass over, as they were without success, at least directly, I evaporated almost to dryness, in a water-bath, that I might not decompose the uree, about twenty quarts of fresh urine. The residuum powerfully reddened infusion of litmus; and I treated it cold, at several times, with a great deal of alcohol at 36° of strength.

I thus dissolved the greater part of the acid; but I could not effect its complete solution, whatever quantity of alcohol I employed, and even by the assistance of a small degree of heat. Having mixed all the liquors, I concentrated them by evaporation at a low temperature. I then examined the matter, which I had afresh reduced to a sirupy consistence. First I diluted a portion with water, and added to it lime-water and ammonia. No precipitate took place.

or at least it was so slight, that it did not appear till long after the mixture was made. Another portion I calcined. The residuum was not only not acid; but, even treated with water, the calcareous salts and lime-water, added to the solution, gave no indication of an atom of phosphat. That which was not dissolved, and which contained a great deal of coal when completely incinerated, merely left a few traces of phosphat of lime.

Hence it should seem, that urine contains, besides the uric acid, an acid with at least a binary radical. I strongly suspected, that it was the acetous; because I had already found this acid in other animal fluids, it exists in almost all vegetables, and it is formed in almost all the decompositions that organized bodies undergo. In consequence, into the portion I had left, containing the acid, I poured barytes water. Having then evaporated the mixture to dryness still with a gentle heat, I treated it afresh with alcohol, which dissolved the whole, except a yellowish powder, that was true acetat of barytes. Thus from this experiment we may infer, that there is acetous acid in urine; though it does not prove, that there is no phosphoric acid, since urine evaporated by a water-bath, and treated with a great deal of alcohol, always leaves a slightly acid residuum; and this acid, it may be said, is the phosphoric.

To demonstrate that this acid is not really the phosphoric, I could not have recourse to calcination; for the residuum, containing phosphat of ammonia, could not have failed to yield phosphoric acid: I was under the necessity, therefore, of adopting the synthetical method. Accordingly, after having saturated by means of potash the extract of some urine, that I had evaporated to dryness with the precautions already described, I poured in a little vinegar, treated it with alcohol, and obtained the same results as I have already related; that is to say, the portion, that was not dissolved after repeated affusions of alcohol, was acid. This proof I am aware may still be questioned; for, if the phosphoric acid existed in the urine, it would be partly retained by the salts present in it, in the same manner as the acetous, and would become insoluble in alcohol. But if it be considered, that the existence of the acetous acid in urine appears certain[*]; that nothing demonstrates the presence of the phosphoric; that the greater part of the free acid of the urine evaporated to the consistence of a sirup dissolves in alcohol; and that all this acid, thus dissolved, is the acetous: lastly, if we recollect, that the residuum is slightly acid; and that, if saturated with potash, afterward acidulated with vinegar, and treated afresh with alcohol, it remains equally acid; all these circumstances compared together, I conceive, will require such a degree of certainty, as absolutely to convince us, that it is the acetous acid alone in urine which dissolves the phosphat of lime, and which alone too most commonly imparts to it the property of reddening infusion of litmus.

But, to render this last conclusion still more evident, I ought to demonstrate, more directly than has hitherto been done, that the benzoic acid is not in fact a constant principle of urine. For this, instead of employing sublimation with or without an excess of another acid, when the urine is reduced to a sirupy consistence; a method always inaccurate, since the benzoic acid combined with ammonia is carried off more or less with the water that rises in vapour; I added lime before I began the evaporation, and treated the extract with alcohol.

It is true, by this method, we dissolve, beside the benzoat of lime, some uree, muriat of ammonia and soda, and acetous acid: but if the alcoholic solution be converted into a concentrated aqueous solution, the acids added afterward will soon manifest the presence of benzoic acid, if there be ever so little in the solution.

Thus, when we would analyse urine, the benzoic acid should be first sought for, either by this or some analogous process. If by this we discover no trace of it in the liquid, which is most commonly the case, we may conclude, that it does not contain any sensible quantity of it: then, after having evaporated another portion of the urine in a water-bath, and thus ascertained the quantity of water that enters into its composition, the residuum must be treated repeatedly with alcohol at 36°; thus we shall dissolve the uree, the muriat of ammonia, some muriat of soda, and the greater part of the acetous acid.

The mixture of these different substances should be divided into three portions. From the first the acetous acid is to be separated by the means pointed out. From the second the uree is to be extracted by concentrated nitric acid, from which again it is to be separated by the carbonat of potash and alcohol[†]. Lastly, from the third part the

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[*] I believe, that, in the evaporation of the urine in a water-bath, a little uree is decomposed, and that ammonia, and perhaps a little acetous acid, is formed. Supposing this to be the case, it still remains very probable, that the acid of urine is the acetous acid, and not any other; for in favour of this opinion I might not only adduce the reasons that have been, or that will be given, but even the tendency the uree would have in this case to be converted into acetous acid.

[†] Pure uree does not crystallise: it is only when combined with certain salts, which

quantity of sal ammoniac and muriat of soda is to be ascertained by sublimation. In this sublimation the uree is destroyed, the acetous acid is volatilized, the muriat of soda remains behind, and is to be weighed: the sal ammoniac sublimes, and is to be collected; and as it is always mixed with black matters, and may besides contain a little carbonat of ammonia, it is to be purified by dissolving it in water and evaporating the solution.

The matters contained in urine, that are soluble in alcohol, are five; namely, acetous acid, benzoic acid, muriat of ammonia, muriat of soda in part, and uree. Those that are insoluble in it are more numerous, as at least eight may be reckoned; namely, four phosphats, two sulphats, muriat of soda, and uric acid. On treating with water these eight substances insoluble in alcohol, we dissolve the phosphats of soda and ammonia, a very little phosphat of magnesia, the muriat of soda, the sulphats of potash and soda, which are known by their crystallization, and which may be separated from one another in a certain degree by solutions of platina. We may judge that phosphat of magnesia is present by means of potash, which will precipitate a small quantity of this earth.

The substances insoluble in water then are the phosphat of lime, some phosphat of magnesia combined with phosphat of ammonia, and uric acid, which may be separated in the usual way. This method, however, differs very little from those that have been given by other chemists; and I describe it here in a concise manner, because it is intimately connected with my subject.

The changes produced in urine by disease are considerable, and of importance to be known. It is of a red colour, small in quantity, and peculiarly acrid, in inflammatory diseases; but deposits no sediment on standing. Corrosive muriat of mercury throws down from it a copious precipitate. Toward the termination of such diseases, it becomes more abundant, and deposits a copious pink-coloured sediment, consisting of rosacic acid, with a little phosphat of lime and uric acid.

In jaundice it contains a deep yellow colouring matter, capable of staining linen. Muriatic acid renders it green, and thus indicates the presence of bile. Sometimes, too, according to Fourcroy and Vauquelin, it contains a substance analogous to the yellow acid, which they formed by the action of nitric acid on muscular fibre.

In hysterical affections it is copious, limpid, and colourless, containing much salt, but scarcely any uree or gelatine.

In dropsy the urine is generally loaded with albumen, so as to become milky, or even coagulate by heat, or on the addition of acids. In dropsy from diseased liver, however, no albumen is present; but the urine is scanty, high-coloured, and deposits the pink-coloured sediment.

In dyspepsy, or indigestion, the urine abounds in gelatine, and putrefies rapidly.

In rickets the urine contains a great deal of a calcareous salt, which has been supposed to be phosphat of lime, but according to Bonhomme it is the oxalat.

Some instances are mentioned, in which females have voided urine of a milky appearance, and containing a certain portion of the caseous part of milk.

But among the most remarkable alterations of urine is that in the diabetes, when the urine is sometimes so loaded with sugar, as to be capable of being fermented into a vinous liquor. Upwards of one twelfth of its weight of sugar was extracted from some diabetic urine by Cruickshank, which was at the rate of twenty-nine ounces troy a day from one patient. In this disease, however, the urine, though always in very large quantity, is sometimes not sweet, but insipid.

The urine of some animals, examined by Fourcroy, Vauquelin, and Rouelle jun., appears to differ from that of man in wanting the phosphoric and lithic acids, and containing the benzoic. That of the horse, according to the former two, consists of benzoat of soda ·024, carbonat of lime ·011, carbonat of soda ·009, muriat of potash ·009, uree ·007, water and mucilage ·940. Giese, however, observes, that the proportion of benzoat of soda varies greatly, so that sometimes scarcely any can be found. Notwithstanding the assertions of these chemists, that the urine of the horse contains no phosphoric acid, Giobert affirms that phosphorus may be made from it.

That of the cow, according to Rouelle, contains carbonat, sulphat, and muriat of potash, benzoic acid, and uree: that of the camel differed from it in affording no benzoic acid: that of the rabbit, according to Vauquelin, contains the carbonats of lime, magnesia, and potash, sulphats of potash and lime, muriat of potash, uree, gelatine, and sulphur. All these appear to contain some free alkali, as they turn sirup of violets green. In the urine of domestic fowls Fourcroy and Vauquelin found lithic acid.

Urine has been employed for making phosphorus, volatile alkali, and sal ammoniac; it adds to the produce of nitre-beds; and it is very useful in a putrid state for scouring woollens.—*Ann. de Chim.*—*Journ. de Phys.*—*Scherer's Journ.*—*Mem. de l'Instit.*—*Rollo on Diabetes.*—*Fourcroy.*—*Thomson.*

URINARY CALCULI. See CALCULUS.

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frequently happens, that it forms crystals. I believe, but I am not certain, that it renders several salts soluble in alcohol, which when alone are insoluble in it. This might easily be verified with muriat of barytes.

V.

Vake. The name used by some French mineralogists for Wacke; which see.

Vapour. The elastic fluids, or subtile invisible matters, which fly off from bodies subjected to chemical operations or otherwise, are called vapours. But accurate chemical writers confine this appellation to such exhalations only as may be condensed into the fluid state by cold, in contradistinction to the aërial fluids, or gasses, of which scarcely any are so convertible by any means in our power.

Varnish. Lac varnishes or lacquers consist of different resins in a state of solution, of which the most common are mastich, sandarach, lac, benzoin, copal, amber, and asphaltum. The menstrua are either expressed or essential oils, as also alcohol. For a lac varnish of the first kind, the common painter's varnish is to be united by gently boiling it with some more mastich or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the glossy appearance and drying of the varnish.

Of this sort is the amber-varnish. To make this varnish, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a small hole, till it is observed to become soft, and to be melted together into one mass. As soon as this is perceived, the vessel is taken from off the fire, and suffered to cool a little; when a pound of good painter's varnish is added to it, and the whole suffered to boil up again over the fire, keeping it continually stirring. After this, it is again removed from the fire; and when it is become somewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varnish, when it is cool, happen to be yet too thick, it may be attenuated with more oil of turpentine. This varnish has always a dark-brown colour, because the amber is previously half-burned in this operation; but if it be required of a bright colour, amber-powder must be dissolved in transparent painter's varnish, in Papin's machine by a gentle fire.

As an instance of the second sort of lac-varnishes with ethereal oils alone, may be adduced the varnish made with oil of turpentine. For making this, mastich alone is dissolved in oil of turpentine by a very gentle digesting heat, in close glass vessels. This is the varnish used for the modern transparencies employed as window-blinds, fire-screens, and for other purposes. These are commonly prints, coloured on both sides, and afterward coated with this varnish on those parts that are intended to be transparent. Sometimes fine thin calico, or Irish linen, is used for this purpose; but it requires to be primed with a solution of isinglass, before the colour is laid on.

Copal may be dissolved in genuine Chio turpentine, according to Mr. Sheldrake, by adding it in powder to the turpentine previously melted, and stirring till the whole is fused. Oil of turpentine may then be added, to dilute it sufficiently. Or the copal in powder may be put into a long-necked matrass with twelve parts of oil of turpentine, and digested several days on a sand-heat, frequently shaking it. This may be diluted with one fourth or one fifth of alcohol. Metallic vessels, or instruments, covered with two or three coats of this, and dried in an oven each time, may be washed with boiling water, or even exposed to a still greater heat, without injury to the varnish.

A varnish of the consistence of thin turpentine is obtained for aërostatic machines, by the digestion of one part of elastic gum, or caoutchouc, cut into small pieces, in thirty-two parts of rectified oil of turpentine. Previously to its being used, however, it must be passed through a linen cloth, in order that the undissolved parts may be left behind.

The third sort of lac-varnishes consists in the spirit-varnish. The most solid resins yield the most durable varnishes; but a varnish must never be expected to be harder than the resin naturally is of which it is made. Hence, it is the height of absurdity to suppose, that there are any incombustible varnishes, since there is no such thing as an incombustible resin. But the most solid resins by themselves produce brittle varnishes; therefore something of a softer substance must always be mixed with them, whereby this brittleness is diminished. For this purpose gum elemi, turpentine, or balsam of capaiva are employed in proper proportions. For the solution of these bodies the strongest alcohol ought to be used, which may very properly indeed be distilled over alkali, but must not have stood upon alkali. The utmost simplicity in composition with respect to the number of the ingredients in a formula is the result of the greatest skill in the art; hence it is no wonder, that the greatest part of the formulas and recipes that we meet with are composed without any principle at all.

In conformity to these rules, a fine colourless varnish may be obtained, by dissolving eight ounces of gum sandarach and two ounces of Venice turpentine in thirty-two ounces of alcohol by a gentle heat. Five ounces of shell-lac and one of turpentine, dissolved in thirty-two ounces of alcohol by a very gentle heat, give a harder varnish, but of a reddish cast. To these the solution of copal is undoubtedly preferable in many respects. This is effected by triturating an ounce of powder of gum copal, which has been well dried by a gentle heat, with a drachm of camphor, and, while these are mixing together, adding by degrees four ounces of the strongest alcohol, without any digestion.

Between this and the gold varnish there is only this difference, that some substances that communicate a yellow tinge are to be added to the latter. The most ancient description of two sorts of it, one of which was prepared with oil, and the other with alcohol, is to be found in Alexius Pedemontanus De i Secreti, Lucca, of which the first edition was published in the year 1557 But it is better prepared, and more durable, when made after the following prescription: —Take two ounces of shell lac, of arnatto and turmeric of each one ounce, and thirty grains of fine dragon's-blood, and make an extract with twenty ounces of alcohol in a gentle heat.

Oil varnishes are commonly mixed immediately with the colours, but lac or lacquer varnishes are laid on by themselves upon a burnished coloured ground: when they are intended to be laid upon naked wood, a ground should be first given them of strong size, either alone or with some earthy colour, mixed up with it by levigation. The gold lacquer is simply rubbed over brass, tin, or silver, to give them a gold colour.

Pere d'Incarville has informed us, that the tree which affords the varnish of China is called Tsi-chou by the Chinese. This tree is propagated by offsets. When the cultivator is desirous of planting it, he takes a branch, which he wraps up in a mass of earth, by means of flax. Care is taken to moisten this earth; the branch pushes out roots, and is then pruned and transplanted. This tree grows to the size of a man's leg.

The varnish is drawn in spring. If it be a cultivated tree, it affords three gatherings. It is extracted by incisions made in the spring; and when the varnish, which is received in shells, does not flow, several hogs bristles moistened with water or saliva are introduced into the wound, and cause it to run. When the tree is exhausted, the upper part of it is wrapped in straw, which is set on fire, and causes the varnish to precipitate to the bottom of the tree, where it flows out of perforations made for that purpose.

Those who collect the varnish set out before day-break, and place their shells beneath the apertures. The shells are not left longer than three hours in their place, because the heat of the sun would evaporate the varnish.

The varnish emits a smell, which the workmen are very careful to avoid respiring. It produces an effect, which they call the bud of the varnish

When the varnish issues from the tree, it resembles pitch. By exposure to the air, it gradually becomes coloured, and is at last of a beautiful black.

The juice which flows from incisions made in the trunk and branches of the rhus toxicodendron possesses the same properties. It is a white milky fluid, which becomes black and thick by the contact of the air.

To make the varnish bright, it is evaporated by the sun; and a body is given to it with hog's gall and sulphat of iron.

The Chinese use the oil of tea, which they render drier by boiling it with orpiment, realgar, and arsenic.

To varnish any substance, consists in applying upon its surface a covering of such a nature, as shall defend it from the influence of the air, and give it a shining appearance.

A coat of varnish ought therefore to possess the following properties:—1. It must exclude the action of the air; because wood and metals are varnished to defend them from decay and rust. 2. It must resist water; for otherwise the effect of the varnish could not be permanent. 3. It ought not to alter such colours as are intended to be preserved by this means.

It is necessary therefore, that a varnish should be easily extended or spread over the surface, without leaving pores or cavities; that it should not crack or scale; and that it should resist water. Now resins are the only bodies, that possess these properties.

Resins consequently must be used as the bases of varnish. The question which of course presents itself must be then, how to dispose them for this use; and for this purpose they must be dissolved, as minutely divided as possible, and combined in such a manner, that the imperfections of those which might be disposed to scale, may be corrected by others.

Resins may be dissolved by three agents —1. By fixed oil 2. By volatile oil. 3. By alcohol And accordingly we have three kinds of varnish: the fat or oily varnish, essential varnish, and spirit varnish.

Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides, in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxigen of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine.

The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

The coloured resins or gums, such as gamboge, dragon's blood, &c., are used to colour varnishes.

To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice stone and water; which being dried with a cloth, the work is afterward rubbed with an oiled rag and tripoli. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

Vegalkali. The name given by Dr. Pearson to *potash*, or the vegetable alkali.

Vegetable Kingdom. In the mineral kingdom little of chemical operation takes place, wherein the peculiar locality or disposition of the principles which act upon each other appears to have any considerable effect. The principles, for the most part simple, act upon each other by virtue of their respective attractions; if heat be developed, it is for the most part speedily conducted away; if elastic products be extricated, they in general make their escape;—in a word, we seldom perceive in the operations in the mineral kingdom any arrangement, which at all resembles the artificial dispositions of the chemist.

But in the animal and vegetable kingdoms it is far otherwise. In the former of these, bodies are regularly changed by mechanical division, by digestion, and the application of peculiar solvents, in a temperature exceeding that of the atmosphere, and the whole of the effects are assisted, modified and kept up by an apparatus for admitting the air of the atmosphere. The subjects of the vegetable kingdom possess undoubtedly a structure less elaborate. They exhibit much less of those energies, which are said to be spontaneous. The form of their vessels is much simpler, and, as far as we can perceive, their action is obedient to the changes of the atmosphere in quality and moisture, the mechanical action of winds, the temperature of the weather, and the influence of light. In these organized beings, the chemist discovers principles of a more compounded nature, than any which can be obtained from the mineral kingdom. These do not previously exist in the earth, and must therefore be results of vegetable life.

The most obvious difference between vegetables and animals is, that the latter are in general capable of conveying themselves from place to place; whereas vegetables, being fixed in the same place, absorb by means of their roots and leaves such support as is within their reach. This appears on the whole to consist of air and water. The greatest part of the support of animals are

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at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnet supported plants with moss, and fed them with mere water: they observed, that the vegetation was of the most vigorous kind; and the naturalist of Geneva observes, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gramineous kind, in a similar manner; with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed, that a plant, which weighed three pounds, gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water? And Braconnot has lately found mustard seed to germinate, grow, and produce plants, that came to maturity, flowered, and ripened their seed, in litharge, flowers of sulphur, and very small unglazed shot. The last appeared least favourable to the growth of the plants, apparently because their roots could not penetrate between it so easily.

All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots: but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principle, which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, the ulva, &c., have no roots whatever.

The purer the water, the more salutary it is to plants. Mr. Duhamel has drawn this consequence from a series of well-made experiments, by which he has proved, that water impregnated with salts is fatal to vegetation. Hales caused them to absorb various fluids by making incisions in their roots, and plunging them into alcohol, mercury, and various saline solutions; but he was convinced, that all these were poisons to the vegetables. Besides, if these salts were favourable to the plants, they would be again found in the individual, which had been watered with a solution of them; whereas Messrs. Thouvenel and Cornette have proved, that these salts do not pass into the vegetable. We must nevertheless except the marine plants, because the sea-salt of which they have need is decomposed in them; and produces a principle, which appears necessary to their existence, since they languish without it.

Though it is proved, that pure water is more proper for vegetation than water charged with salts, it must not on this account be concluded, that water cannot be disposed in a more favourable manner to the development of vegetables, by charging it with the remains of vegetable and animal decomposition. If, for example, the water be loaded with principles disengaged by fermentation or putrefaction, the plant then receives juices already assimilated to its nature, and these prepared aliments must hasten its growth. Independent of those juices already formed, the nitrogen gas, which constitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, must facilitate their development. A plant supported by the remains of vegetables and animals is in the same situation as an animal fed on milk only; its organs have less difficulty in elaborating this drink, than that which has not yet been animalized.

The dung, which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken of, but likewise favours the growth of the plant by that constant and steady heat, which its ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the development of leaves and flowers in that part of a tree only, which was in the vicinity of a heap of dung.

From the preceding circumstances it appears, that the influence of the earth in vegetation is almost totally confined to the conveyance of water, and probably the elastic products from putrefying substances to the plant. See Arable Lands, and Earth Vegetable.

Vegetables cannot live without air. From the experiments of Priestley, Ingenhousz, and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere; and this principle appears to be the cause of the fertility, which arises from the use of putrefying matters in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. If in large quantity, it is fatal to them.

Chaptal has observed, that carbonic acid predominates in the fungus and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an almost absolute darkness into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed, which he ascribes to the oxigen of the same acid. Sennebier has observed, that the plants which he watered with water impregnated with carbonic acid, transpired an extraordinary quantity of oxigen, which likewise indicates a decomposition of the acid.

Light is almost absolutely necessary to plants. In the dark they grow pale, languish, and die. The tendency of plants toward the light is remarkably seen in such vegetation as is effected in a chamber or place where the light is admitted on one side; for the plant never fails to grow in that direction. Whether the matter of light be condensed into the substance of plants, or whether it act merely as a stimulus or agent, without which the other requisite chemical processes cannot be effected, is uncertain.

It is ascertained, that the processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere. Dr. Hunter, quoted by Chaptal, observed by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap which, out of the tree, would freeze at 32°, did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Buffon.

The principles of which vegetables are composed, if we pursue their analysis as far as our means have hitherto allowed, are chiefly carbon, hidrogen, and oxigen. Nitrogen is a constituent principle of several, but for the most part in small quantity. Potash, soda, lime, magnesia, silex, alumine, sulphur, phosphorus, iron, manganese, and muriatic acid, have likewise been reckoned in the number: but some of these occur only occasionally, and chiefly in very small quantities; and are scarcely more entitled to be considered as belonging to them than gold, or some other substances, that have been occasionally procured from their decomposition.

The number of their immediate principles, or such more compounded substances, possessed of distinct characters, as have been extracted from them, has been much increased by the investigation of modern chemists. Of these we shall here give an enumeration from the latest chemical writer on the subject, Dr. Thomson, with their characters, referring to th
alphabetical order for a m
count of the greater part.

1. *Sugar.* Crystallizes.
and alcohol. Taste sweet.
acid, and yields oxalic aci

2. *Sarcocol.* Does not
ble in water and alcohol.
Soluble in nitric acid, and

3. *Asparagin.* Crystalli
ing and nauseous. Solub
Insoluble in alcohol. Solu
and converted into bitter
tificial tannin.

4. *Gum.* Does not crys
sipid. Soluble in water,
lage. Insoluble in alcohol.
silicated potash. Soluble i
forms mucous and oxalic a

5. *Ulmin.* Does not cr
insipid. Soluble in wate
form mucilage. Precipitat
oxymuriatic acids in the st
soluble in alcohol.

6. *Inulin.* A white pow
cold water. Soluble in bo
precipitates unaltered aft
cools. Insoluble in alcohol
tric acid, and yields oxalic

7. *Starch.* A white po
sipid. Insoluble in cold w
hot water; opake and glu
tated by an infusion of nut
redissolved by a heat of 12
alcohol. Soluble in dilute
precipitated by alcohol.
yields oxalic acid and a wa

8. *Indigo.* A blue pow
pid. Insoluble in water, alc
luble in sulphuric acid.
acid, and converted into
and artificial tannin.

9. *Gluten.* Forms a duc
with water. Partially so
precipitated by infusion of
igenized muriatic acid. S
acid and muriatic acid. I
hol. By fermentation bec
adhesive, and then assume
of cheese. Soluble in nitri
oxalic acid.

10. *Albumen.* Soluble in
agulated by heat, and be
Insoluble in alcohol. Preci
sion of nutgalls. Soluble
Soon putrefies.

11. *Fibrin.* Tasteless. In
and alcohol. Soluble in dil
in nitric acid. Soon putref

12. *Gelatine.* Insipid. S
Does not coagulate when h
tated by infusion of galls.

13. *Bitter principle.* Co
brown. Taste bitter. Equ
water and alcohol. Soluble
Precipitated by nitrat of sil

14. *Extractive.* Soluble i
cohol. Insoluble in ether.

oxigenized muriatic acid, muriat of tin, and muriat of alumine; but not by gelatine. Dyes fawn colour.

15. *Tannin.* Taste astringent. Soluble in water and in alcohol of 0·810. Precipitated by gelatine, muriat of alumine, and muriat of tin.

16. *Narcotic principle.* Crystallizes. Sparingly soluble in hot water and alcohol.

17. *Fixed oils.* No smell. Insoluble in water and alcohol. Forms soaps with alkalis. Coagulated by earthy and metallic salts.

18. *Wax.* Insoluble in water. Soluble in alcohol, ether, and oils. Forms soap with alkalis. Fusible.

19. *Volatile oil.* Strong smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into resinous substances.

20. *Camphor.* Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils, acids. Insoluble in alkalis. Burns with a clear flame, and volatilizes before melting.

21. *Birdlime.* Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

22. *Resins.* Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether, and alkalis. Soluble in acetic acid. By nitric acid converted into artificial tannin.

23. *Guaiacum.* Possesses the characters of resins, but dissolves in nitric acid, and yields oxalic acid and no tannin.

24. *Balsams.* Possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. By nitric acid converted into artificial tannin.

25. *Caoutchouc.* Very elastic. Insoluble in water and alcohol. When steeped in ether reduced to a pulp, which adheres to every thing. Fusible, and remains liquid. Very combustible.

26. *Gum resins.* Form milky solutions with water, transparent with alcohol. Soluble in alkalis. With nitric acid converted into tannin. Strong smell. Brittle, opake, infusible.

27. *Cotton.* Composed of fibres. Tasteless. Very combustible. Insoluble in water, alcohol, and ether. Soluble in alkalis. Yields oxalic acid to nitric acid.

28. *Suber.* Burns bright, and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

29. *Wood.* Composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

VEGETABLE ACID SPIRIT. A compound of the citric and acetous acids, recommended by Guhliche in some processes in the art of dyeing, and called by Berthollet acetocitric acid. It is prepared as follows:

He takes any quantity of lemons, those of which the rind is rotten will do, removes the peel, and the skin that adheres to it, and slices them into a vessel, which should not be made of wood. He then sprinkles them with such a quantity of good vinegar, as he thinks nearly equal to that of the lemon-juice, squeezes out the liquor through a flannel, by means of a press, and filters the expressed liquor through paper. It may be used with success, in this state; but it is apt to grow mouldy, and the acid is watery. In order that it may keep therefore, and not dilute the baths into which it is put, he directs it to be purified and concentrated as follows:—The liquor is to be exposed to the sun till a sediment forms, and it grows clear. It is then to be filtered, and distilled on a sandheat. The receiver is to be changed when the liquor that drops becomes acid, and the distillation continued till oily streaks are perceptible in the neck of the retort. The acid found in the receiver is to be kept for use.—*Berthollet on Dyeing.*

VEGETATION (SALINE). The crystallization of salts in a fluid is usually ascribed to a disposition of the parts to come together in a certain order, dependent on a principle somewhat resembling that polarity, which produces a symmetrical arrangement in particles of steel in the vicinity of a magnet. But there seems to be some other principle concerned in crystallization, which causes the whole structure or group of crystals to occupy more space than before, and in a certain loose mode of expression may be called a disposition in the parts to recede from each other. Thus a drop of water in a very cold atmosphere not only freezes, but puts forth rays in the form of a star, and ice is universally less dense than water. So likewise in the transition of metals from the fluid to the solid state, they not only crystallize internally, but part of the crystals protrude themselves above the common surface, so as to destroy its uniformity, and produce those figures, with which the imagination of the alchemists was so much struck. Saline bodies, of which the crystallization forms one of the most common, but by no means the least interesting of the effects of chemistry, likewise exhibit this appearance. For the saline matter of the solutions slowly creeps up the sides of the vessels, passes over the rim and down the external surface.

Mr. Chaptal has given us a good memoir on this subject in the Journal de Physique for October 1788, entitled Observations on the Influence of the Air and Light upon the Vegetation of Salts.

In the operations in the large way of his manufactory of medical and chemical products, he often observed that salts, particularly the metallic, vegetated on the side most exposed to the light, and the frequency of the effect induced him to make some direct experiments on the subject. For this purpose he took several capsules of glass, and covered the half of each, as well above as below, with black silk. At the same time he prepared solutions of almost all the earthy, alkaline, or metallic compound salts in distilled water, at the temperature of the atmosphere. These capsules were placed on tables in a well closed chamber which had no chimney, and of which the doors and windows were carefully stopped up, in order that the evaporation might not be hastened by any agitation of the air. Reflected light, by which I understand the light from the clouds, was admitted through a small aperture in one of the window-shutters. By this management, as well as the disposition of the capsules, one half of each of their respective cavities received light from the aperture, and the other was almost perfectly in darkness. The solutions were then carefully poured into the capsules by means of a funnel resting on the middle of the bottom, so that the border of the fluid was neat and uniform, without any irregularity or drop of the fluid falling on the bare surface of the glass.

Upwards of two hundred experiments were made with variations of the principal trials, so as to leave no doubt with regard to the constancy of the results. The most remarkable fact is, that the vegetation took place on those surfaces only which were illuminated. This phænomenon was so striking in most of the solutions, that in the space of a few days, and frequently even within one single day, the salt was elevated several lines above the liquor upon the enlightened surface, while there did not appear the smallest crust or edge on the dark part. Nothing could be more interesting than to observe this vegetation, projecting frequently more than an inch, and marking the line of distinction between the illuminated and dark parts of the vessel. The sulphats of iron, of zinc, and other metals, more especially presented this appearance. It was generally observed, that the vegetation was strongest toward the most enlightened part.

This phænomenon may be rendered still more interesting by directing the vegetation at pleasure toward the different parts of the vessel. For this purpose, nothing more is required than to cover the several parts in succession. For the vegetation always takes place in the enlightened part, and quickly ceases in that which is covered.

When the same solution has stood for several days, the insensible evaporation gradually depresses its surface, and a crust or edge of salt is left in the obscure part. But the salt never rises, or at least very imperfectly, above the liquor, and cannot be compared with the true vegetation.

When salts are suffered to
manner, the spontaneous eva
fluid affords very few crysta
line matter extends itself on
vessel.

This property of vegetatio
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quescent moisten the sides o
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but form neither crust nc
Those salts which are le
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among these the metallic s
have the preeminence.

Very singular varieties ar
the form affecfed by each s
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crust is formed, which swe
proportion to its growth, b
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plates opposed to each othe
no determinate form.

In other salts, needles a
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vessel, and by crossing eac
very curious kind of net-
of tin presented our auth
these very singular appear
too rapid action of aqua re
whitish magma was obtaine
luted with water and filtere
The solution was always
this state was submitted to e
days afterward, a saline cru
on the border of the enligh
vessel. This crust increase
peared to take root in the
titude of oblong pyramidal
entered into the solution.
when once the depression
left their extremities bare,
by transversal lines, and a
beautiful yellow colour.

It frequently happens, t
crystals diverge from a com
form the most beautiful fea
pearance was presented b
lime.

The vegetation in many
a thin even covering on the
sels. Alum, nitre, and se
this appearance.

The vegetation of certa
favoured by the addition
acid. Sulphat of potash is
then forms white feathers
the glass and the surface of t
sometimes entirely cover it
borders of the vessel in th
and striking manner. A
ther does not exceed these v
in whiteness or beauty. C
some which were eight or t
meter. They soon efflores
be not supplied with a
the solution, because this

up a large quantity of fluid in a short time.

This chemist observed, that when the acid solution was charged with sulphat of potash in excess by the assistance of heat, the salt is precipitated in fine crystals at the simple temperature of the atmosphere, and these crystals have no excess of acid. But if distilled water be saturated with sulphat of potash at the temperature of the atmosphere, and the same excess of acid be added, the salt afforded by spontaneous evaporation will have an excess of acid. The form of these crystals was constantly that of a six-sided flattened prism, terminating in two facets. From these phænomena Mr. Chaptal was led to believe, that light is the sole determining cause of vegetation, but subsequent experiments convinced him, that air is the principal agent.

1. A solution of copperas in a capsule well enlightened and covered with a clean glass, afforded no appearance of vegetation.

2. A similar solution left in a very obscure place, vegetated in that part only which was uncovered, but more slowly than when a greater quantity of light was admitted.

3. The solution placed in a well closed bottle, reversed upon water and exposed to daylight, does not vegetate.

4. The vegetation takes place sooner in a very open vessel, such as a cup, than in a cylindrical vessel; sooner in this last than in an uncorked bottle; and in closed vessels not at all.

If a glass funnel be reversed in a capsule containing a saline solution, the vegetation takes place on the external surfaces, but scarcely at all within. It appears therefore, that the access of air and its free circulation are peculiarly advantageous to the production of this appearance.

It must be observed, that the nature of the vessels is not a matter of indifference in these experiments. Glass is very proper, and metal much less so. But Chaptal remarks, that the phænomenon does not arise from an affinity between the vessel and the fluid, because if so the exposure and light would not be required.

Similar experiments on the vegetation of salts, which effloresce on the surface of earths, afforded results of the same kind. He affirms, that they all depend on the action of the air, slightly assisted by the concurrence of light. The contact or privation of these agents either favours or interrupts the effect. The nitrous, aluminous or sulphuric earths exhibit striking effects of this kind. Their vegetations are often five inches in length.

The author is averse to entering into conjecture relative to this appearance. He only demands whether it be a kind of affinity between the air, light, and saline substances, which elevates the latter contrary to their gravitation. Or is it, he demands, a virtue truly vital, which the contact of air determines and foments? It cannot be denied, but that much of obscurity attends the consideration of what happens among the particles of matter, and that the caution of this author is to be applauded for encouraging a disposition to generalize the facts, rather than to multiply speculations. I shall likewise therefore avoid any attempt at particular explanation, but the following facts seem to throw some light on the subject.

Crystallization, properly so called, is an effect of the mutual tendency of the parts of a body to come together, and takes place whenever the quantity of solvent becomes diminished. See Crystallization. When the quantity of solvent is slowly diminished, and external agitation prevented, the crystals are large and of a determinate figure; but in opposite circumstances they are small, irregular, and in confused groups.

The presence of light is found to interrupt crystallization nearly in the same manner as agitation would have done.

The vegetation of salts consequently appears to be of a distinct nature in certain respects from crystallization within a fluid. The crystallization which approaches most nearly to vegetation is effected when a thin covering of saline solution is spread out upon a pane of glass. In this case the attractions of the particles of the salt to each other are all nearly in the same plane, and may therefore, notwithstanding the speedy evaporation, be expected to produce effects more symmetrical, than when a much greater thickness of fluid is said to crystallize.

The manner in which the air acts is a subject of no difficulty; since it favours the crystallization by abstracting the water. But the agency of light in the experiments of Mr. Chaptal is much more obscure. Experiment leads us no farther than to assert, that it singularly favours the assumption of the elastic state; insomuch that principles, which in the dark would have remained united, become separated by the agency of light, which gives elasticity to one or more of them. This is seen in the decomposition of nitrous acid in half-filled vessels; the extrication of oxigen gas from vegetables, and other similar effects. Simple evaporation is likewise so far favoured or modified, that the fluid in a closed vessel or bottle, partly filled with water or saline solution, rises and is condensed in drops on the side nearest the light. This fact helps us forward in a certain degree. For the light must raise part of the solution, whether merely aqueous or saline, on that side of the vessel which is most illuminated; and when once the surface is wetted, the saline solution will rise to a certain height by cohesive attraction. In this situation, it becomes the film of liquid exposed on a pane of glass. Speedy evaporation affords crystals more or less regular, on the same principle as ramified crystals are produced in the instance last mentioned. The interstices between these minute crystals are capillary tubes, which carry up more of the saline solution, which is distributed by the agency of light as before, and the vegetation goes on. Hence it appears, that a want either of light or of air must suspend the process, since it is in vain that the light is found to spread the fluid over the surface in a closed vessel, if there be not enough of air in succession to crystallize the salt by evaporation.

The ingenious author remarks, that the vessels themselves are not indifferent as to the production of this phænomenon. He thinks, that it cannot arise from an affinity between the saline solution and the matter of the vessel; but the reason he gives for this opinion is far from being conclusive. For the absolute necessity of two agents in the production of a phænomenon, does not exclude a third efficient cause. If three causes be jointly necessary, the absence of any one of them will be incompatible with the production of the effect. I am disposed however to think, that the different properties of the vessels in this behalf arise either from their nature as conductors of heat or electricity, or else their transparency. It is well known from the numerous instances adduced by Muschenbroek, that the dew falls plentifully upon dishes of certain materials, and avoids others. The exhalation and condensation, here observed as a consequence of the agency of light, will in all probability be modified by the cause, which affects the distribution of the dew: what that cause is must be left to future researches.

