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ELEMENTS
OF
NATURAL HISTORY,
AND OF
CHEMISTRY:

BEING THE SECOND EDITION OF
THE ELEMENTARY LECTURES ON
THOSE SCIENCES,

FIRST PUBLISHED IN 1782,

AND NOW

GREATLY ENLARGED AND IMPROVED,

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OF THE ROYAL ACADEMY OF SCIENCES, &c. &c. &c.

TRANSLATED INTO ENGLISH.

WITH OCCASIONAL NOTES, AND AN HISTORICAL
PREFACE, BY THE TRANSLATOR.

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ACIDS are diſtinguiſhed by their ſour taſte, when diluted with water; they redden vegetable colours. Many acids exiſt in the gaſeous form; they unite with great rapidity to

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* It may be proper, in this place, to remind the reader, that the preſent work is divided into four parts; the firſt, conſiſting of eight chapters, contains general facts and obſervations

to alkalis; their action on inflammable ſubſtances is much ſtronger than that of the laſt mentioned ſalts, and moſt commonly reduces them to the ſtate of bodies which have been burned. As inflammable matters, more eſpecially metallic ſubſtances, are found to contain a large quantity of pure air after having been ſubjected to the action of acids, while the acids themſelves become converted into combuſtible bodies; it may be concluded, that this genus of ſalts is much leſs ſimple than has hitherto been thought, and that they are in general compoſed of inflammable matter, combined with the oxyginous principle or baſis of vital air, according to the opinion of Mr. Lavoiſier. All the phenomena in chemiſtry tend to confirm this theory.

We are acquainted with ſix ſpecies of mineral acids, very different from each other:

The cretaceous acid,
The marine acid,
The ſparry acid,
The nitrous acid,
The vitriolic acid,
The acid of borax, or ſedative ſalt.

ſervations relating to chemiſtry; the ſecond contains the mineral kingdom, or mineralogy; the third contains the chemical hiſtory of vegetables; and the fourth that of animal ſubſtances.

The mineralogical part is divided into three ſections. The firſt exhibits the phyſical and chemical characters of earths and ſtones; the ſecond ſection relates to ſaline ſubſtances, or the ſubject with which we are at preſent occupied.—Note of the Author.

Species I. The CRETACEOUS ACID.

We give the name of cretaceous acid to that which was originally called fixed air by the Engliſh; mephitic acid by Mr. Bewly; mephitic gas by Macquer; and aerial acid by Bergman. Mr. Lavoiſier now calls it carbonaceous acid.

This acid has not always been conſidered as ſuch. Its leading properties were perceived by Paracelſus, Van Helmont, Hales, &c. but it is to Black, Prieſtley, Bewly, Bergman, and the Duke de Chaulnes, that we are indebted for the certain knowledge of its acidity. The name of cretaceous acid agrees very well with this ſubſtance, becauſe it is contained, in very large quantities, in chalk; and there is no other body with which it has ſo ſtrong an affinity, as with the lime which compoſes the baſe of this earthy ſalt.

The cretaceous acid poſſeſſes all the more obvious qualities of air, and exiſts in the atmoſphere of which it is a ſmall part.* It is found

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* Mr. Lavoiſier concludes, from his ingenious experiments, that atmoſpheric air conſiſts of vital air, cretaceous acid, and mephitis, uſually in the following proportions:

Vital air, - - - -	27
Cretaceous acid, - - -	1
Atmoſpheric mephitis, - -	72
Total - -	100

diſengaged and in a ſtate of purity in ſubterraneous cavities, as in the grotto del cane, &c. It exiſts in a ſtate of combination in a great number of natural bodies, ſuch as mineral waters, and ſeveral neutral ſalts: great quantities are produced in the ſpirituous fermentation; it is likewiſe produced in the proceſſes of reſpiration, and of the combuſtion of charcoal; and laſtly, all the parts of plants, more eſpecially the leaves, continually emit it while in the ſhade. This acid, though elaſtic and tranſparent, differs greatly from air, even in its phyſical properties; its ſpecific gravity is double that of air: hence it may be poured, like other denſe fluids, from one veſſel to another; and for this reaſon it flows out of the cock after a caſk of wine has been drawn off. Its taſte is briſk, and ſubacid; animals which reſpire it die inſtantly; and all bodies in a ſtate of combuſtion are extinguiſhed by being plunged in this fluid. It colours the tincture of turnſole with a clear red; which, however, diſappears by expoſure to air, in proportion as the acid evaporates. It does not alter the colour of violets, becauſe its action is too feeble to produce a ſenſible change in deep and fixed colours.

The elective attractions of this acid are in general very weak, as it yields to every other acid: it ſuffers no change by expoſure to light, or at leaſt the change is too ſmall to be perceived.

Heat dilates this fluid, without changing it in any other reſpect.

It mixes with pure or vital air, but without combination; and forms a mixture which may be reſpired for a certain time, provided the cretaceous acid do not exceed the third part of the whole: it may be adminiſtered in this manner as a remedy for diſorders of the lungs.

It combines with water, though ſlowly. When theſe two fluids are agitated together, and their ſurfaces of contact are by that means multiplied, they unite more readily, and form a liquid, which may be called acid ſpirit of chalk. Bergman calls this ſolution aerated water; but this name may be with equal propriety applied to water containing true air, by way of diſtinguiſhing it from water which has been deprived of that fluid by ebullition. Water diſſolves a greater quantity of acid the colder it is; but this ſolution is limited to a certain quantity: the coldeſt water cannot abſorb more than its own bulk of cretaceous acid. *

The acid ſpirit of chalk is ſomewhat heavier than diſtilled water; it ſparkles when agitated; its taſte is briſk and acidulous; and it reddens the tincture of turnſole. Heat

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* Water ſubjected to preſſure takes up a larger quantity of this acid, in proportion as the preſſure is greater; hence it ſhould ſeem, that the acid may exiſt in the pores of water without loſing its elaſtic form. T.

decompoſes this combination, by driving off the elaſtic acid. The contact of air produces the ſame effect the more quickly, as its temperature is higher. It is neceſſary, therefore, for the preſervation of this liquid, that it ſhould be kept in a cool place, in well-cloſed veſſels, or under a ſtrong compreſſion.

This acid ſpirit of chalk is abundantly found in nature, where it conſtitutes acidulous and gaſeous waters. Such as thoſe of Pyrmont, Seltzer, &c.

As this acidulated water is a remedy proper to be uſed in putrid diſorders, both internally and externally, philoſophers have contrived various apparatus for ſpeedily impregnating water, with the whole quantity of cretaceous acid it is capable of diſſolving. A proceſs for acidulating water was firſt publiſhed by Dr. Prieſtley, in the year 1772. Dr. Nooth has invented a machine for producing this effect, which has been ſince ſucceſſively improved by Mr. Parker and Mr. Magellan. This is at preſent to be met with in all philoſophical laboratories. A good deſcription and engraving may be ſeen in the fifth volume of Prieſtley's experiments.

The cretaceous acid does not act on ſiliceous earth. It is well known that this earth does not cryſtalize in acidulated water, as was aſſerted ſome years ago.

The cretaceous acid unites with clay, ponderous

derous earth, and magneſia, and forms ſeveral kinds of neutral ſalts.

A combination of this acid with the ſolution of lime in water, is conſtantly attended with a phenomenon, which forms a criterion of the preſence of this acid; when it comes in contact with the lime-water, white clouds are immediately produced, which increaſe in bulk, and form a very abundant precipitate. Theſe clouds ariſe from the combination of the cretaceous acid with the lime, with which it forms chalk; a compound, which being ſcarcely at all ſoluble in pure water, falls to the bottom: lime-water is therefore a teſt for diſtinguiſhing the nature and quality of the acid we are treating of. If an additional quantity of the acid be added after the precipitate is formed, this exceſs will cauſe it to diſappear, by a ſecond ſolution. Chalk diſſolved in water, by a ſuper-abundance of the cretaceous acid, is precipitated by boiling, by expoſure to air, and, in a word, by every proceſs which can take away this exceſs. Hence it is that cauſtic fixed alkalis, poured into a ſolution of chalk, by exceſs of the cretaceous acid, precipitate the chalk by abſorbing that exceſs.

Spirit of chalk, or acidulated water, poured into lime-water, produces exactly the ſame effect.

The cretaceous acid combines rapidly with the three alkalis. If a ſmall quantity of cauſtic fixed alkali, in a liquid ſtate, be put into a veſſel full of this acid obtained from chalk, or taken from the ſurface of a vat of beer in a ſtate of fermentation, and the orifice of the veſſel be quickly cloſed with a wetted bladder, the veſſel being then moved in ſuch a manner, as that the liquid alkali may be ſpread over its internal ſurface, the bladder will be obſerved to be preſſed inwards; the abſorption of the cretaceous acid by the alkali cauſing a vacuum within the veſſel. This combination is attended with heat, and the ſides of the glaſs are in a ſhort time covered with cryſtals, which become larger and larger. We call this ſalt cretaceous tartar, when the vegetable alkali has been uſed; or cretaceous ſoda, when the mineral alkali has been uſed. Theſe two ſalts, which are truly neutral, were formerly called by the names of ſalt of tartar, and ſalt of ſoda: we ſhall ſpeak of their properties in the next chapter.

The contact of alkaline gas, and the aeriform cretaceous acid in cloſed veſſels, likewiſe produces an inſtantaneous vacuum; it is attended with heat, and forms a thick white cloud, which becomes adherent to the glaſs, either in the form of cryſtals, or of an incruſtation. It is a true imperfect neutral ſalt, which we ſhall diſtinguiſh by the name of cretaceous ammoniacal ſalt.

The cretaceous acid adheres to theſe baſes with different degrees of force. According to Bergman, its affinity with ponderous earth is the ſtrongeſt: after which follow in ſucceſſion, lime, vegetable fixed alkali, mineral fixed alkali, magneſia, and volatile alkali. The phenomena on which Bergman has eſtabliſhed this gradation of affinity will be ſeen when we ſpeak of neutral ſalts.

The nature and compoſition of the cretaceous acid have for ſome years paſt engaged the attention of chemiſts. Prieſtley, Cavendiſh, Bergman, and Scheele, appear to be of opinion that it is formed by the combination of pure air and phlogiſton; but as the exiſtence of this laſt-mentioned principle has been juſtly doubted by many celebrated French chemiſts, we cannot think that this theory ought to be admitted. I formerly thought that the cretaceous acid might be a compound of inflammable gas and pure air; many experiments made ſince the year 1782, have cauſed me entirely to give up this opinion, and to adopt that of Mr. Lavoiſier, which appears to me to be much more probable. This chemiſt, to whom the ſciences are indebted for the vaſt number of ingenious and accurate experiments he has made, burned a determinate quantity of charcoal, in glaſs veſſels filled with vital air, over mercury. The charcoal was deprived of aqueous inflammable air, by a previous calcination in cloſe veſſels, as he had obſerved, that without this precaution drops of water were obtained, by which the accuracy of the reſults were affected. The combuſtion began by the help of a quarter of a grain of fungus placed on the charcoal, in contact with a very ſmall particle of phoſphorus: a bent wire, whoſe end was heated red, being paſſed through the mercury, ſerved to ſet the phoſphorus on fire; this communicated to the fungus, and the latter to the charcoal. The inflammation was very rapid, and attended with much light. The whole apparatus being cold, Mr. Lavoiſier introduced cauſtic fixed alkali in the fluid ſtate, which abſorbed the cretaceous acid formed during this combuſtion, and left a portion of vital air as pure as at the beginning of the experiment. This chemiſt thinks, that in the preſent operation the oxyginous principle, whoſe combination with the matter of fire forms vital air, combines with the carbonaceous ſubſtance, and produces the cretaceous acid, while the other principle is diſengaged with heat and light. Some aſhes remained, and the quantity of cretaceous acid formed, exceeded the weight of the vital air made uſe of, by a quantity equal to the loſs ſuſtained by the charcoal. From many experiments of the ſame nature, made in various circumſtances, Mr. Lavoiſier concludes,

cludes, that a centenary of this, which he now calls carbonaceous acid, or acid of charcoal, from its origin, is compoſed of about twenty-eight parts of carbonaceous matter, and ſeventy-two parts of the oxyginous principle.

The reſpiration of animals, in his opinion, diſengages from the blood a true carbonaceous matter, which combining with the oxyginous principle of the atmoſphere, forms the carbonaceous acid conſtantly produced during this proceſs; and that the combination of the carbonaceous matter of ſugar, with the oxyginous principle of water, is the cauſe of the production of the cretaceous acid in the ſpirituous fermentation.

Several philoſophers have obſerved, that the cretaceous acid poſſeſſes the property of preſerving animal ſubſtances, by retarding putrefaction, and even diminiſhing its effects after it has commenced. Hence it was, that M'Bride ſuppoſed that it unites with the putrid ſubſtance, and reſtores the acid it had loſt during the time of putrefaction. For this laſt phenomenon, according to his doctrine, ariſes from the natural decompoſition of bodies, and the diſſipation of the cretaceous acid: for which reaſon he ſuppoſed that the application of this acid was indiſpenſably neceſſary to compenſate the loſs ſuſtained in the animal œconomy, and to reſtore the fluids to their former ſtate, when changed

changed by heat and motion. He admits the exiſtence of this acid in freſh vegetables, eſpecially ſuch as are ſuſceptible of fermentation, as the decoction of barley, which has been ſuffered to germinate, or the infuſion of raiſins, &c. all which he thinks are equally ſerviceable in ſeptic or ſcorbutic diſorders.

The acid ſpirit of chalk has likewiſe, in ſeveral caſes, been ſucceſsfully preſcribed in putrid, bilious fevers. It is ſaid that the Engliſh uſe the cretaceous acid, mixed with common air, in diſorders of the lungs.

It has been ſtrongly recommended as a lithontriptic, or ſolvent of the ſtone in the bladder; but we are not in poſſeſſion of any authenticated facts in proof of its efficacy.

The public prints contain accounts of ſeveral inſtances of the cure of the cancer, made in England by the application of the cretaceous acid. We can nevertheleſs aſſert, that this means has been uſed by ourſelves and others, without ſucceſs, ſeveral times. After the firſt application, the cancerous ulcer exhibits a more favourable appearance; the ſanies, which commonly flows, becomes white, conſiſtent, and laudable; the fleſh aſſumes a lively colour: but theſe flattering appearances do not continue; the ulcer ſoon returns to its former ſtate, and paſſes through the uſual changes with unabated violence.

Species II. THE MARINE ACID.

The fluid called by the name of marine acid, or ſpirit of ſalt, in our laboratories, has a taſte ſufficiently ſtrong to corrode our organs when concentrated, and when much diluted impreſſes a ſenſation of acidity and ſtipticity. It is abſolutely colourleſs when pure. When it is of a red, or orange colour, as moſt of the marine acid of the ſhops is, it is owing to certain combuſtible bodies, moſt frequently iron. This acid is obtained from marine ſalt, as we ſhall ſee in the hiſtory of that ſubſtance. If it be ſtrong and concentrated, it emits a white vapour or fume. When expoſed to the air, it has a lively and penetrating ſmell, which, when diluted or faint, reſembles that of citron, or the apple called golden rennets: it is then called the fuming ſpirit of ſalt. The fumes are much more viſible when the air is moiſt. If a bottle containing this acid be opened, and the hand brought near its orifice, a ſenſible heat is perceived, which ariſes from the combination of the acid vapour with the water in the atmoſphere. Spirit of ſalt ſtrongly reddens the ſyrup of violets, and all blue colours of vegetables, but does not deſtroy them. This liquid, however concentrated and ſmoking, does not conſiſt of the pure diſengaged marine acid, but contains that

that acid united to much water. Dr. Prieſtley has eſtabliſhed the truth of this, by teaching us how to obtain the acid in the permanent form of gas over mercury: we muſt therefore attend to the properties of this gas, which in fact is the marine acid unmixed, and in a ſtate of perfect purity.

The marine acid gas is obtained by heating the fuming ſpirit of ſalt in a retort, whoſe neck is plunged beneath the orifice of a veſſel filled with mercury. This gas, which is much more volatile than water, paſſes into the veſſel. It has the uſual properties of common air, but is heavier. Its ſmell is penetrating, and it is ſo cauſtic, as to inflame the ſkin; it ſuffocates animals, extinguiſhes the flame of a taper, firſt enlarging it by the addition of a green or blueiſh circumambient flame. It is abſorbed by porous bodies.

Light does not ſeem to produce any ſenſible change in it; it is rarified, and its elaſticity is prodigiouſly augmented by heat. Atmoſpheric air, mixed with marine gas, included in glaſs veſſels, produces fumes or vapours attended with a ſlight degree of heat; a proof that combination takes place. The more humid the air, the denſer theſe vapours appear; and for that reaſon they are not at all ſeen at the ſummits of lofty mountains, where the air is very dry, according to the obſervation of M. D'Arcet: the white vapours, which are exhaled from marine acid,

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are therefore a conſequence of the water contained in the atmoſphere. This liquid acid, as well as the marine gas, does not abſorb vital air when in the elaſtic ſtate, though there are methods of combining them, as we ſhall ſhew hereafter.

Marine gas eagerly unites with water. Ice abſorbs it very quickly, being inſtantly melted. Water is ſtrongly heated during its union with this gas; when ſaturated, it perfectly reſembles the ſpirit of ſalt, from which the marine gas was originally obtained by heat. It emits white vapours, is colourleſs, reddens ſyrup of violets, &c. We ſhall hereafter ſee that this elaſtic fluid, received in pure water, produces the pureſt and moſt concentrated marine acid.

Marine gas has no action on quartzoſe earth; it combines with clay, forming a peculiar ſalt.

It unites with the ſalino-terreſtrial ſubſtances, with which it forms marine ſalts, with baſes of ponderous earth, of magneſia, or of calcareous earth.

Its combination with the fixed vegetable alkali produces the febrifuge ſalt of Sylvius: with the mineral alkali it forms marine or common ſalt.

Marine gas, in contact with alkaline gas, in veſſels over mercury, becomes much heated; the fluids mutually penetrate each other, and a white cloud is immediately formed; the mercury riſes in the

veſſels,

veſſels, and their internal ſurfaces are covered over with ramified cryſtals of ſal ammoniac. If the two gaſes are very pure, they completely diſappear when they aſſume the concrete form, and the diſengagement of heat has taken place. This experiment is one of thoſe which prove, 1ſt, That all bodies, which paſs from the liquid to the elaſtic ſtate, abſorb at the ſame time a certain quantity of the matter of fire, or heat; for the ſpirit of ſalt does not become gas without heat. 2d, That elaſtic fluids, in their tranſition to the liquid or ſolid ſtate, give out the heat they before took up. 3d, That the elaſtic ſtate depends on this abſorbed and combined heat; and that all aeriform fluids are compounds to which the matter of heat gives this form, as M. Lavoiſier ſuppoſes.

The marine acid abſorbs the cretaceous acid; the mutual action of theſe two bodies has not yet been properly examined; it is known, that the cretaceous acid is leſs powerful than the marine, and is diſengaged from all baſes by this laſt. As to the different degrees of attraction for the various baſes, Bergman lays them down in the following order: ponderous earth, vegetable fixed alkali, mineral fixed alkali, lime, magneſia, volatile alkali, clay.

The intimate nature of the marine acid, or the principles which enter into its compoſition, are not yet known. Beccher thought

thought it to be formed of the vitriolic acid, united to mercurial earth, becauſe he obſerved that this acid has a ſtrong affinity to all ſuch bodies as he ſuppoſed to contain that principle, ſuch as arſenic, mercury, &c. Stahl made no addition by way of explaining this opinion of Beccher. And among the numerous and ingenious experiments of the moderns, there are not any which throw much light on this ſubject.

Scheele is the only chemiſt who has made any diſcovery of importance reſpecting the different ſtates in which this acid exiſts: this philoſopher having diſtilled ſpirit of ſalt from the calx of mangaueſe, obtained the acid in the form of a yellowiſh gas, of a very penetrating ſmell, and capable of diſſolving all metals with great facility, not excepting mercury and gold. He thinks that in this operation the manganeſe, which he takes to be very greedy of phlogiſton, ſeizes that of the marine acid; for which reaſon he calls the elaſtic fluid, dephlogiſticated marine acid, and ſuppoſes it to diſſolve gold, in conſequence of its ſtrong affinity to phlogiſton. There is, however, no direct experiment which ſhews the preſence of the inflammable principle in this acid; and it is four years ſince I ſuſpected that the vital air of the manganeſe is united to the marine acid, as may be ſeen in the articles aqua regia, manganeſe, &c. in the firſt edition of theſe elements. Mr. Berthollet has proved the truth of this, by a very accurate and ingenious ſeries of experiments.

The marine acid, poured on the calx of mangameſe, affords yellow vapours before the application of heat. If the retort be heated, and the vapours received in veſſels containing water, a very ſmall quantity is diſſolved, and the water is very ſoon ſaturated; the gas which continues to be produced takes a concrete form, and falls to the bottom of the liquid in cryſtals. The water, in this experiment, muſt be cooled almoſt to freezing, becauſe the ſlighteſt heat diſſolves this concrete ſalt, and occaſions it to eſcape in the form of bubbles.

The dephlogiſticated marine acid, in a liquid form, or diſſolved in water, has, according to Mr. Berthollet, an auſtere, but not acid taſte. It deſtroys the colours of vegetables, and renders them white, without firſt cauſing them to become red. It does not diſengage the cretaceous acid from its baſes, and conſequently cauſes no efferveſcence when applied to them: in a word, it has no acid properties.

The dephlogiſticated marine acid efferveſces when heated with quick lime, vital air being diſengaged. The reſidue is calcareous marine ſalt. The dephlogiſticated marine acid produces an effervеſcence in its combination with the cauſtic volatile alkali; but the bubbles

bles which ariſe during this combination are produced by the decompoſition of a part of this latter ſalt: the inflammable gas, which is one of its principles, unites with the dephlogiſticated marine acid, and forms water; while the phlogiſticated gas, or the other principle of the volatile alkali, being ſet free, is ſeparated in its elaſtic form, and produces the effervеſcence obſerved in this experiment. All theſe experiments prove, that the dephlogiſticated marine acid of Scheele is a combination of this pure acid with vital air, and may, with greater propriety, be called aerated marine acid, as I propoſed in the firſt edition of theſe elements. Mr. Berthollet has not yet determined the quantity of air abſorbed by the marine acid in theſe experiments.*

The marine acid is employed in the arts, and more eſpecially in the art of aſſaying in the humid way.† In medicine it is adminiſtered, in a very diluted ſtate, as a diuretic and antiſeptic; and it is the chief ingredient in the remedy of the Prior de Chabrieres for ruptures. It is externally uſed as an eſcharotic; and likewiſe in gangrenes of the throat, aphthæ, &c. Mixed with a certain quantity of water, it

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* Rozier's Journal, May 1785.

† See Bergman's Eſſays, vol. ii. either in the Engliſh tranſlation, or original Latin.

conſtitutes a bath for the feet, which is a great ſecret with ſome practitioners, and is uſed for the purpoſe of removing the ſeat of the gout from the nobler to the inferior parts.

The dephlogiſticated, or aerated marine acid, has not been known a ſufficient time to apply it to any uſe. Mr. Berthollet thinks that it may be uſed for the purpoſe of diſcovering, in a few minutes or hours, the effects which expoſure to air will produce on certain dyed ſtuffs; and that their durability may by that means be aſcertained.

Species III. THE SPARRY ACID.

The ſparry acid, or fluor acid, diſcovered by Mr. Scheele, received its name from a kind of neutral ſalt, called fluor, or vitreous ſpar, from which it is obtained.

This acid, in a ſtate of purity, has the form of gas; in which ſtate, therefore, we ſhall examine its properties. It is heavier than air, extinguiſhes fire, and deſtroys animal life; has a penetrating ſmell, ſimilar to that of marine acid, but more powerful; and its cauſticity is ſuch, that it corrodes the ſkin in a ſhort time; light does not ſenſibly alter it; and heat dilates it, without producing any other change.

The addition of atmoſpherical air has the ſame effect on this, as on the marine acid gas,

gas, producing a white vapour, which is more or leſs abundant, in proportion to the humidity of the atmoſphere.

The ſparry gas unites to water very rapidly, and with heat; a peculiar phenomenon attends their combination, namely, the precipitation of a very fine white earth, of a ſiliceous or quartzoſe nature: it therefore ſeems, that this acid, in the ſtate hitherto deſcribed, is very far from being pure. For this reaſon, I am inclined to think that it cannot be had pure, but by depriving it of the earth it took up during its volatilization. This gas, diſſolved in water, forms the acid ſpirit of ſpar, whoſe ſmell and cauſticity are very powerful when the water is ſaturated. This liquid acid ſtrongly reddens ſyrup of violets. It poſſeſſes the ſingular property of corroding and diſſolving ſiliceous earth, according to Scheele and Bergman.

Dr. Prieſtley obſerved that ſparry gas corrodes and penetrates glaſs; which circumſtance obliged him to make uſe of very thick glaſs in his experiments. Macquer thought that this acid does not produce this effect, but in its ſtate of gas; and that in its liquid ſtate, or when combined with water, it ceaſes to poſſeſs that property: his opinion is founded on the conſideration, that water precipitates the ſiliceous earth, which is held in ſolution by the ſparry gas.

The acid ſpirit of ſpar may be decompoſed in the ſame manner as ſpirit of ſalt, by heating it in a retort, whoſe neck is plunged under the orifice of a veſſel filled with mercury. The ſparry acid gas is obtained, and the water remains pure.

The two French chemiſts, who, under the name of Boullanger, publiſhed in the year 1773, a ſeries of experiments on the fluor or vitreous ſpar, are of opinion, that this acid is nothing elſe but the marine acid, combined with an earthy ſubſtance, ſeparable only by water. But Bergman conſiders it as a peculiar acid, ſufficiently diſtinguiſhed from all others by its combinations. This laſt opinion is almoſt univerſally received.

The ſparry is the only mineral acid which poſſeſſes the property of diſſolving ſiliceous earths. In the year 1779, Bergman thought that this earth might be a compound of the ſparry acid and water, becauſe of the conſiderable quantity of ſilex depoſited, when this acid gas comes in contact with water; but the experiments of Mr. Meyer prove that the ſiliceous earth is obtained from the glaſs veſſels which are corroded. This chemiſt took three cylindrical veſſels of tin, in each of which he put an ounce of vitreous ſpar, with three ounces of vitriolic acid, which having a ſtronger affinity with lime than the ſparry acid, is ſucceſsfully employed in procuring the latter. To one of theſe mixtures he added an ounce of quartz, in powder; to the

the ſecond, an ounce of glaſs, in powder; and the third was left without addition. In each of theſe cylinders he ſuſpended a moiſtened ſponge, and expoſed the cloſed veſſels to a gentle heat. Half an hour after, he found a ſiliceous powder depoſited on the ſponge, included over the mixture containing powdered glaſs; twelve hours after, the mixture containing quartz likewiſe exhibited a ſiliceous incruſtation on its ſponge; but the mixture which contained neither quartz nor glaſs, preſented no appearance of any depoſition, even at the end of ſeveral days. Bergman himſelf forwarded an account of this experiment to Mr. de Morveau, informing him at the ſame time, that he renounced his former opinion reſpecting the formation of ſiliceous earth by the union of ſparry acid and water. The precipitation, therefore, depends on the quartzoſe earth diſſolved in the ſparry gas; and the acid is not in a ſtate of purity, till the earth has been precipitated by water, as we obſerved in our former edition.

The acid ſpirit of ſpar, and the gas, unite with clay, and form a ſweetiſh neutral ſalt, ſpathic clay, or argillaceous fluor, which eaſily takes the conſiſtence of a thick jelly.

It combines with ponderous earth: the ſalt reſulting from this combination, which we diſtinguiſh by the name of ponderous fluor, is of a pulverulent form.

The ſparry acid forms a cryſtallizable ſalt with magneſia; ſpathic magneſia, or magneſian fluor.

It precipitates lime-water, forming immediately the fluor ſpar.

It likewiſe combines with the fixed vegetable alkali, and conſtitutes ſpathic tartar, or tartareous fluor: with the mineral fixed alkali it forms ſpathic ſoda, or fluor of ſoda; laſtly, with the volatile alkali it forms a ſalt, which we diſtinguiſh by the name of ammoniacal fluor, or ſpathic ſal ammoniac.

The foregoing ſhort account of theſe ſaline combinations, prove that the acid of ſpar differs greatly from the marine acid; and this proof is ſtill further confirmed by the order of its affinities with the ſeveral baſes. Bergman obſerves, that the ſparry acid, united to the vegetable fixed alkali, is ſeparated by lime-water, from which fluor is ſeen to precipitate; the ſame appearance is obſerved when lime-water is added to the ſolution of ponderous fluor. This philoſopher arranges its affinities in the following order: lime, ponderous earth, magneſia, vegetable fixed alkali, mineral alkali, volatile alkali; but he obſerves that a greater number of experiments are required to give the neceſſary degree of accuracy to this arrangement.

The ſparry acid has not yet been applied to any uſe; but its property of diſſolving ſiliceous

liceous earth will probably render it of great uſe in chemical operations, when means ſhall have been diſcovered for obtaining it more commodiouſly than at preſent.

Species IV. NITROUS ACID.

The fluid called nitrous acid in chemical laboratories, is the ſpirit of nitre, or a combination of the acid with water: this ſpirit, when very pure, is white; but a very ſmall change cauſes it to become yellow, or red, and to exhale fumes of the ſame colour in great abundance. Its cauſticity is ſuch, that it immediately burns and deſtroys the organization of the ſkin and muſcles: it reddens, and entirely deſtroys the colour of ſyrup of violets.

Expoſed to the rays of the ſun, it becomes of a deeper colour, and more volatile, according to Scheele, which ſhews that it is acted upon by light: heat alone produces the ſame change: it attracts the humidity of the air when it is ſtrongly concentrated.

It unites with great violence to water, which becomes at firſt green, afterwards blue, and laſtly red. Much heat is given out in this combination. When united to a conſiderable quantity of water, it is called aquafortis.

The white and red nitrous acids were formerly conſidered as one and the ſame acid, differing

differing only in the degree of concentration; and that which had the moſt colour, was conſidered as the moſt concentrated: but the nature of this ſaline ſubſtance being at preſent much better underſtood, it is admitted that it may exiſt in two different ſtates. In the one, the nitrous acid is colourleſs, more ponderous, leſs volatile, and does not emit fumes; in the other, it is tinged from yellow to a brown red, being lighter, more volatile, and continually emitting red vapours, more or leſs abundant, accordingly as its temperature is higher. Bergman diſtinguiſhes theſe two ſtates of the nitrous acid, by the names of dephlogiſticated and phlogiſticated nitrous acid; we ſhall hereafter explain the cauſe of theſe differences; it will be ſufficient in this place to obſerve, that if the coloured and fuming nitrous acid be diſtilled in a glaſs retort, the red part comes over firſt in vapours, and the acid which remains in the retort becomes white and colourleſs. The deeper the colour of the nitrous acid, the larger will be the quantity of vapours, and the leſs the quantity of clear nitrous acid remaining in the retort; and on the contrary, if a nitrous acid, of a pale red, be ſubmitted to the ſame proceſs, the quantity of vapour is very inconſiderable, and the clear acid, which remains, is in much greater quantity than in the former caſe. This experiment proves, that the deep coloured nitrous

nitrous acid is more volatile than the paler ſort; and that as all ſpirit of nitre is compoſed of theſe two acids, they may be obtained ſeparate, by diſtillation properly managed. In this operation, a certain quantity of vital air is always diſengaged, which may be collected by adapting a pneumatic apparatus to the receiver. It muſt be obſerved, that the ſame proceſs of diſtillation made with the paleſt nitrous acid, always diſengages ſome red vapours, and changes the colour of the acid, which becomes reddiſh. But this change produced by mere heat, diſappears when the acid grows cold; and the vapour, which had ariſen, is again diſſolved in the liquor.

Spirit of nitre has no action on the vitrifiable and quartzoſe earths; it unites with clay, ponderous earth, magneſia, lime, and the three alkalis, with which it forms nitre, with baſe of ponderous earth, and the ſeveral nitres diſtinguiſhed by the names, magneſian, calcareous, common, rhomboidal, and ammoniacal; its affinities with theſe different baſes are the ſame as thoſe of the marine acid. Bergman arranges them in the following order: ponderous earth, fixed vegetable alkali, fixed mineral alkali, lime, magneſia, volatile alkali, clay.

The nitrous acid unites with the cretaceous acid, which it abſorbs in a conſiderable proportion: the mutual action of theſe two bodies is not well known.

The nitrous acid combines very readily with the marine acid: the alchemiſts gave the name of aqua regia to this compound, becauſe they uſed it to diſſolve gold, the king of the metals. It muſt always have appeared ſingular, that two acids, neither of which ſingly has any action on gold, ſhould become capable of diſſolving it when united. The alchemiſts, happy in having diſcovered a ſolvent for this precious metal, did not trouble themſelves about the cauſe of the phenomenon. It is but a few years ſince two Swediſh chemiſts, Scheele and Bergman, attempted to diſcover the change which the admixture of theſe two acids produces in each. Scheele, as we have already obſerved, perceived, that the yellow vapour produced when the marine acid is diſtilled from the calx of manganeſe, has the ſame ſmell as aqua regia; that it deſtroys the blue colours of vegetables; and that its action on metals is very ſtrong, eſpecially on gold, which it perfectly diſſolves, like aqua regia. He thinks that theſe new properties ariſe, from its being deprived of phlogiſton by the calx of manganeſe, and that conſequently it has a ſtrong tendency to ſeize that principle from other bodies; and therefore acts powerfully on combuſtible bodies. From theſe facts and ſuppoſitions, he gave it the name of dephlogiſticated marine acid. We muſt here obſerve, this explanation is abſolutely contrary to the

theory

theory of Stahl, which Scheele appears to have adopted; ſince the marine acid, by the loſs of its phlogiſton, acquires new properties, which that great man attributed to the preſence of the inflammable principle, ſuch as volatility, a ſtrong odour, and a power of acting on combuſtible bodies. We apprehend, moreover, that all theſe phenomena are much more naturally explained by the new theory, as we ſhall preſently ſhew.

Bergman thinks, that the nitrous acid ſeizes the phlogiſton of the marine acid, and becomes partly diſſipated, in the form of vapour; and that the marine acid is converted into the ſame ſtate as it poſſeſſes, when diſtilled from the calx of manganeſe. Aqua regia, therefore, diſſolves gold by virtue of the dephlogiſticated marine acid it contains. Such is the opinion of the celebrated chemiſt of Upſal. The following theory, however, appears to agree better with the facts. When nitrous acid is poured upon ſpirit of ſalt, the two liquors grow hot, and deeper coloured; an efferveſcence is produced, attended with a mixed ſmell, leſs penetrating than that of pure ſpirit of ſalt, but perfectly reſembling marine acid, diſtilled from calx of manganeſe. Mr. Berthollet has diſcovered, that dephlogiſticated, or aerated marine acid, is diſengaged during this ſtrong action of the two acids. Spirit of ſalt, therefore, takes from the nitrous acid

acid part of the pure air it contains, and is diſſipated in the form of aerated marine acid. A portion of this dephlogiſticated ſpirit of ſalt remains charged with nitrous gas, and this mixture conſtitutes aqua regia.. Hence it may be eaſily conceived, why a very ſmall quantity of nitrous acid is required to give the marine acid the characters of aqua regia; and why the ſalt of gold affords, by diſtillation, nothing but the marine acid, as likewiſe happens with aqua regia diſtilled alone. But it muſt be obſerved, that as a much greater quantity of nitrous acid than is neceſſary is commonly uſed to ſaturate the marine acid with air, or to dephlogiſticate it, aqua regia contains theſe two acids, which act each according to its peculiar nature, and form various compounds with bodies expoſed to their action. It is therefore a deſideratum to aſcertain what quantity of nitrous acid is required to ſaturate a given quantity of marine acid, and to convert it into aqua regia, without its containing any portion of aqua fortis, which would only tend to alter its properties, and render its effects uncertain. Hence it is neceſſary, in the recording of nice chemical operations, to point out the reſpective quantities of the acids made uſe of in compounding the aqua regia employed.