Veins. The ores of metals are frequently found to fill certain clefts in mountains. These masses, when they run out in length, are called veins. Inconsiderable veins, which diverge from the principal, are called slips; and such masses of ore as are of considerable magnitude, but no great length, are called bellies or stock works. See Metals, Metallurgy, and Ores.

Venus. The name of the planet Venus has been given to copper, but it is now scarcely ever used. The chemical character or sign of copper is the same as the astronomical character of the planet. See the plate of Chemical Signs.

Verdigrise is copper corroded, and reduced to a very beautiful green rust, by a vinous acid. This matter, which is useful to painters, is conveniently manufactured at Montpellier; the vines of Languedoc, of which that city is the capital, being very proper for this preparation.

The following process for making verdigrise is described by Mr. Monet of the Royal Society of Montpellier, and is published among the Memoirs of the Academy for the years 1750 and 1753.

Vine-stalks well dried in the sun are steeped during eight days in strong wine, and afterward drained. They are then put into earthen pots, and upon them wine is poured. The pots are car
The wine undergoes the ac
tion, which in summer is fi
or eight days, but requires a
winter, although this opera
performed in cellars. When
tion is sufficiently advanced,
known by observing the inne
lids of the pots, which durin
of the fermentation is cont
by the moisture of the risin
stalks are then to be taken o
These stalks are by this m
nated with the acid of the
remaining liquor is but a v
gar. The stalks are to be
some time in baskets. and
are to be put into earthen p
of Swedish copper, so disp
plate shall rest upon, and b
layers of stalks. The pots ar
with lids, and the copper is
the action of the vinegar,
four days or more, in which
become covered with verdig
are then to be taken out of
left in the cellar three or fo
end of which time they are t
with water, or with the weak
mentioned, and left to dr
moistening and drying of
been thrice repeated, the ve
found to have considerabl
quantity, and it may then
for sale.

A solution or erosion of c
sequently a verdigrise, may
employing ordinary vinegar
as is directed in the above p
would not have the unct
nary verdigrise, which quali
in painting. Good verdigri
Macquer, must be prepare
a vinous acid, or solvent ha
spirituous. Accordingly th
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fermentation, to which the
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Verdigrise is used for pai
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acid, and for the preparatio
verdigrise, or of Venus.

Chaptal informs us, that
of this article was till late
Montpellier, from a prejudi
lars of that city alone were
operation. His account of t
is less ample than the foreg
fect the same. This article
Grenoble, where ready made
and sprinkled on plates of
verdigrise contains one six

copper than that of Montpellier, and has not the empyreumatic smell of the latter. The vinegar it affords by distillation is likewise stronger and in greater plenty. Whence he concludes that part of the oxide of copper in this compound is really dissolved, and brought into the saline state.

VERDITER is a blue pigment, obtained by adding chalk or whiting to the solution of copper in aqua fortis. It is prepared by the refiners, who employ for this purpose the solution of copper, which they obtain in the process of parting, by precipitating silver from aqua fortis with plates of copper. See PARTING. It is said, that a fine coloured verditer cannot be obtained from a solution of copper prepared by dissolving directly that metal in aqua fortis; and that the silver is necessary. We know, that it is actually made of a good quality by the refiners only. Dr. Merret says that it is prepared in the following manner: A quantity of whiting is put into a tub, and upon this the solution of the copper is poured. The mixture is to be stirred every day for some hours together, till the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper colour. Then it is to be spread on large pieces of chalk, and dried in the sun.

We have two kinds of verditer in the English market: the one, called refiners' verditer, has the form of a very soft impalpable powder, and possesses a stronger body of colour than the other. The other verditer has the form either of hard irregular lumps, or powder, in which last state it is much harsher to the feel, and is by no means so readily diffusible in water. The best verditer is, as I understand, made by the refiners, not because their solution of copper possesses any peculiar advantage over any other nitric solution, but because they obtain it more cheaply, than if the acid had not been already paid for in their process of parting. The value of the article is not sufficient to pay for the expense of a direct solution in this country.

Common verditer is made from the sulphat of copper, which may be had at a reasonable rate from the manufacturers at Sheffield and Birmingham. I am not acquainted with that part of their manufactories which affords it, but understand, that it is not produced in a direct way, but from clippings of metal or other savings. It is frequently contaminated with iron. The copper of a solution of this sulphat is precipitated by an addition of lime in the making of common verditer. Whiting will not effect a separation. The precipitate afforded by the lime is blue, but requires some management as to the quantities of water as well as of the other principles, and the method of the drying, to produce the best effect.

The flintiness or harshness of the common verditer arises no doubt from an admixture of sulphat of lime; whereas in the refiners' verditer little of lime is found, because the nitrat of lime is very soluble in the water. If the object should be found of sufficient commercial importance, it is probable, that the blue oxide of copper in verditer might be obtained by an indirect process of transferring nitric acid to the metal. Thus, if the solutions of nitre and of sulphat of copper be mixed, the alkali unites with the sulphuric acid, and sulphat of potash falls down, if the quantity of water be not considerable, at the same time that the nitric acid transferred to the copper remains in solution.

Other methods of decomposition might be easily pointed out, but every thing of this nature must be referred to the test of experiment. For in some instances, triple compounds are formed where perfect decomposition was expected, and in most instances the complete edulcoration of the product is required, and many apparently minute circumstances must be investigated and attended to, where so delicate a thing as the colour of a metallic oxide is the object aimed at.

The refiners' verditer is more than twice as dear as the common. Both are used in water colours only, chiefly by the paper stainers. It is said, that the greater intensity of colour, added to the facility with which it may be uniformly spread over any surface, affords the advantage even of cheapness to the refiners' verditer; but the last-mentioned quality is communicated to common verditer, by steeping it for several days in water before it is used.

In the 13th volume of the *Annales de Chimie* is inserted a chemical examination of verditer, by Pelletier, extracted from a memoir read to the Academy of Sciences. After giving a short history of the article according to the usual and excellent custom of the French writers, he proceeds to relate his own experiments. He used that article which we call refiners' verditer.

1 Verditer was totally dissolved in the nitric and muriatic acids, and carbonic acid was separated with effervescence.

2. The sulphuric acid attacked verditer with strong effervescence, so as almost to throw the mixture out of the matrass. The solution was not perfectly clear. After evaporation to dryness, distilled water was added. It took up the whole, which was found to be sulphat of lime and of copper. The former was first separated by evaporation, and afterward the latter. From these products it was ascertained, that a hundred grains of the verditer contained seven grains of lime, and fifty grains of pure copper. The inferior verditers were found to contain more lime and less copper, the quantity of the former in some amounting

to near 14 grains. Their colour was accordingly less intense.

3. Ammonia takes up the copper from verditer, and leaves a small portion of carbonat of lime. But the numerical results of this experiment could not be depended on, because the chalk exists in the verditer so minutely divided, or perhaps because it unites with the compound in the solution, and cannot therefore be well separated.

4. By distillation in the pneumatic apparatus, by a gradual heat, a loss of accurately two thirds of its weight was experienced. The volatile product was almost totally air, soluble in water, converting tincture of litmus to a red, and precipitating lime water. It was therefore carbonic acid. A few drops of water were perceived in the neck of the retort, which being deducted by estimate from the weight of the elastic product left 30 per cent of carbonic acid.

5. The residue of this distillation was divided into two parts, and reduced with a proper quantity of black flux and charcoal with common salt. The quantity of copper in one of these reductions proved to be 49 parts in the hundred of the original weight of verditer, and the other proved to be $49\frac{1}{2}$. With a small allowance therefore, for loss and inaccuracy, this result may be taken as a confirmation of the humid analysis, which gave 50.

6. The quantity of oxigen in the oxide was ascertained by inference from the preceding facts. From a hundred parts the products were 30 carbonic acid, $3\frac{1}{3}$ water, 7 lime, and 50 copper. In order to complete the hundred parts, it is necessary to add $9\frac{2}{3}$. This will be the weight of oxigen. With a view to ascertain more perfectly, that oxigen is really contained in verditer, a certain quantity was distilled till it afforded no more carbonic acid. A little charcoal in powder was then added, and the distillation being renewed, more carbonic acid was obtained, which Mr. Pelletier considers as a conclusive proof of the existence of oxigen in the oxide.

Hence it follows, that 100 grains of the very best verditer contain, of carbonic acid 30, of water $3\frac{1}{3}$, of pure lime 7, of oxigen $9\frac{2}{3}$, and of pure copper 50. The author a second time remarks, that the verditers of inferior quality contain more chalk and less copper. It is not directly asserted, that the other principles in these verditers are unaltered in their proportions. In the above numbers it is observable, that more carbonic acid enters into the compound, than is requisite to convert the lime into chalk. The rest must therefore, in all probability, have united with the oxide of copper. Whether the blue colour be owing to its presence chiefly is an object deserving more minute inquiry. It is also observable, that Mr. Pelletier's humid analysis by sulphuric acid, is not alone sufficient to show, that the lim
verditers did not possess
phat, instead of that of cl

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aware, that Berthollet ha
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made, and sufficiently d
assumes in time, after qui
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that of verditer. He n
without success, some of
They deserve the notice
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following:

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with a small portion of

At the instant of this addition, the mass assumed a lively blue colour. The quantity of lime made use of is from 7 to 10 per cent of the weight of the precipitate. But this quantity may be ascertained by trials of a small quantity of the mixture, which may be dried either in the sun, or in a warm place during the time of triturating. If its colour when dry appear too pale, a small quantity of the precipitate of copper may be added to the mass, taking care that it shall not be enough to make any difference in the liveliness of the blue. The whole is then to be dried, which is speedily done, and the mass then proves to be of a colour equal, or even superior to the English verditer, and possessing the same habitudes when chemically analysed. The influence of light is of no consequence in this operation. For the conversion is instantaneous, and takes place in the dark.

Mr. Pelletier is of opinion, that the lime takes the oxigen from the oxide of copper. I have been disposed to suspect the formation of ammonia in this process, which still deserves to be farther examined. He distinguishes verditer from the crystals of azure, because these last are a combination of copper with carbonic acid, and from malachite, which may be considered as a combination of carbonic acid with copper superoxigenated.

VERJUICE. A kind of harsh, austere vinegar, made of the expressed juice of the wild apple, or crab. The French give this name to unripe grapes, and to the sour liquor obtained from them.

VERMILION. The red sulphuret of mercury, or cinnabar.

A kind of garnet, the red of which inclines rather to yellow than to purple, is likewise known by this name.

VESSELS CHEMICAL. See APPARATUS.

VESUVIAN. The leucite of Werner, white garnet of some. It is in small white, or grayish white, opake. and generally friable crystals, from the size of a pin's head to that of a small nutmeg, with 24 trapezoidal faces; specific gravity 2·464.

That from Vesuvius gave Klaproth, in 100 parts,

Silex 35·5.
Lime 33.
Alumine 22·25.
Oxide of iron 7·5.
Oxide of manganese 0·25.

That from Siberia,

Silex 42.
Lime 34.
Alumine 16·25.
Oxide of iron 5·5.
Manganese a trace only.

VINEGAR. See FERMENTATION, ACETOUS; and also ACID, ACETOUS, where the mode of making it is given.

VINEGAR (DISTILLED). Acetous acid.

VINEGAR OF SATURN. Solution of acetat of lead.

VINEGAR OF VENUS. Acetic acid was formerly called sometimes by this name, because obtained from distillation of acetat of copper

VINEGAR (RADICAL). Acetic acid.

VIOLET. From the flower of this plant a blue sirup is made, which was formerly used in medicine, but now chiefly as a test, being turned green by an alkali, and red by an acid. It loses its colour by keeping, but this may be restored by agitation for a few minutes in contact with oxigen gas.

VIRGULA DIVINATORIA. See ROD (DIVINING).

VITAL AIR. See GAS (OXIGEN).

VITRIFICATION. See GLASS, also SILEX.

VITRIOL. The saline combination of copper with the sulphuric acid is called blue vitriol, in commerce. Sulphuric acid and iron form green vitriol, or the green copperas of the shops. The sulphat of zinc is called white vitriol or white copperas. The looseness and inaccuracy of these denominations are evident. Some chemists have endeavoured to generalize the term, by applying it to all combinations containing sulphuric acid. Thus they would say, vitriol of iron, or of copper, or of lime; but this method has never been generally adopted; and in modern chemistry the term vitriol is entirely discarded for sulphat. See ACID (SULPHURIC); SULPHUR; PYRITES, and the several Metals.

VITRIOLIC ACID. See ACID (SULPHURIC).

VOLATILE ALKALI. See AMMONIA.

VOLATILITY. That property of bodies by which they are disposed to assume the vaporous or elastic state, and quit the vessels in which they are placed. In many instances of chemical operation, the most simple substances are found to be the most volatile, and many principles are rendered more fixed by combination. This is the most general observation; but there are a number of instances, in which volatility follows from combination, though for the most part less in degree than was possessed before by the more volatile of the matters so combined. Of all substances known the earths are the least volatile, next to these are some of the metals, and these are followed by the fixed alkalis and a few of the acids. All other bodies possess considerable volatility. Very volatile bodies are in many instances fixable in combination with others by the sudden application of a fusing heat.

VOLCANOES. The combustion of those enormous masses of bitumen, which are deposited in the bowels of the earth, produces volcanoes. They owe their origin more especially to the strata of pyritous coal. The decomposition or action of water upon the pyrites determines the heat, and the production of a great quantity of hidrogen, which exerts itself against the surrounding obstacles, and at length breaks them. This effect appears to be the chief cause of earthquakes; but when the concourse of air facilitates the combustion of the bitumen and the hidrogen, the flame is seen to issue out of the chimneys or vents which are made: and this occasions the fire of volcanoes.

There are many volcanoes still in an active state on our globe, independent of those of Italy, which are the most known. The Abbé Chappe has described three burning in Siberia. Anderson and Von Troil have described those of Iceland. Asia and Africa contain several, and we find the remains of these fires or volcanic products in all parts of the globe.

Naturalists inform us, that all the southern islands have been volcanized; and they are seen daily to be formed by the action of these subterraneous fires. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances with those of the volcanoes at present burning, are all in favour of the opinion that their origin was the same.

When the decompostion of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phænomena of earthquakes. Mephitic vapours are multiplied on the surface of the ground, and dreadful hollow noises are heard. In Iceland, the rivers and springs are swallowed up; a thick smoke mixed with sparks and lightning is then disengaged from the crater; and naturalists have observed, that, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which show the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and lastly appears a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains that surround volcanoes. Montenuevo, which is a hundred and eighty feet high, and three thousand in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes, which darken the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out is that which the heat has half vitrified. In the year 1767, the ashes of Vesuvius were carried twenty leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, E
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Lava is sometimes swelled up and porous. The lightest is called pumice-stone.

The substances thrown out by volcanoes are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, feldt-spar, mica, shells, schorl, &c.

The fire of volcanoes is seldom strong enough to vitrify the matters it throws out. We know only of the yellowish capillary and flexible glass thrown out by the volcanoes of the island of Bourbon, on the 14th of May 1766 (M. Commerson) and the lapis gallinaceus ejected by Hecla. Mr. Egolfrigouson, who is employed by the observatory at Copenhagen, has settled in Iceland, where he uses a mirror of a telescope, which he has made out of the black agate of Iceland.

The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every where volcanized. Chaptal observed several ancient volcanoes at present cultivated; and the line which separates the other earths from the volcanic earth, constitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature, to extract virgin earth out of the bowels of the globe, and repair the exhausted surface.

The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since in some instances it appears to have required nearly two thousand years before lava was fit to receive the plough. In this respect, however, lavas differ very widely, so that our reasoning from them must at best be very vague. An argument has been drawn from this phænomenon to prove the antiquity of the globe: but the silence of the most ancient authors concerning the volcanoes of the kingdom of France, of which we find such frequent traces, indicates that these volcanoes have been extinguished from time immemorial; a circumstance which carries their existence to a very distant period. Beside this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Ætna; nevertheless these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when we observe, that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth.

The height of Vesuvius above the level of the sea is three thousand six hundred and fifty-nine feet; its circumference, thirty-four thousand four hundred and forty-four. The height of Ætna is ten thousand and thirty six feet; and its circumference one hundred and eighty thousand.

The various volcanic products are applicable to several uses.

1. The puzzolano is of admirable use for building in the water: when mixed with lime it speedily fixes itself; and water does not soften it, for it becomes continually harder and harder. Chaptal has proved that oxided ochres afford the same advantage for this purpose; they are made into balls, and baked in a potter's furnace in the usual manner. The experiments made at Sette, by the commissary of the province, prove, that they may be substituted with the greatest advantage instead of the puzzolano of Italy.

2. Lava is likewise susceptible of vitrification; and in this state it may be blown into opake bottles of the greatest lightness, which Chaptal says he has done at Erepian and at Alais. The very hard lava, mixed in equal parts with wood-ashes and soda, produced, he says, an excellent green glass. The bottles made of it were only half the weight of common bottles, and much stronger; as was proved by Chaptal's experiments, and those which Mr. Joly de Fleury ordered to be made under his administration.

3. Pumice-stone likewise has its uses; it is more especially used to polish most bodies which are somewhat hard. It is employed in the mass or in powder, according to the intended purpose. Sometimes, after levigation, it is mixed with water to render it softer.

VOLCANITE. See PYROXENE.

W.

WACKE. This stone, which is more liable to decomposition than basaltes, belongs to the recent or floetz trap formation, and is found in beds or veins. These veins are of subsequent formation to those of metallic ores, since they always cross them, and scarcely ever contain any metallic substance.

Its common colours are deep greenish-gray, blackish-green, grayish, and sometimes brown, or reddish.

Its fracture is dull and smooth, sometimes conchoidal, sometimes unequal and fine-grained. It is not rough to the touch, pretty soft, and very easily broken. It does not adhere to the tongue, frequently acts

It is distinguishable from argils in not forming a paste with water, and being of a more compact and homogeneal texture; from marls, in not effervescing with acids.

It includes minerals of very different kinds, which are irregularly disseminated through it, and appear not to have been formed in it, but rather to have been enveloped in it while soft. Such are basaltic hornblende, native bismuth, magnetic iron, and black shining mica. The last is among those that most generally accompany it, and may in some cases serve to distinguish it. It is in pretty large laminæ, and these not very near together.

It likewise contains nodules and little veins of calcareous spar: at Goachimsthal, in Bohemia, petrified wood has been found in it; and at Kallnnordheim, in Franconia, fossil bones.—*Brongniart.*

WADD. This name is given to plumbago, or black lead.

WADD BLACK. An ore of manganese found in Derbyshire. It is remarkable for the property of taking fire when mixed with linseed oil.

WALKIORD. The Swedish name for a gray stone marrow. The word signifies Fuller's-earth; in German *Walkerde.*

WAND. See ROD (DIVINING).

WASH. The technical term for the fermented liquor, of whatever kind, from which spirit is intended to be distilled. See ALCOHOL.

WASHING. See ELUTRIATION; also TIN.

WATER. It is scarcely necessary to give any definition or description of this universally known fluid. It is a very transparent fluid, possessing a moderate degree of activity with regard to organized substances, which renders it friendly to animal and vegetable life, for both which it is indeed indispensably necessary. Hence it acts but slightly on the organs of sense, and is therefore said to have neither taste nor smell. It appears to possess considerable elasticity, and yields in a perceptible degree to the pressure of air in the condensing machine, as Canton proved, by including it in an open glass vessel with a narrow neck. This condensation is proportioned to the pressure, and it recovers its original dimensions, when the force is removed. The same elastic force is shown by the rebounding of stones or bullets, which strike the surface of water obliquely, as is seen in the diversion of boys, which in this country they call making ducks and drakes. A flat stone is thrown from the hand, nearly in a horizontal direction, with its surface parallel to that of the water, upon which it passes, by repeated bounds, with nearly the same facility as if the water were frozen; till at last the force of projection being expended, it sinks. The musical sonorous-

sion of its particles.

Water does not possess any considerable density. Most mineral substances are heavier than this fluid, and among organized matters, there are perhaps none, except oils, and the products of art, which, if lighter than water, do not owe this property to their mechanical structure. At a moderate temperature water assumes the solid state, or freezes; and at a degree of heat far below that required to fuse any of the simple metals but mercury, its internal parts assume the elastic state, and fly off with ebullition. The freezing and boiling points of water are assumed as the standards for admeasurements of heat. See THERMOMETER, also CALORIC. Its weight also is used as the standard for specific gravities; see GRAVITY, SPECIFIC; also ALCOHOL. Its capacity for heat is taken as the standard of the specific heats of bodies. And in a word, the solubility or insolubility of bodies in this fluid composes a large part of the science of chemistry.

When water is cooled gradually, it contracts in its dimensions till within 8° of freezing, and then expands till it begins to assume the solid state. Congealed water or ice is considerably larger in its dimensions than water, upon which it therefore floats. The expansion of ice, at the time of its formation, is made with such force, as to burst the strongest metallic vessels. The assumption of the solid state in water is effected, like other crystallizations, under a symmetrical figure. The parts which become solid first by freezing have the form of daggers crossing each other at angles of 60 degrees. The crystallization of ice is also seen to advantage in snow and hoar frost, which are of the nature of the vegetation of salts, though probably they may not require the cooperation of light.

Steam, or the vapour of water, possesses a strong power of expansion, which is greater the higher its temperature. This power has within the last century been very advantageously applied to mechanical purposes. The vapour of water is more expansible in the same weight and temperature than air; whence the steam in half-filled vessels always occupies the upper place, and moist air is less heavy than dry. Common air imbibed by water, and afterward expelled again, is found to contain somewhat more of oxigen than before. It follows therefore, that the vital part of the atmosphere is more disposed to combine with water than the azotic part. This effect is remarkably perceived in fogs, which commonly exhibit the peculiar smell of burned gunpowder or nitrogen gas; and must be ascribed to a proportion of the oxigen having combined with the water of the fog.

The eolipile is a copper vessel, or globe, with a small aperture on one side. If this be heated and then immersed in water, it will be partly filled by the pressure of the atmosphere; and if this water be then made to boil, the steam will issue out with considerable violence, and excite a fire in the same manner as bellows. This has been thought to indicate a decomposition of the water; but it is not the steam which produces this effect, but the air it carries with it by its mechanical impulse; for if the nozzle of an eolipile be inserted directly into the fire, without leaving any space for the interposition of a body of air, it will not excite but extinguish the fire, as Dr. Lewis proved by experiment.

Water is not only the common measure of specific gravities, but the tables of this element (see GRAVITY, SPECIFIC) may be usefully employed in the admeasurement of irregular solids; for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the specific gravities do therefore denote likewise the number of ounces avoirdupois in a cubic foot of each substance.

Native water is seldom, if ever, found perfectly pure. The waters that flow within or upon the surface of the earth contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances over or through which they pass. Rain and snow waters are much purer than these, although they also contain whatever floats in the air, or has been exhaled along with the watery vapours. Margraaf has analysed by gentle distillation some clear rain and snow waters, that he had very carefully collected in glass vessels. The several residuums obtained by distilling a hundred measures of rain water, each of which contained thirty-six ounces, he distilled and evaporated, till no more remained than six or eight ounces of water, which was very turbid. From this remainder he obtained by filtration a hundred grains of a yellowish white calcareous earth; and the filtrated liquor still contained some earthy particles suspended in it. Upon adding some drops of a solution of subcarbonat of potash to this filtrated liquor, he obtained by evaporation a few grains of crystals, which had the appearance of nitre and common salt. From these crystals he inferred, that the rain water contained a small portion of nitric and muriatic acids; and from the colour of the crystals, which was brownish, he concluded that it also contained some oil and viscous particles. He farther proved the presence of muriatic acid in rain water, by adding a concentrated residuum of distilled rain to solutions of silver, mercury, and lead, in nitric acid; from all which solutions precipitates were thereby formed. He discovered the earthy, saline mucilaginous, and oily principles, by exposing rain water to the rays of the sun, during some months, in a glass vessel covered so as to exclude the dust, but not air; by which means the water underwent a kind of fermentation or putrefaction, and a greenish slime was formed on the sides and bottom of the containing vessel. This fermentation he found could not be excited by treating in the same manner the rain water, that had passed over in the distillation made in order to procure the abovementioned residuum.

Margraaf, having treated a hundred measures of snow water in the same manner as he had done the rain water, obtained sixty grains of a similar white calcareous earth, together with the same saline, mucilaginous, and oily principles; but observed, that the rain water contained a larger proportion of the nitric acid, and the snow water more of the muriatic acid. Upon a farther examination of the calcareous earths obtained from rain and snow, he discovered that they contained a ferruginous manner.

The purity of water may be known by the following marks or properties of pure water:

1. Pure water is lighter than water that is not pure; for not only the substances usually dissolved in water are heavier than water, but also the specific gravity of a solution of any of these substances in water is generally greater than the intermediate specific gravity of the water and of that substance.

2. Pure water is more fluid than water that is not pure; hence it is said to occasion a louder sound when poured from one vessel into another.

3. It has no colour, smell, or taste.

4. It wets more easily than the waters containing metallic and earthy salts, called hard waters, and feels softer when touched.

5. Soap, or a solution of soap in alcohol, mixes easily and perfectly with it.

6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury, in nitric acid, or a solution of acetat of lead in water.

Boerhaave, Macquer, and other chemists, maintain, that pure water is unalterable; and others, as Borichius, Boyle, Wallerius, that it may be decomposed or resolved into other principles, especially into earth.

Boyle relates, that one ounce of water, distilled carefully in glass vessels two hundred times, yielded six drachms of a white, light, insipid earth, fixed in the fire, and indissoluble in water. Boerhaave attributed the earth obtained by distillation of water to dust floating in laboratories. Other chemists have made experiments to ascertain the truth of that of Boyle. Liedenfrost found, that when pure distilled water is dissipated or evaporated by throwing it into a red hot iron spoon, he always obtained a quantity of earth. Wallerius obtained a scruple and a half of fine white earth by triturating during two hours a drachm of distilled water. This earth, he says, is soluble in acids, is convertible into a hard mass by a red heat, which mass is insoluble by acids, and is vitrifiable into a white transparent glass by a more violent heat. He found also, that a larger quantity of earth is deposited from boiling water with a strong, than with a gentle fire. See the Swedish Memoirs for the year 1760.

Margraaf has made experiments with his accustomed accuracy, from which it appears, that by distillation, and also by evaporation with the heat of the sun, of rain water, the purity of which had been previously ascertained by thirteen distillations, he obtained a white, light, shining earth. This earth could not be vitrified with the heat requisite for the fusion of ordinary glass; but by a more violent and longer continued fire it was melted into a yellow grayish mass. He found, that about half of this earth was soluble in nitric acid, and that the other half was not fusible by fire; but that, by addition of half its quantity of subcarbonat of potash, it was convertible into a transparent glass. The part of the earth that was dissolved into nitric acid was afterward precipitated from that acid by sulphuric acid, with which it formed sulphat of lime; and hence Margraaf infers, that it is a true calcareous earth. He does not determine the class of earths to which the insoluble part of the earth thus obtained by distilling water ought to be referred. The quantity of earth that he obtained, in one experiment, from seventy-two ounces of distilled water, by twelve distillations, was nine or ten grains.

Lavoisier however maintains, that the earth thus obtained by distilling water proceeds from the vessels employed; and the experiments of Scheele appear to have decided that it is so. See his Treatise on Air and Fire.

Margraaf obtained earth from water by another experiment. He put two ounces of distilled water into a glass vessel ten inches high, and from one to two inches in
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the saline substances, tha
in an ounce of water, w
of Fahrenheit's scale, a
ments made by Mr.
Chemiæ, p. 48.

Acetat of potash
Salt of Sedlitz
Sulphat of magnesia
Subcarbonat of potas
Neutral tartrit of pot
Sulphat of zinc
Sal gem
Subcarbonat of soda
Sal ammoniac
Common salt
Sulphat of soda
Salt of Lorraine
Muriat of potash
Tartrit of soda
Sulphat of copper
Sulphat of iron
Purified nitre
Sal polychrest of Gla
Sulphat of potash
Corrosive muriat of
Borax
Alum
Succinic acid
Arsenious acid
Crude tartar
Cream of tartar

The following table is copied from Muschenbroek. The eight first exp
by Boerhaave, and the rest by Muschenbroek, with a heat

Sea salt	oz.	2	were dissolved in	oz.	6	and dr. 3
Sal gem	oz.	1		oz.	3	and dr. 2
Sal Ammoniac	oz.	1		oz.	3	and dr. 2
Nitre	dr.	9		oz.	6	
Borax	dr.	4		oz.	10	
Alum	oz.	1		oz.	14	
Sulphat of magnesia	oz.	1		oz.	1	and dr. 2
Sulphat of iron	dr.	1½		oz.	3	
Arsenious acid	oz.	1		oz.	30	
Sulphat of copper	gr.	50		gr.	850	
Salt of hartshorn	gr.	50		gr.	765	
Acetat of lead	gr.	50		gr.	595	
Subcarbonat of potash	gr.	50		gr.	85	
Glass gall	gr.	50		oz.	7½	
Cream of tartar	gr.	50		oz.	1000	of boiling

Fifty grains of cream of tartar may be dissolved in 100 grains of lime-water.—*Hist. de l'Acad. Royale*, 1732.

Sugar of milk, dr. 7, were dissolved in lb. 1 of water, heated to 167°.

According to Neumann's experiments, the quantities of salts soluble in an ounce of water are expressed in the following table. He does not mention the heat employed. It was probably between 50° and 60°.

White powd. sugar	oz.	2	
Brown powd. sugar	oz.	2	
White or brown sugar candy	dr.	9	
Acetat of potash	oz.	1	
Sulphat of magnesia	oz.	1	
Sedlitz salt	dr.	6	
Pure fixed alkali	dr.	6	
Sulphat of zinc	oz.	0½	
Sulphat of iron	oz.	0½	
Sal gem	dr.	3	scr. 1
Sea-salt	dr.	3	
Sulphat of soda	dr.	2	
Sal ammoniac	dr.	2	
Carbonat of ammonia	dr.	2	
Potash	dr.	2	
Sulphat of copper	dr.	2	
Pure nitre	dr.	1	gr. 10
Sal prunell	dr.	1	
Neutral tartrit of potash	dr.	1	
Alum	scr.	2½	
Sal polychrest	scr.	2	
Arcanum duplicatum	dr.	0½	
Sulphat of potash	dr.	0½	
Sugar of milk	scr.	1	
Acetat of lead	scr.	1	
Tartarized antimony	scr.	1	
Borax	gr.	15	
Oxalic acid	gr.	10	
White tartar	gr.	5	
Crystals of tartar	gr.	5	

Water when saturated with one salt is capable of dissolving a considerable portion of another salt; and when saturated with this also, it may still dissolve a third, a fourth, or more salts. Thus, according to Neumann, four ounces of water that have been saturated with a drachm and a few grains of alum, will still dissolve five drachms of nitre, then half an ounce of sulphat of iron, six drachms of common salt, three drachms of neutral tartrit of potash, and five drachms of sugar. In the same manner also, four ounces of water saturated with half an ounce of nitre, will dissolve half an ounce of sulphat of zinc, six drachms of common salt, six drachms of sal ammoniac, half an ounce of neutral tartrit of potash; and after all these an entire ounce of sugar.

Mr. Eller has published an account of the following experiments concerning the solutions of different salts in the same water. See Mem. of the Acad. of Berlin for the year 1750.

In each experiment, he employed eight ounces of distilled water. He found that this quantity of water, when saturated

With four ounces of nitre, dissolved one ounce five drachms of fixed alkali, and half an ounce of common salt.

With three ounces one drachm and one scruple of common salt, dissolved three drachms of nitre, and six drachms of fixed alkali.

With three ounces and a half of fossil salt, dissolved half an ounce of nitre.

With half an ounce of cream of tartar, dissolved half an ounce of Sedlitz salt, and half an ounce of fixed alkali.

With an ounce and a half of sulphat of potash, dissolved half an ounce of fixed alkali.

With three ounces and a half of sulphat of soda, dissolved two drachms of nitre and as much sugar.

With four ounces of neutral tartrit of potash, dissolved half an ounce of pure nitre.

With four ounces of sulphat of magnesia, dissolved half an ounce of fine sugar.

With two ounces and a half of sal ammoniac, dissolved five drachms of fossil salt.

With an ounce and a half of volatile salt of hartshorn, dissolved an ounce of nitre, and half an ounce of sugar.

With four drachms and two scruples of borax, dissolved half an ounce of fixed alkali.

With two ounces and a half of alum, dissolved six drachms of common salt, and one drachm of sulphat of magnesia.

With nine ounces and a half of sulphat of iron, dissolved an ounce and a half of Sedlitz salt, two drachms of nitre, and three ounces of refined sugar.

With nine ounces of sulphat of copper, dissolved an ounce of nitre, three drachms of common salt, and an ounce of sugar.

With four ounces and a half of sulphat of zinc, dissolved one ounce of refined sugar.

Water has long been considered as an elementary or simple substance. But the chemists of our own time, in their researches into the nature of elastic fluids, have obtained water in circumstances where there is the highest reason to conclude that it is produced by combination; and in other experiments its decomposition into two principles, namely, oxigen and hidrogen, is judged to take place.

The powers of nature, which are ever the same, and are continually performing their operations before us, whether we understand them or not, often present facts of the utmost value and importance, which we overlook, or regard with indifference. Hence it happens, that, when an enlightened observer makes any discovery, it is almost always remarked, that somebody has seen the fact before him, or given some confused hints respecting its theory. It is evident, however, that the first discoverer, if there be any merit in discovery, is not the man who finds the treasure, and supposes it to be none, but he who is conscious of its value, and applies it to use. On these princi-

The celebrated Macquer, assisted by Mr. Sigaud de la Fond, made an experiment by burning hidrogen gas in a bottle, without explosion, and holding a white china saucer over the flame. His intention appears to have been that of ascertaining whether any fuliginous smoke was produced; and he observes, that the saucer remained perfectly clean and white, but was moistened with perceptible drops of a clear fluid, resembling water, and which in fact appeared to him and his assistant to be nothing but pure water. He does not say whether any test was applied to ascertain this purity, neither does he make any remark on the fact.*

In the month of September, 1777, Messrs. Bucquet and Lavoisier, not being acquainted with the fact, which is incidentally and concisely mentioned by Macquer, made an experiment to discover what is produced by the combustion of hidrogen. They fired five or six pints of hidrogen in an open and wide-mouthed bottle, and instantly poured two ounces of lime-water through the flame, agitating the bottle during the time the combustion lasted. The result of this experiment showed, that carbonic acid was not produced†.

Before the month of April, 1781, Mr. John Warltire, encouraged by Dr. Priestley, fired a mixture of common air and hidrogen gas in a close copper vessel, and found its weight diminished. Dr. Priestley, likewise, before the same period, fired a like mixture of hidrogen and oxigen gas in a closed glass vessel, Mr. Warltire being present. The inside of the vessel, though clean and dry before, became dewy, and was lined with a sooty substance‡. These experiments were afterward repeated by Mr. Cavendish and Dr. Priestley, and it was found, that the diminution of weight did not take place, neither was the sooty matter perceived ||. These circumstances, therefore, must have arisen from some imperfection in the apparatus or materials, with which the former experiments were made.

It was in the summer of the year 1781, that Mr. Henry Cavendish was busied in examining what becomes of the air lost by combustion, and made those valuable experiments, which were read before the Royal to pass through a glass tube eight feet in length, 135 grains of pure water were condensed. He also exploded a mixture of 19,500 grain measures of oxigen gas, and 37,000 of hidrogen, in a close vessel. The condensed liquor was found to contain a small portion of nitric acid, when the mixture of the air was such, that the burned air still contained a considerable proportion of oxigen. In this case it may be presumed, that some of the oxigen combines with a portion of nitrogen present. This great philosopher, who may be considered as the true discoverer of the composition of water, appears to think with Mr. Watt, that in those experiments of Dr. Priestley, wherein the sulphuric and nitric acids seemed to be converted into oxigen, the acids served only to decompose the water, by depriving it, according to the theory of that day, of its phlogistic or combustible part; but he thinks it unnecessary to include the consideration of elementary heat, as Mr. Watt does, because in his opinion it is more likely, that there is no such thing, and that the bringing the consideration forward in every chemical experiment, in which increase or diminution of heat takes place, might occasion more trouble and perplexity than it is worth ¶.

In the mean time, Mr. Lavoisier continued his researches, and during the winter of 1781-1782, together with Mr. Gingembre, he filled a bottle of six pints with hidrogen, which being fired, and two ounces of lime-water poured in, was instantly stopped with a cork, through which a flexible tube communicating with a vessel of oxigen was passed. The inflammation ceased, except at the orifice of the tube, through which the oxigen was pressed, where a beautiful flame appeared. The combustion continued a considerable time, during which the lime-water was agitated in the bottle. Neither this, nor the same experiment repeated with pure water, and with a weak solution of alkali instead of lime-water afforded the information sought after, for these substances were not at all altered.

The inference of Mr. Warltire respecting the moisture on the inside of the glass, in which Dr. Priestley first fired hidrogen and

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* Dictionnaire de Chymie, 2d edition, Paris, 1778. Art. Gas Inflammable, vol. ii. p. 314, 315. † Acad Par. 1781, p. 470, ‡ Priestley, v. 395. || Phil. Trans. lxxiv. 126. Dr. Priestley supposed the sooty matter to be part of the mercury used in filling the vessel. Phil. Trans. lxxiv. 332. § Mr. Lavoisier relates, that Dr. Blagden, Sec. R. S. (who was present at the performing of the capital experiment of burning hidrogen and oxigen gas in a closed vessel on the 24th June, 1783) informed him, that Mr. Cavendish had already done the same thing, and obtained water. See the Memoirs of the Royal Academy at Paris for 1781, p. 472; also Phil. Trans. vol. lxxiv, p. 134. ¶ Philosoph. Trans. vol. lxxiv, p. 330.

common air, was, that these airs by combustion deposited the moisture they contained. Mr. Watt, however, inferred from these experiments, that water is a compound of the burned airs, which have given out their latent heat by combustion, and communicated his sentiments to Dr. Priestley in a letter dated April 26, 1783 *, and he concludes, that in every case wherein oxigen gas was produced, water had been decomposed by the use of some substance, which had a stronger attraction to its phlogiston than is possessed by the oxigen gas, which is therefore set at liberty. He repeated some experiments, particularly with a view to decide this point; and in several of them the quantity of oxigen gas added to the acid which came over, greatly exceeded the original weight of acid employed. He dissolved magnesia, calcareous earth, and minium, respectively, in pale nitric acid, and, on distilling to dryness, found nearly the whole of the nitric acid in the retort highly saturated with nitrogen. From common nitre, the oxigen gas was sixteen times the weight of the nitric acid which was missing. Mr. Watt has therefore a claim to the merit of a discoverer with regard to the composition of water, and has the advantage of priority in the discovery of its decomposition.

It does not appear †, that the composition of water was known or admitted in France till the summer of 1783, when Mr. Lavoisier and Mr de la Place, on the 24th of June, repeated the experiment of burning hidrogen and oxigen in a glass vessel over mercury, in a still greater quantity than had been burned by Mr. Cavendish The result was nearly five gros of pure water ‡. Mr. Monge made a similar experiment at Paris, nearly at the same time, or perhaps before.

The theory which was proposed and explained by Mr. Lavoisier, wherein such phænomena as chemists have usually accounted for by the disengagement or transition of phlogiston are explained, merely by the engagement or contrary transition of oxigen gas, or its base, by him called the oxigenous or acidifying principle, received a great accession from the discovery of the composition of water. For it was easy to attribute the hidrogen, which is disengaged in many processes, to the decomposition of water, which is undoubtedly present in most of them; instead of supposing it to come from such bodies, as former chemists had imagined to contain the principle of inflammability. In the month of September, 1783, Mr. de la Place communicated to Mr. Lavoisier ‖ his thoughts on the decomposition of water, which from Mr. Lavoisier's former experiments he concluded to take place in metallic solutions; and these reasons, added to Mr. Lavoisier's own reflections, induced him to pursue the subject by a new series of experiments.

This assiduous and accurate philosopher was the first, who placed a quantity of iron filings and pure water in the upper part of a vessel inverted over mercury, and observed, that the iron became oxided, hidrogen being at the same time disengaged, the water being, as he says, truly decomposed §. He then proceeded, in conjunction with Mr. Meusnier, to pass the steam of water through a red hot iron tube, and found that the iron was oxided, and hidrogen disengaged; and the steam of water being passed over a variety of other combustible or oxidable substances, produced similar results, the water disappearing, and hidrogen being disengaged. These capital experiments were accounted for by Mr. Lavoisier, by supposing the water to be decomposed into its component parts, oxigen and hidrogen, the former of which unites with the ignited substance, while the latter is disengaged.

The grand experiment of the composition of water by Fourcroy, Vauquelin, and Seguin was begun on Wednesday, May 13, 1790, and was finished on Friday, the 22d of the same month. The combustion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreshed themselves when fatigued, by lying for a few hours on matrasses in the laboratory.

To obtain the hidrogen, 1. Zinc was melted and rubbed into a powder in a very hot mortar. 2. This metal was dissolved in concentrated sulphuric acid diluted with seven parts of water. The air procured was made to pass through caustic alkali. To obtain the oxigen, two pounds and a half of crystallized hyperoximuriat of potash were distilled, and the air was transferred through caustic alkali.

The volume of hidrogen employed was 25963·568 cubic inches, and the weight was 1039·358 grains.

The volume of oxigen was 12570·942, and the weight was 6209·869 grains.

The total weight of both elastic fluids was 7249·227.

The weight of water obtained was 7244 grains, or 12 ounces 4 gros 45 grains.

The weight of water which should have

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[*] Phil. Trans. vol. lxxiv. p. 330. [†] Compare Phil. Trans. vol. lxxiv. p. 138, with the Memoirs of the Royal Academy at Paris for 1781, pages 472 and 474. [‡] The ounce poids de marc being 472·2 grains troy, this quantity will be 295 English grains. [‖] Memoirs of the Royal Academy at Paris, 1781, p. 476. [§] Memoirs of the Royal Academy at Paris, 1781, p. 271.

been obtained was 12 ounces 4 gros 49·227 grains.

The deficit was 4·227 grains.

The quantity of azotic air before the experiment was 415·256 cubic inches, and at the close of it 467. The excess after the experiment was consequently 51·744 cubic inches. This augmentation is to be attributed, the academicians think, to the small quantity of atmospheric air in the cylinders of the gazometers, at the time the other airs were introduced. These additional 51 cubic inches could not arise from the hidrogen, for experiment showed, that it contained no azotic air. Some addition of this last fluid, the experimenters think, cannot be avoided, on account of the construction of the machine.

The water, being examined, was found to be as pure as distilled water. Its specific gravity to distilled water was as 18671 : 18670.

Upon these experiments I shall remark, 1. That the elastic fluids were produced very slowly.

2. That the confining medium was water.

3. That the weight of the respective quantities of these fluids could not be ascertained by any process applicable to the whole mass of each, but was deduced by admeasurement, with corrections for temperature, the pressure of the atmosphere, and the arrangement of the apparatus.

4. That this admeasurement in cubic inches was reduced into weight by the application of an elementary number, expressing respectively the weight of a cubic inch of each of the fluids.

5. That this elementary number was obtained by an experiment of weighing about 810 cubic inches of each of the fluids in a glass globe, the evacuation and repletion of which was effected by means of the air-pump.

6. That the glass vessel when empty weighed 24179 grains, and its contents of hidrogen 35¼ grains. I suppose that the ¼ grain was the minutest quantity capable of being discerned by the balance thus loaded; and this being about the 10,000th part of the load in one scale, is certainly a considerable degree of accuracy An error of ¼ of a grain in this part of the process would affect the number expressing the weight of hidrogen air in the third figure, without mentioning other causes of inaccuracy. That result may, therefore, at best, be considered an estimate in all the figures but the first three.

7. The oxigen was near sixteen times as heavy as the hidrogen, and may therefore, as far as relates to this cause of inaccuracy, be admitted nearly to four places of figures.

8. The expansions and contractions of these fluids at different temperatures were reduced by computation from the experiments of Morveau and du Vernois, which experiments were made upon small quanti-
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one foot square, the knob of which touched the prime conductor.

When the electric shock was passed through the water with a very small interval between the copper ball and the conductor, nothing of consequence happened; but when the distance and consequently the shock was increased, so that the extremity of each wire became tipped with light, a great number of very minute bubbles of air were produced at each commotion, which had the appearance of a continual flux between the two extremities. This production of air was more considerable, and the bubbles at the same time larger, when the distance between the copper ball and the prime conductor was increased, so that sometimes a small spark was seen to pass from the upper wire into the water. The air obtained in this manner occupied the upper part of the tube, and gradually increased in quantity by the continuance of the process, until the water became depressed below the extremity of the upper wire. At this instant the electric spark, which passed through a small portion of the air from the upper wire to the water, set fire to the air, precisely in the same manner as happens with a mixture of hidrogen and oxigen, and the whole disappeared, excepting a very small residue. This residue being taken out, the experiment was again repeated with the same success. The experiment was repeated several times with the same result; excepting only, that the residue of air after each inflammation appeared to be less and less.

Several chemists found it difficult to repeat this experiment, on account of the facility with which the electric shock from wires under water breaks the containing tube. To prevent this effect, these philosophers were careful, that the distance between the two wires should be too great for a spark to pass from the one to the other. And Dr. Pearson, before whom the experiment was repeated by Mr. Cuthbertson, asserts, that the discharges were interrupted; by which word electricians commonly understand, that part of the circuit is an imperfect conductor. It is probably of consequence, that the stream of electricity should be kept up almost steadily, when the expansion from the extricated bubbles has once been produced. The plate-machine of 32 inches diameter, used by these philosophers, was so powerful, as to occasion nearly two full explosions from a square foot of glass in each turn. The smaller shocks here mentioned must therefore have been extremely numerous *.

Since the discovery of galvanism, the apparent decomposition of water has been effected by its means with more singular phænomena. If two wires, about an inch distant, be inserted in a tube 0·2 of an inch in diameter, and these wires be made to communicate with the opposite extremities of a galvanic pile or trough, water in the tube will be decomposed rapidly. The effect takes place, even if the wires be several inches distant, when the pile is powerful. But what is very remarkable, the decomposition may be effected in two different tubes, the wire from one extremity of the pile being introduced into one, and that from the opposite extremity into the other; provided a communication be established by another wire, or good conductor, between the water in the two tubes: and the air evolved from the water in one of the tubes is hidrogen only, and that from the other is only oxigen, both of them nearly pure. The hidrogen uniformly appears in the tube communicating with what is commonly considered as the negative end of the pile, and the oxigen at the positive end.

It has been asserted, however, by some, that the water, instead of being decomposed into oxigen and hidrogen, is converted into an acid and an alkali. This acid is said to be the muriatic, though some assert it to be the nitric; and the alkali according to some is soda. The smallness of the quantities, in which the acid and alkali have been produced, have rendered it difficult to decide upon a subject so much disputed. Veau-de-Launay indeed informs us, that the Galvanic Society at Paris converted an ounce and half of distilled water into oxigenized muriatic acid of such strength, as to dissolve 2¼ inches of gold wire; and that nitrat of silver was speedily precipitated by it in the form of muriat.

These experiments have been considered by some as overturning the hypothesis, that water is a compound of oxigen and hidrogen, which had been apparently proved both synthetically and analytically: but for this in their present state they are certainly not sufficient, though they present difficulties, which yet remain to be explained in a satisfactory manner.

Dr. Priestley published in a separate pamphlet experiments on the generation of air from water. When steam is made to issue from the end of a glass or copper tube into a recipient containing water, every bubble of steam collapses into a small bubble of permanent air. This is generally much purer than common air, and is not found by the test of a candle to contain any mixture of hidrogen. There are some unaccountable circumstances attending this

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* A paper of considerable length on this important experiment by Dr. Pearson is inserted in the first volume of the Journal of Natural Philosophy, Chemistry, and the Arts, 4to.

experiment. The quantity of air is greatly diminished, if the steam be passed through mercury, even though the mercury be as hot as the steam itself. The production is also much less, if the steam be condensed in part before it passes into the water, which may be done by cooling the outside of the pipe. The production does not appear to be affected by the previous purging of the water from air, by boiling or otherwise.

Dr. Priestley varied the experiment, by using the same water repeatedly confined by mercury. He repeated the process till he was thoroughly satisfied, that the air was really produced and not extricated from the water: and he found, that the air was gradually less and less pure, till at length it was wholly nitrogen.

There is another process, used by Dr. Priestley, in which air is extricated from water, by filling a glass vessel with that fluid, the neck of which vessel was narrow, and of the length of a barometer tube. When the bulb or body is full, and the tube is empty, mercury is poured in till the water rises to the top of the tube. In this situation, the whole is to be inverted over mercury like a common barometer. The mercury then descends and occupies the lowest place, namely the tube itself, and the water above it is thus defended from the pressure of the atmosphere, more completely than in the vacuum of an air-pump. Dr. Priestley finds that the water in one of the vessels in this situation, has given out air for upwards of a twelvemonth.

These experiments, though loosely related, and given without any numerical indication as to quantity, are curious, and deserve to be repeated. Whether the quantities of air thus obtained by Dr. Priestley were before in a mere state of mixture with the water, as they do not seem to have been considerable, relative to its bulk or weight; in which case his experiments will point out nothing more than a better method of purging water of its air; or whether they lead to new deductions, respecting the composition of water, must, it should seem, be decided by additional experiments.

Water is known to become putrid, when long kept in casks, as in sea-voyages. This is owing to the matter it takes up from the wood, and may be prevented by charring the inside of the cask.

The art of rendering cloth impermeable to water has lately been practised to some extent. Vauquelin says, that a fluid effectual for this purpose may be made by dissolving soap and glue in water; adding a solution of alum, which will occasion a flocculent precipitate; and then mixing with it a little dilute sulphuric acid, which redissolves the alumine in part, renders the precipitate lighter, and prevents it from falling down. He does not give the proportions, but observes, that there must not be too much acid. It is said, that the Chinese use a solution of wax
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Waters (Mineral).
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less frequently, sulphur, magnesian earth, or, from the decomposition of carbonated iron, ochre.

The following are the ingredients that may occur in mineral waters:

1. Air is contained in by far the greater number of mineral waters: its proportion does not exceed $\frac{1}{28}$th of the bulk of the water.

2. Oxigen gas was first detected in waters by Scheele. Its quantity is usually inconsiderable; and it is incompatible with the presence of sulphuretted hidrogen gas or iron.

3. Hidrogen gas was first detected in Buxton water by Dr. Pearson. Afterward it was discovered in Harrowgate waters by Dr. Garnet, and in those of Lemington Priors by Mr Lambe.

4. Sulphuretted hidrogen gas constitutes the most conspicuous ingredient in those waters, which are distinguished by the name of hepatic or sulphureous.

The only acids hitherto found in waters, except in combination with a base, are the carbonic, sulphurous, and boracic.

5. Carbonic acid was first discovered in Pyrmont water by Dr Brownrigg. It is the most common ingredient in mineral waters, 100 cubic inches of the water generally containing from 6 to 40 cubic inches of this acid gas. According to Westrumb, 100 cubic inches of Pyrmont water contain 187 cubic inches of it, or almost double its own bulk.

6. Sulphurous acid has been observed in several of the hot mineral waters in Italy, which are in the neighbourhood of volcanoes.

7. The boracic acid has also been observed in some lakes in Italy.

The only alkali which has been observed in mineral waters, uncombined, is soda; and the only earthy bodies are silex and lime.

8. Dr. Black detected soda in the hot mineral waters of Geysser and Rykum in Iceland; but in most other cases the soda is combined with carbonic acid.

9. Silex was first discovered in waters by Bergman. It was afterward detected in those of Geysser and Rykum by Dr. Black, and in those of Carlsbad by Klaproth. Hassenfratz observed it in the waters of Pougues, as Brezé did in those of Pu. It has been found also in many other mineral waters.

10. Lime is said to have been found uncombined in some mineral waters; but this has not been proved in a satisfactory manner.

The only salts hitherto found in mineral waters are the following sulphats, nitrats, muriats, carbonats, and borats; and of these the carbonats and muriats occur by

pecially in those mineral waters which are distinguished by the epithet *saline*.

12. Sulphat of ammonia is found in mineral waters near volcanoes.

13. Sulphat of lime is exceedingly common in water. Its presence seems to have been first detected by Dr. Lister in 1682.

14. Sulphat of magnesia is almost constantly an ingredient in those mineral waters which have purgative properties. It was detected in Epsom waters in 1610, and in 1696 Dr. Grew published a treatise on it.

15. Alum is sometimes found in mineral waters, but it is exceedingly rare.

16. Sulphat of iron occurs sometimes in volcanic mineral waters, and has even been observed in other places.

17. Sulphat of copper is only found in the waters which issue from copper mines.

18. Nitre has been found in some springs in Hungary, but it is exceedingly uncommon.

19. Nitrat of lime was first detected in water by Dr. Home of Edinburgh, in 1756. It is said to occur in some springs in the sandy deserts of Arabia.

20. Nitrat of magnesia is said to have been found in some springs.

21. Muriat of potash is uncommon; but it has lately been discovered in the mineral springs of Uhleaborg in Sweden, by Julin.

22. Muriat of soda is so extremely common in mineral waters, that hardly a single spring has been analysed without detecting some of it.

23. Muriat of ammonia is uncommon, but it has been found in some mineral springs in Italy and in Siberia.

24. Muriat of barytes is still more uncommon, but its presence in mineral waters has been announced by Bergman.

25 and 26. Muriats of lime and magnesia are common ingredients.

27. Muriat of alumine has been observed by Dr. Withering, but it is very uncommon.

28. Muriat of manganese was mentioned by Bergman as sometimes occurring in mineral waters. It has lately been detected by Lambe in the waters of Lemington Priors, but in an extremely limited proportion.

29. The presence of carbonat of potash in mineral waters has been mentioned by several chemists: if it do occur, it must be in a very small proportion.

30. Carbonat of soda is, perhaps, one of the most common ingredients of these liquids, if we except common salt and carbonat of lime.

31. Carbonat of ammonia has been discovered in waters, but it is uncommon.

32. Carbonat of lime is found in almost all waters, and is usually held in solution by an excess of acid. It appears from the different experiments of chemists, as stated by Mr. Kirwan, and especially from those of Berthollet, that water saturated with car-

bonic acid is capable of holding in solution 0·002 of carbonat of lime. Now water saturated with carbonic acid, at the temperature of 50°, contains very nearly 0·002 of its weight of carbonic acid. Hence it follows, that carbonic acid, when present in such quantity as to saturate waters, is capable of holding its own weight of carbonat of lime in solution. Thus we see 1000 parts by weight of water, when it contains two parts of carbonic acid, is capable of dissolving two parts of carbonat of lime. When the proportion of water is increased, it is capable of holding the carbonat of lime in solution, even when the proportion of carbonic acid united with it is diminished. Thus 24·000 parts of water are capable of holding two parts of carbonat of lime in solution, even when they contain only one part of carbonic acid. The greater the proportion of water, the smaller proportion of carbonic acid is necessary to keep the lime in solution; and when the water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked also, that water, however small a quantity of carbonic acid it contains, is capable of holding carbonat of lime in solution, provided the weight of the carbonic acid present exceed that of the lime. These observations apply equally to the other earthy carbonats held in solution by mineral waters.

33. Carbonat of magnesia is also very common in mineral waters, and is almost always accompanied by carbonat of lime.

34. Carbonat of alumine is said to have been found in waters, but its presence has not been properly ascertained.

35. Carbonat of iron is by no means uncommon, indeed it forms the most remarkable ingredient in those waters, which are distinguished by the epithet of *chalybeate*.

36. Borax exists in some lakes in Persia and Thibet, but the nature of these waters has not been ascertained.

37 and 38. The hidrosulphurets of lime and of soda have been frequently detected in those waters which are called sulphureous, or hepatic.

Mr. Westrumb says, that all sulphureous waters contain more or less hydrosulphuret of lime.

To detect this he boiled the mineral water, excluding the contact of atmospheric air, to expel the sulphuretted hidrogen gas and carbonic acid. Into the water thus boiled he poured sulphuric acid, when more sulphuretted hidrogen gas was evolved, and sulphat of lime was thrown down: fuming nitric acid, which separated from it sulphur: and oxalic acid, which expelled sulphuretted hidrogen, and formed oxalat of lime. The water evaporated in open vessels let fall sulphat of lime, and gave out sulphuretted hidrogen gas.

To ascertain the quantity of sulphuretted hidrogen gas and carbonic acid, Mr. West-

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tions it is decomposed into sulphur and a blackish brown resin. It emits a garlic smell; which becomes very strong, and similar to that of assafetida, if water be poured into the alcoholic solution. Its solution acts as an acid.

The resin is soluble in ammonia, and communicates to it a yellow colour. This liquor comports itself like that of Beguin. With lime water a hydrosulphuret is formed. All these solutions act on metallic compounds in the same manner as sulphuretted hidrogen.

As sulphureous mineral waters arise from strata of pitcoal, perhaps the source of this bituminous principle may be traced to pitcoal itself.

Round the baths of Eilsen, as round those of St. Amand, a mud accumulates, which in time grows darker coloured, and ultimately black. From this are obtained, on analysing it, fetid sulphurous resin, hydrosulphuret of lime, sulphur, lime, alumine, magnesia, charcoal, and sand, with some fibrous substances; and a little sulphuretted hidrogen gas, and carbonic acid gas.

Whatever may be the origin of the bituminous principle in the sulphureous waters, Mr. Westrumb, assisted by Mr. Basse, has been able to produce charcoal and the fetid resin from pure sulphur. For this purpose he has digested in alcohol sulphur precipitated from sulphuretted hidrogen by an acid. On distilling off part of the alcohol, sulphur is separated in yellow crystals, or in a yellowish gray powder. The fetid resin is then completely formed in the supernatant liquor, and possesses all the properties mentioned above.

Its formation may be ascribed to the concurrence of the alcohol; particularly as after its separation from the residuum left on evaporating sulphurous water, the pungent smell is manifested on its being taken up by alcohol. Several observations, however, lead Mr. Westrumb to believe, that alcohol does not contribute to the formation of this substance, but rather that it derives its origin from the sulphur itself.

Beside these substances, certain vegetable and animal matters have been occasionally observed in mineral waters. But in most cases these are rather to be considered in the light of accidental mixtures, than of real component parts of the waters in which they occur.

From this synoptical view of the different ingredients contained in mineral waters, it is evident, that these substances occur in two different distinct states, viz. 1. As being suspended in them: and 2. as being dissolved in them chiefly in the form of a salt.

The investigation of mineral waters consists: 1. In the examination of them by the senses. 2. In the examination of them by reagents. 3. In the analysis properly so called.

The examination by the senses consists in observing the effect of the water as to appearance, smell, and taste.

The appearance of the water, the instant in which it is pumped out of the well, as well as after it has stood for some time, affords several indications, from which we are enabled to form a judgment concerning its contents. If the water be turbid at the well, the substances are suspended only, and not dissolved; but if the water be clear and transparent at the well, and some time intervenes before it becomes turbid, the contents are dissolved by means of carbonic acid.

The presence of this gas is likewise indicated by small bubbles, that rise from the bottom of the well, and burst in the air while they are making their escape, though the water at the same time perhaps has not an acid taste. This is the case, according to count Razoumowski, with respect to the tepid spring in Vallais, and the cold vitriolated chalybeate springs at Astracan. But the most evident proof of a spring containing carbonic acid is the generation of bubbles on the water being shaken, and their bursting with more or less noise, while the air is making its escape.

The sediment deposited by the water in the well is likewise to be examined; if it be yellow, it indicates the presence of iron; if black, that of iron combined with sulphur; but chalybeate waters being seldom sulphuretted, the latter occurs very rarely. As to the colour of the water itself, there are few instances where this can give any indication of its contents, as there are not many substances that colour it.

The odour of the water serves chiefly to discover the presence of sulphuretted hidrogen in it: such waters as contain this substance have a peculiar fetid smell, somewhat resembling rotten eggs.

The taste of a spring, provided it be perfectly ascertained by repeated trials, may afford some useful indications with respect to the contents. It may be made very sensible by tasting water, in which the various salts that are usually found in such waters are dissolved in various proportions. There is no certain dependance, however, to be placed on this mode of investigation; for in many springs, the taste of sulphat of soda is disguised by that of the sea salt united with it. The water too is not only to be tasted at the spring, but after it has stood for some time. This precaution must be particularly observed with respect to such waters as are impregnated with carbonic acid; for the other substances contained in them make no impression on the tongue, till the carbonic acid has made its escape; and it is for the same reason, that these waters must be evaporated in part, and then tasted again.

Though the specific gravity of any water contributes but very little towards determining its contents, still it may not be entirely useless to know the specific weight of the water, the situation of the spring, and the kind of sediment deposed by it.

The examination of the water by means of reagents shows what they contain, but not how much of each principle. In many instances this is as much as the inquiry demands; and it is always of use to direct the proceedings in the proper analysis.

It is absolutely necessary to make the experiment with water just taken up from the spring, and afterward with such as has been exposed for some hours to the open air; and sometimes a third essay is to be made with a portion of the water that has been boiled and afterward filtered. If the water contain but few saline particles, it must be evaporated; as even the most sensible reagents do not in the least affect it, if the salts, the presence of which is to be discovered by them, are diluted with too great a quantity of water. Now, it may happen, that a water shall be impregnated with a considerable number of saline particles of different kinds, though some of them may be present in too small a quantity: for which reason the water must be examined a second time, after having been boiled down to three fourths.

The substances of which the presence is discoverable by reagents, are:

1. Carbonic acid. When this is not combined with any base, or not with sufficient to neutralize it, the addition of limewater will throw down a precipitate soluble with effervescence in muriatic acid. The infusion of litmus is reddened by it; but the red colour gradually disappears, and may be again restored by the addition of more of the mineral water. When boiled it loses the property of reddening the infusion of litmus. According to Pfaff, the most sensible test of this acid is acetat of lead.

2. The mineral acids, when present uncombined in water, give the infusion of litmus a permanent red, even though the water has been boiled. Bergman has shown, that paper stained with litmus is reddened when dipped into water containing $\frac{1}{352}$ of sulphuric acid.

3. Water containing sulphuretted hidrogen gas is distinguished by the following properties: It exhales the peculiar odour of sulphuretted hidrogen gas. It reddens the infusion of litmus fugaciously. It blackens paper dipped into a solution of lead, and precipitates the nitrat of silver black or brown.

4. Alkalis, and alkaline and earthy carbonats, are distinguished by the following tests. The infusion of turmeric, or paper stained with turmeric, is rendered brown by alkalis; or reddish brown, if the quantity be minute. This change is produced when the soda in water amounts only to $\frac{1}{2817}$ part. Paper stained with brazil wood, or the infusion of brazil wood, is rendered blue: but this change is produced also by

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acid: if boracic acid be suspected, muriat of strontian must be tried, which is not precipitated by boracic acid. The hidrosulphurets precipitate barytic solutions, but their presence is easily discovered by the smell.

9. Muriatic acid is detected by nitrat of silver, which occasions a white precipitate, or a cloud, in water containing an exceedingly minute portion of this acid. To render this test certain, the following precautions are necessary: The alkalis or carbonats must be previously saturated with nitric acid. Sulphuric acid, if any be present, must be previously removed by means of nitrat of barytes. The precipitate must be insoluble in nitric acid. Pfaff says, that the mild nitrat of mercury is the most sensible test of muriatic acid; and that the precipitate is not soluble in an excess of any acid.

10. Boracic acid is detected by means of acetat of lead, with which it forms a precipitate insoluble in acetic acid. But to render this test certain, the alkalis and earths must be previously saturated with acetic acid, and the sulphuric and muriatic acids removed by means of acetat of strontian and acetat of silver.

11. Barytes is detected by the insoluble white precipitate, which it forms with diluted sulphuric acid.

12. Lime is detected by means of oxalic acid, which occasions a white precipitate in water containing a very minute proportion of this earth. To render this test decisive, the following precautions are necessary: The mineral acids, if any be present, must be previously saturated with an alkali. Barytes, if any be present, must be previously removed by means of sulphuric acid. Oxalic acid precipitates magnesia but very slowly, whereas it precipitates lime instantly.

13. Magnesia and alumine. The presence of these earths is ascertained by the following tests:—Pure ammonia precipitates them both, and no other earth, provided the carbonic acid have been previously separated by a fixed alkali and boiling. Lime water precipitates only these two earths, provided the carbonic acid be previously removed, and the sulphuric acid also, by means of nitrat of barytes.

The alumine may be separated from the magnesia, after both have been precipitated together, either by boiling the precipitate in caustic potash, which dissolves the alumine and leaves the magnesia; or the precipitate may be dissolved in muriatic acid, precipitated by an alkaline carbonat, dried in the temperature of 100°, and then exposed to the action of diluted muriatic acid, which dissolves the maguesia without touching the alumine.

14. Silex may be ascertained by evaporating a portion of water to dryness, and redissolving the precipitate in muriatic acid. The silex remains behind undissolved.

By these means we may detect the presence of the different substances commonly found in waters, but as they are generally combined so as to form salts, it is necessary we should know what these combinations are. This is a more difficult task, which Mr. Kirwan teaches us to accomplish by the following methods:

1. To ascertain the presence of the different sulphats.

The sulphats which occur in water are seven; but one of these, namely, *sulphat of copper*, is so uncommon, that it may be excluded altogether. The same remark applies to sulphat of ammonia. It is almost unnecessary to observe, that no sulphat need be looked for, unless both its acid and base have been previously detected in the water.

Sulphat of soda may be detected by the following method: free the water to be examined of all earthy sulphats by evaporating it to one half, and adding lime water as long as any precipitate appears. By these means the earths will all be precipitated except lime, and the only remaining earthy sulphat will be sulphat of lime, which will be separated by evaporating the liquid till it becomes concentrated, and then dropping into it a little alcohol, and after filtration adding a little oxalic acid.

With the water thus purified, mix solution of lime. If a precipitate appear, either immediately or on the addition of a little alcohol, it is a proof, that sulphat of potash or of soda is present. Which of the two may be determined by mixing some of the purified water with acetat of barytes. Sulphat of barytes precipitates. Filter and evaporate to dryness. Digest the residuum in alcohol It will dissolve the alkaline acetat. Evaporate to dryness, and the dry salt will deliquesce if it be acetat of potash, but effloresce if it be acetat of soda.

Sulphat of lime may be detected by evaporating the water suspected to contain it to a few ounces. A precipitate appears, which, if it be sulphat of lime, is soluble in 500 parts of water; and the solution affords a precipitate with the muriat of barytes, oxalic acid, carbonat of magnesia, and alcohol.

Alum may be detected by mixing carbonat of lime with the water suspected to contain it. If a precipitate appear, it indicates the presence of alum, or at least of sulphat of alumine; provided the water contains no muriat of barytes or metallic sulphats. The first of these salts is incompatible with alum. The second may be removed by the alkaline prussiats. When a precipitate is produced in water by muriat of lime, carbonat of lime, and muriat of magnesia, we may conclude, that it contains alum or sulphat of alumine.

Sulphat of magnesia may be detected by means of hydrosulphuret of strontian, which occasions an immediate precipitate with this salt, and with no other; provided the water be previously deprived of alum, if any be present, by means of carbonat of lime, and provided also that it contains no uncombined acid.

Sulphat of iron is precipitated from water by alcohol, and then it may be easily recognised by its properties.

2. To ascertain the presence of the different muriats.

The muriats found in waters amount to eight, or to nine if muriat of iron be included. The most common by far is muriat of soda.

Muriat of soda and of potash may be detected by the following method: Separate the sulphuric acid by alcohol and nitrat of barytes. Decompose the earthy nitrats and muriats by adding sulphuric acid. Expel the excess of muriatic and nitric acids by heat. Separate the sulphats thus formed by alcohol and barytes water. The water thus purified can contain nothing but alkaline nitrats and muriats. If it form a precipitate with acetat of silver, we may conclude, that it contains muriat of soda or of potash. To ascertain which, evaporate the liquid thus precipitated to dryness. Dissolve the acetat in alcohol, and again evaporate to dryness. The salt will deliquesce, if it be acetat of potash; but effloresce, if it be acetat of soda.

Muriat of barytes may be detected by sulphuric acid, as it is the only barytic salt hitherto found in water.

Muriat of lime may be detected by the following method: Free the water from sulphat of lime and other sulphats by evaporating it to a few ounces, mixing it with alcohol, and adding last of all nitrat of barytes, as long as any precipitate appears. Filter the water; evaporate to dryness; treat the dry mass with alcohol; evaporate the alcohol to dryness; and dissolve the residuum in water. If this solution give a precipitate with acetat of silver and oxalic acid, it may contain muriat of lime. It must contain it in that case, if, after being treated with carbonat of lime, it give no precipitate with ammonia. If the liquid in the receiver give a precipitate with nitrat of silver, muriat of lime existed in the water.

Muriat of magnesia may be detected by separating all the sulphuric acid by means of nitrat of barytes. Filter, evaporate to dryness, and treat the dry mass with alcohol. Evaporate the alcoholic solution to dryness, and dissolve the residuum in water. The muriat of magnesia, if the water contained any, will be found in this solution. Let us suppose that, by the tests formerly described, the presence of muriatic acid and of magnesia in this solution has been ascertained. In that case, if carbonat of lime afford no precipitate, and if sulphuric acid and evaporation, together with the addition of a little alcohol, occasion no precipitate, the solution contains only muriat of magnesia. If these tests give precipitates, we

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Such are the methods, by which the presence of the different saline contents of waters may be ascertained. The labour of analysis may be considerably shortened, by observing that the following salts are incompatible with each other, and cannot exist together in water, except in very minute proportion.

Salts.	*Incompatible with*
Fixed alkaline sulphats	Nitrats of lime and magnesia, Muriats of lime and magnesia.
Sulphat of lime	Alkalis, Carbonat of magnesia, Muriat of barytes.
Alum	Alkalis, Muriat of barytes, Nitrat, muriat, carbonat of lime, Carbonat of magnesia.
Sulphat of magnesia	Alkalis, Muriat of barytes, Nitrat and muriat of lime.
Sulphat of iron	Alkalis, Muriat of barytes, Earthy carbonats.
Muriat of barytes	Sulphats, Alkaline carbonats, Earthy carbonats.
Muriat of lime	Sulphats, except of lime, Alkaline carbonats, Earthy carbonats.
Muriat of magnesia	Alkaline carbonats, Alkaline sulphats.
Nitrat of lime	Alkaline carbonats, Carbonat of magnesia and alumine, Sulphats, except of lime.

Beside the substances above described, there is sometimes found in water a quantity of bitumen combined with alkali, and in the state of soap. In such waters acids occasion a coagulation; and the coagulum collected on a filter discovers its bituminous nature by its combustibility.

Water also sometimes contains extractive matter; the presence of which may be detected by means of nitrat of silver. The water suspected to contain it must be freed from sulphuric and nitric acid by means of nitrat of lead: after this, if it give a brown precipitate with nitrat of silver, we may conclude, that extractive matter is present.

But it is not sufficient to know, that a mineral water contains certain ingredients, it is necessary to ascertain the proportions of these, and thus we arrive at their complete analysis.

The proportion of all the saline ingredients, held in solution by any water, may be in some measure estimated from its specific gravity. The lighter a water is, the less saline matter does it contain; and, on the other hand, the heavier it is, the greater is the proportion of saline contents. Mr. Kirwan has pointed out a very ingenious method of estimating the saline contents of a mineral water, the specific gravity of which is known; so that the error will not exceed one or two parts in the hundred. The method is this: Subtract the specific gravity of pure water from the specific gravity of the mineral water examined (both expressed in whole numbers), and multiply the remainder by 1·4. The product is the saline contents in a quantity of the water denoted by the number employed to indicate the specific gravity of distilled water. Thus let the water be of the specific gravity 1·079, or in whole numbers 1079. Then the specific gravity of distilled water will be 1000. And $\overline{1079 - 1000} \times 1{\cdot}4 = 110{\cdot}6$ the saline contents in 1000 parts of the water in question; and consequently 11·06 in 100 parts of the same water. This formula will often be of considerable use, as it serves as a kind of standard, to which we may compare our analysis. The saline contents indicated by it are supposed to be freed from their water of crystallization; in which state only they ought to be considered, as Mr. Kirwan has very properly observed, when we speak of the saline contents of a mineral water.

Having by this formula ascertained pretty nearly the proportion of saline contents in the water examined, and having by the test just described determined the particular substances that exist in it, we may proceed to ascertain the proportion of each of these ingredients.

1. The different aërial fluids ought to be first separated and estimated. For this purpose a retort should be filled two thirds with the water, and connected with a jar full of mercury, standing over a mercurial trough. Let the water be made to boil for a quarter of an hour. The aërial fluids will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water may be determined either by bringing the mercury within and without the jar to a level; or if this cannot be done, by reducing the air to the proper density by calculation. The air of the retort ought to be carefully subtracted, and the jar should be divided into cubic inches and tenths.

The only gaseous bodies contained in water are common air, oxigen gas, nitrogen gas, carbonic acid, sulphuretted hidrogen gas, and sulphurous acid. The last two never exist in water together. The presence of either of them must be ascertained previously by the application of the proper tests. If sulphuretted hidrogen gas be present, it will be mixed with the air contained in the glass jar, and must be separated before this air be examined. For this purpose the jar must be removed into a tub of warm water, and nitric acid introduced, which will absorb the sulphuretted hidrogen. The residuum is then to be again put into a mercurial jar and examined.

If the water contain sulphurous acid, this previous step is not necessary. Introduce into the air a solution of pure potash, and agitate the whole gently. The carbonic acid and sulphurous acid gas will be absorbed, and leave the other gasses. The bulk of this residuum, subtracted from the bulk of the whole, will give the bulk of the carbonic acid and sulphurous acid absorbed.