The ſpecific gravity of this mixed acid, is leſs than that of either of the two which

which compoſe it; its ſmell is peculiar; its colour citron, verging towards orange: its action on various ſubſtances diſtinguiſhes it from every other acid: it is not ſenſibly changed by light; but heat ſeparates the two acids. Aqua regia combines with water in all proportions, at the ſame time producing heat; it diſſolves clay very ſlowly, and unites with ponderous earth, magneſia, lime, and the different alkalis, producing mixed ſaline combinations, which either cryſtallize ſeparately or together, according to their ſolubility. Aqua regia is much uſed in chemiſtry, eſpecially in the art of aſſaying, as we ſhall have occaſion to obſerve more largely, when we come to ſpeak of metallic ſubſtances.

The intimate nature and compoſition of the nitrous acid has been greatly attended to by chemiſts, ſince the earlier diſcoveries of Dr. Prieſtley. The opinion of ſuch as think the formation of this acid may be attributed to the vitriolic, and who regard it as a modification of this laſt, has been ſhewn to be founded on fallacious experiments; and it was ſoon found to be compoſed of peculiar principles, in conſequence of the following obſervations.

It has long ſince been obſerved, that the nitrous acid acts ſtrongly on combuſtible bodies, eſpecially metallic ſubſtances; a large quantity of red vapours exhaling at the ſame time

time into the atmoſphere, and the acid in ſome caſes being entirely diſſipated in that form. The combuſtible body is quickly converted into the ſtate of a body which has ſuffered calcination, or combuſtion. And this proceſs is in ſome caſes carried on ſo rapidly, as to cauſe ſudden inflammation of the combuſtible bodies, ſuch as oils, coal, phoſphorus, and certain metals. Stahl attributed this effect to the rapidity with which he ſuppoſed nitrous acid to combine with phlogiſton; but this theory is inſufficient.

Dr. Prieſtley having received, under a glaſs veſſel filled with water, the vapour which is diſengaged during the action of the nitrous acid upon iron, obſerved, that inſtead of a red vaporous fluid, a tranſparent and colourleſs gas, reſembling air, is obtained, which he diſtinguiſhed by the name of nitrous air.

This gas has all the external characters of air, but differs in a great number of its chemical properties: its ſpecific gravity is ſomewhat leſs; it is incapable of maintaining either combuſtion or reſpiration; is ſtrongly antiſeptic; has no ſenſible taſte; and does not immediately produce any change in ſyrup of violets. Nitrous gas is not ſenſibly changed by the action of light; heat dilates it; vital air readily combines with it, and converts it into nitrous acid; atmoſpheric air produces the ſame effect, but with

with leſs intenſity. This combination exhibits many important phenomena. As ſoon as the air comes in contact with the nitrous gas, theſe two colourleſs fluids become red, like the fuming ſpirit of nitre; a conſiderable degree of heat is excited; the water riſes in the receiver, and abſorbs the red vapours, which convert it into a weak aqua fortis. The purer the air, the more rapid and evident are theſe phenomena, and a leſs quantity is required to convert a given quantity of nitrous gas into nitrous acid. Mr. Lavoiſier found, that ſixteen parts of atmoſpheric air are required to ſaturate ſeven parts, and one third of nitrous gas; while four parts of vital, or dephlogiſticated air, are ſufficient to ſaturate completely the ſame quantity of gas. This remarkable phenomenon perfectly reſembles combuſtion, as Macquer thinks. In fact, it is accompanied with heat, abſorption of air, and the production of ſaline matter; and the deep red colour, with which it is accompanied, may be conſidered as a kind of flame.

The effects of air, in this artificial recompoſition of nitrous acid, being different according to the purity of the air made uſe of, Dr. Prieſtley applied nitrous gas, as a teſt to diſtinguiſh the quantity of vital air contained in any given portion of elaſtic fluid; by taking, as the two extremes, the moſt impure gas, which is not changed at all by nitrous gas (as for example, cretaceous acid) and vital or dephlogiſticated air, which is changed the moſt. This proof conſiſts in employing known quantities of the two gaſes, and obſerving the effect, or the quantity neceſſary for the complete ſaturation of each. The leſs the quantity of any kind of air, which is required to ſaturate nitrous gas, the more pure or reſpirable that air is; and on the contrary, the larger the quantity required for that purpoſe, the leſs is its purity.

Many philoſophers have endeavoured to contrive methods of performing this experiment with the greateſt preciſion. The Abbé Fontana has ſucceeded the beſt in his attempts; he has contrived an inſtrument, which is accurately deſcribed by Ingenhouſz in his enquiries concerning vegetables: with this inſtrument, the purity of air may be eſtimated to an extreme degree of accuracy; but a degree of attention and experience is required in its uſe, without which it is very likely to be productive of error, as the author himſelf obſerves.

It is of great conſequence to be obſerved, with regard to theſe experiments, uſeful and ingenious as they are, that they have not been attended with near the advantage to medicine, by determining the ſalubrity of the air, which was at firſt expected. They indicate merely the quantity of reſpirable air contained in the ſpecimen under examination; but teach us nothing concerning the noxious qualities of this fluid, with reſpect to the other animal functions; as for example, its actions on the ſtomach, ſkin, and in particular the nerves, which produce effects well known to phyſicians, and which follow in conſequence of almoſt every alteration the air is ſuſceptible of.

Chemiſts are not yet agreed in their opinions reſpecting the cauſe of the production of nitrous acid, by the mixture of nitrous gas and vital air. Dr. Prieſtley, to whom we are indebted for this diſcovery, thinks that nitrous gas conſiſts of the nitrous acid, loaded with phlogiſton; and that pure air, having a ſtronger affinity for this laſt ſubſtance, takes it from the acid, which it leaves at liberty: but this theory is far from being ſufficient to explain the phenomenon, becauſe there is ſcarcely any reſidue when the experiment is well made, and becauſe the nitrous acid, formed in this operation, weighs much more than the nitrous gas made uſe of. Mr. Lavoiſier imagined, that this property of recompoſing nitrous acid, by the addition of pure air, is ſufficient to ſhew the compoſition of the acid itſelf. By combining two ounces of ſpirit of nitre, of a known ſtrength, with mercury, which is a combuſtible body, he obtained 196 cubic inches of nitrous gas, and 246 inches of dephlogiſticated air; the mercury, after having changed its form during the diſengagement of the firſt gas, was reduced to its metallic ſtate during the diſengagement of the ſecond; and was found to have ſuffered no loſs. From this experiment, performed with great accuracy, he concludes, 1ſt, That the mercury having ſuffered no loſs, the elaſtic fluids cannot be attributed to, or be ſaid to have been obtained from, that metal. 2d, That they muſt therefore be attributed to a decompoſition of the nitrous acid. 3d, That the nitrous acid made uſe of, whoſe ſpecific gravity, compared with diſtilled water, was as 131607 to 100000, appears to be formed of three principles; nitrous gas, vital air, and water, in the following proportions, in the Paris pound, of 9216 grains; nitrous gas, 627¼ grains; vital air, 1082½ grains; water, 7506 grains. 4th, That nitrous gas conſiſts of the nitrous acid, deprived of vital air, or the oxyginous principle. 5th, That in all the operations wherein nitrous gas is obtained, the nitrous acid is decompoſed, and its oxyginous principle abſorbed by the combuſtible body, with which it has a ſtronger affinity than with the nitrous gas.

There is, however, a difficulty atttending this opinion. Mr. Lavoiſier did not ſucceed in recompoſing all the acid he made uſe of, but loſt at leaſt the half, and the quantity

quantity of pure air obtained was much more than neceſſary to ſaturate the whole quantity of nitrous gas: he confeſſes that he cannot account for this circumſtance. Macquer ſuppoſes it to depend on the loſs of phlogiſton, or light, which he conſiders as one of the principles, and ſuppoſes to be diſſipated through the pores of the veſſel during its decompoſition, a part of the pure air, which is not diſſipable in the ſame manner, being left behind. But though this laſt opinion ſeems to remove the difficulty, it is not eaſy to ſay why one part of the phlogiſton ſhould remain in the nitrous gas, while the other eſcapes through the pores of the veſſel.

The ſpecies of gas, which remains after the mixture of nitrous gas and pure air, has been equally embarraſſing to chemiſts; this reſidue was very inconſiderable in Mr. Lavoiſier's experiment, 7 parts and $\frac{1}{3}$d of nitrous gas, with 4 parts of vital air, having left only the 34th part of their whole bulk. This chemiſt has ſince aſcertained, that the reſidue is much ſmaller when the fluids are very pure, and in accurate proportions: if a combination of nitrous gas and vital air ſhould be made, in ſuch proportions as to leave no reſidue, which Mr. Lavoiſier expects to accompliſh, it will greatly add to the probability of his opinion.

There is not the ſame difficulty concerning

ing the aeriform reſidue obtained, after the combination of 16 parts of atmoſpheric air with 7 and $\frac{1}{3}$d of nitrous gas; this fluid is known to be phlogiſticated gas, or atmoſpheric mephitis: it is likewiſe eaſy to conceive, that water, in contact with nitrous gas, may, in proceſs of time, convert it into nitrous acid, by virtue of the air contained in the firſt-mentioned fluid.

But in the theory of Mr. Lavoiſier, the nature of the nitrous acid remains to be enquired into; and this point has been cleared up by a valuable experiment of Mr. Caveniſh: he introduced into a tube of glaſs, 7 parts of vital air, obtained without the aſſiſtance of nitrous acid, and 3 parts of phlogiſticated gas, or atmoſpheric mephitis; the electric ſpark being paſſed through this mixture, its bulk was much diminiſhed, and it became changed into nitrous acid. Hence he concludes, that this acid is a combination of 7 parts of vital, and 3 of phlogiſticated air; and that when a certain proportion of the firſt of theſe principles is taken away, as happens when metals, &c. are diſſolved, it becomes nitrous gas; conſequently, according to this opinion, the latter fluid muſt conſiſt of atmoſpheric mephitis, with a leſs proportion of vital air than is neceſſary to conſtitute nitrous acid; and that the addition of pure air only is wanting to convert nitrous gas into that acid. Theſe experiments,

ments, and the ingenious theory deduced from them, tend greatly to explain the formation of nitrous acid, by the putrefaction of animal matters. It is well known, that a large quantity of phlogiſticated gas is diſengaged from theſe ſubſtances during the putrefactive proceſs; and the neceſſity of the contact of air, for the production of the nitrous acid, is ſufficiently evident, from the conſideration that it is formed by the union of theſe two elaſtic fluids.

Hence it is likewiſe eaſy to aſcertain the difference between the pure, colourleſs nitrous acid, and that which is yellow and fuming, called phlogiſticated nitrous acid by the northern chemiſts. The latter exiſts in all caſes, when the proportion of its two component parts is not accurately ſuch as conſtitutes pure nitrous acid, namely, 3 parts of mephitis to 7 of vital air. But as a great number of circumſtances, and in general every phlogiſticating proceſs, may diminiſh the quantity of vital air, by abſorbing more or leſs of that fluid, it follows naturally, 1ſt, That the nitrous acid is very ſubject to alteration, and muſt be more or leſs fuming according to circumſtances. 2d, That in proportion to the quantity of vital, or pure air, taken away, it may exiſt in many different ſtates from that of the pureſt nitrous acid, which contains the largeſt portion of air to that of nitrous gas, which

which does not contain enough to be truly acid. 3d, That if nitrous gas be totally deprived of vital air, it will be converted into phlogiſticated air, or atmoſpheric mephitis. 4th, That the attraction between pure air, or the oxyginous principle, and nitrous gas, not being conſiderable, and a great number of combuſtible bodies having a ſtronger affinity with the former, the nitrous acid muſt be decompoſed with much facility by ſuch bodies. Theſe four remarkable properties ſerve to explain a great number of chemical phenomena.

The affinities of the nitrous acid to the alkaline baſes, are the ſame as thoſe of the marine acid. They are arranged by Bergman in the following order: ponderous earth, vegetable alkali, mineral alkali, lime, magneſia, volatile alkali, and clay. According to this celebrated chemiſt, the phlogiſticated nitrous acid has the ſame elective attractions as the pure acid itſelf. It is ſtronger than the acids before treated of, and diſengages the cretaceous, ſparry, and marine acids from their baſes.

The nitrous acid is of very extenſive uſe in the arts; under the name of aqua fortis, it is more particularly employed to diſſolve mercury, copper, and ſilver, by water-gilders, engravers, and in domeſtic and metallurgic operations, &c. In ſurgery it is uſed to deſtroy excreſcences, and ſmall indolent tumours.

tumours. In pharmacy it is uſed in many preparations; ſuch as mercurial water, red precipitate, martial alkaline tincture of Stahl, the yellow unguent, &c. &c.

Species V. The VITRIOLIC ACID.

The vitriolic acid is a very cauſtic ſaline ſubſtance, which, when concentrated, burns and corrodes the ſkin, reddens the ſyrup of violets, and exhibits a rough ſtyptic taſte when much diluted with water. This acid has the form of a very tranſparent, oleaginous fluid, twice as heavy as diſtilled water, and without ſmell; it contains the acid united with water, from which it cannot be entirely ſeparated by any known method. It is called vitriolic acid, becauſe it was formerly obtained from martial vitriol, by diſtillation. It is now obtained in France, and in England, by the complete combuſtion of ſulphur, as will be more amply explained in the hiſtory of that combuſtible ſubſtance.

This acid takes the concrete form, either by expoſure to cold, or by combination with ſeveral elaſtic fluids.

The action of light on the vitriolic acid is not known. Some chemiſts have affirmed, that oil of vitriol, expoſed in well-cloſed veſſels to the rays of the ſun, becomes gradually more and more coloured, and even that ſulphur is formed: this phenomenon, which would afford a ſtrong confirmation of the

the doctrine of Stahl, is very far from being proved; and it is even probable that it does not take place: for we ſhall hereafter ſhew that the vitriolic acid cannot be converted into ſulphur, but by the loſs of its pure air, or oxyginous principle, and this ſeparation cannot be made in cloſed veſſels.

Stahl conſidered the vitriolic acid as the moſt univerſally diffuſed, and the principle of all other acids. The firſt of theſe aſſertions, founded on the conſideration that linen cloths, impregnated with fixed alkali, and expoſed to the air, become charged, in proceſs of time, with vitriolated tartar, or the ſalt formed by the union of the alkali with vitriolic acid, is now ſhewn to be falſe; becauſe theſe cloths are not found to contain an atom of vitriolated tartar, though they abound with cretaceous tartar, which has been improperly called aerated alkali. As to the ſecond, it is by no means proved that the other acids owe their origin to the vitriolic. Modern experiments have ſhewn, that each acid has its peculiar principles, different from every other, excepting the oxyginous principle, which is common to all.

Oil of vitriol, heated in a retort, becomes more concentrated by the loſs of a part of its water, and is not volatilized but by a ſtrong heat. Coloured vitriolic acid becomes clear and tranſparent by the action of heat.

heat. During this operation, which is called concentration and rectification of the vitriolic acid, a gas of a very penetrating ſmell, which we ſhall hereafter have occaſion to ſpeak of, under the name of ſulphureous gas, and was the cauſe of its colour, is ſeparated. Though this operation appears to render the vitriolic acid more clear and pure, it muſt be carried ſtill further, if the acid be deſired in a high ſtate of purity. The fact is, that the ordinary method of concentrating oil of vitriol, deprives it only of water and ſulphureous gas, without ſeparating the fixed matters by which it may be changed: its complete purification requires that it be diſtilled to dryneſs; changing the recipient as ſoon as the acid in the retort is ſufficiently concentrated by the firſt part of the proceſs: the dry white reſidue, which finally remains in the retort, conſiſts of vitriolated tartar, and ſome other ſubſtances taken up by the acid at the time of its original manufacture.

Oil of vitriol, expoſed to the air, attracts humidity, and loſes a part of its force and cauſticity; it likewiſe becomes coloured, by means of the combuſtible particles which float in the atmoſphere, and are ſtrongly acted on by this acid: the quantity of moiſture it abſorbs by this expoſure, is nearly double its own weight. The Duc D'Ayen, by a curious ſet of experiments, made during the

the violent froſt in the month of January, 1776, has ſhewn, that highly-concentrated oil of vitriol, expoſed to cold between 13 and 15 degrees of Reaumur's thermometer, becomes congealed; that when it is diluted with 2 or 3 parts of water, it cannot be frozen; and that, if it be left continually expoſed to the air in its frozen ſtate, it becomes again fluid, though the temperature of the atmoſphere continues as cold, or even becomes colder than before. This laſt phenomenon is produced by the water contained in the atmoſphere, with which the acid unites, and produces an increaſe of temperature ſufficient to counteract and overcome the power of congelation.

Oil of vitriol unites to water with phenomena, that indicate a ſudden penetration, and intimate union. A ſtrong degree of heat, attended with a kind of hiſſing noiſe, is produced, a peculiar ſmell being at the ſame time emitted. The acid, thus diluted with water, loſes much of the intenſity of its taſte, and its fluidity is greater.

It is then called ſpirit of vitriol: by concentration it returns again to the ſtate of oil of vitriol.

This acid does not act on quartzoſe earths, not even when they have been previouſly diſſolved in alkalis: it combines with clay, ponderous earth, magneſia, lime, and alkalis, forming alum, ponderous ſpar, Epſom ſalt, ſelenite,

ſelenite, vitriolated tartar, Glauber's ſalt, and vitriolic ammoniac; its elective attractions for theſe baſes have the ſame order as thoſe of the marine and nitrous acids, but they are ſtronger; this acid being capable of diſengaging either of the others from its baſe.

The action of oil of vitriol on other acids has not yet been well aſcertained; we only know, 1ſt, That it abſorbs a large quantity of the cretaceous acid. 2d, That it unites ſo eaſily with the marine acid, as to produce heat, and the diſengagement of a large quantity of marine acid gas in white vapours. Boerhaave affirms, in his chemiſtry, that the marine acid renders oil of vitriol concrete, which may perhaps be true of the aerated or dephlogiſticated marine acid. 3d, That the white and pure nitrous acid, added to oil of vitriol, coloured by a combuſtible body, renders it tranſparent, and is exhaled in the form of nitrous gas, on the application of heat to the mixture. 4th, That nitrous gas, added to oil of vitriol, cauſes it to take a concrete form, as we ſhall more largely ſhew in treating of the decompoſition of nitre by martial vitriol.

The mode of action of the vitriolic acid on combuſtible bodies greatly elucidates the nature and principles of this acid; whenever a combuſtible body, as for example, a metal, or any animal or vegetable ſubſtance, is placed in contact with concentrated oil of vitriol,

vitriol, it paſſes with a greater or leſs degree of rapidity to the ſtate of bodies which have been burned, and the acid is at the ſame time decompoſed.

Bodies containing oil, become black when plunged in cold vitriolic acid, the acid at the ſame time aſſuming firſt a brown, and afterwards a black colour; if an inflammable body in combuſtion, as for example, red hot charcoal, be plunged into this acid, it immediately aſſumes a degree of volatility, with a ſulphureous ſmell, emitting at the ſame time a white ſuffocating fume. If the acid be put in contact with a combuſtible body of a more ſimple nature than organic ſubſtances, the changes which follow may be more eaſily perceived and eſtimated, and the principles of the vitriolic acid may by that means be ſeparated and known. When oil of vitriol and mercury are heated together in a retort, whoſe neck is plunged beneath a glaſs veſſel filled with the ſame metallic fluid, a permanent gas, of a ſtrong and penetrating ſmell, ſimilar to that of burning ſulphur, is produced as ſoon as the acid boils.

This aeriform acid, known by the name of ſulphureous acid gas, is ſomewhat heavier than common air; it extinguiſhes flame, deſtroys animal life, reddens and diſcolours ſyrup of violets, unites to water with leſs rapidity than the marine acid gas, and according to Prieſtley, diſſolves chalk, ſulphur, and

and iron; it is abſorbed by charcoal, and all very porous bodies; it is a peculiar modification of the vitriolic acid, capable of forming with alkalis ſalts, very different from thoſe produced by the combuſtions of that acid itſelf. Stahl, who paid particular attention to theſe important phenomena, imagined, that in this combination the phlogiſton of the metal united with the acid, and gave it ſmell, volatility, &c. but this great chemiſt, not having purſued the experiment to a ſufficient length, was doubtleſs unacquainted with the circumſtance, that the ſtrongeſt objections againſt his doctrine may be deduced from theſe facts. M. Lavoiſier, M. Bucquet, and myſelf, have ſeverally examined the ſucceſſion of phenomena, which take place during the mutual action of mercury and the vitriolic acid. As ſoon as the mixture becomes white and dry, ſcarcely any ſulphureous gas paſſes over; if this vitriolic mercurial ſalt be then ſtrongly heated, a ſmall quantity of water is diſengaged, together with gas of a totally different nature from the former. It conſiſts of air, as pure and reſpirable as that which Dr. Prieſtley calls dephlogiſticated air. In proportion as this air paſſes over, the mercury is reduced to its fluid and metallic ſtate, abſolutely ſimilar to that which it originally poſſeſſed, and is intirely recovered, excepting certain portions, which, together, do not amount to the eighth part

part of the quantity made uſe of. Hence it appears, that the mercury not having been at all altered, the two gaſes, which come over, are produced by a decompoſition of the vitriolic acid itſelf. Sulphureous gas appears to have the ſame relation to this acid as the nitrous gas has to the acid of nitre. There is, however, ſome difference in the compoſition of theſe two acids; for it has not been found practicable immediately to reproduce the vitriolic acid by uniting the two gaſes it affords, though this may be done at pleaſure with the nitrous acid. It is probable, that the recompoſition of the vitriolic acid requires a conſiderable ſpace of time, ſince it really takes place when compounds of the ſulphureous acid, with different baſes, are expoſed to the air, and are found at length to contain mere vitriolic acid. Thus it is that the combination of the ſulphureous acid with the fixed vegetable alkali, commonly known by the name of ſulphureous ſalt of Stahl, being expoſed to the air, becomes converted into vitriolated tartar at the end of a certain ſpace of time.

From theſe experiments, Mr. Lavoiſier concludes, 1ſt, That the vitriolic acid is a compound of ſulphur and vital air, or the oxyginous principle. 2d, That when a combuſtible body is preſented to this acid, which has a ſtronger affinity than vital air to ſulphur, it ſeizes the pure air, and decompoſes

compoſes the acid. 3d, That if the combuſtible matter do not ſeize the whole of the pure air, as is the caſe with moſt metallic ſolutions in oil of vitriol, the ſubſtance diſengaged is not pure ſulphur, but ſulphureous acid gas. 4th, That this gas occupies the middle place between ſulphur and vitriolic acid, and muſt be conſidered as vitriolic acid deprived of a certain quantity of its pure air, or as ſulphur rendered feebly acid by a portion of vital air; in order, therefore, to cauſe this gas to become true ſulphur, nothing more is required than to deprive it of this portion of air; an event which happens towards the end of metallic ſolutions by the vitriolic acid, when theſe ſolutions are evaporated and ſtrongly heated. It may likewiſe be readily underſtood in what manner the ſulphureous acid becomes gradually converted into vitriolic acid, by abſorbing the pure air, or oxyginous principle, contained in the atmoſphere.

Sulphureous gas is capable of uniting ſomewhat intimately with the vitriolic acid, to which it gives the property of emitting thick white vapours. Meyer, in his chemical eſſays on quick-lime, ſpeaks of a ſmoking oil of vitriol, prepared at Narthauſen in Saxony, by the diſtillation of common vitriol. This chemiſt, after Chriſtian Bernhard, a German chemiſt, mentions a concrete and fuming acid ſalt, obtained from the

the ſaid oil of vitriol by diſtillation. Having had an opportunity of procuring a few pounds of this Saxon acid, I obſerved the properties mentioned by Meyer; and by a gentle heat, I obtained a concrete fuming volatile ſalt, in deliqueſcent cryſtals, of two forms, according to the deſcription of Chriſtian Bernhard. A number of experiments which I have deſcribed, in a memoir to be inſerted among thoſe of the Royal Academy of Sciences, have convinced me, 1ſt, That the property of fuming and affording a concrete volatile ſalt, ariſes from the ſulphureous gas contained in a large proportion in the black oil of vitriol of Narthauſen. 2d, That in proportion as it loſes this gas by expoſure to air, it ceaſes to emit fumes, and affords no more concrete ſalt. 3d, That water diſengages this gas, and deprives the Saxon vitriolic acid of its fuming property, &c. 4th, and laſtly, That this concrete and very fuming acid ſalt, obtained by diſtillation, is a ſaturated combination of oil of vitriol and ſulphureous gas, which gradually becomes converted into ordinary vitriolic acid, by expoſure to air. Two concrete vitriolic acids are therefore known; the one formed by the addition of nitrous, and the other of ſulphureous gas: I do not doubt but that other concrete modifications occaſioned by its combination with other gaſes, as the dephlogiſticated marine acid gas, &c. will hereafter be diſcovered.

The vitriolic acid is uſed in many arts, particularly in dying; it is one of the moſt common, and moſt neceſſary ſolvents made uſe of in chemiſtry; it is employed in medicine externally, as a powerful cauſtic, and internally, when diluted with water, ſo as to be ſcarce ſenſibly acid, as a refreſhing, cooling, and antiſeptic medicine.

The ſulphureous acid is employed in dying; it is uſed to whiten ſilks, to take out ſpots occaſioned by vegetable juices, &c.

Species VI. Acid of Borax, or Sedative Salt.

The labours of a great number of chemiſts have ſhewn, that borax is a neutral ſalt, formed by the combination of a peculiar acid with mineral alkali; this acid was called ſedative ſalt by its diſcoverer, Homberg. Some moderns call it the acid of borax; the name of ſedative ſalt, by which it is generally known, is improper, and ought to be rejected.

Many chemiſts have ſuppoſed that this acid is an artificial product, formed by the combination of the ſalts made uſe of in its manufacture; but ſince Mr. Hoefer, apothecary to the Grand Duke of Tuſcany, has diſcovered that the waters of ſeveral lakes in that country contain it, in a ſtate of great purity,

purity, it cannot be doubted but that it is a peculiar acid. The chemiſts of the academy of Dijon have confirmed this diſcovery, by analyzing the waters of Monterotondo which were ſent to them, and in which they found ſedative ſalt, as diſcovered by Mr. Hoefer. It is probable that it may hereafter be found in other mineral waters; it ſeems to be produced by the putrefaction of fat ſubſtances.

Sedative ſalt, whether native, or obtained from borax, by the proceſs to be mentioned under that article, is a concrete ſubſtance, cryſtallized in ſmall white ſcales, exceedingly thin, irregularly cut at their edges, very light, and ſometimes brilliant in a certain degree. Its taſte is feebly, though ſenſibly, acid; it ſlightly reddens the tincture of violets, and alſo that of turnſole much more ſenſibly; it is not volatilized by fire, but melts at a conſiderable red heat into a tranſparent glaſs, which, upon expoſure to the air, becomes opake, and covered with a light white powder. This glaſs is the acid of borax unaltered, and recovers its cryſtalline form, by ſolution in water, and ſubſequent cryſtallization.

The acid of borax is not changed by the action of air, whether it be hot or cold, or in a ſtate of humidity or dryneſs.

It is difficultly ſoluble in water, a pound* of

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* 9216 grains.

of this fluid, boiling hot, diſſolving no more than 83 grains; according to the academicians of Dijon, it cryſtallizes by cooling, and by evaporation. This ſolution immediately reddens the tincture of turnſole, and changes the colour of ſyrup of violets, though ſlowly. If ſedative ſalt, moiſtened with a little water, be heated in a cucurbit with a head, a part of the acid ſublimes with the water which riſes, but the ſublimation ceaſes as ſoon as the water has all riſen; a circumſtance which proves, that this ſalt alone is fixed, as may be ſhewn by melting it in a crucible; by ſublimation in this manner with water, ſedative ſalt may be obtained in fine brilliant cryſtals, if the operation be well managed. This ſalt, called ſublimed ſedative ſalt, is very pure.

The ſedative acid is uſed to fuſe vitrifiable earths, with which it forms clear, and nearly colourleſs glaſſes; by the aſſiſtance of heat, it diſſolves the earth precipitated from the liquor of flints. It unites with ponderous earth, magneſia, lime, and alkalis, and forms with theſe different ſubſtances, ſalts, diſtinguiſhed by the general name of Borax, of which there is only one ſpecies which is yet well known.

All theſe properties, and more eſpecially its taſte, the red colour it communicates to vegetable alkalis, and its neutral combinations with alkalis, ſufficiently indicate its acid nature; but it is the moſt feeble of all the acids, and is diſengaged from its baſes, even by the cretaceous acid.

The action of acids on ſedative ſalt is not well known; it appears to be partly decompoſed by the vitriolic acid, the latter becoming ſulphureous when diſtilled from this ſalt. As to the nitrous and marine acids, it is known that they diſſolve it; but their mutual action has not been obſerved with ſufficient accuracy to determine whether any decompoſition takes place.

There have been many different opinions reſpecting the nature and formation of ſedative ſalt; many chemiſts have thought it to be an intimate combination of vitriolic acid, and vitrifiable earth, with a fat ſubſtance. Meſſrs. Bourdelin and Cadet ſuppoſed it to be formed of marine acid; the latter imagined, that it contains a ſmall proportion of earth of copper, becauſe, like the calces of that metal, it gives a green colour to flame. Cartheuſer affirms, that ſedative ſalt, when dried by a gentle heat, emits vapours of ſpirit of ſalt; that this dry ſalt being diſſolved, a grey earth remained on the filter; laſtly, that by repeating the deſiccations and ſolutions a great number of times, the ſalt is intirely decompoſed, ſo that it ſeemed to be a modification of marine acid, fixed by an earth. Meſſrs. Macquer and Poulletier de la Salle have repeated this experiment;

periment; they obſerved the diſengagement of a vapour during the calcination of the ſedative ſalt, but they were not ſatisfied that its ſmell was that of marine acid. By ſucceſſive deſiccations and ſolutions, they obtained a ſmall quantity of a grey earth, which when combined with marine acid, did not form ſedative ſalt, as Cartheuſer had affirmed; ſo that the opinion of this chemiſt is no more proved than the others. Model conſidered this ſalt as a combination of a peculiar alkali, with the vitriolic acid made uſe of in diſengaging it. But the ſedative acid being always the ſame ſubſtance, whatever may be the acid employed to diſengage it, this opinion cannot be admitted. Mr. Baumé affirms, that he has ſucceeded in forming ſedative ſalt, by leaving a mixture of clay and fat to digeſt together for 18 months. Hence he concludes, that this ſalt is a combination of the acid of fat with a ſubtle earth, of which it cannot afterwards be deprived. He adds, that vegetable oils afford the ſame ſalt, though more ſlowly. Mr. Wiegleb repeated this experiment of Baumé, but no ſedative ſalt was produced.

Chemiſts, at preſent, conſider ſedative ſalt as a peculiar acid, different from all others; and the order of its affinities with the alkaline baſes tend to ſupport this aſſertion. Bergman arranges them as follows: lime, ponderous

earth,

earth, magneſia, vegetable alkali, mineral alkali, volatile alkali.

The acid of borax, or ſedative ſalt, was for ſome time employed in medicine on the authority of Homberg, who affirmed it to be ſedative, and even narcotic; but experience has ſhewn, that the virtues of this ſalt are not extraordinary; it is therefore rejected; and with ſo much the more juſtice, as it is certain that we poſſeſs remedies, whoſe action is much more powerful and certain.

It is uſed in many chemical operations, as a flux, under which character we ſhall hereafter have occaſion to conſider it.

CHAP. V.

ORDER II. Secondary, or Neutral Salts.

UNDER the name of ſecondary ſalts, we comprehend ſuch matters as are compoſed of two primitive ſaline ſubſtances combined together. Theſe ſalts are called neutral, becauſe they do not poſſeſs the characters of primitive ſalts; that is to ſay, they are neither acid nor alkaline. There are, however, many ſalts, ſuch as borax, chalk, and alkalis, when united with the cretaceous acid, which exhibit ſome of the properties of primitive ſalts, though in a leſs eminent

nent degree. Theſe ſecondary ſalts have not ſo ſtrong a taſte as moſt of the primitive, their tendency to combination, and their ſolubility being leſs conſiderable; but the criterion which diſtinguiſhes them more eſpecially from the former is, that they cannot, like the primitive ſalts, communicate the ſaline properties to other bodies; their cryſtalline form is likewiſe a character much attended to by naturaliſts, and ſometimes indicates their nature, though it may be productive of error when too much depended upon.

The term, baſe, is commonly applied to the more fixed matter which enters into the compoſition of neutral ſalts. As this baſe, which is ſometimes volatile, communicates ſeveral general characters, ſufficiently uniform in the ſeveral combinations it makes with acids, we ſhall aſſume the name of the baſe to diſtinguiſh the genera of ſecondary ſalts, and ſhall therefore divide theſe ſalts into as many genera, as there are ſaline or alkaline baſes capable of being united with acids.

The firſt genus comprehends ſuch as are formed by the union of fixed alkalis with acids. We ſhall call them perfect neutral ſalts, becauſe the union of their component parts is very intimate.

The ſecond genus includes ſuch as are formed by the combination of the volatile alkali

alkali with acids. They are diſtinguiſhed by the name of ammoniacal ſalts, from one ſpecies which has long been ſo denominated. They may likewiſe be called imperfect ſalts, becauſe they are much more eaſily decompoſed than ſalts of the firſt genus.

In the third genus are arranged ſuch neutral ſalts as have lime for their baſe. They are in general leſs perfect than thoſe of the ſecond genus, though lime has a ſtronger affinity to acids than the volatile alkalis. Theſe ſalts are denominated neutral calcareous ſalts.

Magneſia, combined with various acids, conſtitutes the fourth genus. They are more decompoſable than thoſe of the laſt-mentioned genus, becauſe lime and alkalis have a ſtronger affinity with acids than magneſia. They are diſtinguiſhed by the name of magneſian neutral ſalts.

The fifth genus comprehends ſuch as have pure argillaceous earth for their baſe. As alum is the principal of theſe combinations, the generic name of aluminous ſalts is given to them. Alkalis, lime, and magneſia, in moſt inſtances, decompoſe ſalts with an argillaceous baſe.

Laſtly, We arrange in the ſixth genus, neutral ſalts, with a baſe of ponderous earth. Theſe ſalts, as well as moſt of the two preceding genera, are little known.

It may eaſily be imagined, that theſe baſes, combined

combined with the acids, whoſe properties we have examined, muſt afford a great number of neutral ſalts; and that this number would be ſtill more conſiderable, if, with Bergman, we were to admit, as peculiar ſalts, the union of the ſame ſubſtances with the acids which he calls phlogiſticated, and are, according to the modern doctrine, deprived of a part of their pure air. But theſe compounds not being durable, but, on the contrary, ſubject to alteration, by the contact of air, which cauſes them in a ſhort time to become true neutral ſalts, I have not judged it neceſſary to add them to the number, but ſhall point out ſuch of their different properties as depend on the ſtate of their acids. We muſt likewiſe obſerve, that the alkaline baſes here enumerated, when combined with aqua regia, afford nitrous and marine ſalts, which may be obtained ſeparate, and are perfectly ſimilar to thoſe afforded by the unmixed acids; we ſhall therefore ſpeak of theſe combinations in treating of thoſe of the ſimple acids.

In the arrangement of the various neutral ſalts, we have followed the order of the affinities of the acids. That is to ſay, we begin with vitriolic ſalts, after which we place nitrous ſalts; and after them, the ſalts into which the marine, the boracic, the ſparry, and the cretaceous acids enter, are ſucceſſively treated of.

GENUS I.

GENUS I. Perfect Neutral Salts, or Salts with Baſe of fixed Alkali.

Species I. VITRIOLATED TARTAR.

Vitriolated tartar, called likewiſe ſal de duobus, polychreſt ſalt, or arcanum duplicatum, is a perfect neutral ſalt, reſulting from the combination of the vitriolic acid with fixed alkali of tartar, or the vegetable alkali. It rarely exiſts in the mineral kingdom, but ſome vegetables contain a ſmall quantity of it.

This ſalt is uſually tranſparent and regular; its cryſtals vary in form and magnitude, according to the circumſtances in which they are obtained. When cryſtallized ſlowly in the ſmall way, it has the figure of tranſparent pyramids, with ſix ſides, nearly ſimilar to the points of roſe diamonds, and ſometimes ſix-ſided priſms, terminated by one or two hexahedral pyramids, like rock cryſtal. But if the evaporation be conducted with rapidity, the cryſtals are agglutinated and confounded, under the form of a ſolid cruſt, whoſe ſurface is full of irregular points or pyramids: the ſalt met with in commerce is of this kind. Laſtly, When the ſolution is expoſed to ſpontaneous evaporation, the cryſtals are frequently twelve-ſided, conſiſting of two hexahedral pyramids, united at at their common baſe, and ſometimes ſeparated by a ſhort ſix-ſided priſm. It is true, that theſe laſt cryſtals are uſually foul, and never poſſeſs either the whiteneſs or the tranſparency of ſuch as are obtained by the firſt evaporation. But this difficulty exiſts in moſt of the neutral ſalts, in which the moſt regular figure, and the moſt perfect tranſparency, are ſeldom united.

Vitriolated tartar has a bitter, diſagreeable taſte. It is not much altered by the action of heat; when thrown on red-hot coals, it flies into a number of ſmall fragments, attended with noiſe, a phenomenon which depends on the ſudden rarefaction of the water contained in its cryſtals. Vitriolated tartar loſes none of its eſſential properties by this decrepitation. It decrepitates in the ſame manner, and becomes dry, friable, and even pulverulent, by the loſs of its water, when expoſed to the action of heat in a crucible. It becomes red-hot before it melts, and is not fuſed but by the application of a conſiderable degree of heat. The melted maſs, when ſuffered to cool, is opake, and not at all changed in its principles; for ſolution in water reſtores its cryſtalline and tranſparent appearance. If it be kept in ſtrong fuſion, in an open veſſel, it is volatilized without decompoſition.

Vitriolated tartar is not changed by expoſure to air, but preſerves its figure and tranſ-

tranſparency without alteration; it is ſparingly ſoluble in water; and the quantity taken up varies conſiderably with the temperature of the fluid. According to Spielman, about 18 parts of cold water are required to diſſolve one of vitriolated tartar, whereas boiling water diſſolves near ¼ of its weight; for Mr. Baumé aſſerts, that 4 ounces of boiling water, diſſolves more than 7 gros, 48 grains, of vitriolated tartar: * it cryſtallizes partly by cooling, and ſtill more by evaporation: it retains but a ſmall proportion of water in its cryſtals, which ſeems to be the cauſe why it does not change by expoſure to air.

Vitriolated tartar does not act on the ſimple earths: it has been obſerved, that the vitriolated tartar, caſually contained among the ſalts uſed as fluxes in the making of glaſs, is found again in the ſcoriæ; and a conſiderable quantity may be obtained from glaſs gall.

Ponderous earth decompoſes vitriolated tartar, according to Bergman, becauſe it has a ſtronger affinity than fixed alkali to the vitriolic acid. If a ſmall quantity of this earth be added to a ſolution of vitriolated tartar, a precipitate is formed, conſiſting of ponderous ſpar, which is perfectly inſoluble,

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* That is to ſay, 2304 grains of boiling water, diſſolve 552 of vitriolated tartar. T.

and will be examined under that baſe; the vegetable fixed alkali, in its cauſtic and pure ſtate, remains diſſolved in the liquid.

Lime and magneſia produce no change in vitriolated tartar; but many acids have a very conſiderable action on it. Rouelle firſt aſſured us, that it is poſſible to combine a larger quantity of vitriolic acid with it than it naturally contains. His proceſs conſiſted in diſtilling oil of vitriol from vitriolated tartar; the latter thus becomes impregnated with the acid, and acquires new properties, ſuch as thoſe of reddening tincture of violets, of being more ſoluble in water, acid taſte, and of effervefcing with cretaceous alkalis, even after ſolution and cryſtallization. Mr. Baumé inſiſts, that this ſuperabundant acid is not really combined, and that the ſalt may be deprived of it, by being placed on bibulous paper, or ſand. Mr. Macquer, however, remarks, that the vitriolic acid adheres with conſiderable force to vitriolated tartar, and thinks that this adherence ariſes from a peculiar affinity between theſe two ſubſtances, ſince, according to him, it cannot be deſtroyed by the action either of fire or water. I have ſeveral times made this combination of vitriolated tartar and oil of vitriol, after the manner of Rouelle, namely, by diſtillation in glaſs retorts, and have obſerved ſeveral facts not mentioned in the learned diſſertation of that author. The vitriolated tartar

tartar is melted into a kind of glaſs, of the appearance of white enamel, of a very acid taſte; but this vitreous frit did not attract the humidity of the air, but, on the contrary, exhibited appearances of effloreſcence. The opinion of Macquer, that the adherence between this neutral ſalt and the acid is conſiderable, appears to be well founded, and doubtleſs ariſes from a peculiar combination.

Baumé has obſerved, that vitriolated tartar is remarkably affected by the nitrous acid; if this fluid be boiled on the ſalt, the nitrous acid ſeizes the vegetable fixed alkali, and diſengages the vitriolic acid. When the mixture is cooled, a cryſtallization of true nitre is perceived. It was at firſt concluded, that this decompoſition is the effect of heat; but the fuming ſpirit of nitre, poured on vitriolated tartar in powder, depoſits cryſtals of nitre at the end of a few hours. It has likewiſe been affirmed, that when the mixture becomes cold, the vitriolic acid reſumes its power, and decompoſes the nitre in its turn. I have nevertheleſs kept by me, for more than four years, a mixture of vitriolated tartar and ſpirit of nitre, at the bottom of which are ſaline cryſtals, capable of detonating on hot coals, which are not changed, though they are immerſed in the vitriolic acid, ſeparated by the nitrous. Mr. Cornette has obſerved, that the concentrated marine acid likewiſe decompoſes vitriolated tartar,

tartar, even in the cold. From theſe two facts, it ſeems, that the law of affinity, with reſpect to the different acids, is not ſo conſtant as has been thought: it muſt, however, be obſerved, with Bergman, 1ſt, That no more than one third of the vitriolated tartar is decompoſed in theſe experiments, however large the quantity of the nitrous or marine acid employed may be; while the vitriolic acid, in a moderate doſe, completely decompoſes nitrous and marine ſalts. 2d, That theſe decompoſitions do not take place, unleſs the vitriolated tartar contains a ſmall proportion of acid more than is neceſſary for its neutralization.*

There is a decompoſition of vitriolated tartar which requires to be more particularly attended to, and is effected by combuſtible bodies, particularly charcoal, and ſeveral metallic ſubſtances. † If a mixture of this ſalt and charcoal be ſtrongly heated in a crucible, the vitriolated tartar will no longer appear, but a combination of ſulphur, united to fixed alkali, will be found inſtead thereof. Stahl regarded this experiment as a very proper demonſtration of the preſence or exiſtence of phlogiſton. Modern chemiſts account

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* This curious ſubject is ably treated of by Bergman, in his Diſſertation on Elective Attractions. See page 47, Engliſh edition.—T.

† See my Memoires de Chimie, page 225.—Note of the author.

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for the fact by the pneumatic theory. We ſhall explain both in the Hiſtory of Sulphur.

One hundred parts of vitriolated tartar, contain, according to Bergman, about 52 parts of fixed vegetable alkali, 40 of vitriolic acid, and 8 of water of cryſtallization.

This ſalt rarely exiſting in conſiderable quantities in nature, is produced artificially for the purpoſes of medicine. There are three methods of doing this: firſt, By directly combining oil of vitriol with the cauſtic vegetable fixed alkali, vitriolated tartar is immediately produced, which may be cryſtallized by ſolution in water. The ſecond method is, to decompoſe, by the vitriolic acid, ſuch neutral ſalts as are produced by the union of the vegetable fixed alkali with other acids, ſuch as nitre, the febrifuge ſalt of Silvius, cretaceous tartar, &c. in theſe decompoſitions, vitriolated tartar is always produced. The third method is, to decompoſe the earthy and metallic vitriols by means of the vegetable fixed alkali. The latter precipitates the ſalino-terreſtrial ſubſtances, or the metals.

Vitriolated tartar is not uſed, except in medicine; it is a good purgative, and is ſometimes given alone, in the doſe of half an ounce or an ounce. It is moſt commonly adminiſtered in a doſe of one or two drachms, together with other purgative medicines. It is likewiſe uſed as a ſolvent in chronical diſorders,

orders, and eſpecially in coagulations of the milk; it is then given in doſes of a few drachms, in proper liquids; but its virtue, in this reſpect, is inferior to that of many other more ſoluble and leſs nauſeous ſalts.

Species II. GLAUBER'S SALT.

This ſalt, diſcovered by Glauber, a German chemiſt, is perfectly neutral, and conſiſts of the vitriolic acid, united to the mineral alkali, or ſalt of Soda. It would be more proper to call it Vitriol of Soda. This ſalt has many of the properties of vitriolated tartar, and others which are peculiar to itſelf. It has a bitter taſte; is very ſoluble in water; and does not unite with earths. Like vitriolated tartar, it is partly decompoſed by the nitrous and marine acids.

Glauber's ſalt is uſually in the form of regular cryſtals, either tranſparent or ſemi-opake. Its cryſtals are priſms, with ſix unequal and ſtriated ſides, terminated with dihedral ſummits. But they have not often this regular form, but are ſubject to very conſiderable variations, as Romé de Lille has ſhewn at large in his Cryſtallographie. The taſte of this ſalt is at firſt cooling, and is ſucceeded by a ſtrong bitter. It does not alter vegetable blue colours.

Expoſed to heat, it melts quickly, and ſoon after becomes dry, and of an opake white appearance, in which ſtate it cannot be melted but by a conſiderable heat. On this occaſion, it is neceſſary to diſtinguiſh two kinds of fuſion, of which ſaline matters are capable. The firſt, called the aqueous fuſion, is produced by the water which enters into the formation of their cryſtals. It obtains only in ſuch ſalts as are more ſoluble in hot than in cold water; whence it follows, as a conſequence, that the water, which enters into the formation of the cryſtals, is rendered capable of diſſolving the ſaline matter. The aqueous fuſion is therefore merely a ſolution in hot water. The Glauber's ſalt, therefore, after this fuſion, aſſumes a concrete form by cooling; but if the heat be urged, it becomes dry and white, and another fuſion enſues, which is called the igneous fuſion, becauſe produced merely by the fire. Glauber's ſalt appears to be as difficult to melt as vitriolated tartar; and like that ſalt is volatilized by a violent heat, without ſuffering any alteration in its principles. After the eſcape of the large quantity of water contained in the cryſtals of Glauber ſalt, it becomes converted into a fine white powder, by expoſure to the air. This phenomenon is termed effloreſcence, becauſe the pulverulent form of the cryſtals reſembles thoſe matters which are obtained in chemiſtry under the name of flowers. The effloreſcence

effloreſcence proceeds more rapidly when the air is very dry, and conſequently greedy of moiſture. The phenomenon of efflorefcence is therefore very analogous to the drying of this ſalt by heat, both depending ſimply on the evaporation of the water, which is a conſtituent part of the cryſtals. But, as the water which enters into the cryſtals of Glauber's ſalt, and of every other ſalt in general, is truly combined, the efflorefcence appears to take place by virtue of an affinity between air and water, which is greater than between water and the ſaline matter. I have always conſidered efflorefcence as a phenomenon of this nature, and ſee no other way of explaining it. (Conſult my Memoires de Chimie.) Glauber's ſalt loſes near half its weight by efflorefcence, but its properties may all be reſtored, together with its cryſtalline form, by the addition of the water it had loſt. No medical author has attended to this circumſtance, which is certainly of conſequence in aſcertaining its doſes in preſcriptions. It ſhould be given with a deduction of about one third of its weight when in efflorefcence, compared with the ſame weight in fine tranſparent cryſtals.

Glauber's ſalt is very ſoluble in water, four parts of the fluid being ſufficient to diſſolve one of the ſalt; and a leſs quantity will ſerve in proportion as its temperature is higher: boiling water diſſolves nearly its own weight of this ſalt. It is on this property that the method of cryſtallizing it is founded. A ſtrong ſolution of the ſalt being left to cool, affords cryſtals ſo much the more beautiful, in proportion as the quantity of matter is larger, and the cooling more ſlow and gradual. When the operation is performed in the large way, ſtriated priſms, of ſeveral inches in length, are often obtained, in which the regular figure of the ſalt may be ſeen.

Glauber's ſalt has no more action on earths than vitriolated tartar, and does not enter into the formation of glaſs. Ponderous earth decompoſes this ſalt, but the ſalino-terreſtrial matters have no action whatever upon it.

The cauſtic vegetable fixed alkali, mixed with a ſolution of Glauber's ſalt, decompoſes it, becauſe of the ſtronger affinity of that alkali to the vitriolic acid. To ſhew this fact, cauſtic vegetable fixed alkali muſt be poured into a hot and ſaturated ſolution of Glauber ſalt. This ſolution, which would have afforded cryſtals of Glauber's ſalt by cooling, affords only vitriolated tartar, and the mother water contains the cauſtic alkali of Soda.

The vitriolic acid combines with Glauber's ſalt, in the ſame manner as it does with vitriolated tartar.

The nitrous and marine acids decompoſe Glauber's ſalt in the ſame manner, and are attended

tended with ſimilar appearances to thoſe mentioned in treating of vitriolated tartar.

When Glauber's ſalt is ſtrongly heated with charcoal, or with certain metals, the vitriolic acid acquires the ſulphureous ſtate, as we ſhall obſerve in our Hiſtory of Sulphur.

All the properties in which Glauber's ſalt differs from vitriolated tartar, ſhew that the two fixed alkalis, which perfectly reſemble each other when conſidered in a ſtate of purity, are certainly different, ſince they form very different ſalts with the ſame acids. The proportion of the component principles is likewiſe very different in the two ſalts we have compared together, a centenary of Glauber's ſalt, containing, as Bergman finds, 15 parts of mineral alkali, 27 parts of vitriolic acid, and 58 of water.

This ſalt is much more abundant in nature than vitriolated tartar. It is found in conſiderable quantities in the waters of the ſea, of ſalt ſprings, and eſpecially in many mineral waters: it can always be produced by art by the three methods ſpoken of in the article of vitriolated tartar. It is not employed in the arts, but is much uſed in medicine; it is given as a cathartic medicine, from half a dram, to an ounce and half, according to circumſtances. Its effects are more conſiderable and ſpeedy than thoſe of vitriolated tartar, becauſe it is more

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ſoluble in the fluids of the animal œconomy; and its taſte is more penetrating.

Species III. NITRE.

Nitre, or ſalt petre, is a perfect neutral ſalt, formed by the union of the nitrous acid with the fixed alkali of tartar. Its taſte is cooling, and it does not alter the colour of ſyrup of violets. Its cryſtals are ſix-ſided priſms, terminated by dihedral pyramids, or cut off with a ſlope, and often perforated quite through in the direction of their axis.

Nitre exiſts in large quantities in nature, and is continually formed in inhabited places; it is found in great quantities upon walls which are ſheltered from the rain; it is then called ſalpêtre de houſſage.

There appear to be three principal circumſtances that promote its formation; the firſt is, the preſence of chalk, or any other calcareous earth, as appears by its being collected from walls covered with plaſter, or from the ruins of ancient edifices. This ſalt is likewiſe found perfectly pure in chalky earths. The Duc de la Rochefoucault obtained it, in the proportion of one ounce in the pound, from the chalk of Roche Guyon.

The ſecond circumſtance neceſſary for the production of this ſalt, is the putrefaction, or ſpontaneous decompoſition of vegetable and

and animal matters. It is a well known fact, that places which are moiſtened with animal liquids, or contain animal matters in a ſtate of putrefaction, ſuch as dunghills, ſtables, privies, &c. produce much nitre. This conſtant obſervation has been applied to the formation of artificial nitre-beds. Dry ditches are dug and covered with ſheds open at the ſides; theſe are filled with animal ſubſtances, ſuch as dung, the excrements of quadrupeds, or birds, with the remains of vegetables. Theſe matters are from time to time watered, eſpecially with water charged with animal or vegetable matters capable of putrefaction, and they are turned up to renew their ſurfaces from time to time. When the putrefaction is in an advanced ſtage, a ſmall portion of the matter is taken up and lixiviated, to aſcertain whether it contains nitre; and when it is found ſufficiently charged with that ſalt, the whole is lixiviated.

The third circumſtance, which is found to favour the production of nitre, is the acceſs of air; this is the cauſe of the formation of the nitre found on walls, and for this reaſon it is that nitre-beds require to be frequently turned over, in order that the air may touch them in all points. The neceſſity of the acceſs of air is ſtill more evidently ſhewn by the nitre contained in chalk, as it is never found below a certain depth. When the three circumſtances

circumſtances here treated of are united, the production of ſalt petre is very abundant. Nitre-beds ought always to be conſtructed on theſe principles.

The theory of the formation of nitre has not been long known. Glauber, and many other chemiſts ſince his time, ſuppoſed nitre to exiſt ready formed in vegetables, from which they imagined it to paſs into animal ſubſtances, and to become diſengaged by putrefaction; but it was ſoon perceived, that vegetables do not contain a ſufficient quantity of nitre to account for what is obtained from nitre-beds. Mr. Thouvenel, whoſe diſſertation on the formation of nitre was honoured with the prize of the academy, has made many experiments to diſcover its origin: he found, that the nitrous acid is formed by the combination of an elaſtic fluid, diſengaged from animal matters in a ſtate of putrefaction, and pure air. He has likewiſe diſcovered, that the nitrous acid, once formed, combines with calcareous earth, when only animal matters are made uſe of; and that the remains of vegetables are uſeful to afford the fixed alkali, which is the baſe of common nitre. But Mr. Thouvenel did not determine the nature of the gas, which is diſengaged from putrefying animal matters. It is to Mr. Cavendiſh that we are indebted for the proof that it is the ſame gas, which conſtitutes one of the principles of the atmoſphere,

moſphere, under the name of phlogiſticated air, or atmoſpheric mephitis. His experiment, wherein the nitrous acid was formed by the combination of this gas with vital air, by means of the electric ſpark, has been already mentioned.

Nitre is very ſubject to alteration by heat: it is quickly melted, and its fuſion is of the igneous kind; for it may be kept fluid for a conſiderable time, and even made red hot, without aſſuming the pulverulent form: when ſuffered to cool, after being melted, it fixes in an opake maſs, called cryſtal mineral, which is as heavy, as fuſible, and as ſoluble in water, as the nitre itſelf. The cryſtal mineral of the ſhops differs from pure nitre, for it contains a ſmall quantity of vitriolated tartar, produced by the combuſtion of the ſulphur, which, according to the Paris Pharmacopeia, is in the proportion of a drachm in the pound. If melted nitre be expoſed to the continued action of the fire, it becomes decompoſed, and is alkalized without addition. This operation ſucceeds equally well in a retort, and affords much inſtruction reſpecting the compoſition of the nitrous acid: inſtead of obtaining the pure acid, a large quantity of an aeriform fluid is diſengaged, which may be collected under water, and is found to be vital air. The alkaline reſidue uſually cauſes the retort to melt, and prevents the completion of the operation.

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Here we ſee the nitrous acid converted intirely into vital air, without any ſenſible quantity of nitrous gas. It is not yet known what becomes of the atmoſpheric mephitis in this decompoſition. If the heat be not urged ſo as intirely to decompoſe the nitre, the fixed alkali remains charged with a certain quantity of nitrous gas, or phlogiſticated nitrous acid, according to Scheele. This acid may be diſengaged by means of vinegar; but if the nitre be more ſtrongly heated, the alkali remains pure and cauſtic. From the facility with which heat decompoſes nitre, we may obſerve, that in the making of cryſtal mineral, the ſalt ought not to be kept in fuſion too long, leſt the quantity of diſengaged alkali ſhould become too conſiderable, and render the effect of the medicine more violent than intended.

When nitre is expoſed to heat, in contact with combuſtible bodies, it is decompoſed with other appearances; a white and ſtrongly brilliant flame is produced, together with a kind of decrepitation. This phenomenon is called the detonation of nitre, and is a character by which it is eaſily known. Stahl ſuppoſed it to ariſe from the rapid combination of the nitrous acid with phlogiſton; and Mr. Baumé, in conformity to this theory, thinks that a nitrous ſulphur is formed, and inſtantly ſet on fire. In the year 1780, I read a memoir at the academy, in which I proved,

proved, that nitre is not combuſtible, and that a nitrous ſulphur is not formed during its detonation; but that the phenomenon ariſes from the rapid combuſtion of the body added to the nitre, which is aſſiſted by vital air diſengaged from nitre ſtrongly heated. This theory is completely proved, from the conſideration, 1ſt, That nitre never detonates without addition. 2d, That during the detonation of nitre, by the addition of inflammable matter, the latter is intirely conſumed. 3d, Becauſe the combuſtion of the inflammable matter is more complete, the larger the proportion of nitre. 4th, and laſtly, Becauſe the detonation of nitre takes place as well in cloſe veſſels, as in the open air, which could not be effected, but by means of the vital air afforded by that ſalt. This aſſertion is clearly proved by the proceſs for making the clyſſus of nitre, which is merely a detonation of this ſalt with different combuſtible matters, in cloſe veſſels: we ſhall only mention, in this place, the operation made with the addition of charcoal. Two or three large receivers, adapted together, are applied to a retort of earth, or iron, in the upper part of which laſt is an aperture, which may be cloſed with a cover or ſtopper. The veſſel is heated, and when its bottom is red, the mixture of nitre and charcoal is thrown in by ſmall quantities at a time, through the aperture, which is immediately

mediately cloſed. During the detonation, the receivers are filled with vapours, part of which condenſes into an inſipid liquor, not at all acid, but frequently alkaline; the reſidue conſiſts of the cretaceous fixed alkali, the nitrous acid being intirely deſtroyed. A large quantity of gas is produced, which I have collected, by adapting to the upper part of the receivers tubulated for that purpoſe, either a bladder, or tubes whoſe extremities were received under glaſs veſſels filled with water. This gas conſiſted, for the moſt part, of the cretaceous acid, mixed with a ſmall proportion of inflammable gas, and phlogiſticated gas.

The reſidue, after the detonation of nitre with charcoal in a crucible, is improperly called nitre fixed by charcoal; it is the fixed vegetable alkali, combined with the cretaceous alkali.

Very pure nitre is not at all altered by expoſure to air.

It is very ſoluble, three or four parts of cold water diſſolving one part of nitre; and boiling water diſſolving twice its weight. It therefore cryſtallizes by cooling; and on this property is founded the art of extracting nitre from the old plaſter, or rubbiſh, in which it is contained. The ſalt petre makers put the pounded rubbiſh into a caſk, with a hole in the bottom, and cover it with aſhes. Through this matter water is paſſed, care being

being taken to pour the firſt water upon ſuch matter as has already been waſhed, that the ſalts may be intirely extracted; and the water, which is already partly impregnated, is paſſed through caſks loaded with unwaſhed rubbiſh, in order that it may be intirely ſaturated. This lixivium is evaporated by heat in copper veſſels. The firſt pellicles, conſiſting of marine ſalt, are taken out. When the water is ſufficiently evaporated to become nearly ſolid in cooling, they pour it into veſſels, where the nitre cryſtallizes. This nitre, which is very impure and dirty, is called nitre of the firſt boiling. Some chemiſts have thought, that the aſhes uſed by the ſalt petre makers ſerve only to deprive the nitre of certain greaſy impurities; and this opinion appeared probable, from the conſideration that theſe aſhes contained ſcarcely any fixed alkali; and more eſpecially, as the aſhes of tamariſk contain only Glauber's ſalt. But this ſalt, as well as vitriolated tartar, is as ſerviceable as an alkali for decompoſing the calcareous nitre which abounds in the rubbiſh, becauſe it acts by the way of double affinity; as Mr. Lavoiſier has obſerved, with reſpect to the aſhes uſed by the ſalt petre makers at Paris, though the alkali has been previouſly waſhed out. We ſhall treat more fully on this fact when we ſpeak of calcareous nitre.

Nitre of the firſt boiling is always very impure; it contains five other kinds of ſalt, namely,

namely, common ſalt, magneſian nitre, calcareous nitre, marine ſalt with baſe of magneſia, and calcareous marine ſalt, which muſt be ſeparated before the nitre can be had in a ſtate of purity. This is done by re-diſſolving it in the ſmalleſt poſſible quantity of water, and clarifying this boiling liquor by the addition of bullocks blood, which carries all the impurities to the top of the liquor in the form of ſcum, by virtue of the property of coagulating, which lymph poſſeſſes. This ſecond lixivium is evaporated, and affords a much purer nitre, called nitre of the ſecond boiling; it is ſtill vitiated by a certain quantity of marine ſalt, and mother water. It is purified a third time, by repeating the ſame proceſs, and is then much whiter. This is nitre of the third boiling. As it is cryſtallized haſtily, it has the form of large maſſes, of a confuſed figure; there is formed, however, in the middle of the veſſels, a bed of long and regularly formed cryſtals, called nitre in ſticks, which is not uſed in making good gunpowder, becauſe it retains a greater quantity of water in its cryſtallization, than the nitre in large irregular maſſes, and is conſequently leſs proper for combuſtion.

Chemiſts and apothecaries purify nitre of the third boiling, by new ſolutions and cryſtallizations, by which means they are certain of having very pure nitre, uncontaminated

nated by any foreign matter, eſpecially the marine ſalts, with baſes of mineral alkali, lime, and magneſia, which are ſcarcely ever taken away intirely in the manufactories.*

Nitre appears to be acted on by vitrifiable earths, ſince its acid may be obtained by diſtillation with ſand; this acid comes over colourleſs, but emits ſome vapours; the reſidue is more or leſs vitreous, according to the quantity of ſand made uſe of, and the degree of heat applied; the ſand appears to decompoſe the nitre, by its tendency to combine with the fixed alkali, ſince diſtillation, without an intermedium, affords pure air inſtead of nitrous acid. I apprehend that this happens, becauſe in the diſtillation of nitre without an intermedium, the alkali reacts on the acid, and contributes to its de-

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* There is no fact more ſingular, in the opinion of naturaliſts and chemiſts, than the production of ſix ſpecies of ſalts in old mortar, and eſpecially the conſtant union of each alkaline baſe to a peculiar acid. The vegetable alkali is always found united with the nitrous acid, and the mineral alkali with the marine acid. There ſeems to be a peculiar relation between theſe different primitive ſalts, by which they are mutually applied to each other; for elſe, why ſhould not the febrifuge ſalt of Sylvius, or cubical nitre be found? The ſame obſervation may be made reſpecting the earthy ſalts: in fact, the quantities of marine ſalt, with baſe of magneſia, and of calcareous nitre, greatly exceed thoſe of nitre with baſe of magneſia, or marine calcareous ſalt; whence it appears, that magneſia has a peculiar affinity with the marine acid, and lime with the nitrous acid. Note of the Author.

compoſition;

compoſition; whereas, when nitre, with ſand, is expoſed to heat, the latter ſubſtance tending to unite with the alkali, and form glaſs, prevents it from re-acting on the acid; which, therefore, comes over unchanged. Argillaceous earths likewiſe decompoſe nitre. The clay commonly uſed, is coloured: Mr. Baumé thinks, that the decompoſition is produced by the vitriolic acid contained in the clay. The diſtillers of aqua fortis make uſe of an earth of the ſame kind; they introduce two pounds of nitre with ſix pounds of coloured clay (of Gentilly), into earthen retorts of a peculiar form, which are placed in a row, on long furnaces, called galleries; their necks are inſerted in bottles of the ſame form, which ſerve as receivers. By this means they firſt obtain a tranſparent liquor, ſcarcely acid, which they call phlegm of aqua fortis, which is followed by the acid itſelf, more and more concentrated; the reſidue is a red and hard earthy ſubſtance, which is uſed as a kind of mortar. This experiment is far from proving that clay decompoſes nitre; for, 1ſt, The diſtillers employ a very impure nitre, which contains much nitre with an earthy baſe. 2d, They make uſe of a very compounded clay, which is often loaded with pyrites, whoſe vitriolic acid may decompoſe the nitre. To aſcertain whether ſuch a decompoſition takes place, the whiteſt clay, or which is ſtill better, the

the baſe of alum, ought to be uſed; this earth not having ſo ſtrong a tendency as ſand to unite with alkali, and not forming glaſs with that ſalt, will not probably decompoſe nitre ſo completely as ſand: Mr. Baumé, however, affirms, that he obtained nitrous acid by the addition of porcelain, and of clay, baked into ſtone ware, which do not contain the vitriolic acid.*

Ponderous earth decompoſes nitre, and ſeparates the alkali. Bergman, in his table of affinities, places this ſalino-terreſtrial ſubſtance before the alkalis, and immediately after the nitrous acid.

Magneſia, lime, and alkalis, have no action on nitre.

The acids have a very ſtrong action on this ſalt, eſpecially the vitriolic acid, which has a ſtronger affinity with alkalis than the nitrous. If oil of vitriol be poured on very dry nitre, a conſiderable effervеſcence is produced, and red vapours eſcape, which are ſpirit of nitre. When the operation is made, in a retort with a receiver, the ſpirit of nitre is collected: this proceſs is called by the name of Glauber's method of diſtilling ſpirit of nitre, becauſe that chemiſt firſt deſcribed it in an intelligible manner. It is neceſſary to leave a ſmall perforation in the re-

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* Theſe, as well as all other natural clays, contain a large proportion of ſiliceous earth. T.

ceiver for the eſcape of the vapours. It was remarked, that theſe vapours being very difficultly condenſed, occaſioned two principal inconveniencies: the firſt was, the loſs of a conſiderable quantity of the ſpirit of nitre, which was diſſipated by the aperture; the ſecond conſiſted in the danger incurred by the operator, from the acrid and corroſive vapours. Mr. Woulfe, a learned Engliſh chemiſt, has contrived a method of remedying theſe inconveniencies: inſtead of employing a perforated receiver, he uſes a receiver with two necks; the neck furtheſt from the retort conſiſts of a tube bent at right angles, the one part being horizontal, and the other vertical; which laſt is inſerted in the neck of a bottle: from the ſides of this bottle proceed two tubes ſimilar to that laſt deſcribed, which paſs each into another bottle; and theſe are in like manner connected with two others, whoſe lateral apertures remain open. The firſt bottle is commonly empty; the collateral bottles contain each a certain quantity of water, in which the inferior extremities of the tubes of communication are plunged, the upper parts of the bottles remaining empty. The acid vapour, which is conducted by the tubes into the water, is there condenſed, either totally or in part; the part which eſcapes is conducted to the ſucceeding bottles; ſo that no part of the acid is loſt, and the operator is is not in the leaſt incommoded. A quantity of vital air, which is diſengaged, paſſes out at the apertures of the exterior bottles, where it might be collected by a proper apparatus if neceſſary.

There is a principal advantage derived from this ingenious contrivance, which muſt not be paſſed over in ſilence. At the end of the operation, when the veſſels are ſuffered to cool, a vacuum is formed within; and the external air preſſing on the ſurface of the water in the laſt open bottles, forces it to return by the tubes into the firſt collateral bottles, and from them into the bottle neareſt the receiver. If the firſt bottle were not empty, and of a ſufficient magnitude to contain all the water of the following bottles, the acid liquors would paſs into the receiver; and as the ſtrongeſt nitrous acid is contained in that veſſel; it would be diluted by the addition of the fluid contained in all the bottles. This inconvenience would be ſtill more prejudicial in other diſtillations we ſhall have occaſion to ſpeak of, where it would not only diminiſh the force, but likewiſe alter the purity of the product.*

To perform this diſtillation in a laboratory, four pounds of pure nitre, fuſed into the form of mineral cryſtal, is put into a

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* On this ſubject, ſee the note, Vol. I. page 206. T.

tubulated ſtone-ware retort, placed in a reverberatory furnace; tubulated retorts of glaſs may likewiſe be uſed, with a ſand bath; two pounds and a half of oil of vitriol is poured at once through the tube, and the aperture is ſtopped; the apparatus we have juſt deſcribed, and which we ſuppoſe to have been prepared and put together the evening before, muſt be adapted and expeditiouſly luted; the heat muſt be gradually raiſed, till nothing more comes over: the diſengagement and paſſage of gas through the water in the bottles, ſerve to direct the operator in managing the proceſs. If it be too rapid, the heat muſt be diminiſhed, leſt the whole maſs in the retort ſhould ſwell up and paſs into the receiver; if on the contrary it be too ſlow, the fire muſt be raiſed, to prevent abſorption: this valuable apparatus has therefore the additional advantage of directing the operator to conduct his proceſs to the beſt advantage.

The reſidue of this decompoſition conſiſts of vitriolated tartar, formed by the union of the vitriolic acid with the vegetable fixed alkali of the nitre. This reſidue is known by the name of ſal de duobus, or arcanum duplicatum. It is uſually in the form of a white ſemi-vitrified maſs, full of cavities, produced during its ſwelling up by the heat; and it is very acid, on account of the exceſs of vitriolic acid made uſe of, which is

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alſo the cauſe of its melting more eaſily, as we have obſerved in the hiſtory of vitriolated tartar. The ſtrong heat made uſe of, occaſions the nitrous acid to be very red and fuming; and as it is always vitiated with a certain quantity of vitriolic acid, it muſt be rectified by diſtilling it a ſecond time from one fourth of its weight of nitre. Very pure nitre muſt be uſed, in order to obtain nitrous acid, whoſe effects can be relied on. The acid obtained from nitre of the ſecond boiling contains marine acid, and is a kind of aqua regia: diſtillation, properly managed, will ſeparate the marine acid, as Meſſ. De Laſſone and Cornett have ſhewn.*

Sedative ſalt decompoſes nitre, by the aſſiſtance of heat, and diſengages its acid in a conſiderable degree of concentration: this decompoſition is produced by virtue of the fixity of the ſedative ſalt, as the academicians of Dijon think. It muſt, however, be attributed, no doubt, in part, to the affinity between ſedative ſalt, and the vegetable fixed alkali of the nitre.

Nitre is of great uſe in the arts: it is the principal ingredient in gunpowder, which we ſhall ſpeak of under the article of ſulphur. Burned with different proportions of tartar, it forms the ſubſtances called fluxes,

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* Memoirs of the Academy for 1781, pages 653, 656.

which are employed in the art of aſſaying, to fuſe and reduce metallic ſubſtances.

It is frequently uſed in medicine as a febrifuge diuretic antiſeptic ſalt; it is adminiſtered in any convenient liquid, from ten or twelve grains, to the quantity of half a drachm or more; and it daily produces the moſt happy effects.

Species IV. RHOMBOIDAL NITRE.