Evaporate the potash slowly, almost to dryness, and leave it exposed to the atmosphere. Sulphat of potash will be formed, which may be separated by dissolving the carbonat of potash by means of diluted muriatic acid, and filtering the solution. 100 grains of sulphat of potash indicate 30 grains of sulphurous acid, or 42·72 cubic inches of that acid in the state of gas. The bulk of sulphurous acid gas ascertained by this method, subtracted from the bulk of the gas absorbed by the potash, gives the bulk of the carbonic acid gas. Now 100 cubic inches of carbonic acid, at the temperature of 60° and barometer 30 inches, weigh 46·393 grains. Hence it is easy to ascertain its weight.

The gas remaining may be examined by the common eudiometrical processes.

When a water contains sulphuretted hidrogen gas, the bulk of this gas is to be ascertained in the following manner: Fill three fourths of a jar with the water to be examined, and invert it in a water trough, and introduce a little nitrous gas. This gas, mixing with the air in the upper part of the jar, will form nitrous acid, which will render the water turbid, by decomposing the sulphuretted hidrogen and precipitating sulphur. Continue to add nitrous gas at intervals as long as red fumes appear, then turn up the jar and blow out the air. If the hepatic smell continue, repeat this process. The sulphur precipitated indicates the proportion of hepatic gas in the water; one grain of sulphur indicating the presence of 3·33 cubic inches of this gas.

2. After having estimated the gaseous bodies, the next step is to ascertain the proportion of the earthy carbonats. For this purpose it is necessary to deprive the water of its sulphuretted hidrogen, if it contain any. This may be done, either by exposing it to the air for a considerable time, or treating it with litharge. A sufficient quantity of the water, thus purified if necessary, is to be boiled for a quarter of an hour, and filtered when cool. The earthy carbonats remain on the filter.

The precipitate thus obtained may be carbonat of lime, of magnesia, of iron, of alumine, or even sulphat of lime. Let us suppose all of these substances to be present together. Treat the mixture with diluted muriatic acid, which will dissolve the whole except the alumine and sulphat of lime. Dry this residuum in a red heat, and note the weight. Then boil it in carbonat of soda: saturate the soda with muriatic acid, and
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196·36 grains of barytes indicate 100 of dry sulphat of potash.

Sulphat of lime is easily estimated by evaporating the liquid containing it to a few ounces (having previously saturated the earthy carbonats with nitric acid), and precipitating the sulphat of lime by means of weak alcohol. It may then be dried and weighed.

The quantity of alum may be estimated by precipitating the alumine by carbonat of lime or of magnesia (if no lime be present in the liquid). Twelve grains of the alumine heated to incandescence indicate 100 of crystallized alum, or 49 of dried salt.

Sulphat of magnesia may be estimated, provided no other sulphat be present, by precipitating the acid by means of a barytic salt; as 100 parts of ignited sulphat of barytes indicate 52·11 of sulphat of magnesia. If sulphat of lime, and no other sulphat, accompany it, this may be decomposed, and the lime precipitated by carbonat of magnesia. The weight of the lime thus obtained enables us to ascertain the quantity of sulphat of lime contained in the water. The whole of the sulphuric acid is then to be precipitated by barytes. This gives the quantity of sulphuric acid; and subtracting the portion which belongs to the sulphat of lime, there remains that which was combined with the magnesia, from which the sulphat of magnesia may be easily estimated.

If sulphat of soda be present, no earthy nitrat or muriat can exist. Therefore, if no other earthy sulphat be present, the magnesia may be precipitated by soda, dried and weighed; 36·68 grains of which indicate 100 grains of dried sulphat of magnesia. The same process succeeds when sulphat of lime accompanies these two sulphats; only in this case the precipitate, which consist both of lime and magnesia, is to be dissolved in sulphuric acid, evaporated to dryness, and treated with twice its weight of cold water, which dissolves the sulphat of magnesia, and leaves the other salt. Let the sulphat of magnesia be evaporated to dryness, exposed to a heat of 400° and weighed. The same process succeeds, if alum be present instead of sulphat of lime. The precipitate in this case, previously dried, is to be treated with acetic acid, which dissolves the magnesia and leaves the alumine. The magnesia may be again precipitated, dried, and weighed. If sulphat of iron be present, it may be separated by exposing the water to the air for some days, and mixing with it a portion of alumine. Both the oxide of iron and the sulphat of alumine, thus formed, precipitate in the state of an insoluble powder. The sulphat of magnesia may then be estimated by the rules above given.

Sulphat of iron may be estimated by precipitating the iron by means of prussic alkali, having previously determined the weight of the precipitate produced by the prussiat in a solution of a given weight of sulphat of iron in water. If muriat of iron be also present, which is a very rare case, it may be separated by evaporating the water to dryness, and treating the residuum with alcohol, which dissolves the muriat, and leaves the sulphat.

5. If muriat of potash or of soda, without any other salt, exist in water, we have only to decompose them by nitrat of silver, and dry the precipitate; for 217·65 of muriat of silver indicate 100 of muriat of potash; and 235 of muriat of silver indicate 100 of common salt.

The same process is to be followed, if the alkaline carbonats be present; only these carbonats must be previously saturated with sulphuric acid; and we must precipitate the muriatic acid by means of sulphat of silver instead of nitrat. The presence of sulphat of soda does not injure the success of this process.

If muriat of ammonia accompany either of the fixed alkaline sulphats, without the presence of any other salt, decompose the sal ammoniac by barytes water, expel the ammonia by boiling, precipitate the barytes by diluted sulphuric acid, and saturate the muriatic acid with soda. The sulphat of barytes thus precipitated indicates the quantity of muriat of ammonia; 100 grains of sulphat indicating 49·09 grains of this salt. If any sulphats be present in the solution, they ought to be previously separated.

If common salt be accompanied by muriat of lime, muriat of magnesia, muriat of alumine, or muriat of iron, or by all these together, without any other salt, the earths may be precipitated by barytes water, and redissolved in muriatic acid. They are then to be separated from each other by the rules formerly laid down, and their weight, being determined, indicates the quantity of every particular earthy muriat contained in the water. For 50 grains of lime indicate 100 of dried muriat of lime; 50 grains of magnesia indicate 100 of the muriat of that earth; and 21·8 grains of alumine indicate 100 of the muriat of alumine. The barytes is to be separated from the solution by sulphuric acid, and the muriatic acid expelled by heat, or saturated with soda; the common salt may then be ascertained by evaporation, subtracting in the last case the proportion of common salt indicated by the known quantity of muriatic acid, from which the earths had been separated.

When sulphats and muriats exist together, they ought to be separated either by precipitating the sulphats by means of alcohol, or by evaporating the whole to dryness, and dissolving the earthy muriats in alcohol. The salts thus separated may be estimated by the rules already laid down.

When alkaline and earthy muriats and

sulphat of lime occur together, the last is to be decomposed by means of muriat of barytes. The precipitate ascertains the weight of sulphat of lime contained in the water. The estimation is then to be conducted as when nothing but muriats are present; only from the muriat of lime that proportion of muriat must be deducted, which is known to have been formed by the addition of the muriat of barytes.

When muriats of soda, magnesia, and alumine, are present together with sulphats of lime and magnesia, the water to be examined ought to be divided into two equal portions. To the one portion add carbonat of magnesia, till the whole of the lime and alumine is precipitated. Ascertain the quantity of lime, which gives the proportion of sulphat of lime. Precipitate the sulphuric acid by muriat of barytes. This gives the quantity contained in the sulphat of magnesia and sulphat of lime; subtracting this last portion, we have the quantity of sulphat of magnesia.

From the second portion of water precipitate all the magnesia and alumine by means of lime-water. The weight of these earths enables us to ascertain the weight of muriat of magnesia and of alumine contained in the water, subtracting that part of the magnesia, which existed in the state of sulphat, as indicated by the examination of the first portion of water. After this estimation precipitate the sulphuric acid by barytes water, and the lime by carbonic acid. The liquid evaporated to dryness leaves the common salt.

6. It now only remains to explain the method of ascertaining the proportion of the nitrats which may exist in waters.

When nitre accompanies sulphats and muriats without any other nitrats, the sulphats are to be decomposed by acetat of barytes, and the muriats by acetat of silver. The water, after filtration, is to be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetats, and leaves the nitre, the quantity of which may be easily calculated. If an alkali be present, it ought to be previously saturated with sulphuric or muriatic acid.

If nitre, common salt, nitrat of lime, and muriat of lime or magnesia, be present together, the water ought to be evaporated to dryness, and the dry mass treated with alcohol, which takes up the earthy salts. From the residuum, redissolved in water, the nitre may be separated, and calculated as in the last case. The alcoholic solution is to be evaporated to dryness, and the residuum redissolved in water. Let us suppose it to contain muriat of magnesia, nitrat of lime, and muriat of lime. Precipitate the muriatic acid by nitrat of silver, which gives the proportion of muriat of magnesia and of lime. Separate the magnesia by means of carbonat of lime, and note its quantity. This gives the quantity of muriat of magnesia; and subt
riatic acid contained in tha
whole acid indicated by th
silver, we have the proport
lime. Lastly, saturate th
precipitate the magnesia
Then precipitate the whol
sulphuric acid; and subtra
whole of the sulphat thus f
tion formed by the carbona
and by the lime containe
the residuum gives us the
in the original nitrat; an
lime form 100 of dry nitrat

From this ample accou
of analysing mineral water
reader will not be at a l
them for himself; at the s
not be unacceptable to him
with an alphabetical list
mineral waters on the Cont
and all those of the Unite
which we are acquainte
component parts, as far a
ascertained, from the bes
thorities.

Abcourt, near St. Germai
from Paris

Is a chalybeate water, co
the iron, a small quantity
with carbonic acid.

Aberbrothic, in the coun
Scotland

Is a chalybeate. It conta
in carbonic acid.

Acton, near London, in
Middlesex.

This water is clear, an
but its taste is somewhat bi

It contains upwards of
sulphat of magnesia in the

Aghaloo, or *Aphaloo*, i
Tyrone, Ireland.

It is a sulphureous water
with that of *Swadlingba*
Like that it is also impreg
and a small quantity of pu

Aix-la-Chapelle, in the
Germany.

This place has long be
hot sulphureous waters a
arise from several source
eight baths constructed in
the town.

Their heat is from from
according to Bergman as h

These waters near the s
and pellucid, and have a st
smell resembling the was
gun; but they lose this sm
to air. Their taste is sa
urinous. They do not con
are also neutral near the f
terward are manifestly and
alkaline, insomuch that clo
with them without soap.

The gallon contains abo
of muriat of soda, the same

bonat of lime, and a drachm and half of carbonat of soda.

They contain too a considerable quantity of sulphuretted hidrogen, in which the sulphur is in very large proportion.

Alford, or *Awford*, in Somersetshire, about 24 miles south of Bath.

This salt spring was discovered in 1670, from the pigeons which flew thither in great numbers to drink the water: those birds being known to be fond of salt.

It contains a purging salt, together with a portion of sea salt.

Alkerton, in Gloucestershire, near the city of Gloucester.

It is a purging water, of the nature of those of Dulwich and Epsom.

Anaduff, in the county of Leitrim, Ireland.

It is a sulphureous water, of the same kind with those of Killasher and Drumasnave, but weaker.

Antonian. See *Tonstein*.

Ashwood, in the county of Fermanagh, Ireland.

It is a sulphureous water; and contains soda, with a small quantity of purging salt.

Askeron, five miles from Doncaster, in Yorkshire.

It is a strong sulphureous water, and is slightly impregnated with a purging salt.

A gallon contains forty-eight grains of sulphat of magnesia, with a little sea salt, and a drachm and a half of earth.

Astrope, near Banbury, in Oxfordshire.

It is a brisk, spirituous, pleasant-tasted chalybeate water, and is also gently purgative.

Asuarby, seven miles from Grantham, in Lincolnshire.

It is a fine bluish chalybeate water, and is gently laxative without occasioning griping or faintness, or a pain in the fundament; which is a common effect of waters impregnated with sea salt. In its virtues it resembles the Cheltenham water.

Athlone, in the county of Roscommon, Ireland.

It is a chalybeate water, without colour or smell, but it will not keep.

It seems to resemble the Hartlepool water.

Ax en Foix, about fifteen leagues west of Toulouse, France.

This place abounds with hot sulphureous waters of different temperatures, similar to those of Aix-la-Chapelle.

Aylesham, in Norfolk.

It is a slight chalybeate water, similar to that of Islington.

Baden, in Austria, Germany.

The waters are warm and sulphureous, and have been recommended in those disorders in which the Bareges and Aix-la-Chapelle waters have been found serviceable.

Baden Baden, in Swabia, Germany.

There are a number of hot sulphureous springs and baths in and near this place, which have the same general virtues as those of Aix-la-Chapelle and Bareges.

Bagneres, in the Bigorre, France.

At this place are a variety of warm baths, which are used in the same disorders as those of Aix-la-Chapelle.

Bagnigge Wells Purging Water.

It is a saline water, containing in the gallon 257 grains of sea salt and sulphat of magnesia mixed.

Bagnigge Wells Chalybeate Water.

It is clear when it comes from the pump, and has a slight irony taste.

In its virtues it resembles the Orston and other similar chalybeates.

Balaruc, in Languedoc, France.

The waters of this place are hot, and gently purgative.

They contain calcareous and magnesian muriat, sea salt, and chalk.

Balemore. See *Ilmington*.

Ball, or *Bandwell*, in Lincolnshire.

It resembles the Dropping-Well water.

Ballycastle, in Antrim, Ireland.

It is a chalybeate water, somewhat of the nature of those of Islington and Hampstead; only it is slightly sulphureous.

Ballynahinch, in the county of Down, Ireland.

It is a very clear, chalybeate, and sulphureous water.

Ballyspellan, near Kilkenny, in Ireland.

It is a slight chalybeate water, similar to those of Islington and Hampstead.

Barèges, in the Bigorre, France.

There are several springs of hot sulphureous water at this place, which form four baths.

The water is at first clear; but by standing throws up a thin pellicle, resembling a fine light oil. It has a slight sulphureous smell, like that of eggs boiled hard. It has a soft and somewhat nauseous taste, and feels soft like soapsuds, or oil. Its volatile parts fly off on exposure to the air; and it is best drunk at the fountain head.

It contains sulphuretted hidrogen, with a very small portion of sea salt, soda, carbonat of lime, alumine, and a bituminous matter.

Barnet and *North Hall*.

The former spring is situate at East Barnet in Hertfordshire.

The latter lies about three miles north of High Barnet.

They are both purging waters somewhat of the nature of Epsom water but much weaker. That of Barnet is the stronger of the two, containing five drachms of sulphat of magnesia, with a little sea salt, in the gallon.

Barrowdale. The spring is about three miles from Keswick in Cumberland.

It is a salt water, and much of the nature of that of the sea.

A gallon affords seven ounces and two drachms of sea salt mixed with a little sulphat of magnesia.

Bath, in Somersetshire.

This place has long been famous for its warm chalybeate waters. There are several springs, but their waters are all of the same nature. There are six baths; but the principal are the King's bath, the Queen's bath, and the Cross bath. The others are only appendages to these. The two former raise the thermometer, as they issue from the pump, to 116°, the latter to 112°.

The water, when viewed in the baths, has a greenish, or sea colour: but in a vial it appears quite transparent and colourless, and it sparkles in the glass.

It has a very slight saline, bitterish, and chalybeate taste; which is not disagreeable, and sometimes somewhat of a sulphureous smell; but the latter is not usually perceivable, except when the baths are filling.

As it comes from the pump, it contains a quantity of air, which rises through the water in the bath in large clusters of bubbles. This is found to consist of equal parts of carbonic acid gas, and hidrogen gas, mixed with a little atmospheric air, amounting in the whole to sixteen cubic inches in the gallon.

Its solid contents are, in the gallon, sulphat of lime 31·5 grs., carbonat of lime 7·25 grs., sulphat of soda 26 grs., muriat of soda 52 grs., silex 15·25, oxide of iron 0·25.

Bilton, near Knaresborough, Yorkshire.

The water has a strong sulphureous smell, and tastes somewhat saltish. It is colder than common water.

It contains soda, with a little sea salt.

Binley, near Coventry, Warwickshire.

It is a chalybeate water, and also purgative and diuretic. It resembles the Scarborough water, but is less purgative.

Birmingham, in Warwickshire.

Near this place is a brisk chalybeate water, which seems to resemble that of Hampstead, in Middlesex.

Bordscheit, or *Borset*, about a mile and half from Aix-la-Chapelle, Germany.

One of the springs of Borset resembles those of Aix in all its constituent parts, but the impregnation with sulphur is much weaker. It deposits however some sulphur in its course through any confined channel on its upper part, but not sufficient to be worth collecting. It is pretty strongly alkaline. Its temperature is 152°, which is nearly as high as the hottest bath at Aix.

The other hot spring differs considerably from the former, in containing no sulphur in any form; it therefore has no smell, nor does it blacken the solutions of silver or lead. It is, however equally alkaline, and the heat is as high as 152°, and therefore much exceeds the hottest of the Aken waters. In this spring there is a large quantity of earth suspended, which is deposited as the water cools, and forms hard incrustations to a considerable thickness round every substance that may lie in its way, and will serve as a nucleus.

Brabach, in the district
chen, in the county of Nass

It is a brisk spirity ch
which may be preserved lo
ped bottles, though it soo
open air. It has a some
phureous, and astringent tas
soda.

Brandola, in Italy.

This contains iron, carb
and a little sulphur.

Brentwood, in Essex.

It is a purging water o
those of Pancras, Epsom, a

Brighton.

The chalybeate spring,
commonly called the Wick
noticed as a ferruginous wa

A gallon of the water, a
Marcet's analysis, contains
11·2 grs., sulphat of lime 3
of soda 12·24 grs., muriat
grs., siliceous earth 1·12 g
160°; carbonic acid gas
inches, or $\frac{1}{13}$ part of its vol

Bristol, in Somersetshire.

The springs are known
the *Hot Wells*.

The water at its origin
pellucid and sparkling; an
stand in a glass, covers its i
air bubbles. It has no sm
and agreeable to the taste
thermometer to about seve
grees. It contains in the ga
of chalk, 7·25 of muriat of
sea salt, sulphat of soda 1
lime 11·75, carbonat of lim
cubic inches of carbonic ac

Bromley, in Kent.

It is a chalybeate water,
of Spa, Islington, and Ham

Broughton, in the west
shire, near Coln, in Lancas

It is a strong sulphureo
silver and copper black, re
of trees, &c., and makes th
basin black.

It is impregnated with
purging salt; and its virtu
those of the Harrogate wat

Buch, situate about a Ge
the Caroline baths in Bohe

The waters have a brisk
and are plentifully impreg
bonic acid. This, on ex
and they become insipid. I
from Seltzer water, which a
taste by standing.

They contain, however,
in the proportion of about
gallon.

Buglawton, near Congleto

It is a sulphureous wat
with a purging salt, and i
to resemble the Askeron wa

It is intensely cold, and
strong sulphureous smell and

Burlington, in Yorkshire.

It is a brisk chalybeate water, and resembles those of Scarborough and Cheltenham, though it seems to be less purgative.

Burnley or *Bournley*, in Lancashire.

It is a chalybeate water of the nature of the Scarborough, but less purgative.

Buxton, in Derbyshire.

This is a hot water resembling that of Bristol. It raises the thermometer to 81° or 82°.

It has a sweet and pleasant taste.

It contains 1·75 grs. of muriat of soda, 2·5 grs. of sulphat of lime, and 10·5 grs. of carbonat of lime in the wine gallon. It contains likewise a sixty-fourth of its bulk of air, which is chiefly nitrogen gas mixed with a little atmospheric air.

Cannock, near Stafford.

It is one of the lightest and best chalybeate waters in Staffordshire. In its virtues it resembles those of Hampstead and Islington.

Cape Clear, situate in the most southern part of Ireland.

It is a smooth, saltish water, and lathers with soap.

It contains about half a drachm of carbonat of soda, mixed with a little sea salt, in the gallon.

Cargyrle, in Wales.

The spring is situate about ten or twelve miles from Chester.

The water is of the nature of Barrowdale water, but much weaker.

Carlton, near Newark-upon-Trent, in the county of Nottingham.

This contains iron dissolved in carbonic acid, along with a bituminous oil, which gives it the smell of horse-dung.

Caroline Baths, at Carlsbad in Bohemia, Germany.

The waters of this place are hot. The highest temperature is 165°, the lowest 114°.

According to Klaproth the *Sprudel* contains in 100 cubic inches carbonat of soda 39 grs., sulphat of soda 70·5, muriat of soda 34·6, chalk 12 grs., silex 2·5 grains, iron 0·125 gr., carbonic acid gas 32 cubic inches.

The *Neubrunnen*, carbonat of soda 38·5 grains, sulphat of soda 66·75, muriat of soda 32·5, chalk 12·4, silex 2·25, iron 0·125 gr., carbonic acid gas 50 cubic inches.

The *Schlossbrunnen*, carbonat of soda 37·5 grains, sulphat of soda 66·5, muriat of soda 33, chalk 12·75, silex 2·125, iron 0·0625, carbonic acid gas 53 cubic inches.

Carrickfergus, in the county of Antrim, Ireland.

The water is of a blueish colour, and a very soft taste, at the fountain-head.

It is weakly purgative; and must be drank to the quantity of two or three quarts.

Near this spring is another, a gallon of the water of which affords about an ounce and a half of sea salt, and a little sulphat of magnesia, with a quantity of an earthy matter.

Carrickmore, in Ireland.

This is situate about five miles from Belturbet, in the county of Cavan.

The water has a soft, milky taste, like Bristol water; and putrefies by keeping.

Cashmore, in the county of Waterford, Ireland.

It is near the *Cross-town* water, which it resembles in its virtues, though stronger. It holds in solution sulphat of iron.

Castleconnel, in the county of Limerick, Ireland.

It is a chalybeate water of considerable repute, and resembles the German Spa waters.

Castle Leod, in Ross-shire, Scotland.

This is a strong sulphureous water. The gallon yielded near 1·8 gr. of carbonat of lime, 26·6 of sulphat of lime, 30·6 of saline matter consisting of sulphat of soda with a little sulphur, and probably a small portion of marine bittern.

Castlemaign, in the county of Kerry, Ireland.

It is a sulphureous, and strongly chalybeate water, the iron being dissolved in carbonic acid.

Cawley, near Dranefield, in Derbyshire.

It is sulphureous, and contains about half a drachm of sulphat of magnesia in the gallon.

Cawthorp, four miles from Bourne, in Lincolnshire.

This contains iron, carbonic acid, and probably soda

Chadlington, near Chipping-Norton, Oxfordshire.

It is one of the waters termed sulphureous.

It contains also soda, together with a little sea salt.

Chaude Fontaine, about two leagues from Liege, and three from Spa, in Germany.

The water of these springs is hot, and supplies fifty baths.

They are impregnated with carbonat of lime and soda, and also with carbonic acid gas.

Cheltenham, in Gloucestershire, six miles from Gloucester.

The gallon contains eight drachms of a purging salt, partly sulphat of soda, partly sulphat of magnesia; twenty-five grains of magnesia, part of which is united with muriatic, part with carbonic acid; and nearly five grains of oxide of iron. It also yields 30·368 cubic inches of carbonic acid gas, and 15·184 of a mixture consisting chiefly of nitrogen gas with a little sulphuretted hidrogen.

Chippenham, in Wiltshire.

It is a pretty strong chalybeate water, resembling those of Islington and Tunbridge.

Cleves, in the duchy of Cleves, Germany.

It is a brisk chalybeate water, and operates by urine. It resembles the Pyrmont waters

Clifton.

This is a village near Deddington, in Oxfordshire.

The well is about a furlong south of

Clifton. The water is clear, and has but little taste.

The principal ingredient is soda, of which about sixty-five grains are contained in the gallon.

Cobham, in the county of Surry.

It is a chalybeate water, of the nature of that of Tunbridge, but rather stronger of the iron.

There is also a purging water near it, from a gallon of which Dr. Hals obtained an ounce or upward of a residuum consisting principally of sulphat of magnesia.

Codsalwood, five miles from Wolverhampton, Staffordshire.

It is a strong sulphureous water, containing carbonic acid gas.

Colchester, in the county of Essex.

It is a purging water of the nature of those of Acton and Epsom.

Colurian, in the parish of Ludgvan, in Cornwall.

It is a chalybeate water, and seems to resemble those of Hampstead and Islington.

Comner, or *Cumner*, in Berkshire, four miles west of Oxford.

The water is of a whitish colour, especially in the summer.

It contains two hundred and forty-four grains of sulphat of magnesia with excess of magnesia, and fifty-two of carbonat of lime.

Coolauran, in the county of Fermanagh, in Ireland.

It is a chalybeate water, containing carbonic acid.

Corstorphin, two miles from Edinburgh, Scotland.

It is a weak sulphureous water, very slightly impregnated with sea salt, and sulphat of magnesia.

Coventry, in Warwickshire.

It is a chalybeate and purging water, containing carbonic acid.

Crickle Spa, situate near Broughton, in Lancashire.

It is strong sulphureous water, a gallon of which contains about four drachms and a half of sea salt and sulphat of magnesia, the former of which is greatly predominant, and about fifty grains of carbonat of lime.

Croft, in the north riding of Yorkshire, on the confines of Durham.

This is a strong sulphureous water, a gallon of which contains one hundred and fifty grains of carbonat of lime, thirty of sulphat of magnesia, and ten of sea salt.

Cross-Town, near the town of Waterford, Ireland.

This is a chalybeate water, containing iron in the state of sulphat.

Cunley-House, near Whaley, in Lancashire.

It is strongly sulphureous, and contains carbonic acid.

Deddington, near Oxford.

This contains iron, sulphur, carbonat of lime, and sea salt, or soda.

Derby, near the town of Der
shire.

In this chalybeate the iro
by carbonic acid.

Derrindaff, in the county o
land.

This is a sulphureous water
with a purging salt.

Derryhence, or *Derryinch*, i
of Fermanagh, Ireland.

The water is sulphureous.

Derrylester, in the county of
three miles from Swadlingbar

The water is of the natu
Drumgoon, but contains mu
salts.

Dog and Duck, St. George
London.

It is a mild purgative, cont
of magnesia mixed with sea sa

Dortshill, near Litchfield, i
The water is a brisk chal
to that of Tunbridge.

Driburg, about half a mile
of Driburg, in Westphalia.

The water, which is in the
tation abroad, very much
Pyrmont; containing the sam
but in a rather larger propor

The quantity of carbonic
from it by Dr. Higgins was
mont as thirteen to twelve.

Drig Well, near Ravenglas
land.

This is a brisk, spirituous
chalybeate; and in its virtues
Deddington water.

Dropping-Well, at Knare
Yorkshire.

It is very cold, limpid, and
and in time petrifies substanc
it. It contains carbonat of li

Drumasnave, called likewise
bell, in the county of Leitrim

This is one of the stronges
waters in Ireland.

It contains about twelve g
with a small quantity of pur
gallon.

Drumgoon, in the county o
Ireland.

The water has a strong sulp
and tinges silver of a coppe
few minutes.

It contains near a drachm
soda in a gallon, with a little

There are two other sulph
in the neighbourhood; the
sembles this, the other is mor
tive nature.

Dublin Salt Springs.

There are five of these sprin
Street, and one in Thomas's C

The waters contain muria
sulphat of magnesia.

Dulwich. The spring is si
Dulwich and Lewisham, in t
Kent.

The water is clear, and has a brackish taste, leaving a bitterness in the throat.

It contains sulphat of magnesia, together with muriat of soda.

Dunmard, about eighteen miles from Dublin.

This is a chalybeate water, resembling that at Peterhead, but weaker.

Dunse, in Scotland.

It contains iron dissolved in carbonic acid, with a little sea salt, and muriat of magnesia.

Durham.

The spring is situate near the city, on the north side of the river Wear.

It is a strong sulphureous water, and is impregnated with sea salt, of which it contains thirty-eight grains in the gallon.

Near to this, in the middle of the river, is a salt spring, which is drunk as a purging water.

Egra, in Bohemia.

This is a chalybeate water, containing less fixed air than the Pyrmont water, and more purgative. It abounds with sulphat of magnesia, mixed with muriat of magnesia.

Englien, or *Anguien*, a city of Hainault.

This water contains sulphur, sulphat of magnesia, and carbonat of lime, and of magnesia.

Epsom, in Surry, about sixteen miles from London.

This water has never been analysed with much nicety. Its solid contents have been made to amount to an ounce and half in the gallon, but according to Dr. Lucas they are only 320 grs. Of these two thirds or more are sulphat of magnesia, the remainder probably muriat of lime and magnesia, with sulphat and carbonat of lime.

Fairburn, in the county of Ross, in Scotland.

It contains sulphur, carbonat of lime, and sulphat of soda.

Felstead, in Essex.

The spring is situate at the bottom of a rock. The water is a light chalybeate, resembling that of Islington.

Filah, near Scarborough, in Yorkshire.

This is a chalybeate water, containing muriat of soda.

Frankfort, in Germany.

There are two strong sulphureous waters in the neighbourhood of Frankfort on the Maine.

The one is called *Faulpump*; the other *Pons Scabiosorum*.

They are also impregnated with sea salt, and are of the nature of the Moffat and Harrogate waters.

Gainsborough, in Lincolnshire.

This is a weak sulphureous chalybeate water, containing also sulphat of magnesia.

Galway, in the county of Galway, Ireland.

It is a chalybeate water, of the nature of that of Tunbridge.

Glenmiley, near Naul, in Ireland.

It is a chalybeate water, resembling that of Peterhead, but weaker.

Glastenbury, in Somersetshire.

This water is of the same nature with those of Tilbury and Clifton; but weaker than either of these.

It has also a small mixture of sea salt.

Glendy, in the county of Merns, Scotland.

This is a strong chalybeate water, little inferior to that of Peterhead.

Granshaw, near Donaghadee, in the county of Down, Ireland.

It is a chalybeate water of the nature of that of Castle Connel.

Grossenendorf, about five leagues from Hanover.

This is a cold sulphureous water, of some repute in the gout, palsy, and diseases of the skin and breast.

Gugga. See *Kuka.*

Haigh, near Wigan, in Lancashire.

This is impregnated with sulphat of iron, and is of the nature of Shadwell water.

Hampstead.

This chalybeate water contains in a wine gallon, oxide of iron gr. 1·5, muriat of magnesia 1·75, sulphat of lime 2·12, muriat of soda 1 nearly, silex about 0·38, of carbonic acid gas 10·1 cubic inches, and of an air somewhat less pure than atmospheric 90·9.

Hanbridge, in Lancashire.

It is a chalybeate water of the nature of that of Scarborough, but less purgative.

Hanlys, near Shrewsbury, in Shropshire.

The water is clear and limpid, and has a saline and bitter, though not disagreeable taste.

The gallon yields one hundred and twenty grains of sulphat of magnesia.

At this place there is also a chalybeate water. It is near the purging water, and is of the nature of those of Scarborough and Landrindod.

It is brisk and pungent to the taste, and as it is taken from the fountain, clear, and not unpleasant; but losses its virtues by keeping.

Harrogate, near Knaresborough, Yorkshire.

There are four springs at this place, but the waters of all of them are nearly alike, except in the quantity of the saline matter they contain.

Of the three old springs, the highest gave three ounces of solid matter to the gallon; the lowest, an ounce and a half; and the middle one, only half an ounce. Of the last one hundred and forty grains were earth.

Of the upper, which alone is used internally, the contents are muriat of soda 615·5 grs., muriat of lime 13, muriat of magnesia 91, carbonat of lime 18·5, carbonat of magnesia 5·5, sulphat of magnesia 10·5, carbonic acid gas 8 cubic inches, nitrogen gas 7, sulphuretted hidrogen 19.

The water as it springs up is clear ar sparkling, and throws up a quantity of bubbles.

It has a powerful smell of sulp

supposed to be the strongest sulphureous water in England.

N. B. Between Harrogate and Knaresborough are also several chalybeate waters, which seem to resemble those of Hampstead and Islington. The most remarkable are, the Alum Well, the Sweet Spa, and the Tuewhet Well. The latter is the strongest.

Hartfell, in the county of Annandale, Scotland.

The gallon of this water contains sulphat of iron 84 grs., sulphat of alumine 12, oxide of iron 15. Some have confounded this with the *Moffat* water, which is in the vicinity.

Hartlepool, in Durham.

This is a fine, clear chalybeate water, with a slight sulphureous smell, and pleasant taste.

Holt, near Bradford, in Wiltshire.

The water is limpid, and has but little taste.

It contains a purging salt, together with a large quantity of earth.

Holt, near Market Harborough, Leicestershire. See *Nevil Holt*.

Jessop's Well, on Stoke Common, near Cobham, in Surry.

This is a strong purging water, with a nauseous taste, containing sulphat of magnesia, and is also slightly chalybeate.

Ilmington, in Warwickshire, on the borders of Worcestershire.

This is a very clear, and sparkling chalybeate water, abounding in carbonic acid, and impregnated also with soda.

Inglewhite, in Lancashire.

It is a strong chalybeate sulphureous water.

Islington, in the county of Middlesex, near London.

This is a slight chalybeate water. The iron in this water is held in solution by means of carbonic acid, as in the Pyrmont water.

Kanturk, in the county of Cork, Ireland.

It is a chalybeate water, of the nature of that of Peterhead, but weaker.

Keddlestone, in Derbyshire.

This is a strong sulphureous water, and stinks intolerably.

It contains thirty-eight grains of sea salt, and forty-two grains of carbonat of lime in a gallon.

Kensington, in the county of Middlesex, near London.

It is a purging water, of the nature of those of Acton and Pancras.

Kilbrew, in the county of Meath, Ireland.

This is a strong vitriolic chalybeate, and resembles the Shadwell water.

Kilburn, in Middlesex, near London.

It is a purging water, containing in a win gallon carbonat of lime 8·40 grains, carbo at of magnesia 10·75, extractive matter 3, m uriat of magnesia 33, muriat of lime 14·75, mu riat of soda 18, sulphat of soda 117·50, sul hat of magnesia 265, sulphat of lime 42, inso uble matter 1·50, and a little

oxide of iron in too small
estimated: beside of carbo
cubic inches, common air of
5·5.

Killingshanvally, in the c
nagh, Ireland.

This is a chalybeate wa
diuretic and gently laxati
resemble the Hanlys chalyb

Killosher, in the county
Ireland.

This water is strongly s
contains soda.

Killroot, in the county of
It is of the nature of Ba
but weaker.

Kinalton, or *Kynolton*, a
tinghamshire.

A gallon contains about o
fifty grains only of sulphat

Kinkardine, in the county
land.

This is a chalybeate wate
in strength to that of Peter

Kingscliff, in Northampto
It is a chalybeate laxative
sembles those of Scarboroug
ham.

Kirby- or *Kirkby-Thouer*, in
There are two springs ne
kind, only the lower one i
strongest chalybeate. The
dissolved by carbonic acid,
little soda.

Knaresborough. See *Dropp*

Knowsley, in Lancashire.

This is a slight acidulous
ter, and both tastes and smel

Korytna, near Hunnobr
Germany.

It is situate on a high and
sible rock, in the midst of a

It has a very fetid disagre
a black colour; and there is
the bottom of the well.

It is reckoned the stronge
water in that country.

Kuka, in the county of Gr
mia, near the town of Jaromi
flux of the rivers Elbe and O

This is a very brisk cha
highly impregnated with carb
also with soda.

La Marquise, and *La Marie*

Lancaster, or *Sale's Spa*, in

This is a clear chalybeate
nature of that of Tunbridge.

Latham, in Lancashire.

It is a fine crystalline chal
nature of the Tunbridge wat

Llandrindod, in the count
South Wales.

In this place there are
springs:

1st. The saline pump, or p

2d. The sulphureous wate
called the black stinking well.

3d. The chalybeate rock wa

We do not know any particular account of the contents of either.

Llangybi, in Caernarvonshire, North Wales.

The water has a harsh taste inclining to bitter. We do not know, that it has been analysed.

Leamington, in Warwickshire.

This is of the nature of Barrowdale water, but much weaker, containing little more than a fourth of the same ingredients in an equal quantity.

Leez, near the Earl of Manchester's, Essex.

It is a chalybeate water similar to those of Islington and Hampstead.

Lincomb, near Bath, in Somersetshire.

This is a chalybeate and acidulous water, containing soda, with a small quantity of purging salt.

Lisbeak, in the parish of Killasher, in the county of Fermanagh, Ireland.

Here are two strong sulphureous waters, much of the same kind.

They yield upwards of thirty grains of soda in the gallon, and it is more free from heterogeneous mixtures than in most waters.

Lis-Done-Varna, in the county of Clare, in Ireland.

This is a strong chalybeate water, and manifests itself as such both to the taste and smell. It is also impregnated with soda.

Loansbury, in Lord Burlington's park, in Yorkshire.

This is a sulphureous water, weakly impregnated with a purging salt.

Maccroomp, in Ireland, about sixteen miles from Cork.

This is a chalybeate water, impregnated with soda, and resembles the Thetford and Islington waters.

Maherebeg, situate near Branden Bay, in the county of Kerry, Ireland.