This perfect neutral ſalt, containing the nitrous acid and fixed mineral alkali, is likewiſe called cubic, or quadrangular nitre: it is uſually formed in regular rhomboidal cryſtals, of conſiderable magnitude; and is therefore more properly called rhomboidal nitre.

Its taſte is cooling, and rather more bitter than that of ordinary nitre.

Fire decompoſes it; but it decrepitates, and does not melt ſo eaſily as the common nitre; but, like that ſalt, it gives out vital air at the ſame time that it becomes alkalized.

It is ſlightly deliqueſcent when expoſed to air.

It is more ſoluble in cold water than the common nitre, two parts of water, at the ordinary temperature of ſixty degrees, diſſolving one part of the ſalt: it is ſcarcely more ſoluble in boiling water, and cannot therefore be had in regular cryſtals, but by ſlow evaporation. When a clear ſolution of this ſalt is expoſed in a dry place, rhomboidal cryſtals, upwards of half an inch, and ſometimes an inch long, are obtained at the end of ſome months. This proceſs, in general, is the beſt for cryſtallizing ſuch ſalts as are equally ſoluble both in hot and cold water.

Rhomboidal nitre detonates on coals, and cauſes the complete combuſtion of inflammable bodies; if it is heated, the detonation is ſomewhat leſs rapid than that of ordinary nitre.

Siliceous earth combines with its baſe, and diſengages the nitrous acid; clay likewiſe ſeparates the acid, and affords a reſidue in the form of frit, which is porous and opake when a ſtrong heat has been given.

Ponderous earth decompoſes this ſalt, and diſengages the mineral alkali. Magneſia and lime do not ſenſibly change it.

The vegetable fixed alkali has a ſtronger affinity with its acid than the mineral alkali; this decompoſition is very eaſily ſhewn. If a heated ſolution of rhomboidal nitre be divided into two parts, and cauſtic vegetable fixed alkali be added to one of them, it will afford priſmatic cryſtals during its cooling; but no cryſtals will be obſerved in the other part, becauſe rhomboidal nitre does not cryſtallize by mere cooling, without evaporation.

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The concentrated vitriolic acid, added to rhomboidal nitre, diſengages the nitrous acid with efferveſcence. Spirit of nitre is obtained by diſtillation from the mixture; the other mineral acids have no more action on this ſalt than on common nitre.

The neutral ſalts hitherto examined, namely, vitriolated tartar, Glauber's ſalt, and nitre, produce no effect whatever on cubic nitre: if theſe ſalts be diſſolved together in the ſame water, they cryſtallize ſeparately, and each in its ordinary manner: the nitre, and Glauber's ſalt, by cooling; and the vitriolated tartar and rhombic nitre, by evaporation. All theſe properties ſhew, that rhomboidal nitre differs from ordinary nitre, in its form, taſte, deliqueſcence, ſolubility, cryſtallization by evaporation, and eſpecially its decompoſition by the vegetable alkali.

Rhomboidal nitre has not yet been found in nature, but is always produced by art, according to one of the five following methods: 1ſt, The direct union of the nitrous acid with the cauſtic mineral alkali. 2d, By decompoſing earthy, or ammoniacal metallic nitre by the ſame alkali. 3d, By decompoſing marine ſalt by the addition of the nitrous acid. 4th, By decompoſing Glauber's ſalt by the fuming nitrous acid. 5th, and laſtly, By decompoſing nitrous metallic ſalts by marine ſalt; in this caſe, in proportion as the marine acid unites with, and ſeparates

ſeparates the metal from the nitrous acid; this laſt combines with the marine alkali, and forms rhomboidal nitre.

Rhomboidal nitre may be applied to the ſame uſes as ordinary nitre; but as it does not produce all the effects of this laſt ſalt, (doubtleſs on account of its greater affinity with water) and likewiſe becauſe it is merely a product of art, no uſe whatſoever has yet been made of it, neither have all the experiments been made, which are neceſſary to afford a complete knowledge of its properties.

Species V. FEBRIFUGE SALT OF SYLVIUS.

The febrifuge ſalt of Sylvius is formed by the union of the marine acid with the vegetable fixed alkali: it has been called regenerated marine ſalt, but improperly, as it differs from that ſalt in the nature of its baſe; its cryſtals are cubical, but almoſt always confuſed and irregular. Its taſte is ſalt, penetrating, bitter, and diſagreeable. In the fire, it decrepitates; that is to ſay, its cryſtals ſuddenly break, and fly in pieces, by the rarefaction of the water, which enters into their compoſition. If the heat be then continued, and ſufficiently ſtrong, it melts, and is volatilized without decompoſition; it may ſerve as a flux to earthy and metallic ſubſtances; its principal uſe in theſe caſes is, is, that the matters being covered with it, the action of the other fluxes is more confined, and the alterations, which the acceſs of air might produce, are prevented.

The febrifuge ſalt of Sylvius is not much altered by expoſure to air; it, however, ſlightly deliqueſces.

About three parts of cold water are required to hold one part in ſolution; hot water does not diſſolve a greater quantity; and therefore recourſe muſt be had to ſlow evaporation to obtain cryſtals: it is one of the moſt difficult ſalts to be procured in cryſtals of a certain magnitude.

Clay appears to diſcompoſe it in part; for marine acid is obtained by diſtillation of the febrifuge ſalt with the clays found in the vicinity of Paris. This operation affords, in fact, only a ſmall quantity of acid, and its reſult is far from being ſuch as is obſerved with nitre: ſand appears to have the ſame effect as clay on the ſalt of Sylvius.

Ponderous earth ſeizes its acid, and ſeparates the alkali, according to Bergman. Magneſia and lime do not at all change it.

The vitriolic and nitrous acids diſengage the marine acid with efferveſcence; and this phenomenon takes place more ſtrongly, in proportion as the febrifuge ſalt is drier.* Such

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* We have already obſerved, in treating of the decompoſition of nitre by oil of vitriol, that the nitrous acid is diſengaged

Such as has been deprived of its water of cryſtallization by decrepitating, produces a very ſtrong efferveſcence, attended with much heat, by the addition of oil of vitriol. When theſe decompoſitions are made in retorts, ſpirit of ſalt is retained in the receiver, and vitriolated tartar remains behind, provided the operation be made with the vitriolic acid; but if the nitrous acid be uſed, the receiver contains aqua regia, and nitre is found in the retort. The acid of borax, or ſedative ſalt, likewiſe decompoſes febrifuge ſalt by diſtillation, and diſengages the marine acid. As all theſe operations may be performed with common ſalt, we ſhall deſcribe them more fully under that article. The cretaceous and ſparry acids have no action on febrifuge ſalt.

Vitriolated tartar, common and rhomboidal nitre, do not act on this ſalt; but

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diſengaged with a ſtrong efferveſcence. We here find the ſame phenomenon with the marine acid, the efferveſcence being conſiderably ſtronger with the febrifuge ſalt, becauſe its acid has a very ſtrong tendency to aſſume the gaſeous ſtate: This is the general cauſe of all efferveſcences, the nature and differences of which have not been well known till lately. It was formerly thought that they aroſe from the diſengagement of air; but it is now well known, that the ſubſtance diſengaged is not air, but may conſiſt of any ſubſtance capable of aſſuming the aeriform aggregation; and for that reaſon we have obſerved, that the ebullition of water may be eſteemed a kind of efferveſcence. As this principle deſerves to be particularly attended to, we ſhall occaſionally repeat the preſent obſervation, where it may appear neceſſary. Note of the Author.

when diſſolved together in the ſame water, each cryſtallizes ſeparately, and in its uſual manner.

Salt of Sylvius is found naturally, but never in conſiderable quantities; it is found in ſea-water, and the water of ſalt ſprings, and it exiſts, though rarely, in the places where nitre is found; it is likewiſe met with in the aſhes of vegetables, and in certain animal fluids: it may be artificially produced, 1ſt, By direct combination of the marine acid with the vegetable alkali. 2d, By decompoſing earthy, ammoniacal, and metallic ſalts by the ſame alkali. 3d, By decompoſing vitriolated tartar, or nitre, by means of the ſame acid, as Mr. Cornett has ſhewn.

This ſalt was formerly employed as an excellent febrifuge, but it does not poſſeſs this property, otherwiſe than in common with all bitter ſalts; vitriolated tartar and Glauber's ſalt are at preſent preferred to it.

The febrifuge ſalt is not uſed in the arts; its diſagreeable bitterneſs prevents its being uſed for culinary purpoſes; its chemical properties agree with thoſe of common ſalt, excepting with reſpect to its bitter taſte, leſs degree of ſolubility, unchangeableneſs in the air, and leſs regular cryſtallization: for this reaſon we ſhall dwell no longer on its hiſtory.

Species VI. MARINE SALT.

Marine or culinary ſalt is perfectly neutral, and is produced by the combination of the marine acid with the fixed mineral alkali.

This ſalt is more abundant in nature than any other; it is found in prodigious maſſes in the internal parts of the earth, in Calabria, in Hungary, in Moſcovy, and more eſpecially at Wieliczka in Poland, near Mount Crapax, where the mines are very large, and afford immenſe quantities of ſalt. This ſalt, when contained in the earth, is ſeldom cryſtallized in any regular figure; it has various degrees of whiteneſs, and is often found coloured, in which ſtate it is called ſal-gem, becauſe it often has the tranſparence of gems: ſea-waters abound with this ſalt, as do likewiſe the waters of certain lakes and ſprings; and from theſe it is obtained by one or other of the four following general proceſſes.

The firſt conſiſts in ſpontaneous evaporation by the heat of the ſun, as is practiſed in the ſouthern provinces of France. Trenches are made near the ſea-ſide, lined with clay well rammed. Theſe are divided by low walls, into ſeveral compartments communicating with each other; and the flood-tide fills them with water, where it is retained by a kind of ſluice gates. Care is taken

taken that the quantity of water ſhall be of an inconſiderable depth, that it may be eaſily evaporated by the ſun. When a ſaline pellicle is formed, the workmen break it, and it falls to the bottom, which they continue to do as long as any water remains. The ſalt is then raked together, and laid in heaps to dry. This is mixed with every other which the ſea-waters contain, ſuch as Glauber's ſalt, Epſom ſalt, magneſian and calcareous marine ſalts; it is likewiſe contaminated by a portion of the clay, which forms the floor of the ſalt-pans; and laſtly, it contains iron, and mercury much divided; the latter of which is eaſily ſhewn, by leaving a maſs of gold for ſome time in the ſalt, which becomes manifeſtly whitened. This very impure ſalt is known in France by the name of ſel de gabelle.

In the northern provinces of France common ſalt is obtained by artificial evaporation, effected by means of heat. In Averanches they take the quickſands on which the ſea-water has depoſited its ſaline cryſtals; theſe are waſhed with the ſmalleſt quantity of water ſufficient to diſſolve the ſalt, and the water is then evaporated to dryneſs in leaden boilers. The ſalt thus obtained, is whiter and more pure than that of the proceſs before deſcribed.*

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* Mr. Guettard has given an accurate account of this proceſs in the Memoirs of the Royal Academy for the year 1758.

There are many ſalt ſprings in Lorrain and Franche-Comté; the water of theſe ſprings is charged with different quantities of this marine ſalt. At Montmorot, in the latter of theſe provinces, ſpontaneous evaporation is united to evaporation by heat: the water of the ſpring is pumped up into a large reſervoir, at the top of a building, or ſhed, beneath which are ſuſpended boards covered with little bundles of thorns or bruſh-wood; on theſe the water falls through ſmall cocks, and becomes divided into minute drops. The large ſurface of water thus expoſed to the air, which circulates quickly through theſe ſheds, cauſes an evaporation of nearly two-thirds. Selenite is depoſited on the bruſh-wood; and when the liquid, upon trial with a kind of hydrometer, is found charged with ſalt to a certain degree, it is conveyed into large iron boilers, ſupported by bars of the ſame metal; theſe boilers are very large and ſhallow, and contain one hundred muids * of ſalt water. A briſk heat is applied; and as ſoon as the water boils ſtrongly, it becomes troubled, and an ochreous earth is ſeparated, in the form of ſcum; another ſalt, of difficult ſolubility, is next ſeparated, which is found to be ſelenite, mixed with a ſmall quantity of common ſalt, Glauber's ſalt; and earthy marine

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* The muid of wine contains 280 French pints.

ſalt. The ſcum is received in little troughs of cloth, placed round the ſides of the boiler, into which it is thrown by the circulation of the boiling liquor. Theſe troughs are taken out and cleared, from time to time, and repeatedly put in again, till a large quantity of ſmall cubical cryſtals appear on the ſurface of the liquor. At this period, the troughs are taken away intirely; the fire is diminiſhed, and the marine ſalt is taken out with ladles, in proportion as it cryſtallizes in ſufficient quantity; the evaporation is continued till no more cubical cryſtals are afforded. The cryſtals are larger, the ſlower the evaporation; and the remaining fluid, called mother water, contains marine ſalts with earthy baſes.*

Wallerius mentions a fourth proceſs uſed in the north to obtain ſalt from ſea water. This water is expoſed in trenches on the ſea ſhore, where it forms ſo thin a ſtratum, that the cold of the atmoſphere ſoon freezes it;

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* A neutral ſalt is prepared at Montmorot, which is known by the name of Epſom ſalt of Lorrain, but it is nothing more than Glauber's ſalt, whoſe cryſtallization has been diſturbed: it may be diſtinguiſhed from the true Epſom ſalt by its efflorеſcing in the air; whereas the Epſom ſalt, ſuch as we receive from England, is deliqueſcent. Note of the Author.

The addition of a fixed alkali to the ſolution of Epſom ſalt, occaſions a cloud, by the precipitation of the magneſia; but Glauber's ſalt, treated in the ſame manner, remains tranſparent. T.

it; but as the ice conſiſts of mere water, the unfrozen part, after the ice is taken out, is of courſe more concentrated, and may be duly evaporated with a leſs degree of heat. It is conveyed into leaden boilers, and evaporated by fire.

The cryſtals of marine ſalt, are very regular cubes; they adhere together by their edges, ſo as to form ſquare maſſes with a pyramidical cavity, having the appearance of ſteps within. Rouelle has obſerved and deſcribed this phenomenon very accurately in his Memoirs on Cryſtallization, and Bergman has very ingeniouſly accounted for the fact.

The taſte of marine ſalt is well known, and generally agreeable.

This ſalt, when expoſed to a briſk heat, burſts and flies in pieces; a phenomenon which, as we have already obſerved, is produced by the rarefaction of the water of cryſtallization: if the heat be continued, it melts after ignition, and being poured on a ſmooth ſtone, becomes a kind of mineral cryſtal; but it is not at all altered, for its original form may be again reſtored by ſolution in water. Fire does not, therefore, decompoſe it; a very ſtrong heat volatilizes it without alteration.

Marine ſalt, when pure, is not ſenſibly changed by expoſure to air; it rather becomes dry than moiſt, and attracts humidity only in ſuch caſes as it contains marine ſalts with earthy baſes.

It is very ſoluble in water; no more than three parts of this fluid being required to diſſolve one of the ſalt. Three ounces and a half of water diſſolve one ounce of ſalt very completely; and it is not more ſoluble in boiling than in cold water. Heat cauſes the ſolution to be made ſomewhat more quickly. The cryſtals of this ſalt are obtained by a very ſlow evaporation. The manner in which theſe cubical cryſtals form ſquare and hollow pyramids, was obſerved by Mr. Rouelle to be as follows: When one cube is formed, its weight cauſes a depreſſion of the ſurface of the water around it; a ſecond cube formed near the firſt is attracted by it, or falls into the cavity, and adheres to one of its ſides; the ſame thing happens with regard to the other ſides, and this ſucceſſive accretion muſt produce hollow pyramids with their baſes uppermoſt, which, when arrived at a certain magnitude, ſink by their own weight.

Marine ſalt appears to facilitate the fuſion of glaſs; it always occupies the upper parts of the pots, and conſtitutes a great part of the matter called glaſs gall.

Common ſalt is uſed to vitrify the ſurface of certain kinds of pottery; this is done by throwing a certain quantity of this ſalt into the furnace, where it is volatilized, and applies

plies itſelf to the ſurface of the pottery, occaſioning fuſion by its extreme heat. This is the kind of glaſing uſed in the making Engliſh pottery.*

Vitrifiable earth does not alter this ſalt, though it ſeems to haſten its fuſion.

Pure clay has much leſs action on marine ſalt than on nitre, affording by diſtillation only a ſmall quantity of weak acid; the diſtillers of aqua fortis, it is true, obtain their ſpirit of ſalt in this manner, but they employ the moſt impure ſalt, which contains much ſalt with an earthly baſe, and likewiſe uſe a coloured and very impure clay.

Ponderous earth decompoſes marine ſalt, as well as all the other alkaline ſalts; as the experiments of Bergman ſhew. Lime and magneſia produce no change in marine ſalt; but theſe two ſalino-terreſtrial ſubſtances combined with the cretaceous acid, may perhaps ſeparate its principles by the way of double affinity.

The cauſtic vegetable fixed alkali decompoſes marine ſalt, becauſe it has a ſtronger

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* The pottery here ſpoken of, is of the kind called ſtone ware. It is not probable that the vitrification is produced by any extreme heat in the vapours of the ſalt, but that the alkali of this laſt, uniting with the ſiliceous earth contained in the ware, compoſes a glaſs; part of the marine acid being at the ſame time ſet at liberty. Hence the ſurface of this pottery is always rough, the argillaceous part of the ware not being equally corroded by the alkali. The glaze of queen's ware is chiefly lead. T.

affinity than the mineral alkali to its acid. A ſolution of marine ſalt, mixed with the cauſtic alkali of tartar, affords the febrifuge ſalt by evaporation, and the mother water contains the mineral alkali pure and diſengaged.

Acids have a powerful action on marine ſalt. If oil of vitriol be poured on this ſalt, a very conſiderable inteſtine motion, attended with a ſtrong heat, is produced; a violent efferveſcence* is perceived, which ariſes from the marine acid diſengaged in the form of gas, as is evident from the white vapour it forms with the water of the atmoſphere; and by its ſtrong ſmell, when the vapour is much diluted. If this operation be made with the pneumato-chemical apparatus, much marine acid gas is obtained. Glauber firſt obſerved, and accurately deſcribed the decompoſition of marine ſalt by the vitriolic acid; whence the acid obtained in this method has been called Glauber's ſpirit of ſalt; it was by examining the reſidue of this operation, that he diſcovered his ſal admirabile.

Moſt authors direct in the diſtillation of ſpirit of ſalt to put decrepitated marine ſalt into a tubulated retort of ſtone ware, and to pour the half of its weight of oil of vitriol through the tubulated part. Vapours of ſpirit of ſalt are plentifully diſengaged, which

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* See the note, page 94.

paſs through the neck of the retort into two receivers, the firſt having two necks, and the ſecond being applied to its external neck; a ſmall hole is drilled in this laſt receiver, that the vapours may eſcape, and the apparatus be prevented from burſting. In this operation, as well as in the common method of diſtilling ſpirit of nitre, a large quantity of the pureſt acid is loſt, which is diſſipated in the form of marine acid gas, through the hole in the receiver; at the ſame time that the corroſive vapours, which fill the laboratory, are very inconvenient, and noxious to the operator. Mr. Baumé, to obviate part of theſe inconveniencies, puts a quantity of water into the retort, which being volatilized in the receiver, abſorbs a great quantity of the marine acid gas. But as this gas riſes much ſooner than the water, the loſs is nevertheleſs very conſiderable. Mr. Woulfe, by a method very different from that of Baumé, procures the ſtrongeſt and moſt concentrated marine acid: inſtead of volatilizing the water after the vapours of marine acid, he cauſes the gas to paſs through that liquid, by means of the apparatus deſcribed at the article nitre.

Eight ounces of diſtilled water are put into the collateral bottles, when a mixture of two pounds of marine ſalt, and one of vitriolic acid, is uſed. The acid gas, conducted by the tubes, is diſſolved in the water of the bottles; the combination of the gas heats the water almoſt to boiling; and the quantity of air abſorbed is nearly equal in weight to that of the water. When it is thus far charged, it diſſolves no more, and becomes cold; but the gas paſſing into the ſecond collateral bottles, unites with, and heats the water they contain.

This ingenious proceſs, beſides the general advantages it produces, as mentioned in treating of the nitrous acid, has the advantage of affording the acid in a ſtate of great purity, conſiſting ſimply of the marine gas diſſolved in water. It is therefore very white, while that formerly obtained was always of a citron colour; a circumſtance which has led chemiſts into the error of aſſuming that character as diſtinctive of the acid; the portion of ſpirit of ſalt, which in this proceſs is condenſed in the receiver, is yellow, and contaminated by the foreign matters which riſe from the matters contained in the retort, in the ſame manner as happens in the ancient proceſs. An additional and moſt valuable advantage of this method is, that it accurately aſcertains the quantity of acid contained in marine ſalt, no portion thereof being loſt.

The nitrous acid likewiſe decompoſes marine ſalt; but as it is itſelf volatile, it riſes and unites with the acid of ſalt, forming the mixture called aqua regia. Baron has diſcovered, that ſedative ſalt diſengages the acid of marine ſalt, by the aſſiſtance of heat; the reſidue of this operation is very pure borax: the cretaceous and ſparry acids have no evident action on marine ſalt.

The neutral ſalts, hitherto deſcribed, do not act on marine ſalt: common nitre, rhomboidal nitre, and febrifuge ſalt being diſſolved in the ſame water as marine ſalt, each cryſtallizes as uſual; the marine ſalt is one of thoſe which cryſtallizes firſt, during the progreſs of the evaporation, and is mixed with a ſmall quantity of vitriolated tartar and febrifuged ſalt; but the Glauber's ſalt and nitre remain longer in ſolution, and cryſtallize by cooling. The mother water, from which marine ſalt has been obtained in Lorrain, is conveyed while hot into caſks, where it is continually agitated during its cooling; by which means the Glauber's ſalt cryſtallizes confuſedly, in ſmall needles, reſembling the true Epſom ſalt.

The uſes of marine ſalt are extenſive and numerous; it is employed, 1ſt, In the glazing of pottery. 2d, In glaſs-making, to render the glaſs whiter and clearer. 3d, In docimaſtic eſſays, either as a flux to facilitate the precipitation of metals from the ſcoriæ, and to prevent their alteration by the contact of the atmoſphere.

Common ſalt is at preſent applied to another uſe, of more conſequence than thoſe we have mentioned; namely, to the extraction of the mineral alkali, or ſalt of Soda, which daily becomes more ſcarce, and is indiſpenſably neceſſary in many of the arts: ſeveral perſons in England poſſeſs this ſecret, and extract the alkali in the large way.* Mr. Scheele has written a valuable diſſertation on this ſubject, which may be found in Crell's Chemical Journal. This chemiſt ſucceeded in obtaining the mineral fixed alkali, by ſimple maceration of common ſalt with litharge in the cold. There appeared to be many analogous proceſſes, in which other metallic calces may be uſed to anſwer the ſame purpoſe, two conditions only being premiſed, the one, that they contain cretaceous acid to act by way of double affinity, and the other, that they form with the marine acid inſoluble ſalts, which may ſeparate from the alkaline lixivium. No metallic calx poſſeſſes theſe properties in a more eminent degree than that of lead; but a ſufficient number of experiments relative to this buſineſs have not yet been publiſhed, to enable us to make uſeful

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* I do not know that the mineral alkali is extracted to advantage, or with ſufficient profit in England, from common ſalt, though ſeveral attempts have been made for that purpoſe. Mr. Turner, under the ſanction of the King's letters patent, extracts it by means of litharge, in the dry way; but his profit ariſes chiefly from a yellow pigment, which is produced by the combination of the marine acid, and the calx of lead. T.

inferences reſpecting the extraction of alkali from marine ſalt in the large way: we ſhall, however, again reſume this ſubject when we ſpeak of lead.

Marine ſalt is univerſally uſed as a ſeaſoning for food; it facilitates digeſtion, by producing a commencement of the putrid alteration in the alimentary ſubſtances. For though it is well aſcertained, by the experiments of Pringle, M'Bride, &c. that it retards putrefaction, and, like moſt ſaline matters, is a powerful antiſeptic when added in conſiderable quantities to animal matters; yet it acts in a very different manner when mixed with thoſe ſubſtances in a ſmall doſe, ſince it cauſes them to putrefy more quickly. This fact is proved, by the experiments of the author of Eſſays intended to ſerve as an hiſtory of putrefaction, and likewiſe by thoſe of Mr. Gardane.

Marine ſalt is not of leſs utility in medicine; it is put into the mouth, and employed externally as a powerful ſtimulant in apoplectic or paralytic diſorders; and is in many caſes a good diſcuſſive. It is particularly recommended by Ruſſel (de tabe glandulari) for lymphatic tumours, ariſing from a ſcrophulous diſpoſition of the animal ſyſtem. I have myſelf obſerved its happy effects in many diſorders of this nature. As the moſt impure marine ſalt is commonly uſed

uſed on thoſe occaſions, its effects muſt be partly attributed to the calcareous and magneſian marine ſalt it contains.

Species VII. BORAX.*

Borax is a neutral ſalt, formed by the combination of the acid improperly called ſedative ſalt, with the marine alkali.

The hiſtory of this ſalt, which comes to us from the Eaſt Indies, is very uncertain: † it is not yet well known whether it be a natural or an artificial product: in fact, though the diſcovery of ſedative ſalt, diſſolved in the waters of certain lakes in Tuſcany, afford reaſon to conclude that borax is a natural product, there are many facts which we ſhall mention that ſeem to prove, that this ſalt may be intirely formed or produced by certain proceſſes. And we may probably, in future, poſſeſs artificial methods of forming borax, in the ſame manner as we have artificial nitre-beds in ſeveral parts of Europe.

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* Hitherto we have ſpoken, firſt, of ſuch marine ſalts as have the vegetable alkali for their baſe; but with reſpect to ſalts, which contain the acid called ſedative ſalt, we are under the neceſſity of beginning by that which has the mineral alkali for its baſe, becauſe it is the only one we are well acquainted with. Note of the Author.

† It is dug out of the earth, in the kingdom of Thibet, in a cryſtalline form. See Kirwan's Mineralogy, page 206. T.

Borax is found in commerce in three different ſtates; the firſt is crude borax, tincal, or chryſocolla, which comes from Perſia. It is in greeniſh maſſes, of a greaſy feel, or in opake cryſtals of an olive green, which are ſix-ſided priſms terminated by irregular priſms. There are two varieties of theſe green cryſtals differing in magnitude: this ſalt is very impure by the admixture of foreign matters.

The ſecond ſpecies of borax is known by the name of borax of China. It is rather purer than the foregoing; in the form of ſmall plates or maſſes irregularly cryſtallized, of a dirty white. It appears to conſiſt of fragments of priſms and pyramids confounded together without any ſymmetrical arrangement; a white powder is obſerved on the ſurface, which is thought to be of an argillaceous nature.

The third ſpecies is the Dutch or purified borax. It is in the form of portions of tranſparent cryſtals of conſiderable purity; pyramids with ſeveral facets may be recognized, the cryſtallization appearing to have been interrupted. This form ſhews to a certainty that the Dutch refine this ſalt by ſolution and cryſtallization.

Laſtly, the Meſſrs. Leſguilliers, chemiſts in the Rue des Lombards, at Paris, prepare a purified borax, in no reſpect inferior to that

that of Holland, and perhaps even of greater purity.

Beſides theſe four kinds of borax, an apothecary at Paris, Mr. La Pierre, has diſcovered that it is continually formed in the ſoap ſuds and refuſe waters of the kitchen, which a certain individual preſerves in a kind of ditch, and from which at the end of certain time he obtains true borax in fine cryſtals. All that we can deduce from the known facts concerning its formation, is ſimply, that it is produced in ſtagnant waters, which contain fat matters. Some authors affirm, that it is produced by art in China; a mixture of greaſe, clay, and dung, is ſaid to be depoſited in a ditch, ſtratum ſuper ſtratum. This mixture is ſprinkled with water, and ſuffered to remain for ſome years, at the end of which time the maſs is lixiviated, and affords crude borax by evaporation. Others have ſuppoſed that it is obtained from water, which filters through copper mines. Mr. Baumé poſitively affirms, that the former of theſe proceſſes ſucceeded very well with him. Chim. Exper. Tom. II. pag. 132.

Purified borax has a very regular form; its cryſtals are ſix-ſided priſms, two of the ſides being commonly larger than the others terminated by triedral pyramids. Its cryſtallization is however ſubject to conſiderable varieties; its taſte is ſtyptic, and acts ſtrongly

ſtrongly on the fibres of the tongue; and, like alkalis, it converts the ſyrup of violets a green.*

Borax expoſed to heat quickly melts, by means of its water of cryſtallization; it loſes this water gradually, ſwelling up, and conſiderably increaſing in magnitude, and is then in the form of a light porous and very friable maſs, diſtinguiſhed by the name of calcined borax. This appearance ariſes from the eſcape of the vapours of water, which raiſe the half dried ſalt into the form of light pellicles, in which form they become dry, ſo as to leave cavities between each other. Calcined borax is not at all altered in its compoſition; nothing being driven off by the heat, but the water of cryſtallization, which is ſomewhat more than a third of its weight. Its original form may be reſtored by ſolution in water and cryſtallization; but when calcined borax is more ſtrongly heated, it melts into the form of a tranſparent greeniſh glaſs, which tarniſhes in the air, and is ſoluble in water. The nature of the borax is not at all changed by this fuſion; all its properties being reſtored by ſolution in water and cryſtallization.

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* The alkali in borax is unſaturated, and would require more than twice the quantity it has of ſedative ſalt for its complete ſaturation; hence borax acts as an alkali in many caſes. T.

Air produces no change in this ſalt, excepting the depriving it of a part of its water of cryſtallization; and by that means cauſing an effloreſcence on its ſurface. It ſeems that this efflorеſcence is not always the ſame in the different kinds of purified borax. The borax of China effloreſces much leſs than that of Holland; and the borax purified at Paris ſtill leſs than either. This trifling difference doubtleſs depends on the proceſſes made uſe of in its purification, the manner of cryſtallizing, and the quantity of water its cryſtals contain, accordingly as they have been formed with more or leſs rapidity.

Borax is very ſoluble in water; twelve parts of cold, or ſix of boiling water, are required to diſſolve one of the ſalt; its cryſtals may therefore be obtained by cooling, but the fineſt and moſt regular are formed by ſuffering the cold ſaturated ſolution to evaporate ſpontaneouſly in the ordinary temperature of the atmoſphere.

Borax ſerves as a flux to vitrifiable earths, with which it forms a good glaſs. It is employed in making artificial precious ſtones, or falſe gems.

It vitrifies clay, but much leſs completely than ſiliceous earths; from this property it adheres to and glazes the inſide of crucibles.

The action of ponderous earth, and of pure magneſia, on borax, is not known. Mr. Bergman,

Bergman, however, places theſe two ſubſtances before the alkalis in the tenth column of his table of affinities; which implies that they are capable of decompoſing borax: but in his diſſertation he affirms, that the affinities of ponderous earth and magneſia with the acid of borax are not yet accurately determined.

Lime has really a ſtronger affinity with the acid of borax than the fixed vegetable alkali has; lime-water precipitates the ſolution of this ſalt; but in order to decompoſe it perfectly, it is neceſſary to boil quick-lime in a ſolution of borax; the precipitate which is then formed is an almoſt inſoluble ſaline compound of lime with the ſedative acid, and the cauſtic mineral alkali remains diſſolved in the water.

The vegetable fixed alkali decompoſes borax, as well as every other ſalt with baſe of mineral alkali: volatile alkali does not act upon it at all.

Acids act ſtrongly upon this ſalt; if the vitriolic acid be gradually poured into a boiling ſolution of borax, till the liquor contains a ſlight exceſs of acid, a very abundant precipitate, in the form of ſmall brilliant ſcales, is obtained by cooling. This muſt be waſhed with diſtilled water, and dried: it is the ſedative ſalt. The liquid being evaporated, and cooled ſucceſſively for ſeveral times, affords more ſedative ſalt; and at at laſt a Glauber's ſalt is obtained, by the union of the mineral alkaline baſe of the borax to the vitriolic acid.

The nitrous and marine acids decompoſe borax in the ſame manner, becauſe of their ſtronger affinity to the mineral alkali; the reſidues of theſe evaporations afford rhomboidal nitre and marine ſalt. The diſcovery of ſedative ſalt appears to have been made by Beccher, but it is commonly attributed to Homberg, who firſt accurately deſcribed a proceſs for obtaining it, in the Memoirs of the Royal Academy. The proceſs conſiſted in diſtilling a mixture of calcined vitriol of iron, borax, and water: he called the ſublimed ſalt, volatile narcotic ſalt of vitriol, on account of the firſt mentioned ingredient, which he ſuppoſed to contribute greatly to its formation. Louis Lemery, eldeſt ſon of the famous Nicholas, has made many experiments with borax; and in the year 1728, he obſerved, that ſedative ſalt may be obtained by means of the pure vitriolic, nitrous and marine acids; but he always uſed the method of ſublimation. It is to Geoffroy the younger, that we are indebted for a complete analyſis of borax; in the year 1732, he obtained ſedative ſalt by evaporation and cryſtallization; and by examining the reſidue of the proceſs, he ſhewed, that marine alkali is one of the principles of borax.

The experiments of Baron, preſented to the

the Academy in the years 1745 and 1748, exhibit two important facts, in addition to thoſe before known. The firſt is, that vegetable acids likewiſe decompoſe this ſalt; and the ſecond is, that borax may be recompoſed by uniting ſedative ſalt with marine alkali, by which it is proved, that the acid exiſts ready formed in the ſalt, and that the other acids made uſe of in procuring it do not at all contribute to its formation.

The ſparry acid, and even the cretaceous acid, though one of the weakeſt, are capable of decompoſing borax, and ſeparating the ſedative ſalt. This laſt readily unites with borax, whoſe alkaline baſe requires for its perfect ſaturation ſomewhat more ſedative ſalt than is equal to the weight of the borax itſelf. Bergman even thinks that this ſalt is imperfectly ſaturated, and that its alkaline properties cannot be removed, but by this addition of ſedative ſalt: the properties of borax, thus ſaturated, have not yet been fully inquired into.

Neutral ſalts, conſiſting of a fixed alkali united with the vitriolic, nitrous, or marine acids, have no action on borax.

This ſalt, fuſed with combuſtible matters, as for example charcoal, acquires a reddiſh colour, but the alteration it ſuſtains is not well known.

Borax is exceedingly uſeful in ſeveral manufactures; it is employed as an excellent flux in the art of glaſs-making, as well as in aſſays. It is advantageouſly uſed in ſoldering, which it promotes by aſſiſting the fuſion of the ſolder, by ſoftening the ſurfaces of the metals, and by defending them from the contact of the air, by which they would otherwiſe be calcined. Borax was formerly much uſed in medicine, but it is at preſent intirely abandoned.

Species VIII. VEGETABLE BORAX.

We give the name of vegetable borax to the combination of the ſedative ſalt or acid with the vegetable fixed alkali. It is well known, that theſe two ſaline ſubſtances are ſtrongly diſpoſed to unite, and that a neutral ſalt, analagous to borax, is produced in this operation; the reſidue of nitre decompoſed by ſedative ſalt is of this kind. Mr. Baumé affirms, that this reſidue is a white maſs, imperfectly melted, and that by ſolution in water it affords a ſalt in ſmall cryſtals. Vegetable borax is therefore fuſible, ſoluble, and cryſtallizable. It is probable that the pure acids would decompoſe this ſalt, as well as common borax; but nothing more is known concerning this ſalt, which has not been ſcarcely at all examined. Baron was acquainted with the poſſibility of producing this ſalt, by the direct combination of ſedative ſalt with ſalt of tartar: he has even made

made a diſtinction between this and the borax with baſe of mineral alkali, but he ſays nothing of its properties.