It is of the nature of the Barrowdale water, but contains a much smaller quantity of sea salt.

Mallow, in the county of Cork, Ireland.

This is a warm water, perfectly limpid and pleasant tasted, and keeps long in bottles well corked. It is similar to that of Bristol.

Malton. The spring lies at the west end of the town of New Malton, in Yorkshire.

It is a strong chalybeate, abounding with carbonic acid when fresh drawn; has a saltish taste, and leaves a bitterness in the throat. A gallon yields near two drachms of sulphat of magnesia.

Malvern, in Gloucestershire.

There are two noted springs at this place, one of them called the Holy Well, in the midway between Great and Little Malvern, the other is about a quarter of a mile from Great Malvern.

The Holy Well water is light and pleasant, slightly impregnated with carbonic acid, and remarkable for being almost entirely free from any earthy matter; for three quarts of the water being evaporated, scarce the fourth part of a grain of sediment was left behind, in a dry season. At others a grain has been left from a pint.

It contains a very little muriat of lime or magnesia, and possibly a little neutral alkaline salt.

The other spring is a slight chalybeate, but is as free from any other heterogeneous matter as the Holy Well.

Mark's-Hall, in Essex.

This is a chalybeate water resembling those of Islington and Hampstead.

Matlock, near Wirksworth, in Derbyshire.

At this place, which is perfectly romantic, are several springs of warm water, the heat of which is about 69°.

It contains a small quantity of a neutral salt, probably muriat of soda; and about as much of an earthy salt, which is chiefly calcareous.

Maudsley, near Preston, in Lancashire.

The water is of a blueish colour, has a fetid smell, and a brackish taste.

It is a strong sulphureous water, and contains about two ounces of sea salt in the gallon.

Mechan, in the county of Fermanagh, Ireland.

In this place there are two sulphureous springs, both of the same nature, containing soda.

Millar's Spa, Stockport, in the county of Lancaster.

It is a chalybeate water of the nature of that of Tunbridge, but seems to be stronger of the iron.

Moffat, in the county of Annandale, Scotland.

At this place there are two springs, or wells.

They are both sulphureous, and have a strong smell and taste.

From a gallon of the water were obtained by Dr. Garnett nothing but 36 grains of muriat of soda; with 5 cubic inches of carbonic acid gas, 4 of nitrogen gas, and 10 of sulphuretted hidrogen.

Moreton, or *Moreton-See*, situate about two miles west of Market-Drayton, in Shropshire.

The gallon contains 200 grains of sulphat of magnesia, and 76 of calcareous earth.

Moss House, near Maudley, in Lancashire.

This is a brisk chalybeate water, and in its properties resembles those of Hampstead and Islington.

Mount d'Or, seven leagues from Clermont, in Auvergne, France.

The water is warm, and of the nature of that of Aix-la-Chapelle.

Mount Pallas, in the county of Cavan, Ireland.

It is a chalybeate water, and seems to be of the nature of the Athlone.

Nevil-Holt, near Market-Harborough, in Leicestershire.

This is an exceedingly clear water as it falls from the spout, and is void of all smell.

It has a brisk, austere, bitter, yet not disagreeable, taste, and abounds in carbonic acid.

A gallon of the water contains two drachms of sulphat of magnesia, two drachms eighteen grains of muriat of alumine, and eighteen grains of muriat of magnesia.

New Cartmal. See *Rougham.*

Newnham Regis, in Warwickshire.

There are three wells at this place · they are all of them chalybeate, laxative, and diuretic; and seem to resemble the Scarborough water.

They have somewhat of a sulphureous smell.

Newton Dale, in the north riding of Yorkshire.

This is a cold petrifying water.

Newton Stewart, near Castlehill, in the county of Tyrone, Ireland.

It is a chalybeate water, of the nature of that of Tunbridge.

Nezdenice, in Germany, about half a mile from Hunnobroda, in the district of the castle of Banow.

This is an acidulous water, impregnated with carbonic acid and iron, and containing soda.

Nobber, in the county of Meath, Ireland.

It is a vitriolic chalybeate, and resembles those of Hartfell and Cross-town.

Normanby, four miles from Pickering, in Yorkshire.

It is a clear and beautiful sulphureous water, and when poured out sparkles like Champaign.

A gallon yields scarcely twenty grains of sulphat of magnesia, and about half that quantity of sea salt.

Near it is a chalybeate water called Nether Normanby Spa; a gallon of which afforded ten grains of sea salt.

North Hall. See *Barnet.*

Nottington, near Weymouth, in Dorsetshire.

This is a strong sulphureous water.

It contains 30 grains of soda, and seven of earth in the gallon.

Nuremberg, in Germany.

Within the walls of this town is a mineral spring, called das Wildbad. It is a chalybeate, has a subastringent taste, and contains some saline matter; but we know of no accurate analysis of its contents.

Orston, in the county of Nottingham, near Thoroton.

This water has a delicious, gentle, rough, sweetish chalybeate taste, and a slight sulphureous smell. It is replete with carbonic acid, sparkles and flies when poured out into a glass, and makes the heads of those who drink it giddy. It contains some sulphat of magnesia, and a little muriat of soda.

Oulton, in Norfolk,

It is a slight chalybeate
that of Islington.

Owen Breun, county of

This is a sulphureous w
with sulphat of magnesia,

Pancras, in Middlesex,

The water is almost ins

It is very slightly impr
phat of magnesia, toget
portion of sea salt.

Passy, near Paris, in Fr

It is a clear, colourless,
with a subacid taste, and
and emits plenty of air bu

Peterhead, county of Ab

This is one of the str
famous chalybeate waters
we know no analysis of it

Pettigoe, in the county
land.

It is one of the stro
waters in Ireland; and is
sulphat of magnesia, of
near 50 grains in the gall

Pisa, in Italy.

About sixteen miles fro
bath, called Bagno a A
bottom of Mount Pisa, no
twelve miles from the tow
of springs of warm wat
drinking and bathing.

The hottest raises Fah
meter to 104°; the cooles

In smell and taste the
common water. They
salt, and sulphat of lime.

Plombieres, in Lorrain,

The water is tepid and
a saltish taste.

According to its analys
contains sulphat of soda
of soda 0·5, silex 2·6, c
carbonat of soda 4·4, album

Pontgibaut, in Auvergn

The water is limpid,
tains about 55 grains of
and 50 of carbonat of lim

Pyrmont, in Westphalia

This is a very brisk ch
ing in carbonic acid; and
from the fountain, sparkle
Champaign wine. It ha
vinous taste, and a some
smell. It is perfectly clea
riage better than the Spa

A gallon of it contains
bonat of lime, 15·6 of carb
30 of sulphat of magnes
2·6 of oxide of iron*; an
cubic inches of carbonic a

Queen Camel, near Winc
setshire.

This is a sulphureous

---

* Dr Marckard, in his Description of Pyrmont, on the authority o
of Hammeln, estimates the iron at somewhat more than eight grains to th

soda, together with sea salt, carbonat of lime, and a bituminous matter.

Richmond, in the county of Surry.

This is a purging water, of the nature of those of Acton and Pancras.

Rippon, in Yorkshire

Near this place a spring of a pretty strong sulphureous water rises from a limestone hill. A gallon yielded, on evaporation, 66 grains, of which nearly half was earth, the remainder sea salt.

Road, in Wiltshire.

This is a chalybeate water, with a sulphureous smell, and is impregnated with soda.

Rougham, in Lancashire.

The gallon contains five drachms of sea salt, and one drachm of sulphat of magnesia.

Saint Amand, a town in French Flanders.

There are two fountains here, one called Bouillon or Bouillant, the other the fountain of Arras, or L'Eveque d'Arras, the latter of which is the strongest.

They somewhat resemble those of Aix-la-Chapelle in appearance, but are inferior in heat, raising Fahrenheit's thermometer to 75° only, when in the open air it stood at 50°.

They principally deserve notice on account of the *boue* or mud baths. The method of using them is to bury the affected limb, or part of the body, even up to the armpits, for some hours, as the case may require: the patient is then carried to a hot bath and cleansed from the black mud, which adheres to the skin.

Saint Bartholomew's Well, Ireland. It is about two miles south-west from Cork.

The water is soft, and mixes smoothly with soap

By keeping it putrefies, and then tinges silver, and throws up a stinking scum, which has somewhat of an irony taste. Galls then give it a purple tinge, which they do not to the fresh water.

The gallon affords 24 grains of residuum, which is chiefly soda.

Saint Erasmus's Well, situate in Lord Chetwynd's grounds in Staffordshire.

The water is of the nature of Barrowdale, but much weaker, the gallon yielding only four drachms 32 grains of sea salt.

It is of the colour of jack, but without much taste or smell.

Sale's Spa. See *Lancaster*.

Scarborough, in Yorkshire.

There are two species of chalybeate waters found in this spot, and they differ considerably in their composition, though they arise nearly contiguous to each other. The one is a simple carbonated chalybeate, similar to the Tunbridge water; the other, which is better known, more frequented, and more particularly distinguished as Scarborough water, has, in conjunction with the iron, a considerable mixture of purging salt, which adds much to its value.

One gallon of this water yields from 240 to 280 grains of solid residuum, of which about two thirds are a soluble crystallizable salt, chiefly sulphat of soda. The remainder is mostly sulphat of lime, mixed with chalk and oxide of iron.

Scolliensés, in Upper Rhœtia, Switzerland.

It is a chalybeate water, impregnated with soda, and so full of carbonic acid gas, that it often bursts the bottles in which it is kept.

Sedlitz, a village in Bohemia.

This purging water is of the same nature as our Epsom, but much stronger, a gallon yielding about two ounces of the purging salt.

Seltzer, in Germany.

The water is remarkably clear and light, and in pouring it from one vessel to another, plenty of air-bubbles arise.

It has, at first, somewhat of a brisk, subacid pungent taste, but leaves behind a lixivial one.

It contains 14 grains of carbonat of lime, 20½ of carbonat of magnesia, 141·6 of carbonat of soda, and 92 of muriat of soda, in the gallon. From this quantity of the water 128 ounce measures of carbonic acid gas were obtained.

Sene, or *Send*, near the Devizes, Wiltshire.

At this place are two chalybeate springs, one of them stronger than the other, but both resembling in virtues the Hampstead and Islington waters.

Seydschutz, in Germany.

It is situate near to that of Sedlitz, and is of the same purgative nature, but somewhat stronger. The gallon contains of sulphat of magnesia 1620 grs., muriat of magnesia 42 grs., sulphat of soda 33 grs., sulphat of lime 83 grs., carbonat of magnesia 30 grs., carbonat of lime 9 grs., and 27 cubic inches of carbonic acid gas.

Shadwell, in the Sun Tavern Fields, near London.

This is a vitriolic chalybeate water, and is one of the strongest waters of the kind in England; it also contains iron held in solution by carbonic acid. The gallon yields 1132 grains of sulphat of iron, and 188 of an ochry coloured earth.

Shapmoor. The spring is in a marshy heath, between Shap and Orton, in Westmoreland.

This is a sulphureous water, impregnated with a purging salt, composed of sulphat of magnesia, sea salt, and soda, about 370 grains in the gallon.

Shettlewood, between Bolsover and Romeley, in Derbyshire.

It is a sulphureous water, containing near two drachms of sea salt in the gallon.

Shipton, in Yorkshire.

It is a sulphureous water, impregnated with sea salt together with a purging salt.

Somersham, in Huntingdonshire.

This is a chalybeate water, impregnated

with sulphat of iron and alum, and contains also carbonic acid gas.

Spa, in the bishopric of Liege, Germany, twenty-one miles south east from the town of Liege.

In and about this town there are several springs, which afford excellent chalybeate waters.

The principal springs are,

1. The *Pohoun*, or *Pouhon*, situate in the middle of the village.
2. *Sauviniere*, about a mile and a half east from it.
3. *Groisbeeck*, near the Sauviniere.
4. *Tonnelet*, a little to the left of the road to the Sauviniere.
5. *Watroz*, near the Tonnelet.
6. *Geronstere*, two miles south of the Spa.
7. *Sarts*, or *Niverset*, in the district of Sartz.
8. *Chevron*, or *Bru*, in the principality of Stavelot.
9. *Coure*,
10. *Beversee*,
11. *Sige*,
12. *Geromont*, } all near Malmdy.

The *Pouhon* is a slow deep spring, and is more or less strong or gaseous according to the state of the atmosphere.

The gallon contains 10 grains of carbonat of lime, 30 of carbonat of magnesia, 10 of carbonat of soda, and 5 of oxide of iron. It yields of carbonic acid gas 132 ounce measures.

It is colder than the heat of the atmosphere by many degrees.

Of the *Sauviniere* water a gallon yields 6·5 grains of carbonat of lime, 4·5 of carbonat of magnesia, 2 of carbonat of soda, 3·5 of carbonat of potash, 2·2 of oxide of iron, and 108 ounce measures of carbonic acid gas.

At the well it has a slight smell of sulphur.

Groisbeeck. The water is of the same nature as the Sauviniere, but contains a somewhat larger proportion of the several ingredients. It has a chalybeate taste, and a slight sulphureous smell.

Tonnelet. This is one of the most sprightly waters in the world. It is much colder than any of the other Spa waters; has no smell; is bright, transparent, and colourless; and has a smart, subacid, sprightly taste, not unlike the briskest Champaign wine.

From a variety of experiments it appears, that this water is more strongly charged than any of the others with carbonic acid, but it parts with it more readily.

It contains more iron than either of the springs, except the Pouhon.

Watroz. Its situation is lowest of any of the springs about Spa, and it is more apt to be foul: but when the well is cleaned out, and the water pure, it is found to be of the same nature as that of Pouhon. It is not purgative, as some have asserted.

Geronstere. This water has much less carbonic acid than the Pouhon. It has a
sulphureous smell at the fountai
loses by being carried to a dist
smell is strongest in warm moist

It is colder than any of the
Tonnelet excepted.

Sarts, or *Niverset*. It resembl
nelet water, but is rather les
gaseous. It is, however, mor
styptic.

Bru, or *Chevron*. The physici
have artfully decried this wate
is not in the principality of Lie
every trial it appears not much
any of the Spa waters. In the
carbonic acid and of iron it co
proaches the Pouhon.

Couve. The Couve nearly re
Tonnelet water, or rather may
a medium between that and the
hardly equals the transparency
and generous vinous taste of th
greatly surpasses the latter.

The *Beversee* agrees with this,
does not retain its smartness
keeping.

La Sige. It has some of the g
perties of the Spa waters, but
spects it is different.

It is moderately subacid, smar
ful, but has no sensible chalybe

It is much more loaded with
ters, and less impregnated wi
carbonic acid, than the other Sp

Geromont. As a chalybeate a
water it seems to be nearly
strength with La Sige; but i
greater quantity of soda, toget
mixture of sea-salt. The eart
however, are less.

Stanger, near Cockermouth,
land.

This is a salt chalybeate, or
ter; and, when drunk to four c
operates with violence both u
downwards.

Stenfield, in Lincolnshire.

It is a chalybeate laxative wa
sembles that of Orston.

Streatham, in Surry, near Lor

The gallon contains 160 gr
composed of sea-salt and sulpha
sia, and 40 of calcareous earth.

Stoke. See *Jessop's Well*.

Suchaloza, about a mile from
Broda, in Germany.

It is an acidulous water resem
Nezdenice in virtues.

Sutton-Bog, in the county of
to Northamptonshire.

This is one of the waters called

It contains 131 grains of carb
mixed with a little sea-salt, and
argillaceous earth, in the gallon.

Swadlingbar, in the county of
land.

This is a sulphureous water,
carbonat of soda, together with
phat of magnesia and earth.

Swansey, in Glamorganshire, North Wales.

It is impregnated with sulphat of iron of which a gallon yields 32 grains.

Dr. Rutty suspects it to contain copper.

Sydenham, in Kent, near London.

It is purgative, and of the nature of Epsom water, but only about half the strength of it.

Tarleton, eight miles from Preston, Lancashire.

This is a chalybeate water, and seems to resemble the Scarborough water.

Tewkesbury, in Gloucestershire.

It is a purging water of the nature of those of Acton, Pancras, and Epsom.

Thetford, in the county of Norfolk.

This is a chalybeate and acidulous water, and contains also soda.

Thoroton near Newark upon Trent, Nottinghamshire.

It is a chalybeate laxative water, resembling that of Orston.

Thursk, in the north riding of Yorkshire.

It is a brisk, sparkling, chalybeate water, and is also purgative and diuretic. It resembles the Scarborough and Cheltenham waters.

Tilshelf, in Derbyshire.

This is a fine clear chalybeate; and when poured from one glass to another, sparkles like the Spa water, which it resembles in its properties.

Tilbury. The spring which affords this water rises near a farm-house at West Tilbury, near Tilbury fort, in Essex.

This water is not quite limpid at the well, but is somewhat straw-coloured.

It is soft and smooth to the taste; though after being agitated in the mouth, it leaves a small degree of roughness on the tongue.

It throws up a scum variegated with several colours, which feels greasy, and effervesces with vitriolic acid.

A gallon of the water contains 37 grains of carbonat of lime, 49 of nitrat of potash, 82 of sea-salt, and 1·5 of carbonat of soda.

Tober Bony, in Ireland.

It contains an alkaline salt, together with a calcareous earth, and an oily or bituminous matter.

Tonstein, in the bishopric of Cologne, in Germany.

This is among the most noted waters of Germany, but we have no accurate analysis of it.

Its virtues are similar to those of the Seltzer waters, but it is more purgative.

Townley. See *Hanlridge*.

Tralee, in the county of Kerry, Ireland.

It is a chalybeate water of the nature of that of Castleconnel.

Tunbridge. The wells are situate about five miles from the town of Tunbridge, in Kent.

A wine-gallon of this water contains of oxide of iron 1 grain, muriat of soda 0·5, muriat of magnesia 2·25, sulphat of lime 1·25; of carbonic acid gas 10·6 cubic inches, nitrogen gas 4, atmospheric air 1·4.

Upminster, near Brentwood, in Essex.

This is a strong sulphureous water, impregnated with a purging salt, and carbonat of soda.

Vahls, in France.

It contains 455 grains of carbonat of lime in the gallon.

Vichy, in the Bourbonnois, in France.

There are six different sources at Vichy which vary a little in temperature, and in the proportion of the foreign contents. The taste of them all is more or less saline, and somewhat bitter, and they possess a degree of pungency to the smell. On the addition of any of the stronger acids, a copious effervescence is excited, indicating the presence of much carbonic acid. The addition of galls causes a slight change of colour to a rose-purple, but this only takes place when the water is fresh. By evaporation, these waters deposit an earth, which effervesces strongly with acids, and is therefore carbonat of lime; and yield at last a residuum, of which a part is easily crystallizable, gives a vivid green with sirup of violets, effloresces in the air, and has all the properties of carbonat of soda.

In their channel they leave a yellowish mud, which is doubtless principally oxide of iron.

All the waters of Vichy, therefore, are warm, chalybeate, and alkaline, probably, too, mixed with some earthy muriats.

The saline nature of these springs is shown in a striking manner by the great eagerness with which sheep, cows, and other animals, crowd to drink these waters, and to lick the stones and sides of the channel through which they flow. Their fondness for this beverage is so great, that at stated times they cross the Allier in numbers, swimming over the river, but without tasting it, as they so much prefer their favourite salt springs. It is found, that this water first purges them, but increases their appetite, and assists in rendering them fat and in good condition.

Walton, near Tewkesbury.

This water contains the same ingredients as that of Cheltenham. The only difference between them consists in the quantity of the purging salt in the latter being somewhat greater, while the Walton water has rather more sulphuretted hidrogen gas.

Wardrew, in Northumberland.

Between Cumberland and Northumberland, on the banks of the river Arden.

It is the coldest sulphureous water in the three northern counties. It contains sea-salt, in the proportion of about 22 grains to the gallon.

Weatherstack, in Westmoreland.

This is a weak chalybeate water, but contains a large portion of sea-salt. In the summer it smells of sulphur, but not in winter.

Wellenbrow, in Northamptonshire.

It is a slight chalybeate water, resembling that of Islington.

West Ashton, in the parish of Steeple Ashton, in Wiltshire.

It is a weak chalybeate water, resembling those of Islington and Tunbridge.

Westwood, near Tandersley, in Derbyshire.

This is a vitriolic chalybeate, somewhat resembling the Shadwell water.

Wexford, in Ireland.

It is an agreeable chalybeate water, similar in virtue to that of Islington.

White-Acre, near Trales, in Lancashire.

This is a very clear, brisk, chalybeate water.

Wigan, in Lancashire.

It is a clear chalybeate water, resembling those of Hampstead and Islington.

From the bottom rises an inflammable vapour, which takes fire at the surface on the approach of a lighted candle.

Wigglesworth, in the parish of Long Preston, in the west riding of Yorkshire, four miles south of Settle.

The water is very black, and has a strong sulphureous smell, with a saltish taste.

Wildungen, in the county of Waldeck, Germany.

This water at the fountain has a brisk subacid taste, which it loses by exposure.

It is of the same kind with that of Buch, but weaker, being one of the mildest acidulæ known.

Wirksworth, in Derbyshire.

It is a weak sulphureous water, impregnated with a purging salt, and is also chalybeate.

Witham, in Essex.

This is a chalybeate water of considerable strength, and is also impregnated with sea-salt.

Zahorovice, in Germany.

It is an acidulous water, salter, but less acid than that of Nezdenice; and is also somewhat pungent and fetid.

Waters (Spirituous, or Strong). Alcoholic liquors to which a flavour is given by infusion of herbs, distillation from fragrant vegetables, solution of essential oils, sugar, or other ingredients, have been called spirituous or strong waters. This term was formerly more generally applied than at present.

Wavellite. See Hidrargillite.

Wax is an oily concrete matter gathered by bees from plants. Proust says, that the bloom on fruit is real wax; and that it is wax spread over leaves, which prevents them from being wetted, as on the cabbage-leaf. He likewise finds it in the fecula of some vegetables, particularly in that of the small house-leek, in which it abounds. Huber, however, asserts, from his observations, that the wax in bee-hives is an artificial production, made by the bees from honey; that they cannot procure it, unless they
have honey or sugar for the p
that raw sugar affords more th

It was long considered as
some properties common to i
Like them, it furnishes an oil
by distillation, and is soluble in
in several respects it differs
resins. Like these, wax has
aromatic taste and smell, but
smell, and when pure, no tast
heat of boiling water no princ
stilled from it; whereas, wi
some essential oil, or at least
tor, is obtained from every res
wax is less soluble in alcohol.
stilled with a heat greater than
ing water, it may be decomp
so easily as resins can. By th
a small quantity of water is
from the wax, and then some
and very penetrating acid,
with a small quantity of a v
very odoriferous oil. As the d
vances, the acid becomes mo
strong, and the oil more and m
its consistence is such, that it
in the receiver, and is then cal
wax. When the distillation is
thing remains but a small qua
which is almost incombustible.

Wax cannot be kindled, un
viously heated and reduced i
in which respect it resembles f
oil of butter of wax may by re
lations be attenuated and re
and more fluid, because som
acid is thereby separated fro
stances; which effect is simi
happens in the distillation of o
oily concretes: but this rema
attends the repeated distillatio
butter of wax, that they beco
more soluble in alcohol; and
ver acquire greater consistence
tion of their more fluid parts.
kept butter of wax in a glass v
carelessly closed, during twenty
out acquiring a more solid co
may be remarked, that wax, it
its oil, differ entirely from esse
resins in all the above-mentione
and that in all these they perfe
sweet oils. Hence Macquer co
wax resembles resins only in
rendered concrete by an acid
differs essentially from these in
the oil, which in resins is of
essential oils, while in wax and
logous oily concretions (as bu
butter of cocoa, fat of animals
and myrtle-wax) it is of the na
unctuous oils, that are not arom
volatile, and are obtained fro
by expression.

It seems probable, that th
principle, or oxigen, and not an
may be the leading cause of the
low fusibility of wax. Wax is

especially as a better material than any other for candles.

Wax may be deprived of its natural yellow disagreeable colour, and be perfectly whitened by exposure to the united action of air and water, by which method the colour of many substances may be destroyed.

The art of bleaching wax consists in increasing its surface; for which purpose it must be melted with a degree of heat not sufficient to alter its quality, in a caldron so disposed, that the melted wax may flow gradually through a pipe at the bottom of the caldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands, thus placed upon the frames, ought not to exceed an inch and a half, and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favourable, the colour will be changed in the space of some days. It is then to be remelted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax is rendered perfectly white, and then it is to be melted into cakes, or formed into candles.

The yellow colour of the wax is evidently destroyed by the combined action of the air, of the water, and of the sun. As the sulphurous acid has the property of destroying still more quickly almost all the colours of vegetables. Macquer supposed, that this bleaching might be shortened by exposing ribbands of yellow wax to the vapour of sulphur, as is practised for wool and silk.

His annotator observes, that this operation of bleaching wax can be performed well in fine weather only, as it depends chiefly on the action of the sun. This circumstance being attended with much inconvenience to the manufacturers, the discovery of a method of whitening wax, independently of the seasons, would be very useful, and has been recommended to the attention of chemists by some œconomical societies.

With a view to discover such a method, Mr. Beckmann has made experiments, an account of which is published in the 5th volume of the Novi Commentarii Societatis Regiæ Scientiarum Gottingensis. According to these experiments, thin pieces of yellow wax were whitened and hardened by being digested and boiled in diluted and undiluted nitric acid in a few hours. But the wax thus whitened, being melted by means of boiling water, was observed to acquire a yellow colour, less intense, however, than it was before it had been treated with the acid. The muriatic and sulphuric acids were less effectual than the nitric. He exposed wax to the flames of burning sulphur, but without success. Yellow wax being melted in vinegar was rendered of a gray colour. The oil of tartar whitened wax, but less effectually than acids had done; and this wax being washed in water, and afterward digested in nitric acid, was rendered still more white; but upon melting it in water a yellowish tinge returned. He liquefied wax in solutions of nitre and alum, but without any good effect. Alcohol, which is recommended by Boyle for this purpose, did indeed whiten the wax, but changed it to a butyraceous substance, so frothy, that its bulk was increased thirty times. Reflecting that tartar is purified from its oily particles by means of a calcareous earth, he tried the effects of a kind of fuller's earth, which he threw upon wax liquefied in water, and he agitated the mixture. This method rendered wax of a grayish colour, and is therefore recommended by him as preparatory to bleaching, the time necessary for which, he thinks, may be thus greatly shortened.

Every kind of wax is not equally capable of being whitened, the colour of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation Macquer received from Mr. Trudon, proprietor of the manufactory of wax at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy: but it is only used externally, mixed with other substances. It is an ingredient in many pomatums, cerates, ointments, and plasters, to most of which it gives their due consistence.

WEIGHTS. For a table of weights see BALANCE. It would certainly be very advantageous for science, if all chemical operations were made with weights decimally divided. For though the absolute quantities used by philosophers in different nations would not by this means be known, yet the proportional results would be every where the same. As the writings of the French chemists frequently convey accounts of weight in pounds, marks, gros, and grains, it may be useful in this place to observe, that

The Paris pound contains 2 marks, and is to the English troy pound as 21 to 16. It is equal to 7560 troy grains.

The Paris mark contains 8 Paris ounces.

The Paris ounce contains 8 Paris drachms or gros, and is equal to 472½ troy grains.

The Paris drachm or gros contains 3 Paris scruples, or deniers, and is equal to 72 Paris grains, or to 59½ troy grains.

The Paris scruple or denier contains 24 Paris grains, and is equal to $19\frac{11}{16}$ troy grains.

The Paris grain is the $\frac{1}{9216}$ part of a Paris pound, and is to the troy grain as 7560 to 9216.

The unit of the decimal system of new weights of France, now generally used by the French chemical writers, is the gramme, which is equal to 15·445 English grains.

Weld, *or* **Woald** (reseda luteola, Lin.), is a plant cultivated in Kent, Herefordshire, and many other parts of this kingdom. It is likewise very common in the environs of Paris, in most of the French provinces, and in a great part of the rest of Europe. It pushes out long narrow leaves, of a lively green: from the midst of these leaves the stalk rises to the height of three or four feet, frequently branchy, and furnished with leaves, narrow like the radical ones, but shorter as they approach the flowers, which are disposed in long spikes. The whole of the plant is used for dyeing yellow: though some assert, that the seeds only afford the colouring matter.

Two sorts of weld are distinguished: the bastard, or wild, which grows naturally in the fields; and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the latter is preferred, it abounding more in colouring matter. The more slender the stalk, the more it is valued.

When the weld is ripe, it is pulled, dried, and made into bundles, in which state it is used.

When the decoction of weld is very strong, it has a yellow colour inclining to brown: if it be greatly diluted with water, its yellow, which is more or less pale, inclines a little to green.

If a little alkali be added to this decoction, its colour grows deeper, and after a certain time, a little ash-coloured precipitate falls down, which is not soluble in alkalis.

Acids in general render its colour paler, and occasion a little precipitate, which will dissolve in alkalis, giving them a yellow colour inclining to brown.

Alum forms with it a yellowish precipitate, and the liquor retains a fine lemon-colour. If a solution of alkali be poured into this liquor, a whitish yellow precipitate, soluble in alkalis, is thrown down, but the liquor still remains coloured.

Solution of common salt, or of sal ammoniac, renders the liquor turbid, and its colour at first a little deeper; by degrees a deep yellow precipitate forms, and the supernatant liquor retains a pale yellow colour, a little inclining to green.

Solution of tin produces a copious bright
yellow precipitate: the liqu
long time turbid, but slightly

Sulphat of iron produces a
gray precipitate, and the supe
is brownish.

Sulphat of copper occasio
green precipitate, and the li
a pale green colour.

The yellow communicate
weld has little permanency, i
not previously prepared by
For this purpose alum and t
by means of which this plan
pure yellow, which has the
being permanent.

For the boiling, which i
the common way, Hellot dire
of alum to every pound of v
one ounce of tartar: many d
use half as much tartar as
renders the colour paler, but

For the welding, that is,
with weld, the plant is boi
bath, enclosing it in a bag of
keeping it from rising to the
of a heavy wooden cross. S
it till it sinks to the bottom
and then let a cross down up
when it is boiled, take it o
and throw it away.

Hellot directs five or six p
for every pound of cloth; bu
use so much, contenting th
three or four pounds, or ev
Many indeed add to the weld
lime and ashes, which favour
of the colouring matter, an
colour, but at the same time
to be changed by the action
quantity of weld, however, ou
portionate to the depth of t
obtained.

Lighter and brighter shade
tained by dyeing after deeper
water at each dipping, and ke
boiling: but light shades p
way are not so lively as wh
are used, proportioning the qu
to the depth of the shade.

Common salt added to t
renders its colour richer and
phat of lime, or gypsum, als
but alum renders it paler and
and tartar still paler. Sulphat
it incline to brown.

The shades obtained from
modified by such additions, b
tion of the weld, by the leng
ration, and by the mordants
preparing the stuff. Thus
that by boiling the wool two
fourth its weight of solution c
same of tartar, washing it a
fifteen minutes with an equ
weld, it will take a fine ye
however, will not penetrate
texture. Mr. Poerner also di
to be prepared as for dyeing

these means greater brightness and permanency are given to the colour, which, *cæteris paribus*, is at the same time lighter.

The colour may be modified also by passing the cloth, when it comes out of the dye, through another bath. Thus, to produce a golden yellow, the cloth, when it comes out of the welding, may be passed through a slight madder-bath; and for a tawny, through a bath made with a little soot.

To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterward alumed and refreshed, that is, washed after the aluming.

A bath is prepared with two pounds of weld for each pound of silk, which after a quarter of an hour's boiling is to be passed through a sieve or cloth into a vat: when it is of such a temperature as the hand can bear, the silk is put in, and turned till the colour is become uniform: during this operation the weld is boiled a second time in fresh water; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former; too great a degree of heat, however, must be avoided, that no part of the colour already fixed may be dissolved; it is to be turned as before, and in the mean time a quantity of the ashes of wine-lees is to be dissolved in a part of the second decoction; the silk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast: if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it deeper. In this way the process is to be continued, until the silk has attained the desired shade; the alkaline solution may also be added along with the second decoction of the weld, always taking care, that the bath is not too hot.

If we wish to produce yellows with more of a gold or jonquille colour, a quantity of anotta proportioned to the shade required must be added to the bath along with the alkali.

For the light shades of yellow, such as pale lemon or canary-bird colour, the silk ought to be scoured as for blue, because the shades are more beautiful and transparent in proportion as the ground on which they are laid is whiter: the strength of the bath is proportioned to the shade we wish to obtain; and if we intend, that the yellow should have a tinge inclining to green, more or less of the indigo vat is added, if the silk has not been azured. To prevent the shades from being too deep, the silk may be more slightly alumed than usual.

Scheffer directs, that the silk should be soaked twenty-four hours in a solution of tin, made with four parts of nitric acid, one of common salt, and one of tin, and saturated with tartar; that it should be washed, and boiled half an hour with an equal quantity of weld flowers. He says, that a fine straw-colour is thus obtained, which possesses the advantage of resisting the action of acids. By following this process, very little tin can remain in the solution, because the acid of tartar precipitates it.

In dyeing cotton yellow, we begin by scouring it in a bath prepared with the ley of the ashes of green wood: it is then washed, dried, and alumed with one fourth of its weight of alum; after twenty-four hours it is taken out of the aluming, and dried without being washed. A weld bath is then prepared, with the proportion of a pound and a quarter of weld for each pound of cotton; in this the cotton is dyed, by being turned and wrought in it until it has acquired a proper shade; it is taken out of this bath to be soaked for an hour and a half, in a solution of sulphat of copper, in the proportion of one fourth of the weight of the cotton; it is then thrown, without being washed, into a boiling solution of white soap made with the same proportions: after being well stirred, it is boiled in it for nearly an hour, then well washed and dried.—*Berthollet.*

A water-colour, called weld-yellow, is much used by paper-hanging manufacturers. This is the colouring matter of weld precipitated with an earthy base. The following is given in the Philosophical Magazine as a method of preparing it very fine:—Into a copper vessel put four pounds of fine washed whiting and as much soft water, and boil them together, stirring them with a deal stick, till the whole forms a smooth mixture: then add gradually twelve ounces of powdered alum, still stirring, till the effervescence ceases, and the whole is well mixed. Into another copper put any quantity of weld, with the roots uppermost, pour in soft water enough to cover every part containing seed; let it boil, but not more than a quarter of an hour; take out the weld, and set it to drain; and pass the whole of the liquor through flannel. To the hot mixture of earth and water add as much of this decoction as will produce a good colour, keep it on the fire till it boils, and then pour out into a deal or earthen vessel. The next day the liquor may be decanted, and the colour dried on chalk.

WELTER'S TUBE. See TUBE OF SAFETY.

WERNERITE. This mineral was discovered and described by Dandrada, who named it after the celebrated Werner, by whom it is called *arctizite*. It is sufficiently hard to scratch glass, and strikes fire with steel. Before the blowpipe it froths, and melts into a white enamel. Its powder phosphoresces when heated. Its fracture is raggedly foliated; its colour a greenish gray, or olive green; its specific gravity 3·6063.

Its crystals are low equiangular octaëdral prisms, terminated by flat quadrilateral pyramids. Its primitive form appears to be a rectangular prism with square bases.

It is a rare mineral, and has only been found at Bouwen, near Arendahl, in Norway; in the mines of Nortbo and Ulrica, in Sweden; and at Campo Longo, in Swisserland. It occurs in rocks composed of red or gray feldspar mingled with quartz, in which it is disseminated in crystals, or in irregular grains.

We know not of any analysis of it.—*Thomson.—Brongniart.*

Wheat. The first part of the preparation of farinaceous seeds to be used as food, consists in mechanical trituration; after which, by the addition of water, and the subsequent action of heat, bread and other well known compounds are formed. Wheat is found by experience to be the most nutritive of vegetable matters, and upon chemical examination it proves to possess more of the gluten, or vegeto-animal matter, than any other substance of this class. Messrs. Beccari, an Italian physician, and Kessel Meyer, in Germany, are the first chemists who attempted to separate the different principles of which farina consists. Messrs. Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, have prosecuted these researches much farther than the above-mentioned naturalists. Mr. Parmentier especially has prosecuted them with very uncommon zeal and industry.

In performing this analysis, a paste is first to be composed of the farina with water; the paste must then be kneaded in an earthen vessel, with water pouring upon it from a cock; the fluid as it falls upon the paste takes up from it a very fine white powder, by means of which it acquires the colour and consistency of milk; let this process be continued till the water runs off clear. The farina is now found to be naturally separated into three distinct substances—a gray elastic matter, constituting about one fifth of the whole, that sticks to the hand, and on account of its properties has gained the name of gluten; a white powder, amounting to about three fifths, which falls to the bottom of the water, and is the feculum or starch; and a matter which remains dissolved in the water, and seems to be a sort of mucilaginous extract. This contains some saccharine matter, and a little phosphat of lime: and Dr. Thomson says, that it appears to contain a small portion of the bitter principle.

If wheat be gently pressed between two heated plates of iron an oily empyreumatic fluid exudes from it. We do not know, that this has ever been examined: but we are told in the Annals of Medicine, that it is very pungent, and that it is a very efficacious application for tetters and other
cutaneous affections. See Brea
Starch.

Whetstone. A general
artists and manufacturers for s
are used to sharpen tools. I do
that it is peculiarly appropriat
Turkey-stone, hone, oil-stone,
lishing gray or blue argillaceo
which are very different in th
from each other.

Whey. The fluid part of
remains after the curd has bee
See Milk. It contains a saccha
some butter, and a small portio

White Copper. See Tute

White, Spanish, and W
See Ceruse.

Whiting. Chalk cleared o
impurities, then ground in a m
up into small loaves, is sold und
of whiting.

Willow. The leaves of th
mentioned by Scheffer, as prop
a fine yellow colour to woo
thread. Bergman asserts, tha
of the sweet willow (laurier
pentandra, should be employe
the leaves of the common w
colour, which is for the mo
charged by the sun in a few w

Scheffer directs, that the
be left a whole night in a cold
three ounces of alum and one
tar to the pound. The boiling
leaves gathered about the end
beginning of September, dried
but airy place: as much of
thought proper is boiled for h
and half a drachm of white pot
pound is added, to render the
bright and deep, and the ba
through the sieve; it is kept n
and the wool left in it until it
desired colour. He directs th
cess for silk, and for thread, ex
proportion of alum is increa
per pound. According to B
count, Mr. Alstroemer has ob
the colour was rendered riche
the thread with six ounces of a
ing and drying it before bein
that half an ounce of pot-ash p
required for the complete extr
colouring matter.

The barks of several species
pentandra, fragilis, caprea, v
amygdalina, have been reco
substitutes for that of cinchon
been said by several authors to
success.

Wine. Chemists give the n
in general to all liquors that
spirituous by fermentation.
beer, hydromel or mead, and
liquors, are wines.

The principles and theory of
ation which produces these liqu
tially the same. The more ge

ples we have explained under the article FERMENTATION.

All those nutritive, vegetable, and animal matters, which contain sugar ready formed, are susceptible of the spirituous fermentation. Thus wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugivorous animals; and lastly, it may be made of all ripe succulent fruits; but all these substances are not equally proper to be changed into a good and generous wine.

As the production of alcohol is the result of the spirituous fermentation, that wine may be considered as essentially the best, which contains most alcohol. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly in the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines, that have a more agreeable, that is, more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France: at least, from these latter wines the best vinegar and brandy are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France.

This juice, when newly expressed, and before it has begun to ferment, is called must, and in common language sweet wine. It is turbid, has an agreeable and very saccharine taste. It is very laxative; and when drunk too freely, or by persons disposed to diarrhœas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried.

When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature between fifty-five and sixty degrees, very sensible effects are produced in it, in a shorter or longer time according to the nature of the liquor, and the exposure of the place. It then swells, and is so rarefied, that it frequently overflows the vessel containing it, if this be nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise and evident ebullition. The bubbles rise to the surface, and at the same time is disengaged a quantity of carbonic acid of such purity, and so subtle and dangerous, that it is capable of killing instantly men and animals exposed to it in a place where the air is not renewed. The skins, stones, and other grosser matters of the grapes are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a scum or soft and spongy crust, that covers the whole liquor. During the fermentation this crust is frequently raised, and broken by the air disengaged from the liquor which forces its way through it; afterward the crust subsides, and becomes entire as before.

These effects continue while the fermentation is brisk, and at last gradually cease: then the crust, being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place.

After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drunk moderately.

If we examine the wine produced by this first fermentation, we shall find, that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of must, but affects the head, and occasions, as is well known, drunkenness. Lastly, if it be distilled, it yields, instead of the insipid water obtained from must by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor called spirit of wine, or alcohol. This spirit is consequently a new being, produced by the kind of fermentation called the vinous or spirituous. See ALCOHOL.

When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time, otherwise the fermentation would probably be very quickly completed, and the appearances would be much more striking: hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous than in another liquor less disposed. Experience has shown, that a wine the fermentation of which is very slow and tedious, is never good or very spirituous; and therefore, when the weather is too cold, the fermentation is usually accelerated by heating the place in which the wine is made. A proposal has been made by a person very intelligent in economical affairs, to apply a greater than the usual heat to accelerate the fermentation of the wine, in those years in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation.

A too hasty and violent fermentation is perhaps also hurtful, from the dissipation and loss of some of the spirit: but of this we are not certain. However, we may distinguish in the ordinary method of making wines of grapes, two periods in the fermentation, the first of which lasts during the appearance of the sensible effects above mentioned, in which the greatest number of fermentable particles ferment. After this first effort of fermentation, these effects sensibly diminish, and ought to be stopped for reasons hereafter to be mentioned. The fermentative motion of the liquors then ceases. The heterogeneous parts, that were suspended in the wines by this motion, and render it muddy, are separated, and form a sediment called the lees; after which the wine becomes clear: but though the operation is then considered as finished, and the fermentation apparently ceases, it does not really cease; and it ought to be continued in some degree, if we would have good wine.

In this new wine a part of the liquor probably remains, that has not fermented, and which afterward ferments, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation therefore still continues in the wine, during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the imperceptible fermentation. We may easily perceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous, namely, the separation of the acid salt called tartar from the wine. This matter is therefore a second sediment, that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it is evident, that the wine, which by means of the insensible fermentation has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason chiefly old wine is universally preferable to new wine.

But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles, or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation.

We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known, that these wines make the corks fly out of the bottles, that

they sparkle and froth whe
into glasses, and lastly, t
taste much more lively a
than wines that do not
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picious to health, as they occasion most terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, should, for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners and murderers of the public. At Alicant, where very sweet wines are made, it is the practice, to mix a little lime with the grapes before they are pressed. This, however, can only neutralize the acid already existing in the grape.

If wine contain litharge, or any other oxide of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small button of lead may be found after the fusion: but an easier and more expeditious proof is by pouring into the wine some liquid sulphuret. If the precipitate occasioned by this addition of the sulphuret be white, or only coloured by the wine, we may know, that no lead is contained in it: but if the precipitate be dark coloured, brown, or blackish, we may conclude, that it contains lead, or iron. The following test by Hahnemann, however, precipitates only lead and copper black, arsenic of an orange colour, and does not throw down iron.

Mix equal parts of oyster shells and crude sulphur in fine powder, put them into a crucible in a wind furnace, bring it suddenly to a white heat, and keep it thus a quarter of an hour. When cold powder, and keep in bottles closely stopped. Into a strong bottle put two drachms of this powder, and as much cream of tartar; fill the bottle with water; boil it for an hour, and let it cool; stop the bottle close, shake it well for some time, and then let it settle. Decant the clear liquor into ounce phials, into which 20 drops of muriatic acid have been previously put; and stop them very close with wax, softened with a small portion of turpentine. One part of this liquor, mixed with three of wine, will show the least trace of lead, copper, &c. by a very sensible black precipitate.

The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is very little acid, and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste.

From what is here said concerning the acescency of wine, we may conclude, that when this accident happens, it cannot by any good method be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar makers, as all honest wine merchants do. It may be observed, that the first sensible fermentation having been too far advanced is not the only cause of the acidity of the wine, but that heat also is capable of producing the same effect. Thus wine, which might have been long preserved in a cool place, very quickly becomes sour when placed in a bad cellar; and even as the best cellars have during the winter a degree of heat much superior to that of the atmosphere, it would be very proper, when wine disposed to become sour is to be preserved, to bring it from the cellar in the beginning of winter, and leave it exposed to the air during all that season.

Wine is also liable to various other changes; such as to become ropy and mucilaginous, by the continuance of the fermentative motion: but these details would require an express treatise.

Wine, and the matters produced from wine, as brandy, spirit of wine, vinegar, lees of wine, tartar, are greatly and extensively useful. The lees of wine are employed in the manufacture of hats. These lees, and also tartar, by incineration, yield a larger quantity than any other vegetable matter of pure fixed alkali.

Wine has been preferred in all times and in all countries to every other alimentary liquor. We may say in general, that it is good and salutary when taken in small quantities, and that it is pernicious when drunk habitually and in too large quantities. Wine becomes then a true slow poison, which is so much more dangerous, as it is more agreeable. But if we observe more particularly the effects of wine, we shall perceive very great differences depending on different constitutions. Some persons drink habitually large quantities of pure wine, without any sensible inconvenience or disease, or apparently shortening their lives: but, on the contrary, many others do also entirely destroy their health and shorten their lives by an habitual use of wine even in small quantity, and mixed with water;—although it is always more safe and prudent for every person to drink little of it habitually, and this moderation is more indispensably necessary to those whose constitutions wine does not suit.

As the diseases consequent upon the too free use of wine come on gradually and insensibly, sometimes even during many years, several persons, especially men otherwise very sober and attentive to health, are every day deceived in this article, drinking more wine than is suitable to their constitution, and gradually ruining their health, without knowing the cause. It is therefore a matter of importance, to show the signs by which wine may be known to be hurtful.

We may know that wine does not suit a person, when, after drinking moderately of it, his breath acquires a vinous smell; when it occasions sour belchings and slight pains in the head; and when, after drinking it more copiously than usual, it produces stupefaction, nausea, and drunkenness, especially when this drunkenness is of the morose, peevish, quarrelsome, and irascible kind. Unhappy is that person who suffers these effects from wine, and notwithstanding persists in the habitual use of it. These imprudent persons never fail of coming to a miserable death, preceded by languor; and premature, their common age being about fifty years, or a little more. The diseases to which they are most subject are obstructions in the liver, in the mesenteric glands, and in other abdominal viscera, which are almost always succeeded by an incurable dropsy. Those who digest wine well do not suffer, or much less sensibly, the above-mentioned effects of drinking it. Their drunkenness is accompanied with vivacity and joy. Such persons seldom die of the obstructions and dropsy above mentioned: but wine is nevertheless so much more dangerous to them, that, as they suffer none of the disagreeable effects, they are more liable to contract the habit of drinking too much. Drinkers of this class generally live somewhat longer than the former; but their constitution generally changes before sixty years of age; and the inheritance of their old age is either a severe gout or palsy, stupidity, imbecility, or an accumulation of these diseases.

We need not mention that the too frequent use of brandy, liqueurs as they are called, or cordials, and other spirituous liquors, is still more pernicious and fatal than that of wine.

Wine is used in medicine as a vehicle in the composition of many internal and external remedies. As wine is composed of alcohol, water, extractive saponaceous matter, and acid of tartar, it may be very usefully employed for the extraction of almost all the proximate principles, and consequently of the medicinal parts, of vegetables. Many extracts are made with wine, which may be considered as being more complete than those made with water: but physicians who prescribe these extracts ought to remember, that, beside the principles of the vegetables, they also contain the extractive part of the wine, that is, all the principles of wine, excepting the alcohol, which is too volatile to remain in an extract.

As wine when good may be preserved during a long time, several medicinal wines prescribed in dispensatories are kept in the shops of apothecaries. In many cases, as in several chronical diseases, where tonic, cordial, fortifying, and exciting remedies are indicated, physicians prefer the use of wine to water, as a vehicle for the infusion of purgative, aperitive, and other medicinal substances. See Alcohol.

Witherite. The native carbonat of barytes.

According to the analysis of Klaproth its component parts are,

Carbonat of barytes	-	98·246
———— of strontian	-	1·703
Alumine with iron	-	0·043
Carbonat of copper	-	0·008
		100·000

Woad, Isatis, Glastum, is a plant with long green leaves, the lower ones narrow at both ends; those which grow upon the stalk broad at bottom, like the head of an arrow. On the tops come forth numerous yellow flowers, which are followed by little flat pods containing the seeds. It grows wild in some parts of France, and on the coasts of the Baltic sea: the wild woad, and that which is cultivated for the use of the dyers, appear to be the same species of plant.

The preparation of woad for dyeing, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc.—The plant puts forth at first five or six upright leaves about a foot long and six inches broad; when these hang downwards, and turn yellow, they are fit for gathering: five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan-mills, and ground into a smooth paste. If this process were deferred for some time, they would putrefy, and send forth an insupportable stench. The paste is laid in heaps pressed close and smooth, and the blackish crust, which forms on the outside, reunited if it happen to crack: if this were neglected, little worms would be produced in the cracks, and the woad would lose part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, and the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun they turn black on the outside, in a close place yellowish, especially if the weather be rainy. The dealers in this commodity prefer the first, though it is said the workmen find no considerable difference between the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and, when rubbed, of a violet colour within.

For the use of the dyer these balls require a farther preparation; they are beaten with wooden mallets, on a brick or stone floor, into a gross powder, which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder moistened with water ferments, grows hot, and throws out a thick fetid fume. It is shovelled backward and forward, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures of different shades to water, to alcohol, to ammonia, and to fixed alkaline lixivia; rubbed on paper, it communicates a green stain. On diluting the powder with boiling water, and, after standing for some hours in a close vessel, adding about one twentieth its weight of lime newly slaked, digesting in a gentle warmth, and stirring the whole together every three or four hours, a new fermentation begins; a blue froth rises to the surface, and the liquor, though it appears itself of a reddish colour, dyes woollen of a green; which like the green from indigo changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

Astruc proposes the manufacturing of fresh woad leaves in Europe, after the same manner as the indigo plant is manufactured in America, and thus preparing from it a blue fecula similar to indigo, which from his own experiments he has found to be practicable. Such a management would doubtless be accompanied with some advantages, though possibly woad so prepared might lose those qualities, which now render it in a large business preferable on some accounts to indigo, as occasioning greater dispatch when once the vat is ready, and giving out its colour less hastily, so as to be better fitted for dyeing very light shades.

Hellot suspects, that a like blue fecula is procurable from many other vegetables. Blue and yellow blended together compose a green: he supposes the natural greens of vegetables to be compounded in like manner of these two colours; and that the blue is oftentimes the most permanent, so as to remain entire, after the putrefaction or destruction of the yellow. The theory is specious, and perhaps just; we know of no other that accounts in any degree for the production of the indigo and woad blue. In the experiments however, which Dr. Lewis made, of putrefying different herbs in water, the blue and the yellow colour, if the green were really composed of these, were both destroyed together; no appearance being observed either of one or the other during the whole process.

Wolf. This name was given by the alchemists to the sulphuret of antimony, because, to use their words, by its ferocious nature it consumes all metals, except the lion, or gold. Thus it was sometimes used to separate the baser metals from gold, by heating them together, when it carried off the base metals, while part of it combined with the gold. This was separated by oxidizing the gold by heating it with nitre.

Wolfram. See Tungsten.

Wood. See Vegetables.

Wood-Lice. See Millepedes.

Wood-Sorrel. See Acid (Oxalic).

Wood-Stone. The name of *holz-stein*, or wood-stone, has been given by Werner to that siliceous stone, which is commonly considered as petrified wood, the agatized wood of French writers. Werner makes it a third subspecies of hornstone, the other two being the conchoidal hornstone, and splintery hornstone.

It occurs in sandy loam, or sandstone; is of various colours, from ash gray, pearl gray, or yellowish gray, to ochre yellow, pale red, deep red, or brown red; not in general singly, but mixed in clouds or streaks; and exhibits the appearance of trunks or branches of trees, even in their internal structure. The hones from Loch Neagh, in Ireland, are of this substance.

Wood-Tin. A tin ore of a brown colour, containing

Oxide of tin	-	91
Oxide of iron	-	9
		100.

Wood (Rock). The ligniform asbestus.

Wool. The principal differences in wool consist in the length and fineness of its filaments. That which has the finest filaments is reserved for fine cloths. The most beautiful wool is brought to us from Spain. It is said that the highland wool of Scotland is equal in quality to this. Mr. d'Aubenton has shown, that it may be produced in France of a quality not inferior to that of Spain, by folding the sheep through the whole year, and choosing the rams with care. Lately the breed of Merino, or fine woolled Spanish sheep, has been introduced into this country by his majesty, and found to retain the excellent qualities of the fleece. It has likewise been crossed with our own breeds with advantage, so that we may hope to become independent of Spain for fine wool.

Simple inspection may easily lead to errour respecting the fineness of wool, which it is important the manufacturer should know with accuracy; and Mr. d'Aubenton has proposed a method of attaining this accuracy, by employing a micrometer for comparing, by means of a microscope, the fineness of the wool to be examined with that of other wools chosen as standards.

Though the long wool is not so fine as the Spanish, and cannot be employed for fine cloths, it is still very useful for a variety of fabrics; and as the sheep which produce it have much larger fleeces, the profit they bring is not inferior to that of the fine woolled sheep; besides, the cloths made of their wool, being cheaper, have a much more extensive sale. The prosperous state of the woollen manufactures of England is partly owing to our abundance of this wool. But the breed of sheep which produces one or the other kind of wool is connected with the nature of their pasture, which ought to determine us in the choice of them.

Wool is naturally covered with a kind

of grease, which preserves it from moths. Reaumur has observed, that a stuff may be preserved from these insects, by rubbing it with greasy wool. Hence wool is not scoured till it is about to be dyed or spun.

In order to scour wool, it is put for about a quarter of an hour into a kettle, containing a sufficient quantity of water, mixed with a fourth of putrid urine, heated to such a degree as the hand can just bear, and it is stirred from time to time with sticks; it is then taken out and put to drain: it is next carried in a large basket to a stream of running water, where it is moved about till the grease is entirely separated, and no longer renders the water turbid; it is then taken out and left to drain. It sometimes loses in this operation more than a fifth of its weight. The scouring should be carefully performed, because the wool is thereby better fitted to receive the dye.

The ammonia or volatile alkali, formed in putrid urine, has been supposed to unite with the grease, producing a kind of soap, which is soluble in water. But Vauquelin thinks, if any thing in the urine have an effect upon the grease, or yolk as the French call it, it is the uree. Fresh urine will not answer, on account of the acid it contains. According to him, soapsuds are the best menstruum for scouring wool, after simple water has washed off all it can remove. He observes too, that wool kept too long in its grease swells, splits, and is weakened.

The wool is dyed in the fleece, or before it is spun, chiefly when it is intended to form cloths of mixed colours; or else it is dyed after being spun, and it is then intended principally for tapestry; but it is most commonly dyed after having been wrought into cloth.

When wool is dyed in the fleece, its filaments being separate absorb a larger quantity of the colouring particles than when it is spun; for the same reason woollen yarn takes up more than cloth; but cloths themselves vary considerably in this respect, according to their degree of fineness, or the closeness of their texture: besides, the variety in their dimensions, the different qualities of the ingredients employed in dyeing, and a difference of circumstances in the process, prevent us from relying upon the precise quantities we find recommended for the processes described. This consideration may be extended to all dyes.

For most colours, wool requires to be prepared by a bath, in which it is boiled with saline substances, principally with alum and tartar: but there are some dyes for which the wool does not require such a preparation; then it must be well washed in warm water, and wrung out or left to drain. This is a general rule, which should be observed with respect to all the substances intended to be dyed, in order that the colour may penetrate them more easily, and be distributed more uniformly.

Mr. Monge has explained the operation of felting, and the effects of fulling, by the external conformation of the wool and hair of animals. He has made some curious observations on this subject, of which the following are the chief:

Nothing particular can be discovered by means of the microscope in the filaments of wool or in the hairs of animals; yet the surfaces of these bodies are not smooth: they must be formed either of small laminæ placed over each other in a slanting direction from the root toward the point, like the scales of fish, which cover each other from the head of the animal to the tail, or more probably, perhaps, of zones placed one upon another as we see in the horns of animals.

If a hair be laid hold of by the root in one hand, and drawn between the fingers of the other, from the root towards the point, scarce any friction or resistance is perceived, and no noise is heard; but if, grasping it by the point, it is passed in the same manner between the fingers of the other hand, from the point toward the root, a resistance is felt, which did not take place in the former place, and a tremulous motion is perceptible to the touch, and a noise sensible to the ear.

We perceive then, that the texture of the surface of hair is not the same from the root toward the point, as it is from the point toward the root, and that a hair when pressed must meet with greater resistance in sliding or moving toward the point than toward the root; but as it is this texture itself which forms the principal subject of Mr. Monge's memoir, it is necessary to confirm it by some farther observations.

If, after having laid hold of a hair between the thumb and fore-finger, we rub them against each other in the longitudinal direction of the hair, it acquires a progressive motion in that direction toward the root. This effect depends neither on the nature of the skin of the finger, nor on its texture; for if the hair be turned, so that the point shall be placed where the root was before, its motion will now be in an opposite direction, that is, it will still be toward the root.

These observations, to which Mr. Monge adds some others, are related of human hair, taken as an example; but they are equally applicable to the filaments of wool, to horse-hair, and to that of animals in general. The surface of all these bodies then is formed of rigid laminæ, laid upon each other like tiles, from the root to the point, which allow a progressive motion in the direction of the root, but oppose one in the direction of the point.

This structure is the principal cause of the disposition to felting, which the hair of animals generally possesses: the hatter, by striking the flocculi of wool with the string of his bow, detaches and disperses in the air each of the filaments separately; these fall back one upon another in all directions on the table, where they form a layer of a certain thickness; the workman then covers them with a cloth (I suppose linen), upon which he presses on all parts with his hands extended.

The pressure brings the filaments of wool nearer to each other, and multiplies the points of contact; the agitation gives each of them a progressive motion in the direction of its root, by means of which they entangle each other; and the laminæ of each filament taking hold of those of the other filaments, which are in an opposite direction, the whole is retained in the state of close contexture, which it had acquired by the pressure.

In proportion as the texture becomes closer, the pressure of the hands ought to be increased, both in order to make it still more compact, and to keep up the progressive motion and intermixture of the filaments, which now meet with greater resistance: but during the whole of this operation, the filaments of wool lay hold of each other only, and not of the cloth, the fibres of which, as has been already observed, are smooth, and have not the same properties in this respect.

The aptitude for felting in wool and hair does not depend entirely on the structure of their surface; it is not enough, that each filament should have a progressive motion in the direction of its root; nor that the inclined laminæ, by laying hold of each other, should retain the contexture in the state to which it has been reduced by compression: it is also necessary, that the filaments should not be straight like needles; for, by a continuance of the motion and pressure, each of them would continue its course progressively, without changing its direction, and the effect of the operation would be to remove them all from the centre, without producing any contexture. It is therefore necessary, that each filament should be crooked, so that the extremity nearest the root should be disposed to change its direction continually, to entwine itself round fresh filaments, and to return back upon itself, if it should be so determined by any change in the position of the rest of its length.

Wool, possessing this structure naturally, is peculiarly fitted for this kind of work, and may be employed in it, without being subjected to any previous preparation; but the furs of rabbits, hares, and beavers, are naturally straight, and cannot be employed alone for felting, without having undergone a previous operation, which consists in rubbing them, before they are stripped, with a brush moistened with a solution of mercury in nitrous acid; this liquor, by acting only on one side of the hairs, changes their rectilinear direction, and communicates to them that disposition for felting, which wool naturally possesses.

The operation of fulling woollen stuffs depends on the same property as felting.

The asperity of the surface of the filaments of wool, and their disposition to acquire a progressive motion in the direction of the root, form an obstacle to the spinning of wool, and the working it into stuffs. All the filaments must therefore be covered with a coat of oil, which, by filling the cavities, renders the asperities less sensible; just as a coat of oil renders a fine file still smoother. When the piece of stuff is wrought, it must be freed from that oil, which gives it a disagreeable smell, renders it dirty, and would prevent it from taking the colour we wish to dye it: for this purpose, it is taken to the fulling-mill, where it is beaten with large beetles in a trough of water, through which some clay has been diffused. The clay uniting with the oil, renders it soluble in the water, and both are carried off together, by fresh water brought thither by the machine; and after some time, the stuff is found clean scoured. See EARTH (FULLER'S).

But scouring is not the only object in fulling; the alternate pressure of the beetles on the stuff, particularly when the scouring is advanced, produces an effect analogous to that of the pressure of the hatter's hands; the filaments of wool, which compose a thread of the warp or of the woof, acquire a progressive motion, insinuate themselves into the adjoining threads, then into those which are next, and presently all the threads, both of the warp and woof, are felted together. The stuff is now found contracted in length and breadth, and participates both of the nature of cloth and of felt; it may be cut without being subject to ravel, and there is no necessity for hemming the different pieces of it employed to make a garment. If it be common woollen stocking web, the stitches are now no longer subject to run, when one of them happens to slip; finally, the threads of the warp and the woof are now no longer so well defined, or so distinct from each other; and the stuff being also thickened forms a warmer clothing.

Berthollet obtained a large proportion of acid of sugar by abstraction of nitric acid from wool.

If wool be boiled with pure weak alkali, it is dissolved, with the escape of ammonia, and forms a soap, likely to be of use in the arts. See SOAP OF WOOL.—*Mém. de l'Acad.* —*Berthollet on Dyeing.*—*An. de Chim.*

WOOTZ. The metal extracted from some kind of iron ore in the East Indies, apparently of good quality. It contains more carbon than steel, and less than cast iron, but from want of skill in the management is far from homogeneous.—*Phil. Trans.*

WORMS. See EARTH WORMS.

shops. It does not differ from other alkalis when purified. The leaves of wormwood are intensely bitter, and have a strong and somewhat aromatic smell. They yield, ac- extract.

Wort. The infusion of malt, before it is made into beer by fermentation. See Beer.

Y.

YANOLITE. See Thummerstone.

Yeast. The use of yeast in promoting the vinous fermentation appears to be in some respect that of rendering the process more uniform through a considerable mass. But the chief efficacy of its action does not seem to be well understood. Bodies remain unchanged so long as the elective attractions are satisfied, or in equilibrio. Chemical operations are effected in no other way than by disturbing this state of repose, which may be done, either by mere change of temperature, or by the addition of some other principle. Thus an ignited coal may be considered as the ferment, by which a large quantity of combustible matter may be made speedily to change its state of combination throughout. And so likewise it may be conceived, at least hypothetically, that the addition of a body considerably changed by the fermentative process may hasten the commencement of a similar change in a larger mass, more especially since the fermentative process is of the nature of combustion. See Fermentation.

The following mode of making yeast is practised in Germany and Sweden:—To one hundred pounds of the best malt, consisting of one part of malted wheat and two parts of malted barley, dried in the open air and well ground or bruised, add ten pounds of good hops, and brew the mixture with three hundred and fifty pounds of water, to form wort, in the common way. After a short boiling separate the grains and hops from the wort, which last by continual boiling may be reduced to the half, or one hundred and seventy-five pounds. Cool it down as soon as possible to 70° Fahr., and mix it with thirty-two pounds of good yeast, which this first time may be common brewer's yeast, but in every subsequent operation the artificial. The wort will very soon ferment, and after four or five hours it will be covered with a thick, white yeasty froth. When this appears, the whole mass must be strongly agitated, and at the same time mix it well with from fifty to seventy-five pounds of fine ground meal of wheat or barley, either malted or unmalted. By keeping it constantly in a cool place, it will continue in a good state for ten or fifteen days in summer, and in winter from four to six weeks, and still longer if stirred once or twice daily. This yeast, when employed in distilleries, breweries, or for making cider and vinegar, as also by bakers and pastrycooks, is asserted to be as useful and effectual as the best common yeast.

There has been for some time a manufactory of yeast in this metropolis, but whether it be made in this manner, or not, I am unable to say.

Yellow Acid. Fourcroy and Vauquelin have given this temporary name to a substance of a yellow colour, possessing acid properties, which they obtained by treating muscular fibre with nitric acid. See Analysis of Animal Substances.

Yellow Cobalt Ochre. An ore of cobalt, of a light dirty yellow colour, containing oxide of cobalt.

Yellow Earth. A species of lithomarge, found in Upper Saxony along with iron-stone in the floetz clay formation. It is of an ochre yellow colour, has a slaty fracture in one direction, and its cross fracture is earthy. It is light, very soft, adheres strongly to the tongue, feels a little greasy, and marks substances on which it is rubbed.

It is used as a pigment.

Yellow (Naples). A pigment made by calcining lead with a little antimony and an alkaline salt. See Naples Yellow.

Yolk. See Egg.

Yolk of Wool. The greasy matter adhering to wool in its natural state. See Wool.

Yttria. An earth discovered lately by Gadolin. See under the article Earths, also Gadolinite.

Yttrotantalite. See Tantalium.

Z.

ZAFFRE, or SAFFRE, is the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral have been expelled by calcination. It is therefore an impure oxide of cobalt, of a gray or reddish colour. The use of cobalt is to produce a very fine blue colour, when it is melted with fusible and vitrifiable matters.

The oxide of cobalt is the sole cause of the blue colour produced by zaffre. But as the quantity of cobalt contained in its ores is variable, some zaffres furnish more blue than others. The heterogeneous fixed matters contained in cobalt ores contribute likewise according to their quantity to the greater or less intensity of the blue colour. For this reason the manufacturers of zaffre make frequent essays of the roasted ore, by mixing it with vitreous matters, to discover the intensity and beauty of the blue colour.

Good cobalt oxided would form too deep a blue, and almost a black glass, if it were not previously mixed with a certain quantity of vitreous fritt. In the manufacture of zaffre, therefore, the oxide of cobalt, the strength of which has been previously determined by essays, is mixed with such a quantity of sand, or of powdered flints and quartz, that with the addition of some saline flux a deep blue glass may be formed.

The zaffre that is commonly sold, and which comes from Saxony, is a mixture of oxide of cobalt with some vitrifiable earth. It is of a gray colour, as all the oxides of cobalt are before vitrification. Some zaffres are dearer than others, according to the intensity of the colour which they are capable of producing. Zaffre is employed in the manufacture of pottery and of porcelain, for painting the surface of the pieces of ware, upon which it is applied together with some saline flux, previously to the baking or glazing, that the same fire may also vitrify this colouring material.

The blue of zaffre is the most solid and fixed of all the colours that can be employed in vitrification. It suffers no change from the most violent fire. It is successfully employed to give shades of blue to enamels, and to the crystal glasses made in imitation of some opake and transparent precious stones, as the lapis lazuli, the turquois, the sapphire, and others of this kind. See AZURE; COBALT; INK (SYMPATHETIC); and SMALT.

ZEOLITE. This stone was unknown to mineralogists before the celebrated Cronstedt gave a description of it.

It is usually of a semitransparent white; but this colour is sometimes altered by metallic mixtures, and then it assumes all kinds of tinges.

The name of zeolite has been given to it on account of its property of forming a jelly with acids. This property has even been considered as exclusive and characteristic. But Mr. Schwab has very justly observed, in the year 1758, that all zeolites do not possess this property; and Mr. Pelletier has proved, in the xxth volume of the Journal de Physique, that this property is not even peculiar to zeolites.

The existence of zeolites in certain lavas has induced some naturalists to consider them as produced by the decomposition of volcanic earths.

The most beautiful zeolites come to us from the islands of Ferroe, near Iceland. The form of these is constant. The radii which compose them diverge as it were from a central point, and are disposed after the manner of a fan. The radii, which terminate at the external surface, are found to exhibit a trihedral or tetrahedral pyramid.

The white zeolite affects two principal forms, the cubic and the tetrahedral prism, sometimes flattened and terminated by an obtuse tetrahedral pyramid.

Its specific gravity is from 2·1 to 3·15.

The zeolite, exposed to a strong heat, dilates, and swells more or less, according to the proportion of water it contains, and at length melts into a porous scoria. Soda fuses it with effervescence; the borate of soda dissolves it more difficultly; and the phosphates of urine have scarcely any action upon it.

Bergman obtained from one hundred parts of the red zeolite of Adelfors, 83 silex, 9·5 alumine, 6·5 pure lime, and 4 water.—Letters on Iceland, p. 370.

The white zeolite of Ferroe contains, according to Vauquelin, 50·24 silex, 29·30 alumine, 9·46 lime, and 10 water.

In a zeolite in the basaltic rock at Edinburgh Dr. Kennedy found silex 51·5, lime 32, clay 0·5, oxide of iron 0·5, soda about 8·5, carbonic acid and other volatile matter 5, with some traces of magnesia and muriatic acid.

The most recent division of the zeolite is into four subspecies. 1. Mealy zeolite. 2. Fibrous zeolite. 3. Radiated zeolite; *mesotype* of Haüy. 4. Foliated zeolite; *stilbite* of Haüy.

The first, according to the analysis of Pelletier, contains

Silex	- -	50
Alumine	- -	20
Lime	- -	8
Water	- -	22
		100.

The second, according to Meyer,

Silex	41
Alumine	31
Lime	11
Water	15
	98.

The third, according to Vauquelin,

Silex	53
Alumine	27
Lime	9·46
Water	10
	99·46.

The fourth, according to the same chemist,

Silex	52
Alumine	17·5
Lime	9
Water	18·5
	97.

Kirwan observes, that the crystallized species contain more water than the others. They are subject to decomposition on exposure to air, and said to be often found passing into calcedony.

Zillerthite. See Strahlstein.

Zinc is a semimetal, of a blueish white colour, somewhat brighter than lead; of considerable hardness, and so malleable, as not to be broken with the hammer, though it cannot be much extended in this way. It is very easily extended by the rollers of the flatting mill. In a temperature between 210° and 300° of Fahr., it has so much ductility, that it can be drawn into wire, as well as laminated, for which a patent has been obtained by Messrs. Hobson and Sylvester, of Sheffield. The zinc thus annealed and wrought retains the malleability it had acquired.

When broken by bending, its texture appears as if composed of cubical grains.* On account of its imperfect malleability, it is difficult to reduce it into small parts by filing or hammering; but it may be granulated, like the malleable metals, by pouring it, when fused, into cold water; or, if it be heated nearly to melting, it is then sufficiently brittle to be pulverized.

It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer;* and, soon after it becomes red-hot, it burns with a dazzling white flame, of a blueish or yellowish tinge, and is oxided with such rapidity, that it flies up in the form of white flowers, called the flowers of zinc, or philosophical wool. These are generated so plentifully, that the access of air is soon intercepted; and the combustion ceases, unless the matter be stirred, and a considerable heat kept up. The white oxide of zinc is not volatile, but is driven up merely by the force of the combustion. When it is again urged by a strong heat, it becomes converted into a clear yellow glass. If zinc be heated in closed vessels, it rises without decomposition. Zinc appears to be the most volatile of metallic substances except arsenic.

The diluted sulphuric acid dissolves zinc: at the same time that the temperature of the solvent is increased, and much hidrogen escapes, an undissolved residue is left, which has been supposed to consist of plumbago. Proust, however, says, that it is a mixture of arsenic, lead, and copper. As the combination of the sulphuric acid and the oxide proceeds, the temperature diminishes, and the sulphat of zinc, which is more soluble in hot than cold water, begins to separate, and disturb the transparency of the fluid. If more water be added, the salt may be obtained in fine prismatic four-sided crystals. The white vitriol, or copperas, usually sold, is crystallized hastily, in the same manner as loaf-sugar, which on this account it resembles in appearance: it is slightly efflorescent. The white oxide of zinc is soluble in the sulphuric acid, and forms the same salt as is afforded by zinc itself.

The hidrogen gas, that is extricated from water by the action of sulphuric acid. carries up with it a portion of zinc, which is apparently dissolved in it; but this is deposited spontaneously, at least in part, if not wholly, by standing. It burns with a brighter flame than common hidrogen.

Sulphat of zinc is prepared in the large way from some varieties of the native sulphuret. The ore is roasted, wetted with water, and exposed to the air. The sulphur attracts oxigin, and is converted into sulphuric acid; and the metal, being at the same time oxided, combines with the acid. After some time the sulphat is extracted by solution in water; and the solution being evaporated to dryness, the mass is run into moulds. This, the white vitriol of the shops, generally contains a small portion of iron, and sometimes of lead.

Sulphurous acid dissolves zinc, and sulphuretted hidrogen is evolved. The solution, by exposure to the air, deposits needly crystals, which, according to Fourcroy and Vauquelin, are sulphuretted sulphit of zinc. By dissolving oxide of zinc in sulphurous acid, the pure sulphit is obtained. This is soluble, and crystallizable.

Diluted nitric acid combines rapidly with zinc, and produces much heat, at the same time that a large quantity of nitrous air flies off. The solution is very caustic, and affords crystals by evaporation and cooling, which slightly detonate upon hot coals, and leave oxide of zinc behind. This salt is deliquescent.

Muriatic acid acts very strongly upon zinc, and disengages much hidrogen; the solution, when evaporated, does not afford crystals, but becomes gelatinous. By a strong heat it is partly decomposed, a portion of the acid being expelled, and part of the muriat sublimes and condenses in a congeries of prisms.

Phosphoric acid dissolves zinc. The phosphat does not crystallize, but becomes gelatinous, and may be fused by a strong heat. The concrete phosphoric acid heated with zinc filings is decomposed.

Fluoric acid likewise dissolves zinc.

The boracic acid digested with zinc becomes milky: and if a solution of borax be added to a solution of muriat or nitrat of zinc, an insoluble borat of zinc is thrown down.

A solution of carbonic acid in water dissolves a small quantity of zinc, and more readily its oxide. If the solution be exposed to the air, a thin iridescent pellicle forms on its surface.

The acetic acid readily dissolves zinc, and yields by evaporation crystals of acetat of zinc, forming rhomboidal or hexagonal plates. These are not altered by exposure to the air, are soluble in water, and burn with a blue flame. On distillation they yield water, an inflammable liquid, and some oil; and toward the end of the process oxide of zinc sublimes. This salt may be made by digesting pulverized zinc, or oxide of zinc, in distilled vinegar. Mr. Henry has lately recommended it as an excellent application in cases of inflammation. We have known it given as a tonic, in doses of a few grains, apparently with advantage.