Species IX. SPARRY TARTAR.

By this name, or by the names of fluor tartar, or tartareous fluor, we may diſtinguiſh the combination of the ſparry acid with vegetable alkali or tartar. This kind of neutral ſalt has hitherto been only ſlightly examined by Scheele and Boullanger. It is always in a gelatinous form, and never cryſtallizes. According to Scheele, it is acrid, cauſtic, and deliqueſcent, when dried and melted: he compares it in this ſtate to the liquor of flints. It appears that the fire diſengages the ſparry acid, and that the ſiliceous earth, always taken up by this acid, melts into a ſoluble glaſs by means of the fixed alkali.

Sparry tartar is very ſoluble in water, of which fluid it always retains ſo large a quantity, as to render it incapable of taking the cryſtalline form. When well ſaturated, its ſolution produces no change in ſyrup of violets.

The action of the quartzoſe, argillaceous, ponderous, and magneſian earths on this ſalt, are not known.

According to Scheele and Bergman, lime has a ſtronger affinity than the fixed vegetable alkali with the ſparry acid. Sparry tartar is immediately decompoſed by lime-water; the lime unites with the acid, and forms an inſoluble ſalt, which is the vitreous or fluor ſpar. We ſhall hereafter obſerve, that the neutral ſalts formed by the cretaceous acids and fixed alkalis, are likewiſe decompoſed by lime. We have alſo ſeen that borax is precipitated by lime-water; the ſparry is not, therefore, the only acid which has a ſtronger affinity to this ſalino-terreſtrial ſubſtance than to fixed alkalis.

Oil of vitriol decompoſes the ſparry tartar, and diſengages its acid, which, according to Mr. Boullanger, exhibits the white vapours and ſmell peculiar to marine acid. When this experiment is made, in a proper apparatus for diſtillation, the ſparry acid is collected in the ſame manner as the acids of nitre and marine ſalt are, by the addition of the oil of vitriol.

The action of the nitrous and marine acids, as well as that of the neutral ſalts upon ſparry tartar, has not, that we know of, been examined into.

This ſalt is not applied to any uſe.

Species X. SPARRY SODA.

We uſe this name to denote the combination of the ſparry acid with mineral alkali; other chemiſts have called it fluor of ſoda, or fluorated ſoda. Like the preceding ſalt, it has been very little examined. Meſſ.

Scheele and Boullanger ſpeak of this combination, but their accounts do not agree.

Scheele affirms, that the marine alkali, united to the ſparry acid, forms a jelly, reſembling ſparry tartar; Mr. Boullanger, on the contrary, affirms, that this combination affords very ſmall, hard, brittle cryſtals, in oblong ſquares, of a bitter and rather ſtyptic taſte. On hot coals it decrepitates, like marine ſalt; and it is ſcarcely ſoluble in water.

Lime-water decompoſes this ſalt, in the ſame manner as it does ſparry tartar.

Oil of vitriol diſengages the acid with effervеſcence and the production of white ſtrong-ſmelling vapours, reſembling thoſe of marine acid.

This ſhort account ſhews, that ſparry ſoda is not better known than the ſparry tartar.

Species XI. CRETACEOUS TARTAR.

The two perfect neutral ſalts, which remain to be examined, are combinations of the cretaceous acid with fixed alkalis.

Theſe ſubſtances have never been ranked among neutral ſalts, though they are truly ſuch, as we ſhall ſhew.

By the name of cretaceous tartar, or chalk of tartar, we diſtinguiſh a neutral ſalt, produced by the combination of the cretaceous acid with the fixed vegetable alkali. Some modern chemiſts diſtinguiſh it by the name of mephitic tartar, aerated vegetable alkali, &c. This ſaline ſubſtance was not known to be a neutral ſalt, but was always taken for a pure alkali, till the time of Dr. Black. It was formerly called fixed ſalt of tartar, becauſe it is obtained by the incineration of tartar of wine. It was conſidered as an alkali, becauſe it has ſome of the properties of thoſe ſalts; in fact, it reddens the ſyrup of violets; but borax and the vitriols have the ſame property; beſides which, it does not deſtroy or diminiſh the colour of violets, like the pure or cauſtic vegetable fixed alkali. Borax likewiſe has an alkaline taſte. It was diſtinguiſhed from the alkali of Soda, by the property it was ſaid to have of ſtrongly attracting the humidity of the air, and its being incapable of cryſtallization;* but theſe two properties depend on the ſalt of tartar not being perfectly neutralized, as it contains a certain quantity of pure cauſtic vegetable alkali, by reaſon of which exceſs it is deliqueſcent. Cretaceous tartar is now

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* Bohnius reports, that having evaporated oil of tartar ſlowly, by a gentle heat, he obtained under a ſaline pellicle, fine cryſtals, which he preſerved for ſix years without alteration, though expoſed to different temperatures. (Diſſert. Phyſico-Chim. 1666.) Mr. Montet, a celebrated chemiſt of Montpelier, doubtleſs unacquainted with the diſcovery of Bohnius, likewiſe diſcovered a proceſs for cryſtallizing the fixed ſalt of tartar. Memoirs of the Academy of Sciences, 1764, page 576. Note of the Author.

obtained very cryſtallizable, and which rather effloreſces than attracts the humidity of the air. The Duc de Chaulne, who has made many experiments relating to this ſubject, prepares the ſalt, by expoſing the fixed alkali in a place filled with the cretaceous gas; as for example, the upper part of a vat of beer in a ſtate of fermentation. The alkali becomes ſaturated with the cretaceous acid, and cryſtallizes regularly in quadrangular priſms, terminated by very ſhort four-ſided pyramids.

The taſte of cretaceous tartar is urinous, but much leſs ſtrong than that of the cauſtic vegetable alkali, as it may be employed in medicine in a doſe of ſeveral grains. This neutral ſalt melts readily in the fire, and quickly becomes alkalized; if it be diſtilled in a pneumato-chemical apparatus, water and cretaceous acid are obtained, and the alkali remains fixed in an irregular maſs, together with a ſmall portion of the cretaceous acid, which cannot but with the greateſt difficulty be expelled. According to the analyſis of Bergman, cretaceous tartar, ſaturated with acid, and in perfect cryſtals, which he calls aerated vegetable alkali, contains, in the centenary, twenty parts of cretaceous acid, forty-eight of pure alkali, and thirty-two of water. But it muſt be obſerved, that cretaceous ſalts appear to be more particularly ſuſceptible of variation, with reſpect to the doſes

doſes of acid they may contain. However, as the ſalt we now ſpeak of never cryſtallizes regularly but when it is perfectly ſaturated, the calculation of Bergman may be eſteemed accurate.

Cretaceous tartar, when well cryſtallized, is not altered in any reſpect by expoſure to air. As it may be of great utility in many experiments to have this ſalt ſufficiently pure to poſſeſs this property of withſtanding the effects of the air, we think it neceſſary to obſerve, that it may be conveniently prepared by the method of the Duc de Chaulne, already mentioned; that is to ſay, by expoſure of a ſolution of very pure ſalt of tartar to the cretaceous acid in the upper part of fermenting veſſels.

This ſalt diſſolves in four parts of cold water, and requires rather leſs hot water for the ſame purpoſe. During the time of ſolution cold is produced. This laſt property, which diſtinguiſhes the neutral from the ſimple ſalts, is ſufficiently characteriſtic of the difference between cretaceous tartar and the pure or cauſtic vegetable fixed alkali. It cryſtallizes by evaporation and cooling: if its ſolution be too concentrated, it takes the form of an irregular maſs, a circumſtance which often happens in laboratories.

Like the pure vegetable fixed alkali, it may be uſed as a flux for vitrifiable earths, becauſe the action of the fire diſſipates the cretaceous

cretaceous acid; if a mixture of ſand with this ſalt be ſtrongly heated in a crucible, a conſiderable efferveſcence will be obſerved at the inſtant of vitrification, a phenomenon which proves that ſiliceous earth cannot combine with the alkali while ſaturated with the cretaceous acid. This efferveſcence is ſo conſtant, that it is aſſumed as a characteriſtic of ſiliceous earth by Bergman, in his treatiſe on the blow-pipe, who directs its fuſion with ſalt of tartar for the purpoſe of obſerving this character.

Clay has no action on the cretaceous tartar, which reduces this earth, by fuſion, into a vitreous frit, though rather more difficultly than the pure vegetable fixed alkali. Ponderous earth deprives this ſalt of the fixed air it contains.

Lime likewiſe decompoſes it, by virtue of its greater affinity than that of vegetable fixed alkali with the cretaceous acid: if lime-water be poured into a ſolution of cretaceous tartar, a ſalt ſcarcely ſoluble is formed, by the union of the lime with the cretaceous acid, which falls down, and the pure or cauſtic alkali remains diſſolved in the fluid; this decompoſition is uſed in pharmacy to prepare the lapis cauſticus, which conſiſts of the fixed alkali, deprived of cretaceous acid by means of lime. Modern diſcoveries have ſhewn, that the proceſs of Lemery, adopted in many pharmacopeias, is very defective. It conſiſted in mixing two pounds of crude alkali,* with one pound of quick-lime, to which ſixteen pounds of water were added; this being filtered and evaporated in a copper veſſel, afforded a reſidue, which was melted in a crucible, and poured out on a ſmooth ſtone. In this operation, an impure and ſcarcely cauſtic alkali, charged likewiſe with copper, is obtained.

Bucquet, aware of theſe inconveniencies, directs the proceſs to be made, in a more expenſive and leſs expeditious way, but with much more certainty in the procuring a very pure vegetable alkali, ſo neceſſary to be had in chemical experiments. Two pounds of good quick-lime is moiſtened with a ſmall quantity of water, to cauſe it to fall into powder; one pound of fixed ſalt of tartar is added, together with a ſufficient quantity of water to form a paſte; when the whole is grown cold, ſixteen pints of water are added, and the mixture is placed on a paper, ſupported by a piece of linen. About twelve pounds of a clear liquor paſs through, and the reſidue is waſhed with four pints of boiling water, to carry off the whole of the al-

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* Or cendres gravélees. Theſe are the aſhes afforded by the combuſtion of the marc or huſks of grapes, and the dregs of wine. They contain much vegetable alkali, or cretaceous tartar, together with ſome vitriolated tartar. Note of the Author.

kali.

kali. This liquor does not effervefce with acids; but the beſt teſt of its perfect cauſticity is, its not occaſioning a cloud in lime-water, which it will do, if it contain the ſmalleſt quantity of cretaceous acid. The liquid is not, however, ſufficiently pure to ſtand this teſt, and muſt be again treated with two additional pounds of quick-lime, to bring it to that degree of perfection which is deſirable for nice experiments. If the alkali be obtained from this liquid, by evaporation in open veſſels, it ſeizes the cretaceous acid contained in the atmoſphere; it muſt therefore be evaporated to dryneſs in a retort when the ſolid form is wanted. This tedious operation is not neceſſary in making the lapis cauſticus, which will anſwer its intention, provided it contain a ſufficient quantity of cauſtic alkali to corrode the ſkin; but as the accurate experiments of modern chemiſtry require the dry cauſtic vegetable fixed alkali in a ſtate of purity, it is proper to obſerve, that the evaporation of the cauſtic alkaline lixivium ought to be made in cloſed veſſels, and that this evaporation requires the fire to be carefully managed towards the end, on account of the great denſity the liquid acquires. The fixed alkali obtained by this proceſs ought to be exceeding white, to make no efferveſcence with acids, and to produce no precipitation when added to lime-water.

Magneſia produces no effect on cretaceous tartar, becauſe the vegetable fixed alkali has a ſtronger affinity to the acid it is combined with.

The vitriolic, nitrous, marine, and ſparry acids, decompoſe cretaceous tartar, by uniting with the fixed alkali, and ſeparating the cretaceous acid, which is diſengaged with effervеſcence. This acid, in the gaſeous ſtate, may be collected over water and mercury; it is known by the four following characters: it is heavier than the air of the atmoſphere, extinguiſhes flame, reddens turnſole, and precipitates lime-water.

The acid of borax does not ſeparate the cretaceous acid from this ſalt in the cold, but very eaſily produces that effect when heated.

The neutral ſalts hitherto examined have no action on cretaceous tartar. This ſalt is very abundantly found in nature: it exiſts ready formed in vegetables, and is obtained by the incineration of theſe organic bodies, as we ſhall more particularly deſcribe in our account of the vegetable kingdom. It is obtained more particularly from burned tartar, and is likewiſe prepared by the detonation of nitre.

The uſes of cretaceous tartar in the arts are many; it is employed in medicine as a very active ſolvent; in obſtructions of the meſentery and the urinary paſſages, it is not adminiſtered

adminiſtered but in ſmall doſes, together with ſome ſubſtance which may moderate its action.

Species XII. CRETACEOUS SODA, OR NATRUM.

This neutral ſalt, like the foregoing, was till lately conſidered as an alkali, though it is a combination of the mineral fixed alkali with cretaceous acid: it may be diſtinguiſhed by its ancient name, natrum. It is commonly called ſalt of Soda, becauſe it is obtained in a conſiderable degree of purity, and well cryſtallized by evaporating a lixivium of Soda. The diſtinction made between the vegetable fixed alkali and the marine alkali, founded on the property of the latter to cryſtallize and fall into efflореſcence, ariſes merely from its being ſaturated with cretaceous acid in its ordinary ſtate.

Cretaceous ſoda has an alkaline taſte, and renders the ſyrup of violets green, though this does not alter its colour ſo much as the cauſtic mineral alkali does; its taſte is urinous, but neither ſo burning nor ſo cauſtic as that of the ſame alkali in a ſtate of purity.

This ſalt is commonly found purer than cretaceous tartar, becauſe its property of cryſtallizing has long been known; this property, as we have before obſerved, is a general

general criterion to diſtinguiſh neutral from ſimple ſalts.

Cretaceous ſoda, or natrum, haſtily cryſtallized, appears to be formed of rhomboidal laminæ, obliquely applied on each other, after the manner of tiles. When it is ſlowly cryſtallized, it takes the form of rhombic octahedrons, whoſe pyramids are truncated very near their baſe, or decahedral ſolids, with two acute and two obtuſe angles.

This ſalt is more fuſible than cretaceous tartar, and is for that reaſon preferred by glaſs-makers; it loſes the greateſt part of its acid by the action of heat, but always retains a part. Bergman, by an accurate analyſis, found that one hundred parts of cretaceous ſoda, which he calls aerated mineral alkali, contain ſixteen parts of cretaceous acid, twenty parts of pure alkali, and ſixty-four parts of water, ſo that the mineral alkali requires a larger portion of that acid for its ſaturation than the vegetable alkali, and retains twice the quantity of water; its more regular cryſtallization, and its property of effloreſcing, ſeem to depend on this portion of water.

Cretaceous ſoda is more ſoluble than cretaceous tartar, as it requires only twice its weight of cold water, or half that quantity of boiling water, to hold it in ſolution. It cryſtallizes by cooling; but ſpontaneous evaporation affords more regular cryſtals. Cre-

taceous

taceous ſoda expoſed to the air, readily falls into powder by the loſs of its water of cryſtallization; it is not, however, altered by this effloreſcence, but recovers its original form by ſolution in water and cryſtallization.

The fuſion of vitrifiable earths is greatly facilitated by this ſalt, and the glaſs it forms is more durable than that into which the cretaceous tartar enters; which is a ſecond reaſon for preferring it in the glaſs manufactories. The ſame diſengagement of the cretaceous acid from this ſalt, when fuſed with ſand, as was obſerved to take place in cretaceous tartar, is alſo found to take place with this. It has no more action on clay than the laſt mentioned ſalt.

Ponderous earth, lime, and its aqueous ſolution, decompoſe cretaceous tartar, and diſengage the cauſtic mineral alkali. When a ſolution of this ſalt is added to lime-water, a precipitate of chalk falls down, which is not obſerved when the cauſtic alkali is uſed. The cauſtic mineral alkali may be obtained for exact or minute chemical purpoſes by the ſame proceſs with this ſalt, as we have before directed to be made for the preparation of the lapis cauſticus with cretaceous tartar.

Natrum is alſo decompoſed by the vitriolic, nitrous, and marine acids, and the cretaceous gas may be collected over water or mercury.

This ſalt is found ready formed on the ſurface of the earth in Egypt, and elſewhere. It is likewiſe found in the aſhes of marine plants, but not ſaturated with acid. To render it perfectly neutral, it may be directly combined with the cretaceous acid, either by agitating it over liquors in fermentation, or by receiving the cretaceous acid diſengaged from chalk, by ſpirit of vitriol, into its ſolution. The impregnation of a ſolution of ſoda poured into a veſſel covered with a wet bladder, produces a vacuum, as has been obſerved in ſpeaking of the cretaceous acid.*

The ſoda, or natrum, may alſo be diſengaged by decompoſing marine ſalt by the medium of litharge.† This calx of lead, containing the cretaceous acid, acts by double affinity: 1ſt, That of the lead with the marine acid, which forms a ſalt nearly inſoluble, called plumbum corneum. 2d, That of the cretaceous acid, with the mineral alkali, which is therefore obtained under the form of cretaceous ſoda. To decompoſe the marine ſalt in this way, nothing more is required, than to leave the litharge with the ſalt, and a ſmall quantity of water, to macerate at the temperature of about 70 degrees. The decompoſition is gradually effected, and at the end of three or four days, the liquor

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* Vol. II. page 8.

† Vol. II. page 106.

that floats above a kind of magna, is found to contain cretaceous mineral alkali. The ſalt may be obtained from the decanted liquor by evaporation. Such is the general reſult of Scheele's diſcoveries relating to the decompoſition of marine ſalt; but I muſt not conceal, that the decompoſition has not ſucceeded ſo well in my attempts, which were made at ſeveral different times with the quantity of a pound of ſalt, from which I obtained no more than a few particles of ſalt of ſoda.

Cretaceous ſoda may be employed for the ſame uſes as cretaceous tartar; and as it is much more valuable in the manufactories of glaſs, ſoap, &c. an effectual method of obtaining it from marine ſalt would be a valuable acquiſition to ſociety.

CHAP. VI.

GENUS II. Imperfect Neutral Salts, with Baſe of Volatile Alkali, or Ammoniacal Salts.

AMmoniacal ſalts are formed by the combination of the volatile alkali with an acid; their taſte is in general urinous, and they are all more or leſs volatile, and more eaſily decompoſed than the perfect neutral ſalts. We are acquainted with ſix ſpecies; ammoniacal vitriol, ammoniacal nitre, ammoniacal marine ſalt, or ſal-ammoniac properly ſo called, ammoniacal borax, ammoniacal ſpar, and ammoniacal chalk.

Species I. AMMONIACAL VITRIOL.

Ammoniacal vitriol, or vitriolic ſal-ammoniac, is the reſult of a ſaturated combination of the vitriolic acid with the volatile alkali; it has been called Glauber's ſecret ſal-ammoniac, becauſe it was diſcovered by that chemiſt.

When very pure, it has the form of needles, which, on careful examination, are found to be flattened priſms of ſix ſides, two of which are very broad, terminated by ſix-ſided pyramids irregularly formed; but the whole figure of the cryſtallization is ſubject to conſiderable varieties. This ſalt is ſometimes in the form of quadrangular priſms, and I have often obtained it in very thin ſquare plates.

Its taſte is bitter and urinous; it is light, and very friable. As it contains much water, it quickly melts with a low heat, after which it gradually becomes dry. In this ſtate it melts ſoon after the red heat, and does not ſublime, according to Bucquet; but Baumé aſſerts that it is ſemi-volatile.

I have obſerved, in repeating this experiment, that a portion of the ſalt ſublimes, the reſt remaining fixed in the veſſel. Bucquet, doubtleſs, means to ſpeak of this laſt.

Ammoniacal vitriol is ſcarcely changed by expoſure to air; it does not effloreſce like Glauber ſalt, but, on the contrary, ſlightly attracts the humidity of the air.

It is very ſoluble in water; two parts of cold, or one of hot water, being ſufficient to hold it in ſolution: it cryſtallizes by cooling; but the fineſt cryſtals are obtained by ſpontaneous evaporation. It likewiſe unites with ice, which it melts, producing at the ſame time an exceſſive degree of cold. It does not act on earths, nor on magneſia; though this laſt ſeems to decompoſe it after a length of time, as Bergman obſerves.

Since ponderous earth and pure fixed alkalis diſengage the volatile alkali, if cretaceous tartar or natrum be diſtilled with vitriolic ſal-ammoniac, a double decompoſition and combination take place. The vitriolic acid unites with the fixed alkali, and forms either vitriolated tartar or Glauber's ſalt. The cretaceous acid, at the ſame time, being volatilized, together with the alkaline gas, both unite and form a peculiar ammoniacal ſalt, which cryſtallizes in the recipient. We ſhall ſpeak more fully on this ſubject in the hiſtory of ſal-ammoniac.

The nitrous and marine acids ſeparate the vitriolic

vitriolic acid of the ammoniacal vitriol, in the ſame manner as from vitriolated tartar.

It has not hitherto been found in nature; yet we find in the Cryſtallographie of Romé de Liſle, 1772, page 57. that, according to Mr. Sage, the native ſal-ammoniac of volcanos is of this kind. It is artificially produced by the direct combination of the vitriolic acid, and volatile alkali; or by decompoſing vitriolic, earthy or metallic ſalts, by means of volatile alkali; or laſtly, by the decompoſition of nitrous, marine, and cretaceous ammoniacal ſalts by the vitriolic acid.

Ammoniacal vitriol is of no uſe, though Glauber recommends it ſtrongly, for metallurgic operations.

Species II. AMMONIACAL NITRE.

Ammoniacal nitre, or nitrous ammoniacal ſalt, is alſo a production of art, prepared by the direct combination of the nitrous acid with the volatile alkali; its cryſtals are priſms, whoſe figure has not been accurately deſcribed. Romé de Liſle affirms, that it cryſtallizes in fine needles, reſembling thoſe of vitriolated tartar; but they are in fact very long and ſtriated, and reſemble common nitre more than vitriolated tartar.

Its taſte is bitter, penetrating, and urinous. It is friable like ammoniacal vitriol. When expoſed to the action of fire it liquifies,

liquifies, gives out aqueous vapours, becomes dry, and, long before the red heat, detonates alone without the contact of any inflammable matter, and even in a cloſe veſſel. In the firſt edition of this work we obſerved, that this ſingular property appeared to depend on the volatile alkali, becauſe alkaline gas ſeems to be in ſome degree combuſtible, and becauſe it augments the flame of candles before it extinguiſhes them. Mr. Berthollet having expoſed ammoniacal nitre to the action of heat in a pneumato-chemical and diſtillatory apparatus, and having obſerved the phenomena of this operation more carefully than had been done before, remarks, that it is not a true detonation which takes place, but a ſudden and inſtantaneous decompoſition, in which part of the volatile alkali is entirely deſtroyed. The water obtained in the receiver contains a ſmall part of the nitrous acid diſengaged in proportion to the quantity of volatile alkali decompoſed; and the latter gives out phlogiſticated air or atmoſpheric mephitis. The liquid product of this operation being weighed, a greater quantity of water is found than exiſted in the ammoniacal nitre; and Mr. Berthollet thinks that this ſuperabundant water is formed by the union of the inflammable gas, which is one of the principles of the volatile alkali, with the vital air of the nitrous acid. The atmoſpheric mephitis, or other principle of the

the volatile alkali, which is ſix times more in quantity than the inflammable gas, is diſengaged and collected under the veſſels of the pneumatic apparatus.

Nothing can be ſaid reſpecting the fuſibility and volatility of this ſalt, as its ſudden decompoſition is effected before the period at which thoſe events uſually take place.

It ſlightly attracts the humidity of the air, which agglutinates its cryſtals, and forms it into clots or balls.

It is very ſoluble in water; unites with, and melts ice, producing a conſiderable degree of cold. Half its weight of hot water is required to diſſolve it, and a ſomewhat greater of cold; it cryſtallizes irregularly by cooling, but the moſt perfect cryſtals are obtained by ſpontaneous evaporation.

Ammoniacal nitre is decompoſed by ponderous earth, lime, and fixed alkalis. The alkaline gas ſeparated by theſe cauſtic ſubſtances being very volatile and expanſible, the decompoſition of ammoniacal nitre, as well as of other ſalts of this kind, is practicable in the cold, and may be effected by triturating this ſalt with lime; but when the decompoſition is intended to be made in cloſe veſſels, by means of fire, the heat muſt be very carefully regulated, to avoid ſpontaneous combuſtion.

The vitriolic acid diſengages ſpirit of nitre from this ſalt with efferveſcence, and forms ammoniacal

ammoniacal vitriol, or the ſecret ſalt of Glauber, with its baſe.

Cretaceous tartar, and cretaceous ſoda, decompoſe it by double affinity, and in the operation a concrete volatile alkali is ſublimed, which we ſhall examine under the name of ammoniacal chalk.

The ammoniacal nitrous ſalt is not applied to any uſe.

Species III. SAL AMMONIAC.

Sal-ammoniac is a combination of the marine acid with the volatile alkali. The ancients diſtinguiſhed it by this name, becauſe they received it from that part of Lybia, in which the temple of Jupiter Ammon was ſituated.

Sal ammoniac is found native in the vicinity of burning mountains, where it has the form of an efflореſcence, or groups of needles, either ſeparate or together, uſually of a yellow or red colour, and mixed with arſenic and orpiment. This is not uſed, the factitious ſort prepared in the large way being the only ſort met with in commerce.

The true origin of this ſalt was not known till the commencement of the preſent century, though the ſalt itſelf has been uſed from time immemorial. By a letter of Mr. Lemere, conſul at Cairo, in the year 1770, we became acquainted with the art of of obtaining ſal ammoniac from the ſoot of camels dung, which is burned at Cairo inſtead of wood. This ſoot is put into large round bottles, a foot and a half in diameter, terminated by a neck two inches high, which is filled to within four inches of the neck; each bottle contains about forty pounds of this ſoot, and affords nearly ſix pounds of the ſalt. Theſe veſſels are placed on a furnace, ſo formed, that the neck only is expoſed to the air; a fire is made with camels dung, and continued for three days and three nights; and the ſalt ſublimes on the ſecond and third day. The bottles are then broken, and the loaves of ſal ammoniac are taken out; theſe loaves, which we receive in the form they obtain from the ſubliming veſſels, are convex and unequal, having a protuberance on one ſide formed from the neck of the ſubliming veſſel. The inferior as well as the ſuperior ſurface is ſoiled by a kind of ſoot.

Pomet has deſcribed a kind of ſal ammoniac in loaves ſimilar to thoſe of ſugar, with the point cut off, which is imported by the way of Holland. Geoffroy, who firſt diſcovered in France the materials of this ſalt, and conjectured the proceſs employed for its preparation, diſcovered likewiſe, that this ſecond kind of ſal ammoniac is made in the Indies, where it is prepared in much larger quantities than in Egypt, from which it differs

fers only in its form, being likewiſe ſublimed. Theſe loaves of fourteen or fifteen pounds each, are hollow at their baſe, and formed of three different layers. The cone is truncated, becauſe the point, conſiſting of impure matter, has been cut off.

Mr. Baumé has eſtabliſhed a manufacture of ſal ammoniac in the neighbourhood of Paris, where this ſalt is entirely compoſed by a different proceſs from that of the Egyptians, who only extracted it. Mr. Baumé's ſalt is much purer than the Egyptian.*

The taſte of ſal ammoniac is penetrating, acrid, and urinous. The form of its cryſtals is a long hexahedral pyramid; the feathered form conſiſts of a number of theſe pyramids joined together under various angles. Romé de Liſle thinks that the cryſtals

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* Sal ammoniac is now made in large quantities in Britain. The volatile alkali is obtained in an impure liquid ſtate from ſoot or bones, or any other ſubſtance that affords it; to this the vitriolic acid is added: and the vitriolic ammoniac thus produced, is decompoſed by common ſalt by double affinity; the vitriolic acid combining with the mineral alkali, and the marine acid with the volatile alkali. The liquor therefore contains Glauber's ſalt and ſal ammoniac, which are ſeparated by cryſtallization; and the ſal ammoniac is ſublimed into cakes for ſale. The cheapneſs of the vitriolic acid, and of common ſalt, is the cauſe why they are made uſe of inſtead of the marine acid, with which the ſal ammoniac might have been directly formed.

Lord Dundonald extracts volatile alkali from pit coal; but whether it can be afforded cheaper for the general purpoſes of commerce than that of the above proceſs, is not, I believe, yet aſcertained. T.

of ſal ammoniac are octahedrons joined together. Cubical cryſtals of this ſalt are formed, though rarely, in the middle of the concave and hollow parts of the loaves formed by ſublimation.

This ſalt poſſeſſes a ſingular phyſical property, namely, a kind of ductility, ſo that it rebounds under the hammer, and may be bended; a circumſtance which renders it difficult to pulverize.

Sal ammoniac is entirely volatile, but requires a conſiderable heat to raiſe it. This method is uſed in order to procure it in a ſtate of purity, and perfectly dry. It is pulverized, and placed in matraſſes plunged up to their middle in a ſand bath; heat being gradually applied for ſeveral hours, the ſalt ſublimes, and forms a maſs compoſed of ſtriated needles joined to each other length-ways. When the operation is well managed, regular cubical cryſtals are often found in the middle of the loaf; but if the heat is too great, the maſs is denſe, ſemi-tranſparent, and as if melted.

Mr. Baumé has obſerved, that when this ſalt is ſublimed ſeveral times, there is each time diſengaged a ſmall quantity of volatile alkali and marine acid; ſo that it may perhaps be poſſible by repeated ſublimations to decompoſe ſal ammoniac entirely: this fact requires to be confirmed.

Sal ammoniac is not ſenſibly changed by expoſure to air, but may be kept for an unlimited time without alteration. It is very ſoluble in water, ſix parts of cold water diſſolving one of the ſalt, and a conſiderable degree of cold being produced. The cold is much greater when the ſalt is mixed with ice. This artificial cold cauſes ſeveral phenomena, which cannot be exhibited at pleaſure by any other means, ſuch as the congelation of water, the cryſtallization of certain ſalts, the fixation of evaporable fluids, &c.

Boiling water diſſolves nearly its own weight of ſal ammoniac; the ſalt cryſtallizes by cooling, but, like other ſalts, the beſt cryſtals are obtained by ſpontaneous or inſenſible evaporation. A very ſaturated ſolution of this ſalt being cloſed in a bottle, frequently depoſits, at the end of ſome days, cryſtals in the form of a plume of feathers, compoſed of a middle fibre, to which a great number of other fibres are joined perpendicularly; and theſe laſt ſuſtain others which are ſmaller, in ſuch a manner, that the whole perfectly reſembles vegetation. I have often obſerved this phenomenon in my laboratory.*

Sal

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* Every chemiſt muſt know how neceſſary it is to viſit from time to time the products preſerved in a laboratory, eſpecially ſaline ſolutions. When curious facts caſually offer themſelves, they ought to be immediately recorded to prevent

Sal ammoniac is not decompoſed by clay; neither does magneſia decompoſe it, but with difficulty, and in part, as Bergman obſerves: if a mixture of magneſia and ſolution of ſal ammoniac be put into a bottle, vapours of volatile alkali, according to the remark of the celebrated chemiſt of Upſal, are diſengaged at the end of ſome hours. But this diſengagement ſoon ceaſes, and the quantity of ſal ammoniac which is decompoſed, is very ſmall.

Lime, and likewiſe ponderous earth, ſeparate the volatile alkali, even in the cold: if ſal ammoniac be triturated with quick lime, the ſtrong ſmell of alkaline gas is immediately perceived. When this operation is performed in cloſe veſſels, the volatile alkali may be collected. But this operation, not having been accounted for by authors, in as accurate a way as the modern diſcoveries permit, we ſhall proceed to give a more minute deſcription. If newly made quick lime and very

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prevent their being loſt, together with the important conſequences to which they often lead. I have in very many inſtances obſerved cryſtals formed in this way, where none were obtainable by evaporation. It likewiſe happens not unfrequently on opening bottles, which have ſtood for ſome time, cryſtals are depoſited, whoſe origin is ſingularly favoured by agitation and the contact of air. This note, which is ſuperfluous to ſuch as are already in the habit of chemical obſervation, is inſerted for the uſe of beginners. Note of the Author.

dry ſal ammoniac be heated in a retort, whoſe neck is plunged beneath a veſſel of mercury, a large quantity of alkaline gas is obtained. This is known to be the cauſe why in diſtilling without the pneumato-chemical apparatus, the product obtained is inconſiderable, at the ſame time that there is great danger of burſting the veſſels. Mr. Baumé, to prevent theſe inconveniencies, adviſes, that water be put into the retort, which is certainly productive of a good effect; but as the alkaline gas is much more volatile than the water, a large quantity is always loſt. Chemiſts now employ the apparatus of Mr. Woulfe with the greateſt ſucceſs in the diſtillation of volatile alkali. This apparatus, as we have before obſerved, conſiſts of a receiver with two necks, one adapted to the retort, and the other connected with an empty bottle; from which laſt collateral tubes iſſue, and are inſerted through the necks of additional bottles, which have likewiſe collateral tubes of communication ſimilar to the firſt, for the purpoſe of connecting additional bottles of the ſame kind. The mixture of quick lime and dry ſal ammoniac in powder is put into a ſtone-ware retort, and a gradual heat is cautiouſly applied, and increaſed to redneſs, ſo as even to vitrify the bottom of the retort. The alkaline gas diſengaged by the lime, paſſes into the receiver, and

and the bottles, and uniting with heat to the water in the latter, ſaturates it, and forms the moſt highly cauſtic alkaline ſpirit. By this means no part of the volatile alkali is loſt: the product is very pure and white, and the proceſs may be conducted to the beſt advantage, without any inconvenience to the operator from the fumes, or danger from the probable rupture of the veſſels. The late Mr. Bucquet and myſelf have aſcertained, that inſtead of three parts, as commonly directed, one part and a half of lime is ſufficient to decompoſe one part of ſal ammoniac. Lime ſlaked in the air decompoſes this ſalt as well as quick lime; the reſidue is calcareous marine ſalt, which we ſhall hereafter examine. It is proved by this operation, that lime has a ſtronger affinity than the volatile alkali to the marine acid.

The two fixed alkalis decompoſe ſal ammoniac as well as lime, and diſengage the pure volatile alkali in the gaſeous form; they may be employed with the ſame ſucceſs as lime; but the expence of theſe being much greater than that of the ſalino-terreſtrial ſubſtance, and no greater advantages ariſing from the uſe of them than of this laſt, they are never uſed for this purpoſe.

The vitriolic and nitrous acids ſeparate the marine acid from the volatile alkali by ſtronger affinity, and compoſe ammoniacal vitriol and nitre.

Neutral ſalts have no effect on ſal ammoniac, thoſe only excepted which are formed by the cretaceous acid; for example, cretaceous tartar and cretaceous ſoda. A double decompoſition takes place in theſe mixtures: while the marine acid unites to the fixed alkali to form febrifuge or common marine ſalt, the cretaceous acid being diſengaged, ſeizes the volatile alkali, and forms a neutral ammoniacal ſalt, which ſublimes in cryſtals, ſo as to line the interior part of the receiver, and which we call ammoniacal chalk, or cretaceous ſal ammoniac. To perform this operation, one part of very dry cretaceous tartar or ſoda is mixed with one part of ſublimed ſal ammoniac in powder. The mixture is introduced into a ſtone-ware retort, to which a large receiver or cucurbit of glaſs is fitted; and a gradual heat being applied till the bottom of the retort becomes red hot, a very white cryſtallized ſalt ſublimes, which is the cretaceous ammoniacal ſalt. A ſmall quantity of moiſture likewiſe paſſes over; the reſidue is febrifuge, or marine ſalt, according to the alkali made uſe of. A very conſiderable quantity of cretaceous ammoniacal ſalt, equal in weight to nearly two-thirds of the ſal ammoniac made uſe of is obtained. This phenomenon cauſed Mr. Duhamel to conclude, that ſome of the fixed alkali paſſed over it with the volatile alkali. It is eaſy to conceive,

ceive, ſince this theory has been explained by modern experiments, that the acceſſion of the cretaceous acid muſt greatly increaſe the weight of the ſublimed ſalt. The concrete volatile alkali has nevertheleſs, till very lately, been eſteemed in a ſtate of purity, and the properties of cryſtallizing and of effervеſcing with acids, have been aſſumed as ſpecific characters; while the alkali obtained by lime, which is truly the pure volatile alkali, was ſuppoſed to be the ſame ſalt altered, and partly decompoſed. Hence we may ſee how much the diſcoveries of Dr. Black have elucidated the theory of ſaline matters: it may even be affirmed, that they have created a new theory of chemiſtry.