The succinic acid dissolves zinc with effervescence, and the solution yields long, slender, foliated crystals.

Zinc is readily dissolved in benzoic acid, and the solution yields needleshaped crystals, which are soluble both in water and in alcohol. Heat decomposes them by volatilizing their acid.

The oxalic acid attacks zinc with a violent effervescence, and a white powder soon subsides, which is oxalat of zinc. If oxalic acid be dropped into a solution of sulphat, nitrat, or muriat of zinc, the same salt is precipitated; it being scarcely soluble in water, unless an excess of acid be present. It contains seventy-five per cent of metal

The tartarous acid likewise dissolves zinc with effervescence, and forms a salt difficult of solution in water.

The citric acid attacks zinc with effervescence, and small brilliant crystals of citrat of zinc are gradually deposited, which are insoluble in water. Their taste is styptic and metallic, and they are composed of equal parts of the acid and of oxide of zinc.

The malic acid dissolves zinc, and affords beautiful crystals by evaporation.

The compound called lactic acid acts upon zinc with effervescence, and produces a crystallizable salt.

The metallic acids likewise combine with zinc. If arsenic acid be poured on it, an effervescence takes place, arsenical hidrogen gas is emitted, and a black powder falls down, which is arsenic in the metallic state, the zinc having deprived a portion of the arsenic, as well as the water, of its oxigen. If one part of zinc filings and two parts of dry arsenic acid be distilled in a retort, a violent detonation takes place when the retort becomes red, occasioned by the sudden absorption of the oxigen of the acid by the zinc. The arseniat of zinc may be precipitated by pouring arsenic acid into the solution of acetat of zinc, or by mixing a solution of an alkaline arseniat with that of sulphat of zinc. It is a white powder, insoluble in water.

By a similar process zinc may be combined with the molybdic acid, and with the oxide of tungsten, the tungstic acid of some, with both of which it forms a white insoluble compound; and with the chromic acid, the result of which compound is equally insoluble, but of an orange red colour.

Zinc likewise forms some triple salts. Thus, if the white oxide of zinc be boiled in a solution of muriat of ammonia, a considerable portion is dissolved; and though part of the oxide is again deposited as the solution cools, some of it remains combined with the acid and alkali in the solution, and is not precipitable either by pure alkalis, or their carbonats. This triple salt does not crystallize.

If the acidulous tartrit of potash be boiled in water with zinc filings, a triple compound will be formed, which is very soluble in water, but not easily crystallized. This, like the preceding, cannot be precipitated from its solution either by pure or carbonated alkalis.

A triple sulphat of zinc and iron may be formed by mixing together the sulphats of iron and of zinc dissolved in water, or by dissolving iron and zinc in dilute sulphuric acid. This salt crystallizes in rhomboids, which nearly resemble the sulphat of zinc in figure, but are of a pale green colour. In taste, and in degree of solubility, it differs little from the sulphat of zinc. It contains a much larger proportion of zinc than of iron.

A triple sulphat of zinc and cobalt, as first noticed by Link, may be obtained by digesting zaffre in a solution of sulphat of zinc. On evaporation large quadrilateral prisms are obtained, which effloresce on exposure to the air.

Zinc is precipitated from acids by the soluble earths and the alkalis: the latter redissolve the precipitate, if they be added in excess.

Zinc decomposes, or alters, the neutral sulphats in the dry way. When fused with sulphat of potash, it converts that salt into a sulphuret; the zinc at the same time being oxided and partly dissolved in the sulphuret. When pulverized zinc is added to fused nitre, or projected together with that salt into a red hot crucible, a very violent detonation takes place; insomuch that it is necessary for the operator to be careful in using only small quantities, lest the burning matter should be thrown about. The zinc is oxided; and part of the oxide combines with the alkali, with which it forms a compound soluble in water.

Zinc decomposes common salt, and also sal ammoniac, by combining with the muriatic acid. The filings of zinc likewise decompose alum, when boiled in a solution of that salt, probably by combining with its excess of acid.

Sulphur, though its action is almost general on metallic substances, does not combine directly with zinc. This property affords a ready means of purifying the semimetal, by projecting sulphur upon it, when melted in a shallow crucible. It has been a subject of remark among chemists, that many of the zinc ores consist of this semimetal combined with sulphur, though art has not yet discovered the means of effecting the same combination. But the difficulty is removed by the consideration, that the sulphur does not unite with zinc itself, yet it readily does with its oxide, and forms a compound similar to the zinc ores, called blendes; in which, for this reason, the zinc may be presumed to exist in the oxided state.

Zinc may be combined with phosphorus, by projecting small pieces of phosphorus on the zinc melted in a crucible, the zinc being covered with a little resin, to prevent its oxidation. Phosphuret of zinc is white, with a shade of blueish gray, has a metallic lustre, and is a little malleable. When zinc and phosphorus are exposed to heat in a retort, a red sublimate rises, and likewise a blueish sublimate, in needly crystals, with a metallic lustre. If zinc and phosphoric acid be heated together, with or without a little charcoal, needly crystals are sublimed, of a silvery white colour. All these, according to Pelletier, are phosphuretted oxides of zinc.

Most of the metallic combinations of zinc have been already treated of. It forms a brittle compound with antimony; and its effects on manganese, tungsten, and molybdena, have not yet been ascertained.

Native zinc has been very seldom found. The oxided ores of zinc are the zinc spar, of a whitish gray colour, resembling a lead spar; and the impure oxide called calamine, which is of a white, gray, yellow, brown, or red colour, containing iron, clay, calcareous and other earths, and lead. The ore called blende, mock-lead, or black jack, consists of zinc mineralized with sulphur and iron: of this there are several varieties. They are in general of a plated texture, and frequently of a quadrangular form, like galena, or potters' lead ore, though they are considerably less heavy. These ores are found in various parts of Europe, and in considerable plenty in the mine counties of England. See Ores.

Native zinc may be assayed, in the humid way, by the mineral acids. When it is dissolved in these, if there be any other metal present, it may be precipitated by the addition of a known quantity of zinc. The weight of oxide of zinc precipitated by subcarbonated alkali from its sulphuric solution, will amount to 193 grains for every 100 of the metal it represents. The sulphureous zinc ores must be carefully treated with nitric acid; which will dissolve the zinc, and leave the sulphur. Extraneous metals may be precipitated, and the quantity of zinc ascertained, as before.

The essay of calamines is sometimes made by pounding and mixing them with charcoal, and then heating them in a crucible covered with a copper plate. The reduced zinc rises, and converts the copper into brass; and in this way some judgment may be formed of its value in the operation of brass-making. Most of the zinc, whether in the metallic state or in the form of an impure oxide called cadmia fornacum, is obtained in the roasting of various kinds of ores at Ramelsberg. For this purpose the interior part of the furnace is kept cold by wetting it: by which means the volatilized zinc is condensed, and falls into a cavity, containing charcoal dust, which defends it from oxidation.

The process for obtaining zinc from its ores by distillation, which is practised in England, and said to have originally been derived from the Chinese, is performed in a furnace in the form of a circular oven; in which are placed six pots, each about four feet in height, and of a conical shape, resembling an oil jar. Into the bottom of each pot an iron tube is inserted, which passes through the floor of the furnace into a vessel of water. These pots are filled with a mixture of calamine and charcoal; and their mouths are then close stopped with clay. The fire being then properly applied, the metallic vapour of the calamine issues through the iron tube, which is the only place where it can escape. In this way it is condensed into small particles in the water; which are afterward melted into ingots for sale, under the name of spelter. The substance sold in London by the name of spelter is a kind of soft brass, in a granulated form, which is used by the braziers and others for soldering.

The chief purpose to which zinc is applied consists in the fabrication of brass and other gold-coloured mixtures. Its oxides and salts have been occasionally employed in medicine.

Zircon. An earth discovered by Klaproth in the zircon, or jargon, of Ceylon. See under the article Earths.

Zoisite. A mineral lately introduced into the system by Werner, who has thus named it from baron von Zois, its discoverer. According to Haüy it is a variety of the piztazite.

It is found in primitive mountains in Carinthia, Bayreuth, Saltzburg, the Tyrolese, and Valais.

It is of a yellowish gray, smoky gray, or brownish gray colour, with somewhat of a pearly lustre; massive, or crystallized in oblique rhomboidal prisms, frequently with their obtuse angles rounded off, and streaked longitudinally.—*Thomson.*—*Brongniart.*

Zoonic Acid. Berthollet imagined he had discovered in the liquid procured from animal substances a peculiar acid, to which he gave the name of zoonic. Thenard however has shown, that it is merely acetous acid combined with some animal matter.

Zoöphytes. Many of the substances called *zoöphytes* have the hardness and appearance of shell or bone, and may therefore be included among them without impropriety. Others, indeed, are soft, and belong rather to the class of membrane or horn; but of these very few only have been examined. Indeed scarcely any chemical experiments have been published on these interesting subjects, if we except the admirable dissertation by Hatchett in the Philosophical Transactions for 1800. From this dissertation, and from a few experiments of Merat-Guillot, we learn that the hard zoöphytes are composed chiefly of three ingredients: 1. An animal substance of the nature of coagulated albumen, varying in consistency; sometimes being gelatinous and almost liquid, at others of the consistency of cartilage. 2. Carbonat of lime. 3. Phosphat of lime.

In some zoöphytes the animal matter is very scanty, and phosphat of lime wanting altogether; in others the animal matter is abundant, and the earthy salt pure carbonat of lime; while in others the animal matter is abundant, and the hardening salt a mixture of carbonat of lime and phosphat of lime; and there is a fourth class almost destitute of earthy salts altogether. Thus there are four classes of zoöphytes; the first resemble porcellaneous shells, the second resemble mother-of-pearl shells, the third resemble crusts, and the fourth horn.

1. When the *madrepora virginea* is immersed in diluted nitric acid it effervesces strongly, and is soon dissolved. A few gelatinous particles float in the solution, which is otherwise transparent and colourless. Ammonia precipitates nothing; but its carbonat throws down abundance of carbonat of lime. It is composed, then, of carbonat of lime and a little animal matter. The following zoöphytes yield nearly the same results:

Madrepora muricata
———— labyrinthica
Millepora cerulea
———— alcicornis
Tubipora musica.

2. When the *madrepora ramea* is plunged into weak nitric acid, an effervescence is equally produced; but after all the soluble part is taken up, there remains a membrane which retains completely the original shape of the madrepore. The substance taken up is pure lime. Hence this madrepore is composed of carbonat of lime, and a membranaceous substance which, as in mother-of-pearl shells, retains the figure of the madrepore. The following zoöphytes yield nearly the same results:

Madrepora fascicularis
Millepora cellulosa
———— fascialis
———— truncata
Iris hippuris.

The following substances, analysed by Merat-Guillot, belong to this class from their composition, though it is difficult to say what are the species of zoöphytes which were analysed. By *red coral* he probably meant the *gorgonia nobilis*, though that substance is known, from Hatchett's analysis, to contain also some phosphat.

	White coral.	*Red coral.*	*Articulated coralline.*
Carbonat of lime	50	53·5	49
Animal matter	50	46·5	51
	100	100·0	100*

3. When the *madrepora polymorpha* is steeped in weak nitric acid, its shape continues unchanged; there remaining a tough membranaceous substance of a white colour and opake, filled with a transparent jelly. The acid solution yields a slight precipitate of phosphat of lime when treated with ammonia, and carbonat of ammonia throws down a copious precipitate of carbonat of lime. It is composed therefore of animal substance, partly in the state of jelly, partly in that of membrane, and hardened by carbonat of lime, together with a little phosphat of lime.

Flustra foliacea, treated in the same manner, left a finely reticulated membrane, which possessed the properties of coagulated albumen. The solution contained a little phosphat of lime, and yielded abundance of carbonat of lime when treated with the alkaline carbonats. The *corallina opuntia*, treated in the same manner, yielded the same constituents; with this difference, that no phosphat of lime could be detected in the fresh coralline, but the solution of burnt coralline yielded traces of it. The *iris ochracea* exhibits the same phænomena, and is formed of the same constituents. When dissolved in weak nitric acid, its colouring matter falls in the state of a fine red powder, neither soluble in nitric nor muriatic acid, nor changed by them; whereas the tingeing matter of the *tubipora musica* is destroyed by these acids. The branches of this iris are divided by a series of knots. These

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* Merat-Guillot, *Ann. de Chim.* xxxiv. 71.

knots are cartilaginous bodies connected together by a membranous coat. Within this coat there is a conical cavity filled with the earthy or coralline matter; so that, in the recent state, the branches of the iris are capable of considerable motion, the knots answering the purpose of joints.

When the *gorgonia nobilis*, or red coral, is immersed in weak nitric acid, its colouring matter is destroyed, an effervescence takes place, and the calcareous part is dissolved. There remains an external tubulated membrane of a yellow colour, enclosing a transparent gelatinous substance. The solution yields only carbonat of lime; but when red coral is heated to redness, and then dissolved, the solution yields a little phosphat of lime also. Red coral is composed of two parts: an internal stem, composed of gelatinous matter and carbonat of lime; and an external covering or cortex, consisting of membrane hardened by the calcareous salts, and both coloured by some unknown substance.

The *gorgonia ceratophyta* likewise consists of a stem and cortex. The stem is composed of cartilage, hardened chiefly by phosphat of lime, and containing little carbonat of lime; but the cortex consists of membrane hardened almost entirely by carbonat of lime. The *gorgonia flabellum* is almost exactly similar. The cortex of the *gorgonia suberosa* yielded gelatine to boiling water; when steeped in acids, it left a soft yellowish membrane, and the acid had taken up a little phosphat and a large portion of carbonat of lime. The stem contained scarcely any earthy salt. When burnt, it left a little phosphat of lime. To water it yielded a little gelatine; but it consisted chiefly of a horny substance, analogous to coagulated albumen. The *gorgonia setosa* and *pectinata* exhibited the same phænomena.

4. *Gorgonia antiphates*, like the other species of gorgonia, has a horny stem, but it is destitute of a cortex. To boiling water it gives out some gelatine. When steeped in nitric acid it becomes soft, and exhibits concentric coats of thin opake brown membranes, of a ligneous aspect. It contains no earthy salt. With potash it forms an animal soap, and possesses nearly the properties of horn.

The stems of the *gorgonia umbraculum* and *verrucosa* resemble that of the gorgonia antiphates; but these are both provided with a cortex composed of membrane and carbonat of lime.

The *antiphates ulex* and *myriophylla* resemble almost exactly the horny stem of the gorgonia antiphates.

Mr. Hatchett analysed many species of sponges, but found them all similar in their composition. The *spongia cancellata*, *oculata*, *infundibuliformis*, *palmata*, and *officinalis*, may be mentioned as specimens. They consist of gelatine, which they gradually give out to water, and a thin brittle membranous substance, which possesses the properties of coagulable albumen. Hence the effect of acids and alkalies on them.

The *alcyonium ficus*, *asbestinum*, and *arboreum*, resemble very much the cortex of the gorgonia suberosa in their composition. They yield a little gelatine to water. In nitric acid they soften, and appear membranous. The acid takes up the carbonat of lime, and likewise a little phosphat, at least when the substance has been previously heated to redness.

Such is an abstract of Mr. Hatchett's instructive analysis of the zoöphytes.—*Thomson's Chemistry.*

Zundererz. Tinder ore. An ore of silver, consisting of suberiform asbestus, in which red silver ore is intimately mixed to the amount of about 15 per cent, giving it a reddish brown colour resembling that of the *boletus igniarius*, or spunk, mentioned under the article Agaric, which the Germans use as tinder.

☞ *Communications containing corrections or hints for improving future Editions of this Dictionary, will be thankfully received by the publisher at No. 6, Bridge-street, Blackfriars, London.*

APPENDIX.

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APPENDIX.

As a full account of a discovery, that will form an epoch in the history of chemistry, that of the metallic bases of the fixed alkalis by Mr. Davy, could not be obtained when the article Soda *was sent to press, the statement of it at large, as given by that gentleman in the Philosophical Transactions for* 1808, *Part I,* p. 1, *is here inserted.*

The Bakerian Lecture, on some new Phænomena of chemical Changes produced by Electricity, particularly the Decomposition of the fixed Alkalis, and the Exhibition of the new Substances which constitute their Bases; and on the general Nature of alkaline Bodies; By Humphry Davy, *Esq. Sec. R.S. M.R.I.A.*

Read November 19, 1807.

I. *Introduction.*

IN the Bakerian Lecture, which I had the honour of presenting to the Royal Society last year, I described a number of decompositions and chemical changes produced in substances of known composition by electricity; and I ventured to conclude, from the general principles on which the phænomena were capable of being explained, that the new methods of investigation promised to lead to a more intimate knowledge than had hitherto been obtained, concerning the true elements of bodies.

This conjecture, then sanctioned only by strong analogies, I am now happy to be able to support by some conclusive facts. In the course of a laborious experimental application of the powers of electrochemical analysis to bodies, which have appeared simple when examined by common chemical agents, or which at least have never been decomposed, it has been my good fortune to obtain new and singular results.

Such of the series of experiments as are in a tolerably mature state, and capable of being arranged in a connected order, I shall detail in the following sections, particularly those which demonstrate the decomposition and composition of the fixed alkalis, and the production of the new and extraordinary bodies that constitute their bases.

In speaking of novel methods of investigation, I shall not fear to be minute. When the common means of chemical research have been employed, I shall mention only results. A historical detail of the progress of the investigation, of all the difficulties that occurred, and of the manner in which they were overcome, and of all the manipulations employed, would far exceed the limits assigned to this lecture. It is proper to state, however, that when general facts are mentioned, they are such only as have been deduced from processes carefully performed and often repeated.

II. *On the Methods used for the Decomposition of the fixed Alkalis.*

The researches I had made on the decomposition of acids, and of alkaline and earthy neutral compounds, proved, that the powers of electrical decomposition were proportional to the strength of the opposite electricities in the circuit, and to the conducting power and degree of concentration of the materials employed.

In the first attempts that I made on the decomposition of the fixed alkalis, I acted upon aqueous solutions of potash and soda, saturated at common temperatures, by the highest electrical power I could command, and which was produced by a combination of Voltaic batteries belonging to the Royal Institution, containing 24 plates of copper and zinc of 12 inches square, 100 plates of 6 inches, and 150 of 4 inches square, charged with solutions of alum and nitrous acid; but in these cases, though there was a high intensity of action, the water of the solutions alone was affected, and hidrogen and oxigen disengaged with the production of much heat and violent effervescence.

The presence of water appearing thus to prevent any decomposition, I used potash in igneous fusion. By means of a stream of oxigen gas from a gasometer applied to the flame of a spirit lamp, which was thrown on a platina spoon containing potash, this alkali was kept for some minutes in a strong red heat, and in a state of perfect fluidity. The spoon was preserved in communication with the positive side of the battery of the power of 100 of 6 inches, highly charged; and the connection from the negative side was made by a platina wire.

By this arrangement some brilliant phænomena were produced. The potash appeared a conductor in a high degree, and as long as the communication was preserved, a most intense light was exhibited at the negative wire, and a column of flame, which seemed to be owing to the developement of combustible matter, arose from the point of contact.

When the order was changed, so that the platina spoon was made negative, a vivid and constant light appeared at the opposite point: there was no effect of inflammation round it; but aëriform globules, which inflamed in the atmosphere, rose through the potash.

The platina, as might have been expected, was considerably acted upon: and in the cases when it had been negative, in the highest degree.

The alkali was apparently dry in this experiment; and it seemed probable, that the inflammable matter arose from its decomposition. The residual potash was unaltered; it contained indeed a number of dark gray metallic particles, but these proved to be derived from the platina.

I tried several experiments on the electrization of potash rendered fluid by heat, with the hopes of being able to collect the combustible matter, but without success; and I only attained my object, by employing electricity as the common agent for fusion and decomposition.

Though potash, perfectly dried by ignition, is a nonconductor, yet it is rendered a conductor by a very slight addition of moisture, which does not perceptibly destroy its aggregation; and in this state it readily fuses and decomposes by strong electrical powers.

A small piece of pure potash, which had been exposed for a few seconds to the atmosphere, so as to give conducting power to the surface, was placed upon an insulated disc of platina, connected with the negative side of the battery of the power of 250 of 6 and 4, in a state of intense activity; and a platina wire, communicating with the positive side, was brought in contact with the upper surface of the alkali. The whole apparatus was in the open atmosphere.

Under these circumstances a vivid action was soon observed to take place. The potash began to fuse at both its points of electrization. There was a violent effervescence at the upper surface; at the lower, or negative surface, there was no liberation of elastic fluid; but small globules having a high metallic lustre, and being precisely similar in visible characters to quicksilver, appeared, some of which burnt with explosion and bright flame, as soon as they were formed, and others remained, and were merely tarnished, and finally covered by a white film which formed on their surfaces.

These globules numerous experiments soon showed to be the substance I was in search of, and a peculiar inflammable principle, the basis of potash. I found that the platina was in no way connected with the result, except as the medium for exhibiting the electrical powers of decomposition; and a substance of the same kind was produced, when pieces of copper, silver, gold, plumbago, or even charcoal were employed for completing the circuit.

The phænomenon was independent of the presence of air; I found that it took place when the alkali was in the vacuum of an exhausted receiver.

The substance was likewise produced from potash fused by means of a lamp, in glass tubes confined by mercury, and furnished with hermetically inserted platina wires, by which the electrical action was transmitted. But this operation could not be carried on for any considerable time; the glass was rapidly dissolved by the action of the alkali, and this substance soon penetrated through the body of the tube.

Soda, when acted upon in the same manner as potash, exhibited an analogous result; but the decomposition demanded greater intensity of action in the batteries, or the alkali was required to be in much thinner and smaller pieces. With the battery of 100 of 6 inches in full activity I obtained good results from pieces of potash weighing from 40 to 70 grains, and of a thickness which made the distance of the electrified metallic surfaces nearly a quarter of an inch; but with a similar power it was impossible to produce the effects of decomposition on pieces of soda of more than 15 or 20 grains in weight, and that only when the distance between the wires was about $\frac{1}{8}$ or $\frac{1}{10}$ of an inch.

The substance produced from potash remained fluid at the temperature of the atmosphere at the time of its production; that from soda, which was fluid in the degree of heat of the alkali during its formation, became solid on cooling, and appeared having the lustre of silver.

When the power of 250 was used, with a very high charge for the decomposition of soda, the globules often burnt at the moment of their formation, and sometimes violently exploded and separated into smaller globules, which flew with great velocity through the air in a state of vivid combustion, producing a beautiful effect of continued jets of fire.

III. *Theory of the Decomposition of the fixed Alkalis; their Composition, and Production.*

As in all decompositions of compound substances, which I had previously examined, at the same time that combustible bases were developed at the negative surface in the electrical circuit, oxigen was produced, and evolved or carried into combination at the positive surface, it was reasonable to conclude, that this substance was generated in a similar manner by the electrical action upon the alkalis; and a number of experiments made above mercury, with the apparatus for excluding external air, proved that this was the case.

When solid potash, or soda in its conducting state, was included in glass tubes furnished with electrified platina wires, the new substances were generated at the negative surfaces; the gas given out at the other surface proved by the most delicate examination to be pure oxigen; and unless an excess of water was present, no gas was evolved from the negative surface.

In the synthetical experiments, a perfect coincidence likewise will be found.

I mentioned, that the metallic lustre of the substance from potash immediately became destroyed in the atmosphere, and that a white crust formed upon it. This crust I soon found to be pure potash, which immediately deliquesced, and new quantities were formed, which in their turn attracted moisture from the atmosphere, till the whole globule disappeared, and assumed the form of a saturated solution of potash*.

When globules were placed in appropriate tubes containing common air or oxigen gas confined by mercury, an absorption of oxigen took place; a crust of alkali instantly formed upon the globule; but from the want of moisture for its solution, the process stopped, the interior being defended from the action of the gas.

With the substance from soda, the appearances and effects were analogous.

When the substances were strongly heated, confined in given portions of oxigen, a rapid combustion with a brilliant white flame was produced; and the metallic globules were found converted into a white and solid mass, which in the case of the substance from potash was found to be potash, and in the case of that from soda, soda.

Oxigen gas was absorbed in this operation, and nothing emitted which affected the purity of the residual air.

The alkalis produced were apparently dry, or at least contained no more moisture than might well be conceived to exist in the oxigen gas absorbed; and their weights considerably exceeded those of the combustible matters consumed.

The processes on which these conclusions are founded will be fully described hereafter, when the minute details which are necessary will be explained, and the proportions of oxigen, and of the respective inflammable substances, which enter into union to form the fixed alkalis, will be given.

It appears then, that in these facts there is the same evidence for the decomposition of potash and soda into oxigen and two peculiar substances, as there is for the decomposition of sulphuric and phosphoric acids and the metallic oxides into oxigen and their respective combustible bases.

In the analytical experiments, no substances capable of decomposition are present but the alkalis and a minute portion of moisture; which seems in no other way essential to the result, than in rendering them conductors at the surface; for the new substances are not generated, till the interior, which is dry, begins to be fused; they explode when in rising through the fused alkali they come in contact with the heated moistened surface; they cannot be produced from crystallized alkalis, which contain much water; and the effect produced by the electrization of ignited potash, which contains no sensible quantity of water, confirms the opinion of their formation independently of the presence of this substance.

The combustible bases of the fixed alkalis seem to be repelled as other combustible substances, by positively electrified surfaces, and attracted by negatively electrified surfaces, and the oxigen follows the contrary order†; or, the oxigen being naturally possessed of the negative energy, and the bases of the positive, they do not remain in combination, when either of them is brought into an electrical state opposite to its natural one. In the synthesis, on the contrary, the natural energies or attractions come in equilibrium with each other; and when these are in a low state at common temperatures, a slow combination is effected; but when they are exalted by heat, a rapid union is the result; and as in other like cases with the production of fire.—A number of circumstances relating to the agencies of the bases of the alkalis will be immediately stated, and will be found to offer confirmations of these general conclusions.

IV. *On the Property and Nature of the Basis of Potash.*

After I had detected the bases of the fixed alkalis, I had considerable difficulty to preserve and confine them so as to examine their properties, and submit them to experiments; for, like the *alkahests* imagined

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* Water likewise is decomposed in the process. We shall hereafter see, that the bases of the fixed alkalis act upon this substance with greater energy than any other known bodies. The minute theory of the oxidation of the bases of the alkalis in the free air, is this:—oxigen gas is first attracted by them, and alkali formed. This alkali speedily absorbs water. This water is again decomposed. Hence, during the conversion of a globule into alkaline solution, there is a constant and rapid disengagement of small quantities of gas.

† See Bakerian Lecture, 1806, p. 28. Phil. Trans. for 1807.

by the alchemists, they acted more or less upon almost every body to which they were exposed.

The fluid substance among all those I have tried, on which I find they have least effect, is recently distilled naphtha.—In this material, when excluded from the air, they remain for many days without considerably changing, and their physical properties may be easily examined in the atmosphere, when they are covered by a thin film of it.

The basis of potash at 60° Fahrenheit, the temperature in which I first examined it, appeared, as I have already mentioned, in small globules possessing the metallic lustre, opacity, and general appearance of mercury; so that when a globule of mercury was placed near a globule of the peculiar substance, it was not possible to detect a difference by the eye.

At 60° Fahrenheit it is however only imperfectly fluid, for it does not readily run into a globule, when its shape is altered; at 70° it becomes more fluid; and at 100° its fluidity is perfect, so that different globules may be easily made to run into one. At 50° Fahrenheit it becomes a soft and malleable solid, which has the lustre of polished silver; and at about the freezing point of water it becomes harder and brittle, and when broken in fragments, exhibits a crystallized texture, which in the microscope seems composed of beautiful facets of a perfect whiteness and high metallic splendour.

To be converted into vapour, it requires a temperature approaching that of the red heat; and when the experiment is conducted under proper circumstances, it is found unaltered after distillation.

It is a perfect conductor of electricity. When a spark from the Voltaic battery of 100 of 6 inches is taken upon a large globule in the atmosphere, the light is green, and combustion takes place at the point of contact only. When a small globule is used, it is completely dissipated with explosion, accompanied by a most vivid flame, into alkaline fumes.

It is an excellent conductor of heat.

Resembling the metals in all these sensible properties, it is however remarkably different from any of them in specific gravity; I found that it rose to the surface of naphtha distilled from petroleum, and of which the specific gravity was ·861; and it did not sink in double distilled naphtha the specific gravity of which was about ·77°, that of water being considered as 1. The small quantities in which it is produced by the highest electrical powers, rendered it very difficult to determine this quality with minute precision. I endeavoured to gain approximations on the subject by comparing the weights of perfectly equal globules of the basis of potash and mercury. I used the very delicate balance of the Royal Institution, which when loaded with the quantities I employed, and of which the mercury never exceeded ten grains, is sensible at least to the two thousandth part of a grain. Taking the mean of 4 experiments, conducted with great care, its specific gravity at 62° Fahrenheit is to that of mercury as 10 to 223, which gives a proportion to that of water nearly as 6 to 10; so that it is the lightest fluid body known. In its solid form it is a little heavier, but even in this state when cooled to 40° Fahrenheit, it swims in the double distilled naphtha.

The chemical relations of the basis of potash are still more extraordinary than its physical ones.

I have already mentioned its alkalization and combustion in oxigen gas.—It combines with oxigen slowly, and without flame, at all temperatures that I have tried below that of its vaporization.—But at this temperature combustion takes place, and the light is of a brilliant whiteness, and the heat intense. When heated slowly in a quantity of oxigen gas not sufficient for its complete conversion into potash, and at a temperature inadequate to its inflammation, 400° Fahrenheit, for instance, its tint changes to that of a red brown, and when the heat is withdrawn, all the oxigen is found to be absorbed, and a solid is formed of a grayish colour, which partly consists of potash and partly of the basis of potash in a lower degree of oxigenation,—and which becomes potash by being exposed to water, or by being again heated in fresh quantities of air.

The substance consisting of the basis of potash combined with an under proportion of oxigen may likewise be formed by fusing dry potash and its basis together under proper circumstances.—The basis rapidly loses its metallic splendour; the two substances unite into a compound of a red brown colour when fluid, and of a dark gray hue when solid; and this compound soon absorbs its full proportion of oxigen when exposed to air, and is wholly converted into potash.

And the same body is often formed in the analytical experiments, when the action of the electricity is intense, and the potash much heated.

The basis of potash when introduced into oximuriatic acid gas burns spontaneously with a bright red light, and a white salt, proving to be muriat of potash, is formed.

When a globule is heated in hidrogen at a degree below its point of vaporization, it seems to dissolve in it, for the globule diminishes in volume, and the gas explodes with alkaline fumes and bright light, when suffered to pass into the air; but by cooling, this spontaneous detonating property is destroyed, and the basis is either wholly or principally deposited

The action of the basis of potash on water exposed to the atmosphere is connected with some beautiful phænomena. When it is thrown upon water, or when it is brought into contact with a drop of water at common temperatures, it decomposes it with great violence, an instantaneous explosion is produced with brilliant flame, and a solution of pure potash is the result.

In experiments of this kind, an appearance often occurs similar to that produced by the combustion of phosphuretted hidrogen; a white ring of smoke, which gradually extends as it rises into the air.

When water is made to act upon the basis of potash out of the contact of air, and preserved by means of a glass tube under naphtha, the decomposition is violent; and there is much heat and noise, but no luminous appearance, and the gas evolved when examined in the mercurial or water pneumatic apparatus is found to be pure hidrogen.

When a globule of the basis of potash is placed upon ice it instantly burns with a bright flame, and a deep hole is made in the ice, which is found to contain a solution of potash.

The theory of the action of the basis of potash upon water exposed to the atmosphere, though complicated changes occur, is far from being obscure. The phænomena seem to depend on the strong attractions of the basis for oxigen, and of the potash formed for water. The heat, which arises from two causes, decomposition and combination, is sufficiently intense to produce the inflammation. Water is a bad conductor of heat; the globule swims exposed to air; a part of it, there is the greatest reason to believe, is dissolved by the heated nascent hidrogen; and this substance, being capable of spontaneous inflammation, explodes, and communicates the effect of combustion to any of the basis that may be yet uncombined.

When a globule confined out of the contact of air is acted upon by water, the theory of decomposition is very simple, the heat produced is rapidly carried off, so that there is no ignition; and a high temperature being requisite for the solution of the basis in hidrogen, this combination probably does not take place, or at least it can have a momentary existence only.

The production of alkali in the decomposition of water by the basis of potash is demonstrated in a very simple and satisfactory manner by dropping a globule of it upon moistened paper tinged with turmeric. At the moment that the globule comes into contact with the water, it burns, and moves rapidly upon the paper, as if in search of moisture, leaving behind it a deep reddish brown trace, and acting upon the paper precisely as dry caustic potash.

So strong is the attraction of the basis of potash for oxigen, and so great the energy of its action upon water, that it discovers and decomposes the small quantities of water contained in alcohol and ether, even when they are carefully purified.

In ether this decomposition is connected with an instructive result. Potash is insoluble in this fluid; and when the basis of potash is thrown into it, oxigen is furnished to it, and hidrogen gas disengaged, and the alkali as it forms renders the ether white and turbid.

In both these inflammable compounds the energy of its action is proportional to the quantity of water they contain, and hidrogen and potash are the constant result.

The basis of potash, when thrown into solutions of the mineral acids, inflames and burns on the surface. When it is plunged by proper means beneath the surface enveloped in potash, surrounded by naphtha, it acts upon the oxigen with the greatest intensity, and all its effects are such as may be explained from its strong affinity for this substance. In sulphuric acid a white saline substance with a yellow coating, which is probably sulphat of potash surrounded by sulphur, and a gas which has the smell of sulphurous acid, and which probably is a mixture of that substance with hidrogen gas, are formed. In nitrous acid, nitrous gas is disengaged, and nitrat of potash formed.

The basis of potash readily combines with the simple inflammable solids. and with the metals; with phosphorus and sulphur it forms compounds similar to the metallic phosphurets and sulphurets.

When it is brought into contact with a piece of phosphorus, and pressed upon, there is a considerable action: they become fluid together, burn, and produce phosphat of potash. When the experiment is made upon naphtha, their combination takes place without the liberation of any elastic matter, and they form a compound, which has a considerably higher point of fusion than its two constituents, and which remains a soft solid in boiling naphtha. In its appearance it perfectly agrees with a metallic phosphuret, it is of the colour of lead, and when spread out, has a lustre similar to polished lead. When exposed to air at common temperatures, it slowly combines with oxigen, and becomes phosphat of potash. When heated upon a plate of platina, fumes exhale from it, and it does not burn, till it attains the temperature of the rapid combustion of the basis of potash.

When the basis of potash is brought into contact with sulphur in fusion, in tubes filled with the vapour of naphtha, they combine rapidly with the evolution of heat and light, and a gray substance, in appearance like artificial sulphuret of iron, is formed, which, if kept in fusion, rapidly dissolves the glass, and becomes bright brown. When this experiment is made in a glass tube hermetically sealed, no gas is liberated, if the tube is opened under mercury; but when it is made in a tube connected with a mercurial apparatus, a small quantity of sulphuretted hidrogen is evolved, so that the phænomena are similar to those produced by the union of sulphur with the metals in which sulphuretted hidrogen is likewise disengaged, except that the ignition is stronger*. When the union is effected in the atmosphere, a great inflammation takes place, and sulphuret of potash is formed. The sulphuretted basis likewise gradually becomes oxigenated by exposure to the air, and is finally converted into sulphat.

The new substance produces some extraordinary and beautiful results with mercury. When one part of it is added to 8 or 10 parts of mercury in volume at 160° Fahrenheit, they instantly unite and form a substance exactly like mercury in colour, but which seems to have less coherence, for small portions of it appear as flattened spheres. When a globule is made to touch a globule of mercury about twice as large, they combine with considerable heat; the compound is fluid at the temperature of its formation; but when cool it appears as a solid metal, similar in colour to silver. If the quantity of the basis of potash is still farther increased, so as to be about $\frac{1}{30}$th the weight of the mercury, the amalgam increases in hardness, and becomes brittle. The solid amalgam, in which the basis is in the smallest proportion, seems to consist of about 1 part in weight of basis and 70 parts of mercury, and is very soft and malleable.

When these compounds are exposed to air, they rapidly absorb oxigen; potash which deliquesces is formed; and in a few minutes the mercury is found pure and unaltered.

When a globule of the amalgam is thrown into water, it rapidly decomposes it with a hissing noise; potash is formed, pure hidrogen disengaged, and the mercury remains free.

The fluid amalgam of mercury and this substance dissolves all the metals I have exposed to it; and in this state of union, mercury acts on iron and platina.

When the basis of potash is heated with gold, or silver, or copper, in a close vessel of pure glass, it rapidly acts upon them; and when the compounds are thrown into water, this fluid is decomposed, potash formed, and the metals appear to be separated unaltered.

The basis of potash combines with fusible metal, and forms an alloy with it, which has a higher point of fusion than the fusible metal.