The uſes of ſal ammoniac are very numerous and extenſive. It is uſed internally, in doſes of a few grains, in obſtructions, intermitting fevers, &c. Externally, it acts as a powerful antiſeptic in gangrenes, &c.

It is uſed in a great number of arts, but eſpecially in the art of dying, and in the ſoldering or uniting different metals. It is employed by braziers to cleanſe the ſurface of copper previouſly to its being tinned.

Species IV. SEDATIVE SAL AMMONIAC.

Sedative ſal ammoniac, or ammoniacal borax, is a combination of ſedative ſalt with the volatile alkali. No one has yet examined its

its properties that I know of, but I have myſelf made the following obſervations.

Very pure ſedative ſalt being diſſolved in cauſtic vegetable alkali, was diluted with a ſmall quantity of water, and about half the liquid evaporated on a ſand bath; a pellicle of united cryſtals was formed, whoſe ſurface exhibited the figure of polyhedral cryſtals. Its taſte was penetrating and urinous, it converted ſyrup of violets to a green, and gradually loſt its cryſtalline form, and became brown by expoſure to air. It is moderately ſoluble in water, and lime diſengages the volatile alkali.

Such are the principal properties I have obſerved on a firſt examination; but I have not yet made a ſufficient number of experiments to ſpeak deciſively reſpecting its nature.

Ammoniacal borax is not applied to any uſe.

Species V. SPARRY SAL AMMONIAC.

This ſalt, like the foregoing, has not been accurately examined; many chemiſts call it ammoniacal ſpar, or fluor.

Mr. Boulanger agrees with Scheele in affirming that the ſparry acid, combined with the volatile alkali, does not cryſtallize, but forms a jelly, which affords vapours reſembling thoſe of the marine acid, when the vitriolic acid is added. Theſe two chemiſts have not examined the other properties of this kind of ſalt, but their obſervations were ſufficient to enable them to diſtinguiſh the ſparry from the marine acid.

Species VI. CRETACEOUS SAL AMMONIAC.

We give the name of cretaceous ſal ammoniac, or ammoniacal chalk, to that which was formerly called concrete volatile alkali, and is a true neutral ſaline combination of the cretaceous acid with pure volatile alkali. It does not exiſt pure and alone in nature. Moſt animal ſubſtances afford it by the action of heat. It is likewiſe formed by the direct union of the cauſtic volatile alkali with the cretaceous acid, either by agitating the alkali in the upper part of a vat of fermenting liquor; by paſſing the cretaceous acid into volatile alkaline ſpirit; or by pouring the acid into a veſſel, on the ſides of which a few drops of cauſtic volatile alkali are ſpread: in all theſe caſes cryſtals of ammoniacal chalk are formed. It is likewiſe obtained by decompoſing ſal ammoniac, by the addition of cretaceous neutral ſalts, eſpecially the fixed alkalis.

It is capable of a regular form, and its cryſtals appear to be polygonal priſms. Bergman deſcribes them as octahedrons, having four

four of their angles truncated. Romé de Liſle mentions groups of cryſtals of this ſalt, in which it had the form of ſmall flattened tetrahedral cryſtals, terminated at their upper extremity with a dihedral ſummit.

Its taſte is urinous, but much leſs ſo than that of the cauſtic volatile alkali; its ſmell, though ſimilar to this laſt, is likewiſe fainter: it converts ſyrup of violets to a green. We think it neceſſary to obſerve, with reſpect to this laſt property, that the cretaceous is not the only acid which does not completely deſtroy the properties of the alkalis with which it is combined; and that the appellation of neutral may properly be applied to alkalis ſaturated with this weak acid, ſince ſedative ſalt, which has always been reckoned neutral in its combination with borax, has the ſame property.

Cretaceous ſal ammoniac is very volatile, and the ſmalleſt heat ſublimes it entirely, if it be well cryſtallized. The firſt effect of heat is that of liquefaction, by means of its water of cryſtallization, or the aqueous fuſion, but it riſes immediately after, or nearly at the ſame time; ſo that it is ſcarcely poſſible to obtain this ſalt well cryſtallized, and at the ſame time very dry.

It is very ſoluble in water, and, like all other neutral ſalts, produces cold; a property ſo contrary to that of the pure volatile alkali, as to afford an additional argument for ranking it among the neutral ſalts.

Two parts of cold water diſſolve more than one of cretaceous ſal ammoniac; hot water diſſolves more than its own weight; but as this ſalt is diſſipated by the heat of boiling water, the method of cryſtallizing by heat cannot be uſed without riſking the loſs of a great part.

It ſlowly attracts moiſture from the air, eſpecially when it is not intirely ſaturated with cretaceous acid.

The earths have no more action on this than on other ammoniacal ſalts: magneſia decompoſes it very weakly; lime decompoſes it by ſeizing its acid, with which it has a ſtrong affinity. If lime-water be poured into a ſolution of cretaceous ſal ammoniac, a precipitate is immediately formed, and a ſtrong ſmell of volatile alkali is perceived. The lime ſeizes the cretaceous acid, and forms chalk, which falls down, and the volatile alkali is diſengaged: quick-lime being triturated with cretaceous ſal ammoniac, alkaline gas is immediately diſengaged. If this mixture be put into a retort, the cauſtic or fluor volatile alkali is obtained, in the ſame manner as from common ſal ammoniac, by the ſame intermedium; the apparatus of Woulfe being uſed. This fact proves, that lime has a ſtronger affinity than the volatile alkali with the cretaceous acid: and other facts prove the ſame thing with regard to other acids.

Cauſtic fixed alkali decompoſes cretaceous ammoniac in the ſame manner as lime, by ſeparating the volatile alkali, and uniting with its baſe.

Laſtly, the vitriolic, nitrous, marine, and ſparry acids, have a ſtronger affinity than the cretaceous acid to the volatile alkali: when one of theſe acids is poured on the cretaceous ammoniacal ſalt, a ſtrong efferveſcence ariſes from the diſengagement of the cretaceous acid. If this decompoſition be made in a tall ſlender veſſel, the preſence of the cretaceous acid may be obſerved by the extinction of a lighted candle, the reddening of the tincture of turnſole, or the precipitation of lime-water immerſed in a ſmall cup below its orifice. Theſe decompoſitions of the cretaceous ammoniacal ſalt by lime and fixed alkalis, which ſeize its acid and ſeparate the volatile alkali, and by acids which ſeize the alkali and diſengage the cretaceous acid, clearly ſhew the nature of this ſalt. Bergman has found, by accurate experiments, that a centenary of this ſalt contains forty-three parts of alkaline gas, forty-five parts of cretaceous acid, and twelve of water. From the conſideration that this ſalt contains a larger proportion of acid than cretaceous ſoda, and this laſt a larger quantity than cretaceous tartar, he concluded, that the weaker the alkaline baſe, the more acid will be required for its ſaturation. The acid of borax, or ſedative ſalt, does

does not decompoſe ammoniacal chalk in the cold; but when the latter is poured on a hot ſolution of ſedative ſalt, a very ſenſible effervеſcence is produced, and the diſengagement of cretaceous acid is ſhewn by the uſual methods; ammoniacal borax being alſo found at the bottom of the veſſel. This experiment, which I have frequently repeated, proves, that heat modifies or changes the laws of affinity, or elective attraction, as Bergman has obſerved.

Cretaceous ſal ammoniac does not act on the perfect neutral ſalts. We ſhall ſee that it decompoſes neutral calcareous ſalts, by the way of double affinity, which the pure and cauſtic volatile alkali cannot effect. The valuable diſcoveries of Black explain why chemiſts were miſtaken in affirming, that the volatile alkali has a ſtronger affinity than calcareous earths with acids.

Cretaceous ammoniacal ſalt is employed in medicine as a ſudorific, anti-hyſteric, &c. It is mixed with certain aromatic matters. It has been conſidered as a ſpecific againſt the bite of vipers, but the Abbé Fontana with great reaſon combats this opinion. Many have adviſed the uſe of the cretaceous, or concrete volatile alkali, as a remedy in venereal diſorders; experience, however, has not yet decided on this head. All the knowledge the art of medicine poſſeſſes with regard to this ſalt is, that it is purgative, opening,

opening, diuretic, diaphoretic, diſcuſſive, and that it has a good effect in ſuch diſorders as depend on the denſity of the lymph; as certain venereal caſes, coagulations of milk, ſcrophulous diſorders, &c. It is adminiſtered in doſes of a few grains, in a proper vehicle, or compounded with opium.

CHAPTER VII.

GENUS III. Calcareous Neutral Salts.

Species I. VITRIOL OF LIME, SELENITE, GYPSUM.

THE combination of the vitriolic acid with lime is denominated calcareous vitriol, ſelenite, plaſter, or gypſum. This ſalt exiſts in large quantities in nature; it often forms immenſe tracts, or beds, as may be obſerved at Montmartre, near Paris. The mountains of this diſtrict are intirely filled with beds of ſelenite, or plaſter, covered with a kind of argillaceous marle, which almoſt always accompanies it.

Naturaliſts have long conſidered this ſalt as an earthy ſubſtance, on account of its want of taſte and ſolubility; it is diſtinguiſhed

guiſhed into many varieties, on account of the diverſity of its forms and ſtate of purity; the principal are here enumerated.

1. Selenite in rhomboidal laminæ.

It has the tranſparency of ice; the pieces met with in collections of natural hiſtory are irregular, but they always break or ſplit into rhomboidal laminæ. The ſelenite of St. Germain, of Lagny, &c. are of this ſort.

2. Cuneiform ſelenite, or of the figure of arrow-heads.

It conſiſts of two ſcalene triangles, joined in the middle, each being compoſed of triangular laminæ, according to the obſervation of De la Hire. It is called lapis ſpecularis, or talc of Montmartre.

3. Selenite in decahedral rhomboids.

The quarries of Paſſy afford this ſort.

4. Selenite, in decahedral priſms.

It is formed of hexahedral priſms, terminated by dihedral pyramids, or by a concave angle; it is found in Switzerland, &c.

5. Selenite in cock's combs from Montmartre.

It conſiſts of a collection of ſmall lenticular cryſtals, placed obliquely beſide each other, and is formed by the union of the cryſtals decribed No. 2.

6. Silky, or ſtriated ſelenite; ſilky gypſum of China.

It is found in Franche-Comté, Angoumois, &c. It is formed by the union of ſlender

ſlender priſms, which are moſt commonly brilliant, and of the appearance of ſatin. It is very difficult to obſerve the rhomboidal laminæ, which are found in all the other varieties.

7. Common gypſum, or plaſter ſtone.

This ſubſtance is white, more or leſs inclining to grey, interſperſed with ſmall brilliant cryſtals, eaſily cut with a knife. It is found diſpoſed in ſtrata, and forms moſt of the mountains in the vicinity of Paris. We ſhall hereafter find, that it is not pure ſelenite, but owes its moſt valuable property, as plaſter, to the admixture of another kind of earth.

8. Gypſeous alabaſter.

This is a kind of plaſter ſtone, harder and more ancient than the foregoing, from which it differs only in being ſemi-tranſparent, of a yellowiſh grey, and in its laminated form or ſtructure apparently conſiſting of ſmall plates. It is found in great plenty at Lagny, near Paris. This is one of the whiteſt kinds; but it has ſometimes yellow, grey, violet, or black ſpots or veins.

9. Selenite, common gypſum, or gypſeous alabaſter, variouſly coloured, veined, ſpotted, clouded, or punctuated.

This mixture of colour ſhews, that the ſelenite is contaminated by ſome foreign ſubſtance. The colours are almoſt always occaſioned by iron.

Selenite is likewiſe found diſſolved in waters, as in the well-waters of Paris; it is never pure, but is always combined with ſome other earthy ſalt, with baſe of lime or magneſia.

We have already obſerved that ſelenite has long been taken for an earthy ſubſtance by naturaliſts, on account of its poſſeſſing no apparent degree of taſte or ſolubility; it has nevertheleſs a peculiar taſte, which it communicates to water, and which is very ſenſible on the ſtomach. Selenitical waters occaſion a very evident ſenſation of cold and weight in the bowels. The ſolubility, form, tranſparency, quantity, and eſpecially the diſpoſition in beds or ſtrata of cryſtallized ſelenite, more eſpecially in the environs of Paris, ſufficiently ſhew, that it has been originally diſſolved in water, and afterwards depoſited by that fluid.

Selenite, expoſed to the action of heat, loſes its water of cryſtallization, and decrepitates if the heat be ſuddenly applied; it is then of an opaque white, and friable, in which ſtate it is called fine plaſter, or plaſter of Paris, and is capable of aſſuming a certain conſiſtence with water. Very white and beautiful ſtatues of this ſubſtance are caſt in moulds; but the plaſter quickly becoming dry, and retaining but a ſmall proportion of water, they are very eaſily broken. If the heat be conſiderably raiſed, when the

the ſelenite has taken the form of a white powder, it fuſes into a kind of glaſs; but this effect is not produced but by a very ſtrong degree of heat, ſuch as is produced in the porcelain furnaces, or in the focus of burning lenſes. Meſſrs. D'Arcet and Macquer ſucceeded in fuſing ſelenite; the latter obſerved, that when the cuneiform ſelenite is expoſed to the focus of a burning mirror, ſo that the light may fall on its poliſhed ſurfaces, it only becomes white: but if the edges be preſented, it immediately melts and boils up. It may likewiſe be melted by the blow-pipe, and by a ſtream of vital air thrown on burning charcoal.

Selenite placed on a hot iron becomes phoſphoric, a property which is common to all calcareous ſalts, and is likewiſe exhibited by lime during its extinction, as we have already remarked.

Selenite ſuffers no obvious alteration by contact of air; nevertheleſs, the poliſhed and brilliant laminæ of this earthy neutral ſalt become tarniſhed with the colours of the rainbow, ſplit or ſcale off, and are at length deſtroyed by the atmoſphere; but theſe phenomena ariſe from the united action of heat, water, and air.

Selenite is ſoluble in water, though in a degree ſcarcely ſenſible, according to the chemiſts of Dijon. About five hundred parts of water are required to diſſolve one of of ſelenite. Hot water does not diſſolve a greater quantity. When this ſolution is evaporated, cryſtals are obtained, not ſimilar to thoſe found in nature, but in the form of ſmall plates or needles, which are precipitated in proportion as the liquor evaporates. The laminæ afforded by the evaporation of ſelenitical water are often brilliant, and, when minutely examined, are found to conſiſt of very ſmall needles united lengthways.

Ponderous earth has more affinity than lime to the vitriolic acid, and decompoſes ſelenite, according to the obſervation of Bergman.

Fixed alkali likewiſe decompoſes this neutral ſalt: when cauſtic fixed alkali is poured into a ſolution of ſelenite, a white precipitate, apparently mucilaginous, falls to the bottom in flakes, which is found by experiment to be quick lime.

If the ſupernatant liquor be evaporated, vitriolated tartar, or Glauber's ſalt, according to the nature of the alkali made uſe of, is obtained.

The volatile alkali, which has leſs affinity than lime with every acid, does not decompoſe ſelenite; and no change takes place, if the latter be very pure, and the alkali perfectly cauſtic. But if the water in which the ſelenite is diſſolved contains any ſalt with baſe of magneſia, or clay, as the well water of Paris does, the volatile alkali will occaſion a prea precipitate. To ſucceed in the former experiment, calcareous ſpar muſt be diſſolved in the pure vitriolic acid, and the ſelenite diſſolved in diſtilled water; volatile alkali poured on this ſolution, or which is ſtill better, the alkaline gas, occaſions no precipitate.

Selenite has no action on the perfect vitriolic ſalts; but it decompoſes nitrous and marine ſalts with baſe of fixed alkali. Vitriolated tartar, or Glauber's ſalt; and nitre or marine calcareous ſalt are obtained. Theſe decompoſitions are not ſenſible, till the liquids in which they are made are evaporated, becauſe the new ſalts remain diſſolved. Cretaceous tartar and ſelenite mutually decompoſe each other; the vitriolic acid quitting the lime to unite with the fixed alkali, and forming vitriolated tartar, while the cretaceous unites with the lime, and forms the ſalt known by the name of chalk.

Cretaceous ſoda is decompoſed in the ſame manner by this ſalt, Glauber's ſalt being formed by the union of the vitriolic acid with the mineral fixed alkali; at the ſame time that chalk is produced by the combination of the lime with the cretaceous acid.

The cretaceous ammoniacal ſalt likewiſe decompoſes ſelenite by double affinity; while the vitriolic acid ſeizes the volatile alkali, the lime combines with the cretaceous acid, to which it has a ſtrong affinity, and forms chalk.

This decompoſition, whoſe cauſe is ſo well known ſince the diſcoveries of the celebrated Dr. Black, is ſo evident, that if a mixture of the ſolution of ſelenite with cauſtic vegetable alkali be left for ſome time expoſed to the air, it loſes its original tranſparency, and becomes remarkably clouded at its ſurface, by reaſon of the cretaceous acid precipitated from the atmoſphere, which cauſes a double affinity to take place; and the ſame phenomenon is produced by paſſing a few bubbles of cretaceous acid through the liquor. As the concrete volatile alkali, or cretaceous acid was formerly thought to be the pure volatile alkali, Geoffroy, from the precipitation of ſelenite by this ſalt, concluded that the affinity of volatile alkali is greater than that of lime to the vitriolic acid.

Selenite is decompoſed by combuſtible matters, and forms ſulphur by the combination of the phlogiſton of theſe ſubſtances with the vitriolic acid according to Stahl; or by the decompoſition of the acid, and the ſeparation of its vital air, by the charcoal, according to Mr. Lavoiſier, or by both theſe effects united, according to the doctrine of ſeveral modern chemiſts.

Pure ſelenite in a cryſtalline form, is carefully preſerved in cabinets of natural hiſtory. When calcined, it is uſed to caſt ſtatues,

tues, models, &c. Several elegant pieces of ornamental furniture are made of the gypſeous alabaſter, cut and poliſhed. The fine ſpecimens of Lagny are employed for this purpoſe.

Plaſter-ſtone is one of the moſt uſeful articles produced in the mineral kingdom. It conſiſts of a mixture of ſelenite and chalk; when it is expoſed to the action of heat, the ſelenite loſes it water of cryſtallization, and the chalk its acid: burned plaſter is therefore a mixture of lime and ſelenite deprived of water; conſequently, when water is poured on this ſubſtance, it is very rapidly abſorbed by the lime, and heat is produced. The ſmell of liver of ſulphur, which attends the extinction of plaſter, ariſes from a ſmall quantity of ſulphur formed by the vitriolic acid of the ſelenite, which is decompoſed by the carbonaceous animal or vegetable ſubſtances caſually exiſting in the plaſter-ſtone; the ſulphur diſſolved by the lime forms a kind of liver of ſulphur from which the ſmell proceeds. When the lime has abſorbed a ſufficient quantity of water to form a paſte, the ſelenite ſeizes a portion of the fluid, and the whole maſs cryſtallizes ſuddenly, and at the ſame time becomes ſolid. The lime gradually dries, and together with the cryſtals of ſelenite forms the kind of mortar called plaſter. From this theory it is ſeen, why plaſter ought not to be burned beyond a certain point.

point. If it be ſhort of this, the lime will not be ſufficiently deprived of cretaceous acid to unite well with water; if it exceed, the lime, together with the ſelenite, forms a kind of vitreous frit, incapable of uniting with water.

We may likewiſe obſerve that plaſter, by long expoſure to air, loſes its goodneſs by the lime becoming ſlaked, and that its original properties may be reſtored by a ſecond calcination. Laſtly, we may with equal facility account for the preſervation of this ſubſtance in dry and warm ſituations, and its deſtruction or ſcaling off in moiſt places. In the latter caſe, the ſelenite being ſoluble in water loſes by degrees its cryſtalline form and conſiſtence; and this ſolubility conſtitutes the chief difference between plaſter and mortar; the ſand in this laſt, which gives ſolidity, not being attacked by water. Plaſter is not, on this account, uſed in humid or moiſt places, or in any works near or under water, as reſervoirs, &c.

Species II. CALCAREOUS NITRE.

Calcareous nitre, or the ſalt produced by the combination of the nitrous acid with lime, is much leſs abundant than calcareous vitriol or ſelenite. It is only found in ſuch places as afford the nitre with baſe of alkali. It is formed on the ſides of walls in places inhabited by animals, in putrified animal matters, and in certain mineral waters; but as it is very ſoluble in water, and even deliqueſcent, it is diſſolved even almoſt as ſoon as formed. The ſame property is the cauſe why it is retained in large quantities in the mother-water of the ſaltpetre-makers.

When regularly cryſtallized, it has the form of a ſix-ſided priſm, conſiderably reſembling nitre, and terminated by dihedral pyramids. It is not often obtained in this regular form, but is moſt commonly in that of ſmall needles adhering together, whoſe form cannot be determined.

This ſalt has a bitter and diſagreeable taſte, in which reſpect it differs greatly from calcareous vitriol; its taſte is rather cool, like common nitre.

It eaſily melts by heat, and becomes ſolid on cooling; if it be carried into the dark after being thus heated, it appears luminous, and in this ſtate conſtitutes the phoſphorus of Baldwin; it exhibits the ſame phenomenon when laid on a hot iron. On ignited coals it melts and detonates feebly, in proportion as it becomes dry. Calcareous nitre kept hot for a long time loſes its acid, which is decompoſed. When this operation is performed in a retort, whoſe neck is plunged under an inverted veſſel filled with water, a large quantity of very pure dephlogiſticated air is produced, and towards the end a ſmall quantity

quantity of cretaceous acid. The reſidue conſiſts of lime united to a certain quantity of phlogiſticated nitrous acid, if the fire has been not continued for a ſufficient time, or ſufficiently intenſe; but a very powerful degree of heat will at laſt entirely decompoſe the nitrous acid, and leave the baſe in the form of quick lime. This decompoſition is abſolutely ſimilar to that which happens in the diſtillation of common nitre, and has been explained in the hiſtory of that ſalt.

Calcareous nitre quickly attracts the moiſture of the air, and for that reaſon it is neceſſary to keep the cryſtals of this ſalt in well cloſed veſſels, which muſt not be opened too frequently.

It is very ſoluble in water; two parts of cold, or leſs than one part of boiling water, being ſufficient to hold it in ſolution. To obtain it in a cryſtalline form, its ſolution muſt be evaporated nearly to the conſiſtence of ſyrup, and expoſed in a cool place. The cryſtals formed by this means are very long priſms, commonly diverging from one centre. When a ſolution of calcareous nitre, leſs evaporated than the foregoing, is expoſed to a dry and hot air, priſms are formed in proceſs of time, which are more regular, and are ſimilar to thoſe deſcribed at the beginning of this article.

Sand and clay decompoſe calcareous nitre, and ſeparate the acid.

Ponderous earth, according to Bergman, decompoſes this ſalt as it does ſelenite; but magneſia produces no ſenſible alteration in it. Mr. Morveau has obſerved that lime-water, poured into a ſolution of calcareous nitre, occaſions a precipitate. He attributes it to the phlogiſton of quick lime, and he thinks that this laſt has a ſtronger affinity with the nitrous acid than the lime to which it is united has, and which he ſuppoſes to have been already robbed of its phlogiſton by the acid. It is unfortunate that this chemiſt did not examine the precipitate, which might probably have afforded ſome explanation of this ſingular experiment. Mr. Baumé had before obſerved, that a ſolution of calcareous ſpar in the nitrous acid is precipitated by lime-water; but he attributed this phenomenon to a ſmall quantity of argillaceous earth contained in the ſpar. It is likewiſe known that this effect may be produced by the magneſia, which often accompanies calcareous ſubſtances.

Fixed alkalis ſeize the acid of calcareous nitre, and precipitate the lime. Very pure cauſtic volatile alkali does not decompoſe this ſalt, nor any other with a calcareous baſe.

The vitriolic acid diſengages the nitrous acid with effervеſcence, which may be obtained in the ſame manner as from common nitre. Spirit of vitriol poured on a ſolution of calcareous nitre immediately produces a precipitate of ſelenite, and the nitrous acid remains diſengaged in the liquid. The action of other acids on this ſalt is not known.

Calcareous nitre decompoſes the alkaline vitriolic neutral ſalts; ſelenite, and common or rhomboidal nitre being formed. The vitriolic ammoniacal ſalt is likewiſe decompoſed, and ammoniacal nitre, together with ſelenite, are produced: the latter, which, being ſcarcely ſoluble, is precipitated at the inſtant of mixture, leaves no doubt with regard to the nature of theſe double decompoſitions.

Cretaceous tartar and calcareous nitre mutually decompoſe each other, nitre remaining in the ſolution, and chalk being precipitated.

Cretaceous ſoda and calcareous nitre in the ſame manner afford cubic nitre in ſolution, and a precipitate of chalk.*

Selenite does not produce any change in calcareous nitre; but when theſe two ſalts are diſſolved in the ſame water, they may be eaſily ſeparated; for the firſt being very ſparingly ſoluble, and the latter eminently ſo, the ſelenite is precipitated by evaporation, and the calcareous nitre does not cryſtallize

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* It cannot be too often repeated, that theſe double decompoſitions take place in conſequence of the ſtrong affinity between lime and the cretaceous acid; and that this affinity fully juſtifies the denomination of cretaceous acid given to fixed air by Bucquet. Note of the Author.

till great part of the fluid has been driven off, and the reſidue ſet to cool.

Calcareous nitre is not applied to any uſe; might be employed in medicine as a very active ſolvent, and ſome chemical phyſicians affirm, that its application has been attended with ſucceſs.

Species III. CALCAREOUS MARINE SALT.

The calcareous marine ſalt formed by the combination of the marine acid and lime, is abundantly found in all places that abound with marine ſalt, and eſpecially in the waters of the ſea; where it produces that acrid and bitter taſte, which formerly cauſed it to be ſuppoſed to contain bitumen. It is never pure in the ſea, but always mixed with marine ſalt with baſe of magneſia: if it be deſired in a ſtate of great purity, marine acid muſt be directly combined to ſaturation with lime. It has been improperly called fixed ammoniac, becauſe the reſidue of ſal ammoniac decompoſed by lime conſiſts of this ſalt.

Calcareous marine ſalt, in its dry and ſolid ſtate, has the form of four-ſided priſms, ſtriated and terminated with very acute pyramids. It has a very diſagreeable bitter ſaline taſte. When expoſed to the action of a mild heat it is liquified by means of its water of cryſtallization, and becomes ſolid again when cold;

cold; a ſtronger heat ſcarcely alters it. Mr. Baumé has obſerved, that it does not part with its acid: it becomes luminous on a red hot ſhovel, for which reaſon it is called Homberg's phoſphorus.

The calcareous marine ſalt which remains in the retort after the decompoſition of ſal ammoniac by lime, and is called fixed ſal ammoniac, melts into a kind of frit of a light ſlate grey, and does not afford marine acid, though the heat be raiſed ſo as even to vitrify the ſurface of the retort. This frit gives fire with ſteel, and when rubbed in the dark with the ſteel, it gives a phoſphoric light.

It muſt be obſerved, that this ſaline reſidue commonly contains a larger portion of lime than is neceſſary for the complete ſaturation of the marine acid; becauſe more lime is uſually employed than is neceſſary to decompoſe the marine acid. It is doubtleſs from this ſuperabundant lime, that the reſidue acquires the property of affording a hard vitreous frit; which however becomes moiſt in proceſs of time when expoſed to the air. The marine calcareous ſalt, without exceſs of lime, never becomes ſo hard by the action of fire as this reſidue, neither has it the ſame phoſphoric quality.

Pure calcareous marine ſalt expoſed to the air attracts humidity, and liquifies. The

cryſtalline

cryſtalline form cannot, therefore, be preſerved, but in well cloſed veſſels.

This ſalt is very ſoluble in water; one part and a half of cold, or leſs than an equal part of hot water being ſufficient to diſſolve it. When by evaporation the liquid is brought nearly to the conſiſtence of ſyrup, and afterwards ſuffered to cool gradually, priſmatic tetrahedral cryſtals are obtained ſeveral inches in length, diſpoſed in radii iſſuing from a common centre; a figure which we may obſerve is common to moſt calcareous ſalts. If the liquor be too far evaporated, or if it be cooled too quickly, the ſaline maſs is irregularly formed, with the appearance of needles at its ſurface.

A ſolution of marine calcareous ſalt evaporated till it exhibits forty-five degrees of Baumé's aerometer, and expoſed in a bottle to the cold, affords very regular priſms, frequently of conſiderable magnitude.

Ponderous earth decompoſes calcareous marine ſalt, by its greater affinity to the acid, according to the experiment of Bergman. Lime and magneſia do not change it.

Fixed alkalis precipitate lime: if the two fluids be concentrated, the lime abſorbs the ſmall quantity of water they contain, and immediately forms a jelly, which ſoon becomes ſolid. This experiment has been called miraculum chemicum. It does not, however, ſucceed

ſucceed well but with cretaceous alkalis; the pure alkalis precipitating the lime in too divided a ſtate.

Very pure volatile alkali does not decompoſe calcareous marine ſalt, becauſe its affinity is leſs than that of lime to the marine acid. This order of affinity is likewiſe proved from the complete decompoſition of ſal ammoniac by the ſame ſalino-terreſtrial ſubſtances.

The vitriolic and nitrous acids diſengage the marine acid from this ſalt with efferveſcence, and the acid may be obtained by diſtillation in the ſame manner as from common ſalt. When the nitrous acid is uſed, aqua regia is produced, on account of the volatility of both acids.

Calcareous marine ſalt decompoſes vitriolated tartar and Glauber's ſalt. It is eaſy to aſcertain this fact, by mixing ſolutions of theſe ſalts together. A precipitate is immediately formed, which is found to be ſelenite. The fluid contains either febrifuge or marine ſalt, which may be obtained by evaporation, and is diſtinguiſhable by the taſte.

Cretaceous tartar and cretaceous ſoda likewiſe decompoſe the calcareous marine ſalt. In theſe mixtures the decompoſitions are made by double affinity: the acid of the marine calcareous ſalt ſeizes the alkali, and forms febrifuge or common marine ſalt; while the cretaceous acid quits the alkali, and uniting with

with the lime, forms chalk. When the cretaceous alkalis and the ſolution of calcareous ſalt are very ſtrong, this admixture produces a ſolid form, or miraculum chemicum, as we have juſt obſerved.

Cretaceous ſal ammoniac decompoſes calcareous marine ſalt by double affinity, in the ſame manner as has been ſhewn with reſpect to ſelenite and calcareous nitre. The volatile alkali unites with the marine acid, and forms common ſal ammoniac, which remains diſſolved in the liquor, while the cretaceous acid forms a precipitate of chalk by combining with the lime.

When the calcareous marine ſalt is diſſolved in water together with calcareous nitre, it is difficult to ſeparate them; becauſe the law of cryſtallization is the ſame in both: but if ſelenite exiſts in the ſolution inſtead of one of the two ſalts, the ſeparation will be eaſily made, becauſe this laſt cryſtallizes by evaporation, and the calcareous ſalt cryſtallizes by cooling: as theſe ſalts are frequently found diſſolved in the ſame acid, it is of conſequence to attend to theſe properties.

Marine calcareous ſalt is of no uſe. As it exiſts in conſiderable quantities in the ſel de gabelle, which is recommended as a purge in ſcrophulous diſorders; it may be ſuſpected, that a part of its properties depend on the latter ſalt. We think it neceſſary to add, that the ſtrong taſte and great ſolubility of of calcareous marine ſalt, promiſe very uſeful effects in diſorders where a ſolvent is wanting. Mr. Chambon has employed it with ſucceſs, and recommends it, in his Treatiſe on the Diſorders of Women, to diſcuſs milky tumours. It is much to be wiſhed that phyſicians were acquainted with the properties, and availed themſelves of the uſe, of this ſalt, in thoſe numerous caſes where the uſual ſolvents are frequently ineffectual, and more eſpecially in thoſe caſes wherein mercurial remedies cannot be uſed.

Species IV. CALCAREOUS BORAX.

The combination of the ſedative acid with lime may be diſtinguiſhed by this appellation. This ſalt has not been examined, though it is certain that the ſedative acid is capable of uniting with lime, becauſe the latter decompoſes borax, as we have obſerved. The chemiſts of the academy of Dijon have obſerved, that ſedative ſalt, heated with ſlaked lime, afforded a ſubſtance whoſe parts adhered weakly to each other, and not at all to the crucible. This matter when thrown into water, did not exhibit the ſame phenomena as lime; which ſhews that a true combination took place. Mr. Baumé affirms, that having ſaturated lime-water with ſedative ſalt, and expoſed the ſolution to ſpontaneous evaporation, no cryſtals were obtained, but yellowiſh

yellowiſh pellicles, having a ſlight taſte of ſedative ſalt. Laſtly, the academicians of Dijon digeſted on a ſand bath, a ſaturated ſolution of ſedative ſalt with ſlaked lime. The filtrated liquid afforded a plentiful white precipitate, on the addition of fixed alkali. Theſe experiments, indeed, prove that lime is ſoluble in the acid of borax, but they ſhew nothing concerning the properties of the neutral ſalt reſulting from their combination.

Species V. FLUOR SPAR, VITREOUS SPAR, OR SPARRY FLUOR.

This ſpecies of ſalt is a combination of the ſparry acid with lime, and abounds in nature; it is more eſpecially found in the neighbourhood of mines, whoſe exiſtence it indicates. It has been hitherto regarded as a ſtony matter, from its inſipidity, hardneſs, and inſolubility. It is called ſpar, becauſe it has the ſparry form and fracture; fluor, becauſe it melts very readily, and is ſucceſsfully employed in mineral operations; and vitreous, becauſe it has the appearance of glaſs, and may be fuſed into glaſs of no contemptible appearance. Before the diſcovery of Mr. Scheele, the vitreous ſpar, though well diſtinguiſhed from all other mineral matters by workmen, on account of its fuſibility, was confounded by naturaliſts

naturaliſts, either with gypſums, calcareous ſpars, or ponderous ſpars, which have likewiſe been called fuſible. The celebrated Margraf nevertheleſs diſtinguiſhed this ſalt from the ponderous ſpar, by adopting the name of fuſible vitreous ſpar for the firſt, and fuſible phoſphoric ſpar for the ſecond. It is to this chemiſt that we are indebted for the firſt diſcoveries relating to the properties of vitreous ſpar.

This ſalt is commonly cryſtallized in cubes, of various colours, very regular, of an icy or vitreous tranſparency; its fracture is ſparry and it is eaſily broken. It often ſerves as the matrix or bed of ores. It is ſometimes found in irregular opake maſſes; its weight is more conſiderable than that of any ſaline matters we have yet ſpoken of; it is often clouded, veined, ſpotted, and frequently tinged throughout with green, violet, red, roſe colour, &c. Ten principal varieties of this ſubſtance may be diſtinguiſhed.

VARIETIES.

1. Cubic vitreous ſpar, tranſparent and colourleſs.
2. Cubic vitreous ſpar, opake white.
3. Cubic vitreous ſpar, yellow: falſe topaz.
4. Cubic vitreous ſpar, reddiſh: falſe ruby.

5. Cubic vitreous ſpar, pale green: falſe aqua-marine.

6. Cubic vitreous ſpar, green: falſe emerald.

7. Cubic vitreous ſpar, violet: falſe amethyſt.

8. Octahedral vitreous ſpar, with truncated pyramids.

I am in poſſeſſion of a cryſtal of this kind, which is ſemi-tranſparent, and rather blackiſh.

9. Vitreous ſpar, in irregular maſſes.

It is almoſt always of a clear green or violet. It forms the gangue of ſeveral ores.

10. Vitreous ſpar, in layers of different thickneſs, and of various colours.

Theſe different varieties of vitreous ſpar, conſiſt, for the moſt part, of one and the ſame ſaline ſubſtance; that is to ſay, the combination of the ſparry acid with lime: the natural ſpecimens, however, are uſually found by analyſis to contain ſeveral foreign matters, as quartz, clay, and iron, as almoſt all natural products do. England abounds in vitreous ſpar.

Vitreous ſpar, expoſed to a gentle heat, emits a very evident phoſphoric light; but if it be heated to redneſs, it intirely loſes this property, and if the ſpar be of a green colour, it becomes white and friable: when ſuddenly

denly heated, it decrepitates almoſt as ſtrongly as marine ſalt. When powder of vitreous ſpar is thrown on a hot iron, a blueiſh of violet light is perceived, which quickly vaniſhes, and cannot be produced again by the ſame ſpar.

A ſtrong heat fuſes vitreous ſpar into an uniform tranſparent glaſs, adhering to the crucible. Vitreous ſpar fuſes the one fourth of its weight of quartz, and is for that reaſon employed as a flux in ſmelting.

Fluor ſpar is not altered in the air, nor ſoluble in water. Pure fixed alkalis do not decompoſe it, becauſe, according to Bergman, lime has a ſtronger affinity than thoſe ſalts to its acid.

Oil of vitriol diſengages the ſparry acid, and is commonly the medium uſed for that purpoſe. One part of vitreous ſpar, in powder, is put into a retort, with three parts of oil of vitriol; the mixture gradually becomes hot; an effervefcence takes place; and vapours of ſparry acid are diſengaged. This diſtillation commences without the external application of heat; and a white ſubſtance, reſembling an effloreſcence, ſublimes into the receiver. Heat being then applied, the concentrated ſparry acid comes over, covered with a thick earthy pellicle, ſimilar to the white effloreſcence we have mentioned; while the acid falls drop by drop into the water in the receiver. This acid may be obtained in the form

form of gas, while the neck of the retort is plunged beneath an inverted veſſel of mercury. The aeriform acid is tranſparent, and does not depoſit the earth to which it is united to, until it is brought in contact with the water. Hence it may be conceived, why the liquid ſparry acid depoſits ſtony incruſtations in the receiver; for it cannot hold them in ſolution when it comes in contact with the water. We have before obſerved, that this earth, which is of a quartzoſe nature, is taken up by the corroſion of the glaſs veſſel, and is not produced by the combination of the acid with water, as Scheele originally thought. When the diſtillation is finiſhed, the reſidue is obſerved to be hard, white, or reddiſh, and laminated, and the retort is very ſenſibly corroded. This obſervation did not eſcape Margraf. When the nature of the reſidue is examined by different methods, it is found to conſiſt of ſelenite mixed with a ſmall quantity of quartz, frequently clay, and a little magneſia. Theſe two laſt ſubſtances, as well as iron, ſeem to be only accidental in the vitreous ſpar. The cruſt depoſited by the ſparry acid is neither fuſible nor ſoluble in acids, and forms a white and durable glaſs with fixed alkalis. Theſe facts ſhew, that it is of a quartzoſe nature, and alſo that it is impoſſible to diſtill a large quantity of this acid at once. I have ſeveral times attempted to decompoſe a pound of vitreous ſpar, but found the retort capable of withſtanding the corroſive acid.

The nitrous acid decompoſes fluor ſpar, but with very different phenomena from thoſe which attend the vitriolic acid, no cruſt being obſerved in this operation, according to Boulanger: this experiment has not been repeated and examined.

The marine likewiſe ſeparates the ſparry acid, according to Scheele; but he has not deſcribed the phenomena which attend this decompoſition.

The action of moſt neutral ſalts on vitreous ſpar is not known; cretaceous fixed alkalis decompoſe it by double affinity, which the pure alkalis cannot effect. One part of this ſpar being fuſed with four parts of cretaceous tartar, and poured hot into water, a precipitate of chalk, formed by the cretaceous acid united to the lime of the ſpar, is obtained; and the fluid holds in ſolution ſparry tartar, which may be obtained, by evaporation, in the form of a jelly. When the experiment is repeated with cretaceous ſoda, chalk and ſparry ſoda are in like manner obtained.

Vitreous, or fluor ſpar, is of no uſe, excepting in ſome mineral countries, where it is uſed as a very good flux. It might be applied to the ſame purpoſe in aſſays.

Species VI. CHALK; CRETACEOUS SPAR; CALCAREOUS MATTERS IN GENERAL.

Calcareous ſpar, or pure chalk, is a neutral ſalt, formed by the union of cretaceous acid with lime. This ſubſtance has been arranged among ſtones by naturaliſts, becauſe they did not perceive that it has any ſaline properties. We ſhall, however, find that it has a kind of taſte, is ſoluble in water, and in its analyſis affords a large quantity of cretaceous acid, and the ſalino-terreſtrial ſubſtance already deſcribed under the name of lime. As calcareous ſpar is the laſt modification of a ſubſtance which exiſts in a great variety of forms, and paſſes through many ſtates before it is regularly cryſtallized, it is neceſſary to conſider calcareous or cretaceous ſubſtances in general.*

No part of natural hiſtory exhibits a more extended field for the imagination to trace,

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* The ſubſtances uſually called calcareous in natural hiſtory, ought, in my opinion, to be called cretaceous; this laſt term denoting the ſaline neutral combination formed by the union of lime and cretaceous acid; that is to ſay, chalk, creta. The ſecond property belongs to the lime, calx, which forms the baſe of this ſalt. The expreſſion, calcareous earth, or calcareous matter, ought, therefore, to be appropriated to quick-lime; and the term, cretaceous, or chalky matter, will diſtinguiſh the combination of lime with the acid of chalk. Note of the Author.

or a more complete ſeries of well-eſtabliſhed facts, than that which relates to calcareous bodies. Long continued obſervation, which has in no inſtance failed, together with the facts which ſhew the ſucceſſive operations of nature in this reſpect, have proved, that the bed of the ocean is the great laboratory in which theſe matters are continually formed. Among the great number of animals which inhabit thoſe immenſe maſſes of water, there are ſeveral claſſes whoſe individuals, infinite in number, ſeem deſtined to add to the maſs of our globe: ſuch are the ſhell-fiſh, madrepores, and lithopites, whoſe ſolid parts, examined by chemical analyſis ſome time after they have ceaſed to live, exhibit all the characters of calcareous ſubſtances. It is the baſe of this kind of marine ſkeletons, which produces, by their ſucceſſive aggregation, mountains intirely formed of theſe matters. Though the cryſtallization of calcareous ſpar is very far from reſembling the natural ſoft ſtate of theſe animals when living; and though it is difficult at firſt to eſtimate the aſtoniſhing difference between the ſoft and pulpy ſubſtance of the living animal, and the hardneſs of the ſtony ſubſtances which are formed in proceſs of time, and calculated to give ſolidity to the largeſt edifices, it is nevertheleſs poſſible to form an idea of the gradations through which the one muſt paſs, before it aſſumes the ſtate and properties of the other. The following ſketch will exhibit theſe gradations, from the time of the action of the animal organization, to that of the regular depoſition, by which tranſparent ſpar is ſlowly formed.

The waters in the ſea, librating according to laws yet unknown to us, are inſenſibly diſplaced, and change their bed; they quit one coaſt, which gradually encroaches on the ſea, while they advance on another, whoſe extent is diminiſhed in the ſame proportion: this fact is proved in Buffoon's learned Theory of the Earth. In proportion as the waters quit one part of their bed, they leave the bottom uncovered, on which their various motions, ſo well deſcribed by this celebrated writer, have formed beds, by the ſucceſſive depoſitions of ſolid matter, or the ſkeletons of marine animals. Theſe ſtrata are almoſt intirely filled with ſhells, whoſe animal gluten has been deſtroyed by putrefaction, and which, having loſt their colour, poliſh, and conſiſtence, are become friable and earthy, and have paſſed into the ſtate of foſſils. Hence the production of earths and ſtones containing ſhells.

Theſe ſtones, by the action of the rain waters, gradually loſe the organic form, become more and more friable, and form a ſubſtance of a texture ſcarcely conſiſtent, which is called chalk. When a ſtone, compoſed

poſed of ſhells, has acquired ſufficient hardneſs to be capable of poliſh, and when the ſhells have become variouſly coloured, it then conſtitutes the lumachello. If the traces of organization are intirely deſtroyed, and the ſtone be hard and ſuſceptible of poliſh, it is diſtinguiſhed by the name of marble. Water, impregnated with chalk, depoſits it on ſuch bodies as it paſſes over, and forms incruſtations. When it filters through the roofs of ſubterraneous cavities, it forms white opake depoſitions, compoſed of concentric layers, whoſe figure on the whole is conical. Theſe ſtalactites, if united together in large maſſes, and perfectly filling up the caverns, remain a long time in the earth; they acquire conſiderable hardneſs, and produce alabaſter. Laſtly, when water, holding in ſolution chalk in the moſt attenuated ſtate, ſlowly penetrates into the cavities of rocks, it will depoſit this ſubſtance, particle by particle, as it were; and theſe ſmall bodies, being applied to each other by the ſurfaces beſt adapted to unite, will take a ſymetric and regular arrangement, and form hard tranſparent cryſtals, ſimilar to thoſe of ſaline ſubſtances: theſe are calcareous ſpars. This ſtate is the laſt, or moſt remote from its animal origin, in which chalk is found, and in which it has the greateſt reſemblance to a true ſalt.

Theſe various and numerous tranſitions of of the cretaceous ſubſtance, (the conſideration of which affords the greateſt inſtruction to the naturaliſt, concerning the antiquity of the globe, its alterations, and the extent of the animal kingdom, whoſe ſubjects conſtitute a vaſt portion of its ſurface and external ſtrata,) preſent only to the eyes of the chemiſt one ſingle and identical neutral ſalt, formed of lime and cretaceous acid. We ſhall proceed to conſider the ſubject in both points of view.

§ I. The natural hiſtory of calcareous ſubſtances.*

Before we enter into a particular account of calcareous matters, it will be proper to take a general view of their diſpoſition in the earth. Theſe ſubſtances form beds of greater or leſs extent, horizontal or inclined, which appear manifeſtly to have been formed by the action of waters. Theſe beds compoſe whole mountains, hills, &c. and form a great part of the external covering of the globe. They prove that the waters of the ſea have formerly covered the earth, and have depoſited an immenſe quantity of

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* Though we have already, in the Hiſtory of Earths and Stones, exhibited the methodical diviſions of calcareous ſubſtances, uſually diſtributed in this claſs by naturaliſts, yet we think it proper, in this ſection, to exhibit them under another arrangement, which refers to conſiderations different from thoſe by which the compilers of Nomenclatures in general are guided. Note of the Author.

the exuviæ of their inhabitants. The rain waters, filtering through theſe calcareous maſſes, carry a portion along with them, which they diſtribute at greater depths, in ſubterraneous cavities, under the different forms we ſhall proceed to examine.

Their general characters, as given by naturaliſts, are highly uſeful to diſtinguiſh them, and are founded on two remarkable properties: their not giving fire with ſteel, and their effervefcence with acids. As it is evident, from what has been already ſaid, that the form of calcareous matters is conſiderably varied, it is indiſpenſably neceſſary to divide them into ſeveral genera. We admit ſix.*

Genus I. EARTHS AND STONES CONTAINING SHELLS.

Theſe ſubſtances have been arranged among ſtones, becauſe they have no apparent degree of taſte or ſolubility; but their analyſis ſhews that they are truly ſaline, as well as the other genera which follow.† They are known

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* It may perhaps be thought ſtrange, that a diviſion of genera ſhould be made in the hiſtory of one ſpecies of ſalt; but it muſt be obſerved, that theſe genera relate only to natural hiſtory, and that in fact they are referable to the ſpecies of neutral ſalt, whoſe chemical properties we examine. Note of the Author.

† Though theſe ſubſtances are truly ſaline, yet the names of earths and ſtones, which they have received, ought

known by the organic form of the ſhells they contain; theſe are often intire, ſo that the ſtone itſelf is merely a maſs of ſhells: the original colours partly remain in ſome ſpecimens. Among the animals whoſe exuviæ exiſt in this ſtate, ſeveral are obſerved which are extinct, or no longer found living in the ſea; ſuch as many ſpecies of cornua-ammonis, and nautili. On the other hand, foſſil ſhells are found in France, and other parts of Europe, the living individuals of which are found only in America. Some naturaliſts have made very extenſive diviſions of foſſil ſhells; but as they reſemble thoſe of the living animals, we ſhall ſpeak of them in another part of our work.

Many other animal ſubſtances are likewiſe found among calcareous earths. When theſe manifeſtly appear to have belonged to known animals, they are then diſtinguiſhed by a name relative to their origin, and commonly formed out of the claſs of animals to which they belong, adding another name, which denotes their ſtony nature; ſuch as madreporites, &c. But it muſt be obſerved, that

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ought to be ſcrupulouſly preſerved, becauſe, as Mr. Daubenton obſerves, names are public property, which it is not lawful to infringe. If the learned world had univerſally poſſeſſed the diſcretion of this eminent naturaliſt, the ſciences, and more eſpecially natural hiſtory, would not have intimidated beginners, as is ſometimes the caſe, by the magnitude of the nomenclature. Note of the Author.

the bones of men, quadrupeds, birds, and fiſhes, which are dug out of the earth, and are known by the name of foſſils, are not of a calcareous nature, but preſerve the nature of phoſphoric calcareous ſalt: ſo that the ornitholithes, the ichthyolithes, &c. muſt not be arranged among cretaceous ſubſtances.

There are many foſſil organic ſubſtances, whoſe origin is not known; theſe are named from their form, ſuch are the lapides Judaici, which ſome think are the ſpiculæ of ſea hedge-hogs; the lapides numiſmales, reſembling pieces of money, and which appear to be ſmall cornua-ammonis applied upon each other; foſſil-bezoar, a kind of round maſs or concretion in concentric layers; the ludus Helmontii, whoſe ſpaces ſeem to have been formed by the drying and ſhrinking of an earthy ſubſtance, which afterwards became filled with calcareous earth. The trochites, entrochi, and aſtroites, which are produced from a zoophite named ſea-palm; the piſolites, oolites, or meconites, which are thought to be petrified fiſhes eggs or inſects, but whoſe true origin is unknown.

As all petrified ſubſtances, whatever animals they may have belonged to, have been referred to this genus of ſtones, which are truly calcareous; natural hiſtory likewiſe enumerates in this place gammarolites, cancrites, entomolites, amphibiolites, zoolites, antropolites: But ſince the new diſcoveries concerning

cerning the nature of bones, theſe matters can no longer be referred to cretaceous ſubſtances, as we have already pointed out. The ſame obſervation may be made reſpecting the gloſſopetræ, or petrified ſharks teeth, ivory or foſſil unicorn, which is produced from elephants teeth; turquoiſe, or bones coloured green and blue; toad-ſtones; grey or yellow and hollow ſtones, which, according to Mr. Juſſieu, are the upper parts of the grinders of the Brazilian fiſh called Grondeur; and the ſerpents eyes, which, according to that naturaliſt, are the inciſive teeth of the ſame fiſh.

After this previous explanation, the preſent genus may be reduced to two ſpecies, containing every poſſible variety.

Species

1. Entire ſhells or foſſils.

Theſe are diſtinguiſhed by different circumſtances of colour, brilliancy, hardneſs, &c. In this ſpecies are comprehended madrepores, and all the habitations of polypi in the foſſil ſtate.

2. Falun, or cron.

Shells broken, and in the form of earth. The ſoil of Tourain, and ſeveral other provinces of France is entirely of this nature. It is uſed as an excellent manure.

Genus II. CALCAREOUS EARTHS AND STONES.

They are formed out of the ſubſtances of the firſt genus worn down and depoſited by waters. They are found diſpoſed in beds or ſtrata within the earth. We ſhall follow Mr. Daubenton in the diſtinction of the different kinds.

Species

1. Compact calcareous earth; chalk.

Its colour and grain are various; it is employed for many domeſtic purpoſes.

2. Spungy calcareous earth; ſtone-marrow.

3. Calcareous earth in powder; foſſil flour.

4. Calcareous earth of the conſiſtence of cream; lac-lunæ.

5. Soft calcareous earth; tufa.

It hardens and becomes white by drying.

6. Calcareous earth in large grains.

The earth of Arcueil is an inſtance of this; it contains ſhells broken to pieces.

7. Fine grained calcareous earth.

The thunder-ſtone is a variety of this.

Without entering into uſeleſs details, it may eaſily be imagined that the hardneſs, and the ſeveral uſes to which theſe earths and ſtones are applied, afford names to a great number of varieties. In general they ſerve to to make lime, and for other uſes in the conſtruction of edifices.

Genus III. MARBLE.

Marbles differ from calcareous ſtones properly ſo called, in being rather harder; like them they efferveſce with acids, have a granulated fracture, and do not give fire with ſteel; but their grain is much finer and cloſer, their colours more brilliant, and they take a better poliſh. Every one is acquainted with the uſe of marble in ſculpture, architecture, &c. It is likewiſe uſed in ſome countries to make lime.

Species

1. Lumachello.

This name is given by the Italians to marble compoſed of agglutinated ſhells.

2. Breccias.

This marble is compoſed of ſmall round maſſes bedded in a cement of the ſame nature.

3. Marble properly ſo called.

Neither the ſhells nor the lumachellos, nor the round maſſes of the breccias are found in this; its ſpots are irregular, and it is often veined. Mr. Daubenton arranges marbles according to the number and combination of their colours, and includes the lumachellos and the breccias under the ſame denomination.

1. Marble of ſix colours; for example, white, grey, green, yellow, red, and black. Marble from Wirtemberg.

2. Marble of two colours; for example, white and grey. Marble from Carrara.

3. Marble of three colours; for example, grey, yellow, and black. Lumachello.

4. Marble of four colours; for example, white, grey, yellow, and red. Brocatello of Spain.

5. Marble of five colours; for example, white, grey, yellow, red, and black. Breccia of Old Caſtile.

Species

4. Figured marble.

It repreſents ruins, as in the marble of Florence; or plants, as in the Heſſian marble.

It muſt be obſerved that the colours of marble depend almoſt always on iron interpoſed between its grains. This ſtone, though ſuſceptible of a good poliſh, is very porous. It is well known how eaſily it is ſtained, and on this property is founded the art of drawing coloured flowers on marble.

Marble is often mixed with fragments of hard ſtone, ſuch as quartz, or ſilex, in which caſe it gives fire with ſteel at that part. I have frequently obſerved this character in ſeveral ſpecies of black marble.

Genus

Genus IV. CONCRETIONS.

Concretions are formed irregularly by a depoſition of calcareous matter by water on the ſurfaces of bodies. They are not diſpoſed in large beds, but by fragments in maſſes, at firſt ſeparate, which gradually growing larger, join, and become confounded together.

Species

1. Incruſtations.

Waters loaded with chalk depoſit it on the ſurface of all bodies over which they flow. Incruſtations may therefore have every poſſible form, according to the ſubſtance which has ſerved as a nucleus. Such are thoſe ſpecimens from the waters of Arcueil; ſuch likewiſe is Oſteocolla, &c.

2. Stalactites.

They are formed ſlowly, and by concentric layers depoſited by waters at the vaults of caverns, &c. They vary in magnitude, tranſparency, grain, colour, and form; they are in general pyramidical and hollow. The flos-ferri is the pureſt of all. When they are adherent to the ſides of ſubterraneous cavities they are called congelations; when they ſtand on the floor of the cavern, they are denominated ſtalagmites.

3. Alabaſter.

Alabaſter appears to be formed by the pureſt

reſt ſtalactites, after remaining long in the earth; it is not ſo hard as marble, and when it is poliſhed, its ſurface appears greaſy and oily; it is manifeſtly compoſed of layers which have different directions; it has always an imperfect tranſparency, which diſtinguiſhes it from marbles, but it is never ſo clear as ſpars. It is formed into vaſes and ſtatues; many varieties of this ſubſtance may be diſtinguiſhed.

Varieties.

1. Oriental alabaſter.

It is the moſt tranſparent and the hardeſt.

2. Occidental alabaſter.

Leſs beautiful and pure than the foregoing.

3. Alabaſter ſpotted with different colours.

4. Wavy alabaſter.

It is likewiſe called alabaſter of agate.

5. Alabaſter repreſenting figures of herbs.

Genus V. CALCAREOUS SPAR.

Calcareous ſpar differs from the four preceding genera by its form, which is commonly regular, and eſpecially by its fracture. It conſiſts of laminæ applied on each other, as evidently appears from its fracture; it crumbles when ſtruck with a ſteel.

Species

1. Opake calcareous ſpar.

It is white, or variouſly coloured, and uſually in the form of rhomboidal plates.

2. Tranſ-

2. Tranſparent rhomboidal calcareous ſpar; Iceland cryſtal.

It doubles objects.

3. Priſmatic calcareous ſpar, without pyramids.

Theſe are truncated hexahedral priſms, whoſe faces are either equal or unequal, and whoſe angles are ſometimes truncated in ſuch a manner as to form twelve-ſided priſms. It conſequently has three varieties.

4. Calcareous ſpar in priſms, terminated by two pyramids.

There is a conſiderable number of varieties of this ſpar. Some are hexahedral priſms, terminated by hexahedral pyramids, either entire or truncated. Others preſent trihedral pyramids, either entire or truncated, or with dihedral ſummits, at the extremity of the ſame hexahedral priſms. Laſtly, there are quadrangular priſms terminated by dihedral ſummits. All theſe varieties may have either one or two pyramids according to their poſition.

5. Pyramidal calcareous ſpar.

This is compoſed of one or two pyramids united without an intermediate priſm; the hexahedral or triangular form of theſe pyramids, the inequality of their faces, and the truncature of their angles, eſtabliſh a great number of varieties.*

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* An idea of the varieties of form diſtinguiſhable in ſpars, and of the great number of ſpecies thence reſulting, may be had by conſulting the Engliſh work of Dr. Hill, entitled the

6. Dodecahedral calcareous ſpar.

This ſpar, which in its figure reſembles a kind of garnet or marcaſite, appears to be compoſed of two pentagonal pyramids, truncated and united at their baſe.

7. Calcareous ſpar in ſtriæ.

This is an aggregate of long priſms adhering ſide-ways, which do not preſent any determinate or regular form. The ſwineſtone of the Swedes belongs to this ſpecies.

8. Lenticular calcareous ſpar.

This ſpecies is compoſed of flat cryſtals diſpoſed obliquely beſide each other. Romé de Liſle thinks it a variety of the hexahedral priſmatic ſpar, terminated by two obtuſe triangular priſms placed in oppoſite directions. Cryſtallographie, page 123. firſt edition.

§ II. Concerning the Chemical Properties of Spar, and Calcareous Matters in general.

The ſpar we have deſcribed being the moſt pure cretaceous, or calcareous ſubſtance we know, muſt be adverted to in our inquiries into the chemical properties of the ſub-

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the Hiſtory of Foſſils, &c. London, 1748. Romé de Liſle has given an extract in the firſt edition of his Cryſtallography, page 131, and ſeq. page 191, and ſeq. relative to calcareous ſpar and rock cryſtal. He ſhews that Dr. Hill's method is defective and embarraſſing. Note of the Author.

ſtances

ſtances among which it poſſeſſes the firſt place; at the ſame time obſerving, that all the calcareous matters deſcribed in the five foregoing genera, preſent abſolutely the ſame properties in ſimilar circumſtances.

In order to analyze calcareous ſpar, its aggregation muſt be firſt deſtroyed by reducing it to powder. In this form it is white and opake, and has no ſenſible taſte, though it ſeems to contract or harden the fibres of the tongue and palate, when kept for ſome time in the mouth.

When expoſed to the action of heat, it loſes its acid and water of cryſtallization; if ſuddenly heated, it decrepitates, and becomes opake. By diſtillation in a retort, much water and cretaceous acid is obtained; but a conſiderable heat is required to diſengage the latter. After this operation, the ſpar is reduced to the ſtate of quick-lime; and the ſpar may be regenerated by combining quick-lime with the acid obtained in this decompoſition. A diſtillation of chalk, which does not differ from calcareous ſpar, except in its friability and its opacity, has been made by Mr. Jacquin. The Duc de la Rochefoucauld, who repeated this experiment with great care, obſerved, that ſtone-ware retorts ſuffer a part of the gas to eſcape. Dr. Prieſtley has eſtabliſhed this fact by many very accurate experiments. A retort of iron, or gun barrel, may be uſed; but a ſmall quantity of inflammable

inflammable gas is always produced by the action of the water contained in the chalk upon the iron.

Calcareous ſpar, expoſed to a ſtrong heat in crucibles made of clay, is capable of flowing into glaſs, where it touches the veſſel. Mr. D'Arcet has melted ſeveral pieces into a tranſparent glaſs, with a few ſpots. But as Macquer has obſerved that this earthy ſalt did not melt in the focus of Mr. Trudaine's burning lens, it cannot be doubted but that the fuſion obtained by Mr. D'Arcet was produced by the clay of the crucibles.

Calcareous ſpar is not altered by expoſure to pure air; but the contact of the humid atmoſphere, together with the action of the ſun's rays, deprive it of its tranſparency, and deſtroy the coheſion of its laminæ. Its ſurface takes the colours of the rainbow, grows dim, and ſplits off by degrees. It does not appear to be ſoluble in water. Chalk, which cannot by art be diſſolved in this fluid, is nevertheleſs held in ſolution by waters which paſs over beds of cretaceous ſubſtances: ſome waters, ſuch as thoſe of Arcueil, in the neighbourhood of Paris, contain a conſiderable quantity; ſo that in the ſpace of a few months bodies plunged therein become incruſted. The waters of the baths of St. Philip, in Italy, are ſo highly charged with this ſubſtance, that they depoſit it to the thickneſs of about half an inch in the ſpace of a few days.

days. This property is applied to the formation of ſmall tablets and figures; moulds are plunged in theſe waters, and the chalk is depoſited on their internal ſurface.

Calcareous ſpar promotes the vitrification of ſome earthy and ſtony ſubſtances. Mixed with ſiliceous earth, it cauſes fuſion, when the latter is in the proportion of one-third.

Chalk, when naturally mixed with argillaceous earth, forms the ſubſtance called marle. This ſubſtance preſents a great number of varieties, with reſpect to colour, denſity, &c. and melts into a greeniſh yellow glaſs, when urged by a ſtrong heat. It is uſed with great ſucceſs as a manure to fertilize lands.

Ponderous earth and magneſia have no action on calcareous ſpar, by the humid way, the cretaceous acid adhering more ſtrongly to the lime than to either of theſe; but calcareous ſpar, treated by fire with theſe alkaline earths, forms a vitreous combination. Mr. Achard has made a numerous ſeries of experiments on all theſe mixtures by vitrification; accounts of which are inſerted in Rozier's Journal.

Fixed and volatile alkali do not affect calcareous ſpar, their affinity with cretaceous acid being leſs than that of lime.

The vitriolic, nitrous, marine, and ſparry acids decompoſe it, by ſeizing its baſe, and diſengaging the cretaceous acid. If ſpirit of vitriol

vitriol be poured on calcareous ſpar, an ebullition is excited, which ariſes from the diſengagement of the cretaceous acid in the gaſeous form. Naturaliſts avail themſelves, with great ſucceſs, of this chemical character, to diſtinguiſh calcareous ſubſtances. An exact analyſis of calcareous ſpar may be made by acids. For that purpoſe ſpirit of vitriol is poured on this ſalt, firſt reduced to powder. The cretaceous acid, which eſcapes with effervеſcence, may be collected by means of a recurved tube, under veſſels of mercury. The effervеſcence is accompanied with cold, ariſing from the volatilization of the cretaceous acid. When the proceſs is finiſhed, if the new combination be examined, it is found to be ſelenite, formed by the vitriolic acid united to the lime which compoſed the baſe of the calcareous ſpar. Recent experiments have ſhewn, that ſome of theſe ſpars contain a ſmall proportion of magneſia, and afford Epſom ſalt when diſſolved in the vitriolic acid. The nitrous acid, which naturaliſts commonly employ in their aſſays, produces the ſame effervеſcence; when dropped on calcareous ſpar, it diſengages the cretaceous acid, and forms calcareous nitre with its baſe.

The marine acid likewiſe ſeparates the calcareous acid from this ſpar with violent effervеſcence, and forms calcareous marine ſalt by combining with the lime.

The

The ſparry acid decompoſes it in the ſame manner, and forms vitreous ſpar, or ſparry fluor, with its calcareous baſe.

The ſedative acid, or acid of borax, does not decompoſe calcareous ſpar in the cold, but it produces an efferveſcence when mixed with chalk in powder, diluted with a ſufficient quantity of water, and expoſed to heat.

The cretaceous acid has the property of rendering ſpar and calcareous matters ſoluble in water. We have already ſeen, in treating of this acid, that it precipitates lime-water, and that the chalk is re-diſſolved, if more cretaceous acid be added than is ſufficient to produce this effect. The acid ſpirit of chalk, by remaining on calcareous ſpar in powder, becomes gradually charged with a certain quantity of this earthy neutral ſalt. Many waters contain chalk diſſolved by the medium of this acid; but it ſoon precipitates, when the acid is ſuffered to eſcape by expoſure to air. This effect is much more quickly produced by the action of heat; and for that reaſon boiling is ſucceſsfully employed to correct waters loaded with chalk, which, without this precaution, would be crude or hard.

As chalk is almoſt always ſuſpended by means of the cretaceous acid, it is therefore eaſily ſeen why it ſo readily precipitates, and cauſes calcareous depoſitions and incruſtations,

tions, as we have obſerved of the waters of Arcueil, and the baths of St. Philip in Italy. When natural hiſtory was leſs enlightened by chemiſtry, ſprings of this kind were called petrifying waters, and were by the vulgar reckoned among the number of miracles.

Calcareous ſpar has no action on neutral ſalts with baſe of fixed alkali. It decompoſes ammoniacal ſalts, as does likewiſe chalk. A calcareous ſalt, formed by the acid of the ammoniacal ſalts and the lime of ſpar, and alſo cretaceous ammoniacal ſalt, ariſing from the combination of the acid of the calcareous ſpar with the volatile alkali of the ſal ammoniac, are obtained. This operation is made, by diſtilling in a ſtoneware retort, a mixture of one pound of ſal ammoniac, and two pounds of chalk or cretaceous ſpar, in powder. Theſe two ſubſtances muſt be very dry. A receiver or cucurbit of glaſs is adapted to the retort, and the fire is gradually raiſed to a low red heat. White vapours paſs over, which condenſe in very white and pure cryſtals on the ſides of the receiver. This appears to be the proceſs uſed in England for preparing the cretaceous ammoniacal ſalt, which was formerly exported from thence to every part of Europe, under the name of ſal volatile; but at preſent it is prepared every where. The reſidue of this operation is calcareous marine ſalt,

ſalt, which is uſually melted, if a briſk heat be given towards the end.

The uſes of ſpar, and calcareous matter in general, are very extenſive, as we have already ſhewn in treating of their natural hiſtory; but one of the moſt important of theſe uſes is, the preparation of lime. The burning of lime conſiſts in decompoſing calcareous matters by the action of heat, which deprives them of their acid. Stones compoſed of ſhells, marbles, and moſt calcareous ſpars, are the ſubſtances which afford the beſt lime. But the hard calcareous ſtone, called limeſtone, is more commonly uſed, eſpecially in the neighbourhood of Paris. Theſe ſtones in France are arranged in a furnace, or kiln, ſo as to form a kind of vault, beneath which a wood fire is lighted, and kept up till a ſtrong flame, without ſmoke, is raiſed about ten feet above the furnace, and till the ſtones become very white. Pit coal begins to be uſed at Paris for the burning of lime.

Good lime is hard, ſonorous, becomes quickly and ſtrongly heated by the addition of water, and emits a denſe vapour during its extinction. If it be not ſufficiently calcined, it is leſs ſonorous, and heats ſlowly: if the calcination has been too great, it is ſemi-vitrified, emits too clear a ſound when ſtruck, and does not eaſily unite with water. The workmen call it over-burned lime. We ſhall not here enumerate the uſes of lime, but

but refer the reader to the hiſtory of that pure ſubſtance.

But we ſhall here add, that ſuch calcareous ſpar as is naturally found mixed with very ſmall fragments of ſelenite, or gypſum, and which is depoſited in mountains in large regular ſtrata, ſeparated by clay and marle, as is obſerved in the vicinity of Paris, conſtitutes the moſt uſeful lime-ſtone for building. Though we have already ſpoken of this article under the head ſelenite, we think it proper to reſume the ſubject in this place rather at length, becauſe all treatiſes of natural hiſtory, and of chemiſtry, are deficient in this reſpect. It muſt be recollected, that pure ſelenite, by calcination, affords only fine plaſter, which makes an incoherent paſte with water, and is employed to caſt ſtatues. Every one knows how eaſily this paſte is broken when dry; a circumſtance which depends on the maſs being alike throughout. This is not the caſe with ſuch plaſter as is proper for building. The ſtone which affords it at Montmartre, and other places, is a kind of breccia, formed of very ſmall granulated cryſtals of ſelenite, together with thin laminæ of calcareous ſpar: the preſence of the latter may be aſcertained by a drop of nitrous acid applied to the ſtone, which diſengages the cretaceous acid with a ſtrong efferveſcence. When a given quantity of the plaſter ſtone of Montmartre is diſſolved

in

in aqua-fortis, all the calcareous ſpar is decompoſed, in proportion as the lime unites with the nitrous acid. The ſelenite, which is not ſoluble in this menſtruum, remains behind. The relative qualities of calcareous ſpar and ſelenite in different plaſter ſtones may thus be found; and experience ſhews, that the beſt plaſter ſtone contains more than half its weight of the ſpar.

The mixed nature of the plaſter ſtone being admitted, it is eaſy to account for the phenomena exhibited in its burning, its extinction, and its hardening. When this earthy ſalt is burned, the ſelenite loſes its water of cryſtallization, and becomes friable; the calcareous ſpar, at the ſame time, being converted into lime by the loſs of its acid. In this ſtate, the well burned plaſter is acrid and alkaline; converts the ſyrup of violets to a green; becomes hot with acids without effervеſcence; and loſes its goodneſs by expoſure to air, in proportion as the lime is extinguiſhed by attracting humidity and cretaceous acid from the atmoſphere. It abſorbs water with avidity; and with regard to the ſolidity it ſo ſuddenly takes, which is a property oppoſite to thoſe of pure lime, it ariſes from the circumſtance, that when the quicklime has abſorbed as much water as is neceſſary for its extinction, the ſelenite, which is interſperſed between its particles, cryſtallizes ſuddenly, and produces the ſame effect as ſand

ſand in mortar, by giving ſolidity to the whole.

Laſtly, from this theory it is known, why plaſter may be well preſerved in a hot and dry place, but is quickly deſtroyed by humidity. The ſolubility of its two ſaline principles in water is the cauſe of this phenomenon.