The action of the basis of potash upon the inflammable oily compound bodies, confirms the other facts of the strength of its attraction for oxigen.

On naphtha colourless and recently distilled, as I have already said, it has very little power of action; but in naphtha that has been exposed to the air it soon oxidates, and alkali is formed, which unites with the naphtha into a brown soap, that collects round the globule.

On the concrete oils (tallow, spermaceti, wax, for instance), when heated, it acts slowly, coaly matter is deposited, a little gas† is evolved, and a soap is formed; but

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* The existence of hidrogen in sulphur is rendered very probable by the ingenious researches of M. Berthollet, jun. *Annales de Chimie*, Fevrier 1807, p. 143. This fact is almost demonstrated by an experiment, which I saw made by W. Clayfield, Esq., at Bristol, in 1799. Copper filings and powdered sulphur, in weight in the proportion of three to one, rendered very dry, were heated together in a retort, connected with a mercurial pneumatic apparatus. At the moment of combination a quantity of elastic fluid was liberated amounting to 9 or 10 times the volume of the materials employed, and which consisted of sulphuretted hidrogen mixed with sulphurous acid. The first-mentioned product, there is every reason to believe, must be referred to the sulphur, the last probably to the copper, which it is easy to conceive may have become slightly and superficially oxidated during the processes of filing and drying by heat.

† When a globule of the basis of potash is introduced into any of the fixed oils heated, the first product is pure hidrogen, which arises from the decomposition of the water absorbed by the crust of potash during the exposure to the atmosphere. The gas evolved, when the globule is freed from this crust, I have found to be carbonated hidrogen requiring more than an equal bulk of oxigen gas for its complete saturation by explosion. I have made a great number of experiments which it would be foreign to the object of this lecture to give in minute detail, on the agencies of the basis of potash on the oils. Some anomalies occurred which led to the inquiry, and the result was perfectly conclusive. Olive oil, oil of turpentine, and naphtha when decomposed by heat, exhibited as products different proportions of charcoal, heavy inflammable gas, empyreumatic oily matter, and water, so that the existence of oxigen in them was fully proved; and accurate indications of the proportions of their elements might be gained by their decomposition by the basis of potash. Naphtha of all furnished least water and carbonic acid, and oil of turpentine the most.

in these cases it is necessary that a large quantity of the oil be employed. On the fluid fixed oils it produces the same effects, but more slowly.

By heat likewise it rapidly decomposes the volatile oils; alkali is formed, a small quantity of gas is evolved, and charcoal is deposited.

When the basis of potash is thrown into camphor in fusion, the camphor soon becomes blackened, no gas is liberated in the process of decomposition, and a saponaceous compound is formed; which seems to show, that camphor contains more oxigen than the volatile oils.

The basis of potash readily reduces metallic oxides when heated in contact with them. When a small quantity of the oxide of iron was heated with it to a temperature approaching its point of distillation, there was a vivid action; alkali and gray metallic particles, which dissolved with effervescence in muriatic acid, appeared. The oxides of lead and the oxides of tin were revived still more rapidly; and when the basis of potash was in excess, an alloy was formed with the revived metal.

In consequence of this property, the basis of potash readily decomposes flint glass and green glass, by a gentle heat; alkali is immediately formed by oxigen from the oxides, which dissolves the glass, and a new surface is soon exposed to the agent.

At a red heat, even the purest glass is altered by the basis of potash: the oxigen in the alkali of the glass seems to be divided between the two bases, the basis of potash and the alkaline basis in the glass, and oxides, in the first degree of oxigenation, are the result. When the basis of potash is heated in tubes made of plate glass filled with the vapour of naphtha, it first acts upon the small quantity of the oxides of cobalt and manganese in the interior surface of the glass, and a portion of alkali is formed. As the heat approaches to redness, it begins to rise in vapour, and condenses in the colder parts of the tube; but at the point where the heat is strongest, a part of the vapour seems to penetrate the glass, rendering it of a deep red brown colour; and by repeatedly distilling and heating the substance in a close tube of this kind, it finally loses its metallic form, and a thick brown crust, which slowly decomposes water, and which combines with oxigen when exposed to air, forming alkali, lines the interior of the tube, and in many parts is found penetrating through its substance *.

In my first experiments on the distillation of the basis of potash, I had great difficulty in accounting for these phænomena; but the knowledge of the substance it forms in its first degree of union with oxigen afforded a satisfactory explanation.

V. *On the Properties and Nature of the Basis of Soda.*

The basis of soda, as I have already mentioned, is a solid at common temperatures. It is white, opake, and when examined under a film of naphtha, has the lustre and general appearance of silver. It is exceedingly malleable, and is much softer than any of the common metallic substances. When pressed upon by a platina blade, with a small force, it spreads into thin leaves, and a globule of the $\frac{1}{10}$th, or $\frac{1}{12}$th of an inch in diameter is easily spread over a surface of a quarter of an inch †, and this property does not diminish when it is cooled to 32° Fahrenheit.

It conducts electricity and heat in a similar manner to the basis of potash; and small globules of it inflame by the Voltaic electrical spark, and burn with bright explosions.

Its specific gravity is less than that of water. It swims in oil of sassafras of 1·096, water being 1, and sinks in naphtha of specific gravity ·861. This circumstance enabled me to ascertain the point with precision. I mixed together oil of sassafras and naphtha, which combine very perfectly, observing the proportions till I had composed a fluid, in which it remained at rest above or below; and this fluid consisted of nearly twelve parts naphtha, and five of oil of sassafras, which gives a specific gravity to that of water nearly as nine to ten, or more accurately as ·9348 to 1.

The basis of soda has a much higher point of fusion than the basis of potash; its parts begin to lose their cohesion at about 120° Fahrenheit, and it is a perfect fluid at about 180°, so that it readily fuses under boiling naphtha.

I have not yet been able to ascertain at what degree of heat it is volatile; but it remains fixed in a state of ignition at the point of fusion of plate glass.

The chemical phænomena produced by the basis of soda are analogous to those produced by the basis of potash; but with such characteristic differences as might be well expected.

When the basis of soda is exposed to the atmosphere, it immediately tarnishes, and by degrees becomes covered with a white crust, which deliquesces much more slowly

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* This is the obvious explanation in the present state of our knowledge; but it is more than probable, that the silex of the glass likewise suffers some change, and probably decomposition. This subject I hope to be able to resume on another occasion.

† Globules may be easily made to adhere and form one mass by strong pressure: so that the property of welding, which belongs to iron and platina at a white heat only, is possessed by this substance at common temperatures.

The basis of soda combines with oxigen slowly, and without luminous appearance, at all common temperatures; and when heated, this combination becomes more rapid; but no light is emitted, till it has acquired a temperature nearly that of ignition.

The flame that it produces in oxigen gas is white, and it sends forth bright sparks, occasioning a very beautiful effect; in common air, it burns with light of the colour of that produced during the combustion of charcoal, but much brighter.

The basis of soda, when heated with hidrogen, seemed to have no action upon it. When introduced into oximuriatic acid gas, it burnt vividly with numerous scintillations of a bright red colour. Saline matter was formed in this combustion, which, as might have been expected, proved to be muriat of soda.

Its operation upon water offers most satisfactory evidence of its nature. When thrown upon this fluid, it produces a violent effervescence, with a loud hissing noise; it combines with the oxigen of the water to form soda, which is dissolved, and its hidrogen is disengaged. In this operation there is no luminous appearance; and it seems probable, that even in the nascent state hidrogen is incapable of combining with it*.

When the basis of soda is thrown into hot water, the decomposition is more violent, and in this case a few scintillations are generally observed at the surface of the fluid; but this is owing to small particles of the basis, which are thrown out of the water sufficiently heated, to burn in passing through the atmosphere. When, however, a globule is brought into contact with a small particle of water, or with moistened paper, the heat produced (there being no medium to carry it off rapidly) is usually sufficient for the ascension of the basis.

The basis of soda acts upon alcohol and ether precisely in a similar manner with the basis of potash. The water that they contain is decomposed; soda is rapidly formed, and hidrogen disengaged.

The basis of soda, when thrown upon the strong acids, acts upon them with great energy. When nitrous acid is employed, a vivid inflammation is produced; with muriatic and sulphuric acid, there is much heat generated, but no light.

When plunged, by proper means, beneath the surface of the acids, it is rapidly oxigenated; soda is produced, and the other educts are similar to those generated by the action of the basis of potash.

effects of the two new substances, except in the difference of the appearances of the saponaceous compounds formed: those produced by the oxidation and combination of the basis of soda being of a darker colour, and apparently less soluble.

The basis of soda, in its degrees of oxidation, has precisely similar habits with the basis of potash.

When it is fused with dry soda, in certain quantities, there is a division of oxigen between the alkali and the base; and a deep brown fluid is produced, which becomes a dark gray solid on cooling, and which attracts oxigen from the air, or which decomposes water, and becomes soda.

The same body is often formed in the analytical processes of decomposition, and it is generated when the basis of soda is fused in tubes of the purest plate glass.

There is scarcely any difference in the visible phænomena of the agencies of the basis of soda, and that of potash, on sulphur, phosphorus, and the metals.

It combines with sulphur in close vessels filled with the vapour of naphtha with great vividness, with light, heat, and often with explosion from the vaporization of a portion of sulphur, and the disengagement of sulphuretted hidrogen gas. The sulphuretted basis of soda is of a deep gray colour.

The phosphuret has the appearance of lead, and forms phosphat of soda by exposure to air, or by combustion.

The basis of soda in the quantity of $\frac{1}{40}$ renders mercury a fixed solid of the colour of silver, and the combination is attended with a considerable degree of heat.

It makes an alloy with tin, without changing its colour, and it acts upon lead and gold when heated. I have not examined its habitudes with any other metals; but in its state of alloy it is soon converted into soda by exposure to air, or by the action of water, which it decomposes with the evolution of hidrogen.

The amalgam of mercury and the basis of soda seems to form triple compounds with other metals. I have tried iron and platina, which I am inclined to believe remain in combination with the mercury, when it is deprived of the new substance by exposure to air.

The amalgam of the basis of soda and mercury likewise combines with sulphur and forms a triple compound of a dark gray colour.

VI. *On the Proportions of the peculiar Bases and Oxigen in Potash and Soda.*

The facility of combustion of the bases

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* The more volatile metals only seem capable of uniting with hidrogen; a circumstance presenting an analogy.

of their ponderable constituent parts.

I shall mention the general methods of the experiments, and the results obtained by the different series, which approach as near to each other as can be expected in operations performed on such small quantities of materials.

For the process in oxigen gas I employed glass tubes containing small trays made of thin leaves of silver, or other noble metals, on which the substance to be burnt, after being accurately weighed or compared with a globule of mercury equal in size* was placed: the tube was small at one end, curved, and brought to a fine point, but suffered to remain open; and the other end was fitted to a tube communicating with a gasometer, from which the oxigen gas was introduced, for neither water nor mercury could be used for filling the apparatus. The oxigen gas was carried through the tube, till it was found that the whole of the common air was expelled. The degree of its purity was ascertained by suffering a small quantity to pass into the mercurial apparatus. The lower orifice was then hermetically sealed by a spirit lamp, and the upper part drawn out and finally closed, when the aperture was so small, as to render the temperature employed incapable of materially influencing the volume of the gas; and when the whole arrangement was made, the combination was effected by applying heat to the glass in contact with the metallic tray.

In performing these experiments many difficulties occurred. When the flame of the lamp was immediately brought to play upon the glass, the combustion was very vivid, so as sometimes to break the tube; and the alkali generated partly rose in white fumes, which were deposited upon the glass.

When the temperature was slowly raised, the bases of the alkalis acted upon the metallic tray and formed alloys, and in this state it was very difficult to combine them with their full proportion of oxigen; glass alone could not be employed on account of its decomposition by the alkaline bases; and porcelain is so bad a conductor of heat, In all cases the globules of the alkaline bases were carefully freed from naphtha before they were introduced; of course a slight crust of alkali was formed before the combustion, but this could not materially affect the result; and when such a precaution was not used, an explosion generally took place from the vaporization and decomposition of the film of naphtha surrounding the globule.

After the combustion, the absorption of gas was ascertained, by opening the lower point of the tube under water or mercury. In some cases the purity of the residual air was ascertained, in others the alkali formed in the tray was weighed.

From several experiments on the synthesis of potash by combustion, I shall select two, which were made with every possible attention to accuracy, and under favourable circumstances, for a mean result.

In the first experiment 0·12 of a grain of the basis were employed. The combustion was made upon platina, and was rapid and complete; and the basis appeared to be perfectly saturated, as no disengagement of hidrogen took place, when the platina tray was thrown into water. The oxigen gas absorbed equalled in volume 190 grain measures of quicksilver; barometer being at 29·6 inches, thermometer 62° Fahrenheit; and this reduced to a temperature of 60° Fahrenheit, and under a pressure equal to that indicated by 30 inches †, would become 185·67 measures, the weight of which would be about ·0184 of a grain troy ‡; but ·0184 : ·1384 : : 13·29 : 100; and according to this estimation 100 parts of potash will consist of 86·7 basis, and 13·3 oxigen nearly.

In the second experiment ·07 of a grain of the basis absorbed at temperature 63° of Fahrenheit, and under pressure equal to 30·1 barometer inches, a quantity of oxigen equal in volume to 121 grain measures of mercury, and the proper corrections being made as in the former case, this gas would weigh ·01189 of a grain.

But as ·07 + ·01189 = ·08189 : 07 : : 100 :85·48 nearly, 100 parts of potash will consist of 85·5 of basis and 14·5 of oxigen nearly. And the mean of the two experiments will

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* When the globules were very small, the comparison with mercury, which may be quickly made by means of a micrometer, was generally employed as the means of ascertaining the weight: for in this case the globule could be immediately introduced into the tube, and the weight of mercury ascertained at leisure.

† In the correction for temperature, the estimations of Dalton and Gay Lussac are taken, which make gasses expand about $\frac{1}{485}$ of the primitive volume for every degree of Fahrenheit.

‡ From experiments that I made in 1799, on the specific gravity of oxigen gas, it would appear, that its weight is to that of water as 1 to 748, and to that of quicksilver as 1 to 10142, *Researches Chem.* and *Phil.* p. 9; and with this estimation that deducible from the late accurate researches of Messrs. Allen and Pepys on the Combustion of the Diamond almost precisely agree. Phil. Trans. 1807, p. 275.

be 86·1 of basis to 13·9 of oxigen for 100 parts.

In the most accurate experiment that I made on the combustion of the basis of soda, ·08 parts of the basis absorbed a quantity of oxigen equal to 206 grain measures of mercury; the thermometer being at 56° Fahrenheit, and the barometer at 29·4; and this quantity, the corrections being made as before for the mean temperature and pressure, equals about ·02 of a grain of oxigen.

And as ·08 + ·02 = ·10 : ·08 : : 100 : 80, 100 parts of soda, according to this estimation, will consist of 80 basis to 20 of oxigen.

In all cases of slow combustion, in which the alkalis were not carried out of the tray, I found a considerable increase of weight, but as it was impossible to weigh them except in the atmosphere, the moisture attracted rendered the results doubtful; and the proportions from the weight of the oxigen absorbed are more to be depended on. In the experiments in which the processes of weighing were most speedily performed, and in which no alkali adhered to the tube, the basis of potash gained nearly 2 parts for 10, and that of soda between 3 and 4 parts.

The results of the decomposition of water by the bases of the alkalis were much more readily and perfectly obtained than those of their combustion.

To check the rapidity of the process, and, in the case of potash, to prevent any of the basis from being dissolved, I employed the amalgams with mercury. I used a known weight of the bases, and made the amalgams under naphtha, using about two parts of mercury in volume to one of basis.

In the first instances I placed the amalgams under tubes filled with naphtha, and inverted in glasses of naphtha, and slowly admitted water to the amalgam at the bottom of the glass; but this precaution I soon found unnecessary, for the action of the water was not so intense, but that the hidrogen gas could be wholly collected.

I shall give an account of the most accurate experiments made on the decomposition of water by the bases of potash and soda.

In an experiment on the basis of potash conducted with every attention that I could pay to the minutiæ of the operations, hidrogen gas, equal in volume to 298 grains of mercury, was disengaged by the action of ·08 of a grain of the basis of potash, which had been amalgamated with about 3 grains of mercury. The thermometer at the end of the process indicated a temperature of 56° Fahrenheit, and the barometer an atmospheric pressure equal to 29·6 inches.

Now this quantity of hidrogen* would require for its combustion a volume of oxigen gas about equal to that occupied by 154·9 of a grain of mercury, which gives the weight of oxigen required to saturate the ·08 of a grain of the basis of potash at the mean temperature and pressure nearly ·0151 of a grain. And ·08 + ·0151 = ·0951 : ·08 : : 100 : 84·1 nearly.

And according to these indications 100 parts of potash consist of about 84 basis and 16 oxigen.

In an experiment on the decomposition of water by the basis of soda, the mercury in the barometer standing at 30·4 inches, and in the thermometer at 52° Fahrenheit, the volume of hidrogen gas evolved by the action of ·054 of a grain of basis equalled that of 326 grains of quicksilver. Now this at the mean temperature and pressure would require for its conversion into water, ·0172 of oxigen, and ·054 + ·0172 = ·0712 : ·054 : : 100 : 76 nearly; and according to these indications, 100 parts of soda consist of nearly 76 basis and 24 oxigen.

In another experiment made with very great care, ·052 of the basis of soda were used; the mercury in the barometer was at 29·9 inches, and that in the thermometer at 58° Fahrenheit. The volume of hidrogen evolved was equal to that of 302 grains of mercury; which would demand for its saturation by combustion at the mean temperature and pressure ·01549 of a grain of oxigen; and 100 parts of soda, according to this proportion, would consist nearly of 77 basis and 23 oxigen.

The experiments, which have been just detailed, are those in which the largest quantities of materials were employed; I have compared their results, however, with the results of several others, in which the decomposition of water was performed with great care, but in which the proportion of the bases was still more minute: the largest quantity of oxigen indicated by these experiments was, for potash 17, and for soda 26 parts in 100, and the smallest 13, and 19; and comparing all the estimations, it will probably be a good approximation to the truth, to consider potash as composed of about 6 parts basis and 1 of oxigen; and soda, as consisting of 7 basis and 2 oxigen.

VII. *Some general Observations on the Relations of the Bases of Potash and Soda to other Bodies.*

Should the bases of potash and soda be called metals? The greater number of philosophical persons, to whom this question has been put, have answered in the affirmative. They agree with metals in opacity, lustre, malleability, conducting powers as to heat and electricity, and in their qualities of chemical combination.

Their low specific gravity does not appear a sufficient reason for making them a new

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* Researches Chem. and Phil. p. 287

tellurium*; and in the philosophical division of the classes of bodies, the analogy between the greater number of properties must always be the foundation of arrangement.

On this idea, in naming the bases of potash and soda, it will be proper to adopt the termination, which, by common consent, has been applied to other newly discovered metals, and which, though originally Latin, is now naturalized in our language.

Potasium and sodium are the names by which I have ventured to call the two new substances: and whatever changes of theory, with regard to the composition of bodies, may hereafter take place, these terms can scarcely express an error; for they may be considered as implying simply the metals produced from potash and soda. I have consulted with many of the most eminent scientific persons in this country upon the methods of derivation, and the one I have adopted has been the one most generally approved. It is perhaps more significant than elegant. But it was not possible to found names upon specific properties not common to both; and though a name for the basis of soda might have been borrowed from the Greek, yet an analogous one could not have been applied to that of potash, for the ancients do not seem to have distinguished between the two alkalis.

The more caution is necessary in avoiding any theoretical expression in the terms, because the new electro-chemical phænomena, yet far distant; and though, in the explanations of the various results of experiments that have been detailed, the antiphlogistic solution of the phænomena has been uniformly adopted, yet the motive for employing it has been rather a sense of its beauty and precision, than a conviction of its permanency and truth.

The discovery of the agencies of the gasses destroyed the hypothesis of Stahl. The knowledge of the powers and effects of the ethereal substances may at a future time possibly act a similar part with regard to the more refined and ingenious hypothesis of Lavoisier; but in the present state of our knowledge, it appears the best approximation that has been made to a perfect logic of chemistry.

Whatever future changes may take place in theory, there seems however every reason to believe, that the metallic bases of the alkalis, and the common metals, will stand in the same arrangement of substances; and as yet we have no good reasons for assuming the compound nature of this class of bodies†.

The experiments in which it is said, that alkalis, metallic oxides, and earths, may be formed from air and water alone, in processes of vegetation, have been always made in an inconclusive manner‡; for distilled water, as I have endeavoured to show§, may contain both saline and metallic impregnations; and the free atmosphere almost constantly holds in mechanical suspension solid substances of various kinds.

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* Tellurium is not much more than six times as heavy as the basis of soda. There is great reason to believe, that bodies of a similar chemical nature to the bases of potash and soda will be found of intermediate specific gravities between them and the lightest of the common metals. Of this subject I shall treat again in the text in some of the following pages.

† A phlogistic chemical theory might certainly be defended, on the idea, that the metals are compounds of certain unknown bases with the same matter as that existing in hidrogen; and the metallic oxides, alkalis, and acids, cómpounds of the same bases with water; —but in this theory more unknown principles would be assumed than in the generally received theory. It would be less elegant and less distinct. In my first experiments on the distillation of the basis of potash, finding hidrogen generally produced, I was led to compare the phlogistic hypothesis with the new facts, and I found it fully adequate to the explanation. More delicate researches, however, afterward proved, that in the cases when inflammable gasses appeared, water, or some body in which hidrogen is admitted to exist, was present.

‡ The explanation of Van Helmont of his fact of the production of earth in the growth of the willow was completely overturned by the researches of Woodward. Phil. Trans. vol. xxi, p. 193.

The conclusions which Mr. Braconnot has very lately drawn from his ingenious experiments, *Annales de Chimie*, Fevrier 1807, p. 187, are rendered of little avail in consequence of the circumstances stated in the text. In the only case of vegetation in which the free atmosphere was excluded, the seeds grew in white sand, which is stated to have been purified by washing in muriatic acid; but such a process was insufficient to deprive it of substances, which might afford carbon, or various inflammable matters. Carbonaceous matter exists in several stones, which afford a whitish or grayish powder; and when in a stone the quantity of carbonat of lime is very small in proportion to the other earthy ingredients, it is scarcely acted on by acids.

§ Bakerian Lecture, 1806, page 8.

In the common processes of nature, all the products of living beings may be easily conceived to be elicited from known combinations of matter. The compounds of iron, of the alkalis, and earths, with mineral acids, generally abound in soils. From the decomposition of basaltic, porphyritic [*], and granitic rocks, there is a constant supply of earthy, alkaline, and ferruginous materials to the surface of the earth. In the sap of all plants, that have been examined, certain neutrosaline compounds, containing potash, or soda, or iron, have been found. From plants they may be supplied to animals. And the chemical tendency of organization seems to be rather to combine substances into more complicated and diversified arrangements, than to reduce them into simple elements.

VIII. *On the Nature of Ammonia and alkaline Bodies in general; with Observations on some Prospects of Discovery offered by the preceding Facts.*

Ammonia is a substance, the chemical composition of which has always been considered of late years as most perfectly ascertained, and the apparent conversion of it into hidrogen and nitrogen, in the experiments of Scheele, Priestley, and the more refined and accurate experiments of Berthollet, had left no doubt of its nature in the minds of the most enlightened chemists.

All new facts must be accompanied, however, by a train of analogies, and often by suspicions with regard to the accuracy of former conclusions. As the two fixed alkalis contain a small quantity of oxigen united to peculiar bases, may not the volatile alkali likewise contain it? was a query which soon occurred to me in the course of inquiry; and in perusing the accounts of the various experiments made on the subject, some of which I had carefully repeated, I saw no reason to consider the circumstance as impossible. For supposing hidrogen and nitrogen to exist in combination with oxigen in low proportion, this last principle might easily disappear in the analytical experiments of decomposition by heat and electricity, in water deposited upon the vessels employed or dissolved in the gases produced.

Of the existence of oxigen in volatile alkali I soon satisfied myself. When charcoal carefully burnt and freed from moisture was ignited by the Voltaic battery of the power of 250 of 6 and 4 inches square, in a small quantity of very pure ammoniacal gas [†]: a great expansion of the aëriform matter took place, and a white substance formed, which collected on the sides of the glass tube employed in the process; and this matter, exposed to the action of diluted muriatic acid, effervesced, so that it was probably carbonat of ammonia.

A process of another kind offered still more decisive results. In this the two mercurial gasometers of the invention of Mr. Pepys, described in No. XIV of the Phil. Trans. for 1807, were used with the same apparatus as that employed by Messrs. Allen and Pepys for the combustion of the diamond, and these gentlemen kindly assisted in the experiment.

Very pure ammoniacal gas was passed over iron wire ignited in a platina tube, and two curved glass tubes were so arranged, as to be inserted into a freezing mixture; and through one of these tubes the gas entered into the platina tube, and through the other it passed from the platina tube into the airholder arranged for its reception.

The temperature of the atmosphere was 55°; and it was observed, that no sensible quantity of water was deposited in the cooled glass tube transmitting the unaltered ammonia, but in that receiving it after its exposure to heat moisture was very distinct, and the gas appeared in the airholder densely clouded.

This circumstance seems distinctly to prove the formation of water in this operation for the decomposition of ammonia; unless indeed it be asserted, that the hidrogen and nitrogen gasses evolved hold less water in solution or suspension than the

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[*] In the year 1804, for a particular purpose of geological inquiry, I made an analysis of the porcelain clay of St. Stevens, in Cornwall, which results from the decomposition of the feldspar of fine-grained granite. I could not detect in it the smallest quantity of alkali. In making some experiments on specimens of the undecompounded rock taken from beneath the surface, there were evident indications of the presence of a fixed alkali, which seemed to be potash. So that it is very probable, that the decomposition depends on the operation of water and the carbonic acid of the atmosphere on the alkali forming a constituent part of the crystalline matter of the feldspar, which may disintegrate from being deprived of it.

[†] The apparatus in which this experiment was made is described in page 214 Journal of the Royal Institution. The gas was confined by mercury, which had been previously boiled to expel any moisture that might adhere to it. The ammonia had been exposed to the action of dry pure potash, and a portion of it equal in volume to 10980 grains of mercury, when acted on by distilled water, left a residuum equal to 9 grains of mercury only. So that the gas, there is every reason to believe, contained no foreign aëriform matter; for even the minute residuum may be accounted for by supposing it derived from air dissolved in the water.

ammonia decomposed, an idea strongly opposed by the conclusions of Mr. Dalton[*] and the experiments of Messrs. Desormes and Clement[†].

After the gas had been passed several times through the ignited tube from one gasometer to the other, the results were examined. The iron wire became converted superficially into oxide, and had gained in weight $\frac{44}{100}$ parts of a grain, about $\frac{4}{10}$ of a grain of water were collected from the cooled glass tubes by means of filtrating paper, and 33·8 cubic inches of gas were expanded into 55·3 cubic inches, and by detonation with oxigen it was found, that the hidrogen gas in these was to the nitrogen as 3·2 to 1 in volume.

It will be useless to enter into the more minute details of this experiment, as no perfectly accurate data for proportions can be gained from them; for the whole of the ammonia was not decomposed, and as the gas had been prepared by being sent from a heated mixture of sal ammoniac and quicklime into the airholder, it was possible, that some solution of ammonia might have been deposited, which, by giving out new gas during the operation, would increase the absolute quantity of the material acted upon.

In examining the results of Mr. Berthollet's[‡] elaborate experiments on the decomposition of ammonia by electricity, I was surprised to find, that the weight of the hidrogen and nitrogen produced rather exceeded than fell short of that of the ammonia considered as decomposed, which was evidently contradictory to the idea of its containing oxigen. This circumstance, as well as the want of coincidence between the results and those of Priestley and Van Marum on the same subject, induced me to repeat the process of electrization of ammonia, and I soon found, that the quantities of the products in their relations to the apparent quantity of gas destroyed were influenced by many different causes.

Ammonia procured over dry mercury from a mixture of dry lime and muriat of ammonia, I found, deposited moisture upon the sides of the vessel, in which it was collected, and in passing the gas into the tube for electrization, it was not easy to avoid introducing some of this moisture, which must have been a saturated solution of ammonia, at the same time.

In my first trials, made upon gas passed immediately from the vessel in which it had been collected into the apparatus, I found the expansion of 1 of ammonia vary in different instances from 2·8 to 2·2 measures, but the proportions of the nitrogen and hidrogen appeared uniform, as determined by detonation of the mixed gas with oxigen, and nearly as 1 to 3 in volume.

To exclude free moisture entirely, I carefully prepared ammonia in a mercurial airholder, and after it had been some hours at rest, passed a quantity of it into the tube for decomposition, which had been filled with dry mercury. In this case 50 parts became 108 parts by electrization, and there was still reason to suspect sources of error.

I had used iron wires not perfectly free from rust for taking the spark, and a black film from the mercury appeared on the sides of the tube. It was probable that some ammonia had been absorbed by the metallic oxides both upon the iron and the mercury, which might again have been given out in the progress of the operation.

I now used recently distilled mercury, which did not leave the slightest film on the glass tube, and wires of platina. The ammonia had been exposed to dry caustic potash, and proved to be equally pure with that before mentioned. Sixty measures of it, each equal to a grain of water, were electrized till no farther expansion could be produced, the gas filled a space equal to that occupied by 108 grains of water. The thermometer in this experiment was at 56°, and the barometer at 30·1 of an inch. The wire of platina transmitting the spark was slightly tarnished[§]. The 108 measures of gas, carefully analysed, were found to consist of 80 measures in volume of hidrogen, and 28 measures of nitrogen.

The results of an experiment that I made in 1799[‖] give the weight of 100 cubic inches of ammonia as 18·18 of a grain at the mean temperature and pressure. I had reasons, however, for suspecting, that this estimation might be somewhat too low; and on mentioning the circumstance to Messrs. Allen and Pepys, they kindly undertook the examination of the subject, and Mr. Allen soon furnished me with the following data. "In the first experiment 21 cubic inches of ammonia weighed 4·05 of a grain; in a second experiment the same quantity weighed 4·06 of a grain, barometer 30·65, thermometer 54° Fahrenheit."

Now if the corrections for temperature and pressure be made for these estimations, and a mean taken, 100 cubic inches of ammonia will weigh 18·67 of a grain, barometer being at 30, and thermometer at 60° Fahr-

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[*] Manchester Memoirs, vol. v, part ii, p. 585; 1785.

[†] *Annales de Chimie*, vol. xlii, p. 125.

[‡] *Mémoires de l'Académie*, 1785, p. 324.

[§] This most probably was owing to oxidation. When platina is made positive in the Voltaic circuit in contact with solution of ammonia, it is rapidly corroded. This is an analogous instance.

[‖] Researches Chem. and Phil. p. 62.

enheit: and if the quantity used in the experiment of decomposition be calculated upon as cubic inches, 60 will weigh 11·2 grains. But the hidrogen gas evolved equal to 80 will weigh 1·93* grain, and the nitrogen equal to 28†, 8·3. And 1·9 + 8·3 = 10·2, and 11·2 — 10·2 = 1; all the estimations being made according to the standard temperature and pressure.

So that in this experiment on the decomposition of ammonia, the weight of the gasses evolved is less by nearly $\frac{1}{11}$ than that of the ammonia employed; and this loss can only be ascribed to the existence of oxigen in the alkali; part of which probably combined with the platina wires employed for electrization, and part with hidrogen.

After these ideas the oxigen in ammonia cannot well be estimated at less than 7 or 8 parts in the hundred; and it possibly exists in a larger proportion, as the gasses evolved may contain more water than the gas decomposed, which of course would increase their volume and their absolute weight‡.

In supposing ammonia a triple compound of nitrogen, hidrogen, and oxigen, it is no less easy to give a rational account of the phænomena of its production and decomposition, than in adopting the generally received hypothesis of its composition.

Oxigen, hidrogen, and nitrogen are always present in cases in which volatile alkali is formed; and it usually appears during the decomposition of bodies in which oxigen is loosely attached, as in that of the compounds of oxigen and nitrogen dissolved in water.

At common temperatures under such favourable circumstances, the three elements may be conceived capable of combining, and of remaining in union: but at the heat of ignition the affinity of hidrogen for oxigen prevails over the complex attraction, water is formed, and hidrogen and nitrogen are evolved; and according to these conclusions, ammonia will bear the same relations to the fixed alkalis, as the vegetable acids with compound bases do to the mineral ones with simple bases.

Oxigen then may be considered as existing in, and as forming, an element in all the true alkalis; and the principle of acidity of the French nomenclature might now likewise be called the principle of alkalescence.

From analogy alone it is reasonable to expect, that the alkaline earths are compounds of a similar nature to the fixed alkalis, peculiar highly combustible metallic bases united to oxigen. I have tried some experiments upon barytes and strontites; and they go far toward proving, that this must be the case. When barytes and strontites, moistened with water, were acted upon by the power of the battery of 250 of 4 and 6, there was a vivid action and a brilliant light at both points of communication, and an inflammation at the negative point.

In these cases the water might possibly have interfered. Other experiments gave, however, more distinct results.

Barytes and strontites, even when heated to intense whiteness in the electrical circuit by a flame supported by oxigen gas, are nonconductors; but by means of combination with a very small quantity of boracic acid they become conductors; and in this case inflammable matter, which burns with a deep red light in each instance, is produced from them at the negative surface. The high temperature has prevented the success of attempts to collect this substance; but there is much reason to believe, that it is the basis of the alkaline earth employed.

Barytes and strontites have the strongest relations to the fixed alkalis of any of the earthy bodies§; but there is a chain of resemblances, through lime, magnesia, glucine, alumine, and silex. And by the agencies of batteries sufficiently strong, and by the application of proper circumstances, there is no small reason to hope, that even these refractory bodies will yield their elements to the methods of analysis by electrical attraction and repulsion.

In the electrical circuit we have a regular series of powers of decomposition, from an intensity of action, so feeble as scarcely to destroy the weakest affinity existing be-

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[*] Lavoisier's Elements, p. 569. A cubical inch of hidrogen is considered as weighing ·0239.

[†] Researches Chem. and Phil. p. 9. From my experiments 100 cubical inches of nitrogen weigh, at the standard temperature and pressure, 29·6 of a grain.

[‡] In the present state of our knowledge, perfectly correct data for proportions cannot probably be gained in any experiments on the decomposition of ammonia, as it seems impossible to ascertain the absolute quantity of water in this gas; for electrization, according to Dr. Henry's ingenious researches, offers the only means known of ascertaining the quantity of water in gasses.

[§] The similarity between the properties of earths and metallic oxides was noticed in the early periods of chemistry. The poisonous nature of barytes, and the great specific gravity of this substance as well as of strontites, led Lavoisier to the conjecture, that they were of a metallic nature. That metals existed in the fixed alkalis seems, however, never to have been suspected. From their analogy to ammonia, nitrogen and hidrogen have been supposed to be among their elements. It is singular, with regard to this class of bodies, that those most unlike metallic oxides are the first which have been demonstrated to be such.

tween the parts of a saline neutral compound, to one sufficiently energetic to separate elements in the strongest degree of union in bodies undecomposable under other circumstances.

When the powers are feeble, acids and alkalis, and acids and metallic oxides merely separate from each other; when they are increased to a certain degree, the common metallic oxides and the compound acids are decomposed; and by means still more exalted, the alkalis yield their elements. And as far as our knowledge of the composition of bodies extends, all substances attracted by positive electricity are oxigen, or such as contain oxigen in excess; and all that are attracted by negative electricity are pure combustibles, or such as consist chiefly of combustible matter.

The idea of muriatic acid, fluoric acid, and boracic acid containing oxigen, is highly strengthened by these facts. And the general principle confirms the conjecture just stated concerning the nature of the earths.

In the electrization of boracic acid moistened with water, I find, that a dark coloured combustible matter is evolved at the negative surface; but the researches upon the alkalis have prevented me from pursuing this fact, which seems, however, to indicate a decomposition.

Muriatic acid and fluoric acid in their gaseous states are nonconductors: and as there is every reason to believe, that their bases have a stronger attraction for oxigen than water, there can be little hope of decomposing them in their aqueous solutions, even by the highest powers. In the electrization of some of their combinations there is, however, a probability of success.

An immense variety of objects of research is presented in the powers and affinities of the new metals produced from the alkalis.

In themselves they will undoubtedly prove powerful agents for analysis; and having an affinity for oxigen stronger than any other known substances, they may possibly supersede the application of electricity to some of the undecompounded bodies.

The basis of potash I find oxidates in carbonic acid and decomposes it, and produces charcoal when heated in contact with carbonat of lime. It likewise oxidates in muriatic acid; but I have had no opportunity of making the experiment with sufficient precision to ascertain the results.

In sciences kindred to chemistry, the knowledge of the nature of the alkalis, and the analogies arising in consequence, will open many new views; they may lead to the solution of many problems in geology, and show, that agents may have operated in the formation of rocks and earths, which have not hitherto been suspected to exist.

It would be easy to pursue the speculative part of this inquiry to a great extent, but I shall refrain from so occupying the time of the Society, as the tenour of my object in this lecture has not been to state hypotheses, but to bring forward a new series of facts.