CHAPTER VIII.

Genus IV. NEUTRAL SALTS, WITH BASE OF MAGNESIA, OR MAGNESIAN NEUTRAL SALTS.

WE have already obſerved, in the hiſtory of acids, that magneſia readily combines with thoſe ſalts, and forms ſaline compounds different from thoſe which contain other baſes. Theſe ſalts are not yet perfectly known, few chemiſts having paid particular attention to them. The celebrated Dr. Black is the firſt who made a proper diſtinction between theſe ſalts and other terreſtrial-ſaline bodies, with which they were before confounded.

Magneſian ſalts poſſeſs generic characters ſufficient to diſtinguiſh them. They are almoſt all bitter and ſalt; the greateſt part cryſtallize

cryſtallize regularly, though with difficulty; in general they are very ſoluble in water, ſome even attracting the humidity of the air; and they are more eaſily decompoſed than ammoniacal and calcareous ſalts. Ponderous earth, lime, volatile alkali, and the two fixed alkalis, deprive them of their acid.

Theſe ſalts are ſix in number; namely, magneſian vitriol, or Epſom ſalt, magneſian nitre, magneſian marine ſalt, magneſian borax, magneſian fluor, and magneſian chalk.

Species I. MAGNESIAN VITRIOL, OR EPSOM SALT.

The neutral ſalt, compoſed of magneſia, united to the vitriolic acid, has been called Epſom ſalt, from the name of a ſpring in England from which it was formerly obtained: it exiſts likewiſe in the waters of Egra, Sedlitz, and Seydſchutz. Its true name is magneſian vitriol; Bergman calls it vitriolated magneſia.

This ſalt has a very bitter taſte, and on that account has been called ſal catharticus amarus: it is met with in commerce in the form of very ſmall needles, terminated by acute pyramids; in this ſtate it much reſembles Glauber's ſalt, but its taſte is more bitter. It does not effloreſce in the air; and its regular cryſtallization is very different from that which we have juſt deſcribed.

By ſpontaneous evaporation, it is obtained in fine quadrangular priſms, terminated by quadrangular pyramids, all the ſurfaces being ſmooth and without furrows; its cryſtals in general are ſhorter and larger than thoſe of Glauber's ſalt; and it likewiſe differs from that perfect neutral ſalt in all its other properties.

Epſom ſalt retains a ſufficient quantity of the water of cryſtallization to admit the aqueous liquefaction. A very ſlight heat is ſufficient to melt it; and it congeals, by cooling, into a maſs of no determinate form. Continued application of heat dries it into a white friable maſs, which is merely the ſalt deprived of its water of cryſtallization: it does not experience the true igneous fuſion but by an extreme heat. The water of cryſtallization in Epſom ſalt is nearly half its weight.

Macquer and other chemiſts affirm, that it becomes ſlightly moiſtened by expoſure to air, and that it may be thereby diſtinguiſhed from Glauber's ſalt, which effloreſces. But Bergman on the contrary affirms, that Epſom ſalt, expoſed to a dry air, loſes its tranſparency, and is at length reduced into a white powder; and he affirms, that the ſalt ſold in the form of ſmall needles, is humid and deliqueſcent, on account of the magneſian marine ſalt it contains. Mr. Butini, citizen of Geneva, to whom we are indebted for

for a ſeries of valuable inquiries concerning magneſia, affirms, that he found in Engliſh Epſom ſalt, a ſufficient quantity of Glauber's ſalt, to which the efflóreſcence might be attributed; but that vitriol of magneſia, well purified, though its tranſparency is diminiſhed by expoſure to air, is very far from effloreſcing like Glauber's ſalt, which is intirely reduced to powder at the end of a ſhort ſpace of time.

Epſom ſalt is ſo ſoluble in water, that no more than twice its weight of cold, or half its weight of hot water, are required to hold it in ſolution. It cryſtallizes by cooling; but very regular cryſtals can only be produced by ſpontaneous evaporation.

This ſalt is not altered by ſiliceous or argillaceous earths.

Ponderous earth decompoſes it, becauſe its affinity to the vitriolic acid is greater than that of magneſia.

Lime decompoſes it for the ſame reaſon. If a ſmall quantity of Epſom ſalt be added to lime-water, or if the latter be added to a ſolution of the ſalt, a precipitate is formed, conſiſting of magneſia and ſelenite; this precipitation is a diſtinctive character, by which magneſian vitriol may be known from Glauber's ſalt.

Pure alkalis likewiſe decompoſe Epſom ſalt. The cauſtic volatile alkali decompoſing this ſalt, and having no effect on ſelenite,

nite, is a proof that it has a ſtronger affinity than magneſia, and a weaker than lime, with the vitriolic acid: it may therefore ſerve as a teſt of the preſence of Epſom ſalt in waters. Hence, likewiſe, pure magneſia is obtained, by means of the cauſtic volatile alkali. Bergman obſerves, that pure volatile alkali does not completely precipitate the magneſia from Epſom ſalt, but that part remains undecompoſed. The liquid holds in ſolution ammoniacal, vitriol, and Epſom ſalt; ſome chemiſts have imagined, that theſe two ſalts, combining together, formed a triple ſalt, or compound of an acid united to two baſes: but there is a manifeſt error in this opinion; for though theſe ſalts are found in the ſame water, one conſiſts of the vitriolic acid united to volatile alkali, and the other of the ſame acid combined with magneſia. Each has a portion of acid; and it is not one and the ſame acid which adheres to the two baſes, a condition abſolutely neceſſary to conſtitute a true triple ſalt.*

The action of Epſom ſalt on neutral ſalt, with baſe of alkali, is not yet known; it is

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* The ſeparation of ſalts by cryſtallization ſeems to be the only method of aſcertaining whether theſe compounds of more than two principles exiſt or not. In ſuch caſes as they do exiſt, it becomes a queſtion, as for example, in the preſent, whether the three principles be united together as primary component parts, or whether two of them be united ſo as to form a ſecondary principle, to which the other unites, &c. T.

probable that it may decompoſe nitrous and marine ſalts of theſe genera by double affinity.

Mr. Quartremer Dijonval affirms, in a letter to Mr. De Morveau (Roſier's Journal for May 1780) that when a ſolution of Epſom ſalt is added to a ſolution of vitriolic ammoniac, the Epſom ſalt is totally precipitated without decompoſition, in the form of cryſtals of conſiderable magnitude, which may be known by the taſte, &c. He attributes this effect to the vitriolic ſal ammoniac ſeizing the water from the Epſom ſalt, which he thinks cryſtallizable in this manner. We ſhall conſider this explanation in the hiſtory of magneſia and nitre.

It is certain, that Epſom ſalt and the cretaceous ſalts mutually decompoſe each other. When a ſolution of cretaceous tartar, or cretaceous ſoda, is poured into a ſolution of Epſom ſalt, a double decompoſition and combination take place; the vitriolic acid unites to the fixed alkalis, and the cretaceous acid, ſeparated from the latter, ſeizes the magneſia, and forms a neutral ſalt, known by the name of mild or effervescent magneſia. By this proceſs, the mild magneſia, uſed in medicine as an excellent mild purge, is prepared, as will be ſeen more at large at article magneſian chalk.

A ſolution of ſelenite, mixed with a ſolution of Epſom ſalt, affords a precipitation of of the latter, according to Mr. Dijonval: the precipitate is ſcarcely ſenſible on account of the ſmall quantity of ſelenite diſſolved in the water. Nitrous and marine calcareous ſalts decompoſe Epſom ſalt; but we do not think it proper to conclude with Mr. Dijonval, that the nitrous and marine acids have more affinity than the vitriolic acid with magneſia, as theſe experiments certainly depend on double affinity.

Bergman affirms, that a centenary of cryſtallized Epſom ſalt contains nineteen parts of pure magneſia, thirty-three of vitriolic acid, and forty-eight of water.

Epſom ſalt is employed in medicine with great ſucceſs; it is a very uſeful purge, and at the ſame time has an opening quality. It is even preferred to other purgative ſalts, on account of its great ſolubility; it is adminiſtered either alone diſſolved in water, in a doſe from one to two ounces, or as an auxiliary medicine in the quantity of one or two drachms. It mineralizes moſt natural purgative waters, eſpecially thoſe of Egra, Sedlitz, Seydſchutz, &c.

Species II. MAGNESIAN NITRE.

This combination of the nitrous acid with magneſia, called magneſian nitre, or nitrated magneſia, has been examined by Bergman. That illuſtrious chemiſt affirms, that a ſolution

tion of this ſalt made by art, affords, after proper evaporation, priſmatic, quadrangular, ſpathoſe cryſtals, without pyramids.

This ſalt has an acrid and very bitter taſte; it is decompoſed by heat, attracts the humidity of the air, and is very ſoluble in water. It cannot be obtained in cryſtals, but by a ſlow evaporation; and the laws of its cryſtallization are not yet ſufficiently known to enable us to obtain it with certainty in a regular form, as is done with a great number of other ſalts. It is decompoſed by ponderous earth, lime, and alkalis.

As magneſian nitre is diſſolved in the mother waters of nitre, Mr. de Morveau propoſes to obtain the magneſia in the large way, by precipitating it with lime-water. This proceſs might be very advantageous in point of facility and cheapneſs: but the ſame chemiſt aſſerts that lime-water precipitates pure calcareous nitre, as I have myſelf obſerved in many experiments; the magneſia obtained by this proceſs would not therefore have the requiſite degree of purity for ſo uſeful a medicine. This object requires continued attention, and a more minute explanation of its concomitant circumſtances, than the nature of this work admits of.

The vitriolic and fluor acids diſengage the nitrous from magneſia; ſedative ſalt likewiſe ſeparates it by the aſſiſtance of heat, in conſequence of its fixity: theſe properties of magneſian nitre were diſcovered by Bergman. Mr. Quartremer Dijonval, who has made inquiries into many combinations of magneſia, found ſome of the properties of magneſian nitre very different from thoſe attributed to it by the chemiſt of Upſal. He aſſerts, that he obtained cryſtals of magneſian nitre which do not deliqueſce; and even adds, that the magneſian ſalts are as cryſtallizable and effloreſcent, as the calcareous ſalts are greedy of moiſture.

The nitre of magneſia ſeems capable of decompoſing by double affinity the vitriolic ſalts, ſuch as vitriolated tartar, Glauber's ſalt, and vitriolic ammoniac; but theſe decompoſitions are not ſenſible in the mixture of the ſolutions of the different ſalts, as thoſe are which are effected with calcareous nitre: becauſe the common rhomboidal and ammoniacal nitres, as well as the Epſom ſalt, are all very ſoluble in water; while the ſelenite formed by the decompoſition of vitriolic ſalts by calcareous nitre, affords a very plentiful precipitate. The effect of theſe double affinities may however be ſeen by evaporating the fluid; the nitres formed by the combination of the alkalis, and the Epſom ſalt produced by the union of the vitriolic acid of the decompoſed ſalts, with the baſe of magneſian nitre, are by that means obtained.

Mr. Dijonval mentions a fact, which deſerves all the attention of chemiſts; it is the precipitation

precipitation of magneſian nitre by the addition of calcareous nitre. When tranſparent and very pure ſolutions of theſe two ſalts are mixed, the magneſian nitre is immediately depoſited in the cryſtalline form, without being at all decompoſed; the fluid retaining the calcareous nitre in ſolution. It is very ſingular that two ſalts, which when ſeparate had ſufficient water to hold them in perfect ſolution, ſhould when mixed exhibit the appearance of the precipitation and cryſtallization of one of them. Mr. Dijonval thinks, as we have already announced, that this depends on the ſtrong tendency of the calcareous nitre to unite with water; this ſalt, according to him, being capable of abſorbing a larger quantity of water than is neceſſary to hold it in ſolution, and the nitre of magneſia, on the contrary, tending ſtrongly to cryſtallize, the former immediately ſeizes the water which held the latter in ſolution; the magneſian nitre is of courſe precipitated in the cryſtalline form: this explanation does not, however, appear to remove all difficulties. How, in fact, can any ſalt, however ſoluble, or however ſtrong its diſpoſition to combine with water may be, ſeize the water from another ſalt, while itſelf is already united with a ſufficient quantity to hold it in ſolution?

If it be replied that it is not ſaturated with water, it ſhould be obſerved, that there will be a point of ſaturation at which

which calcareous nitre would ceaſe to precipitate the marine ſalt of magneſia in this manner, and this fact ought to have been ſhewn. If the ſuppoſition be even admitted, how can the calcareous nitre ſeize the water of cryſtallization of the magneſian nitre, as Mr. Dijonval aſſerts, ſince the magneſian nitre appears to be precipitated in the cryſtalline form? We therefore think that ſome circumſtance eſcaped Mr. Dijonval in the phenomena he obſerved, and that they depend on a cauſe which will not be clearly aſcertained till the experiment has been repeated in ſeveral different manners, with regard to the quantity of water, of ſalts, the temperature, &c.

Magneſian nitre is not uſed in the arts, nor in medicine. Its ſtrong taſte, its deliqueſcence, and all its other properties, ſhew, that it would act ſtrongly on the animal oeconomy; yet it deſerves to be tried as a ſolvent and aperient medicine.

Species III. MAGNESIAN MARINE SALT.

This ſalt, which is a ſaturated combination of marine acid and magneſia, exiſts in all ſalt waters, and in all ſuch as contain vitriol of magneſia in ſolution, as the waters of Epſom, Egra, Sedlitz, Seydſchutz, and many others; it is much more common than is ſuppoſed.

Magneſian

Magneſian marine ſalt has a very bitter and hot taſte. Bergman affirms that it cannot be obtained in cryſtals, but by ſuddenly expoſing its ſolution, firſt concentrated by evaporation, to a great degree of cold. It is then in the form of ſmall and very deliqueſcent needles. This ſolution moſt commonly has the appearance of a tranſparent jelly. Mr. Dijonval, who affirms that he has obtained this ſalt in a regular and permanent form, thinks it is rather efflореſcent than deliqueſcent.

Marine ſalt of magneſia is decompoſed, and loſes its acid, by the action of fire. The laſt portions of acid are not diſengaged but with great difficulty; the magneſia remains cauſtic after the operation.

This ſalt when expoſed to the air appears to attract humidity ſtrongly, and quickly falls into deliqueſcence. Bergman, and many other chemiſts, have mentioned this property. Mr. Dijonval is the only one who has aſſerted that the marine ſalt of magneſia, as well as magneſian nitre, effloreſces, inſtead of attracting humidity; but this aſſertion requires to be eſtabliſhed by repeated experiments.

Magneſian marine ſalt is very ſoluble in water, and appears to be held in ſolution by leſs than its own weight of that fluid. It is very difficult to obtain it in perfect cryſtals; evaporation by heat does not ſucceed well, becauſe the fluid becomes thick, and almoſt always takes the gelatinous form in cooling. There are more hopes of ſucceſs from the ſpontaneous evaporation of a ſolution of this ſalt during the heat of ſummer; and this method is found to afford cryſtals, though with much difficulty.

The marine ſalt of magneſia heated in a retort with ſiliceous and argillaceous earth gives out its acid; but as this is alſo diſengaged by mere heat, the decompoſition in the preſent caſe cannot be attributed to the earths.

Ponderous earth and lime decompoſe this ſalt, and precipitate the magneſia. As the mother waters of the marine ſalt of ſalt ſprings contain marine ſalt of magneſia mixed with marine calcareous ſalt, the magneſia may be precipitated in the large way, and at a ſmall expence, by means of lime-water.

Pure fixed and volatile alkalis have more affinity than magneſia to the marine acid, and therefore precipitate it from this ſalt. The water holds in ſolution febrifuge ſalt, marine ſalt, or ſal ammoniac, according to the nature of the alkali made uſe of.

The vitriolic and nitrous acids decompoſe this ſalt, and ſeparate the marine acid with efferveſcence. To effect theſe decompoſitions, a mixture of one part of either of theſe acids, and two parts of marine ſalt of magneſia, are to be expoſed to heat in a retort. The acid of the latter becomes volatilized, while

while the ſtronger acid combines with the magneſia, and forms Epſom ſalt, or magneſian nitre. Sedative ſalt likewiſe diſengages the marine acid by heat.

Marine ſalt, with baſe of magneſia, decompoſes the vitriolic and nitrous ſalts, with baſe of fixed or volatile alkali, by the way of double affinity; but in order to be aſſured that theſe decompoſitions take place, the mixture muſt either be evaporated, or ſpirit of wine added, which ſeizes the water; otherwiſe the new ſaline reſults will remain diſſolved in the fluid.

According to Mr. Dijonval, if the ſolutions of febrifuge ſalt and marine ſalt of magneſia are mixed, the latter ſalt is precipitated in cryſtals, in conſequence of its ſtrong diſpoſition to cryſtallize, compared with that of the febrifuge ſalt, which retains the water of ſolution. It is very difficult to conceive, admitting the opinion of this chemiſt, how a ſalt, which is much inferior to the marine magneſian ſalt in point of ſolubility and deliqueſcence, can deprive this laſt of the water which holds it in ſolution. If a ſolution of marine magneſian ſalt be mixed with a ſolution of marine calcareous ſalt, the former is precipitated in cryſtals, according to the ſame chemiſt. All theſe aſſertions require to be confirmed by new experiments, before they can be admitted as part of the elements of chemical ſcience.

Magneſian

Magneſian marine ſalt is of no uſe, but we think it might be advantageouſly employed as an opening medicine; it is continually adminiſtered in ſmall quantities in Epſom ſalt, Sedlitz water, and the impure marine ſalts, theſe ſubſtances always containing it.

Species IV. MAGNESIAN BORAX.

This name may be given to the combination of ſedative ſalt with magneſia. It is ſcarcely known. Bergman obſerved, that magneſia added to a ſolution of ſedative ſalt was diſſolved, though ſlowly. The fluid, by evaporation, affords granulated irregular cryſtals.

This ſalt melts in the fire without decompoſition. Acids decompoſe it by combining with the magneſia, and diſengaging the ſedative ſalt. Spirit of wine combines with the acid, and leaves the magneſia ſeparate: it does not therefore adhere ſtrongly to the acid of borax.

Hence it appears, that for want of experiments, we are ignorant of almoſt all the properties of this ſalt.

Species V. MAGNESIAN FLUOR.

The combination of magneſia with the ſparry acid, which may be called magneſian fluor, fluorated magneſia, or ſparry magneſia, is is not more known than the magneſian borax. Bergman is the only chemiſt who mentions it. According to him, the ſparry acid rapidly diſſolves magneſia, great part of the ſalt being depoſited in proportion as the ſaturation is effected.

The ſolution affords, by ſpontaneous evaporation, a kind of tranſparent froth, which hangs to the ſides of the veſſel, and preſents ſome long and very ſlender cryſtalline needles. Sparry cryſtals are likewiſe formed at the bottom of the veſſel, in hexagonal priſms, terminated by a low pyramid compoſed of three rhombs. This ſalt is not changed by the moſt violent heat, and no acid decompoſes it in the moiſt way. It is one of thoſe neutral fluor ſalts, which deſerve to be particularly examined.

Species VI. CRETACEOUS MAGNESIA, OR MAGNESIAN CHALK; COMMON MAGNESIA.

This ſalt, denominated mild or efferveſcent magneſia by its diſcoverer, Dr. Black, is formed by the intimate union of magneſia with the cretaceous acid.

It has moſt commonly the appearance of an earth, or very white powder. However, Bergman, and Mr. Butini of Geneva, obtained it in a cryſtalline form by the proceſs we ſhall deſcribe below. It is capable of uniting with various quantities of its acid, as all cretaceous ſalts in general are; and its properties differ accordingly. Its taſte is crude and earthy; but its effect is more ſenſible on the inteſtines, as appears by its acting as a purgative.

Expoſed to the fire in a crucible, it loſes its acid and water. Mr. Tingry, apothecary at Geneva, obſerved, that when it is calcined in large quantities, it boils, and has the appearance of a fluid; a phenomenon produced by the diſengagement of its acid gas. A light ſmoke ariſes from the crucible, which being depoſited on the ſurrounding bodies, is found to be powder of magneſia, carried off by the current of cretaceous acid. If a hot body be plunged therein, it adheres to it, according to the ſame chemiſt; a cold ſubſtance takes up, by adheſion, a ſtill greater quantity: towards the end of the operation, the magneſia ſhines, with a blueiſh and phoſphoric light, very ſenſible in the dark.

If cretaceous magneſia be calcined in cloſe veſſels with a pneumatic apparatus, the water and acid may be preſerved. Mr. Butini, who made this experiment with great accuracy, affirms, that thirty-two grains of common magneſia, by which he means ſuch as is prepared for medical purpoſes, and is not entirely ſaturated with acid, contains about thirteen grains of pure earth, twelve grains of acid, and ſeven of water. Bergman eſtimates

mates that cretaceous magneſia contains in the hundred, twenty-five or thirty parts of acid, thirty of water, and forty-five of pure magneſia. If cretaceous magneſia be more ſtrongly heated after it has loſt its acid, its parts agglutinate, and become hard like pure or cauſtic magneſia.

Magneſian chalk is not ſenſibly altered by expoſure to air; yet, as it gathers into lumps when kept in a moiſt place, it ſeems to be ſlightly deliqueſcent.

Water diſſolves but an exceedingly ſmall quantity of cretaceous magneſia; and this ſolubility varies accordingly as the quantity of cretaceous acid is greater or leſs. If it be mixed with a ſmall quantity of water, it forms a kind of paſte, which is ſcarcely ductile, and dries without becoming firm, or contracting in its dimenſions. Common magneſia is ſoluble in the proportion of about a quarter of a grain to an ounce of the fluid, as may be aſcertained by evaporation. But there are means of diſſolving magneſia in much greater quantities, as we ſhall preſently obſerve.

Cretaceous magneſia is not decompoſed by the pure vitrifiable or argillaceous earths; lime deprives it of its acid by greater affinity. Lime-water poured into a ſolution of cretaceous magneſia, occaſions a very ſenſible precipitate, however ſmall the quantity of this neutral ſalt may be. The precipitate conſiſts

ſiſts of chalk, and a ſmall quantity of pure magneſia, which is nearly inſoluble.

Pure fixed and volatile alkalis decompoſe it likewiſe, on account of their ſtronger affinity with the cretaceous acid. In theſe mixtures cretaceous tartar, cretaceous ſoda, or cretaceous ſal-ammoniac, are formed, and the pure magneſia is precipitated.

The vitriolic, nitrous, and marine acids, decompoſe cretaceous magneſia, and render the analyſis of this neutral ſalt complete. They unite to magneſia, with which they have a ſtronger affinity than the cretaceous acid, and diſengage the latter in the aerial form. The cretaceous acid may be known by its uſual characters. Mr. Butini has obſerved that the acids diſengage leſs fixed air than is extricated by the action of fire; for example, the marine acid diſengages more than the nitrous, and the nitrous more than the vitriolic. Whence he concludes, that the neutral ſalts, formed by magneſia with acids, retain a portion of cretaceous acid.

The cretaceous acid renders efferveſcent magneſia much more ſoluble than it is naturally. The new experiments of Mr. Butini depend chiefly on this circumſtance. He has diſcovered, that when common magneſia, which is not ſaturated with the cretaceous acid, is thrown into gaſeous water, or acid ſpirit of chalk, the magneſia immediately becomes ſaturated, by depriving the water

water of a portion of the acid, and is not diſſolved, unleſs the water likewiſe contain a large quantity of the ſame acid. This ſolution converts ſyrup of violets to a green. When expoſed to the cold, it loſes its ſuperabundant air, but without any ſeparation of the magneſia, which remains perfectly combined, even when the water is frozen. If a ſolution of magneſia with exceſs of acid be heated, it becomes clouded, and reſumes a kind of tranſparency by cooling. This ſingular phenomenon preſents, as Mr. Butini has well obſerved, a new kind of ſalt, whoſe character is that of being more ſoluble in cold than in hot water. In order to obſerve the tranſition from opacity to tranſparency by cooling, the ſame chemiſt directs to take a ſolution, which contains two grains per ounce, and to heat it to 170 degrees of Fahrenheit's thermometer: it then becomes of a milky appearance, and all the magneſia, which precipitated by heat, is rediſſolved by cooling.

Bergman having affirmed, that the ſolution of magneſia by the cretaceous acid, afforded by ſlow evaporation, cryſtals, ſome of which are in tranſparent grains, and others reſembling two collections of radii diverging from the ſame point; Mr. Butini obſerved the phenomena of this cryſtallization with great care. He evaporated, by the gentle heat of a lamp, a ſolution charged with nine grains of of the ſalt per ounce of water. A pellicle was firſt formed at the top, whoſe under ſurface, as well as the ſides of the veſſel, had many tufts of cryſtals adhered to it. The reſidue preſented brilliant needles, compoſing ſmall hemiſpheric maſſes of diverging fibres. Theſe needles, which were not a line in length, being examined by the microſcope, were found to be long ſix-ſided priſms, truncated by a hexagon, and reſembling ſome ſpars.

Mr. Butini has likewiſe diſcovered another method of cryſtallizing cretaceous magneſia; it conſiſts in expoſing to the air the ſolution precipitated by heat. At the end of a few days cryſtals are obtained ſimilar to thoſe afforded by evaporation. Magneſia precipitated from Epſom ſalt by cretaceous tartar, and dried, affords no cryſtals; but when it is mixed in water, flocks of an irregular figure are formed; but a ſolution of Epſom ſalt newly precipitated by fixed alkalis, affords needle-form cryſtals at the end of ſome days. The ſame ſolution, ſeparated from its precipitate by the filtre, likewiſe afforded needles of magneſia. I have often obſerved that a ſolution of cretaceous magneſia prepared for chemical experiments, and preſerved in well-cloſed glaſs veſſels, affords at the end of a certain time, a large quantity of very fine brilliant needles, which examined by by the magnifier, were found to be ſix-ſided priſms.

Perfect neutral ſalts and cretaceous magneſia experience no change by ſolution in the ſame water; excepting only that they increaſe the ſolubility of the latter in water, according to Mr. Butini. Cretaceous tartar, however, deprives it of this property.

Calcareous neutral ſalts are decompoſed by double affinity by effervefcent magneſia. As lime has a ſtronger affinity with acids than magneſia, the decompoſitions muſt take place, in conſequence of the preſence of cretaceous acid, to which lime has a ſtrong affinity, and quits its acid to ſeize this, provided another body be preſent with which the diſengaged acid can combine. Conſequently when a ſolution of cretaceous magneſia is poured into a ſolution of ſelenite, calcareous nitre, or calcareous marine ſalt, the vitriolic, nitrous, or marine acid, quits the lime to unite with the magneſia, with which it forms Epſom ſalt, or nitre or marine ſalt with baſe of magneſia, while the lime combining with the cretaceous acid is precipitated in the form of chalk.

Magneſia therefore acts in the ſame manner as volatile alkali. When either of theſe are pure and cauſtic, they cannot decompoſe calcareous ſalts, becauſe of the greater affinity of the lime to acids. But when they are united to fixed air or cretaceous acid, they

they then effect the decompoſition by double affinity.

Cretaceous magneſia is uſed in medicine; it was formerly made with the mother water of nitre evaporated to dryneſs, or precipitated by fixed alkali; it was firſt known by the name of white magneſia, Count Palma's powder, powder of Sentinelli. It has likewiſe been called laxative polychreſt powder by Valentini, white magneſia of nitre, magneſia of common ſalt, becauſe it was likewiſe obtained from the mother water of this laſt ſalt. But the medicine, ſo prepared, always contains calcareous earth, and other foreign ſubſtances. The magneſia at preſent uſed is commonly precipitated from Epſom ſalt by fixed alkali. Mr. Butini has deſcribed a proceſs for obtaining very fine magneſia in the greateſt poſſible quantity: a certain quantity of vegetable alkali is diſſolved in double its weight of cold water, and expoſed to the air for ſome months, if time permits, that it may abſorb cretaceous acid from the atmoſphere. This being filtered, a ſolution of an equal weight of Epſom ſalt in four or five times its weight of water is made; the ſolution is filtered, and freſh water added in about fifteen times the weight of the ſalt. This liquor is heated, and when it boils, the alkaline ſolution is poured in. A precipitate of magneſia being formed, the mixture muſt be agitated and poured on a filter of paper. The precipitate muſt be waſhed on the filter with boiling water, to carry off the vitriolated tartar it may contain. It is then taken from the filter, and thinly ſpread on papers, to dry by the heat of a ſtove; when dry, it is in white pieces, eaſily broken into a very fine powder, which adheres to the ſkin.

Cretaceous magneſia as a purge is to be preferred to that which is cauſtic, becauſe it is much more ſoluble; it is given in the doſe of one or two ounces according to circumſtances. Cauſtic magneſia, on the contrary, is preferable as an abſorbent, and it is therefore neceſſary to be provided with both; the principal reaſon of this preference of each, and the neceſſity of keeping both kinds of magneſia in the ſhops, has been well explained by Macquer, in a paper preſented to the Royal Society of Medicine. When magneſia is adminiſtered as an abſorbent, it is intended to deſtroy and neutralize a diſengaged acid in the firſt paſſages, as happens with infants, young girls, women in child-bed, &c. The acid in the ſtomach is certainly ſtronger than the cretaceous acid; ſo that when cretaceous magneſia is taken, it produces an efferveſcence proportional to the quantity of diſengaged acid in the firſt paſſages. The cretaceous acid, during this efferveſcence, diſtends the ſtomach, and often occaſions pain, nauſea, vomitings, difficulty of reſpiration, and many other ſpaſmodic accidents, according to the ſenſibility of the ſubject. In theſe circumſtances the pure magneſia is greatly to be preferred, as it abſorbs acidities with equal readineſs, and occaſions no efferveſcence.

When on the contrary magneſia is to be given as a purge, and in caſes where there are no ſymptoms of acidity in the firſt paſſages, the cretaceous magneſia may be uſed. The acid is not then diſengaged, and conſequently the accidents to be feared from that circumſtance do not take place.

Mr. Butini propoſes an artificial mineral water made with gaſeous water charged with magneſia; he obſerves that ſuch a fluid may contain three drams of magneſian earth in the pound, and is not more difficult to prepare than the other artificial mineral waters. The manipulation is abſolutely the ſame in both, and there is no doubt but it might in many caſes be uſed with ſucceſs.

CHAP. IX.

Genus V. ARGILLACEOUS NEUTRAL SALTS, OR ALUMINOUS SALTS.

VERY pure clay combines well with moſt acids, and produces neutral ſalts, diſtinguiſhed by the appellation argillaceous or aluminous,

aluminous. This genus of ſaline matters, if we except the firſt ſpecies, has not yet been examined by chemiſts with ſufficient care, and therefore their properties are leſs known than thoſe of the four preceding genera. Argillaceous ſalts are in general leſs perfect than all the neutral ſalts we have yet ſpoken of. They yield their acids to fixed and volatile alkalis, ponderous earth, and magneſia: their taſte is acrid, and aſtringent.

The preſent genus comprehends ſix ſpecies; alum, argillaceous nitre, argillaceous marine ſalt, argillaceous borax, ſparry clay, and cretaceous clay.

Species I. VITRIOL OF CLAY; ALUM.

Alum is a neutral ſalt, formed by the combination of the vitriolic acid with pure clay, and may therefore be named vitriol of clay. Chemiſts have not always been agreed concerning the baſe of alum; ſome chemiſts have called it by the peculiar name of aluminous earth, or earth of alum. Margraaf has ſhewn, that earth of alum, kneaded up with ſilex in fine powder, forms clay. Hellot, Geoffroy, Pott, and eſpecially Baumé, have formed true alum with clay and the vitriolic acid. And if the true characters of clay are to become ductile with water, to contract and become hard by heat, the aluminous

minous earth having all theſe properties in the moſt eminent degree, ought to be regarded as the pureſt clay. This opinion is at preſent univerſally admitted among chemiſts.

Alum has a taſte at firſt ſweetiſh, and afterwards ſtrongly aſtringent; it reddens blue paper; whence it appears that a portion of its acid is unſaturated: it aſſumes a very regular form, hereafter to be deſcribed.

Alum is ſcarcely ever found pure in nature; it is ſometimes found in the neighbourhood of volcanos, but always mixed with argillaceous earth. Mineralogiſts, eſpecially Wallerius, have diſtinguiſhed ſeveral ſpecies of native alum, ſuch as the ſolid alum, cryſtallized alum, alum in effloreſcence, white, grey, brown, black, aluminous earths, aluminous ſhiſti.

Several ſpecies of alum are found in commerce.

1. Rock alum, in conſiderable maſſes; tranſparent. Bergman thinks that this name is derived from the city of Rocca, in Syria, now called Edeſſa, where the moſt ancient manufacture of this ſalt was eſtabliſhed, and not becauſe its form reſembles a rock, or ſtone, or becauſe it is obtained from rocks or ſtones; as ſeveral authors have affirmed. This ſpecies of alum is very impure.

2. Roman alum, which is prepared in the territory of Civita Vecchia, and obtained from

from a place, named in Italian, Aluminiere della Tolfa. This alum is in pieces of the ſize of eggs; it is covered with a reddiſh effloreſcence, and is ſuppoſed to be pure when that effloreſcence is ſeparated.

3. Naples alum, extracted from a peculiar earth at the Solfatara; it is in larger maſſes than the Roman alum, and one of its ſurfaces is covered with pyramidal cryſtals.

4. Alum from Smyrna. The moſt ancient manufactures of alum appear to have been eſtabliſhed near Smyrna and Conſtantinople. This alum is only found in cabinets of natural hiſtory.

5. Alum made in France. It is prepared in many manufactories, eſpecially at Javel, near Paris: it is found in effloreſcent ſhiſti. I have extracted a conſiderable quantity from an earth ſent to me out of Auvergne. This ſalt may be extracted from many ſubſtances of the like nature found in France, by which means we might take this branch of trade out of the hands of foreigners.

6. Alum is likewiſe extracted from earths and ſtones in many parts of Germany, where there have been manufactories ſince the year 1544; and alſo in England, Spain, Sweden, and in moſt parts of Europe.

Beckman has written the hiſtory of the manufacture of alum, in a long diſſertation, which may be ſeen in the Gottingen Acts.

From the inquiries of this learned man it appears, that the orientals were the firſt who prepared or extracted alum from what the ancients, and Pliny in particular, called chiſton, trichites, calchites, and which they ſeem to have confounded with the alum; and the στυπτῆρία of the Greeks appears rather to anſwer to the different ſtates of martial vitriol, or green copperas. The Italians took the alum manufactures in the neighbourhood of Conſtantinople on leaſe: about the year 1459, Bartholomew Perdix, or Pernix, a Genoeſe, diſcovered alum ore in the iſland of Iſchia; about which time Juan de Caſtro founded another at La Tolfa; and a great number of manufactories were ſoon after eſtabliſhed in Italy, more eſpecially when Pope Pius II. prohibited the importation of alum from the eaſt. This art was afterwards carried into Spain, Germany, England, and Sweden, towards the beginning of the ſeventeenth century, (V. Beckman.)

The preparation of alum varies greatly in different countries, and according to the different matters from which it is obtained. Bergman, who has written a very valuable diſſertation on this ſubject, divides the ſubſtances, commonly called alum ores, into two ſpecies, namely, ſuch as contain alum ready formed, and ſuch as contain only its principles. The firſt require only to be lixiviated, in order to obtain the alum: the earth of Solfatara is of this kind, as is likewiſe that of Auvergne, before ſpoken of. It is mixed with water, in leaden caldrons ſunk in the earth; the natural heat of the ſoil favours the ſolution and cryſtallization of the alum, which is purified by a ſecond ſolution in water. The alum earth of Auvergne might be lixiviated in the ſame manner, and the alum made to cryſtallize in leaden caldrons by evaporation.

The natural ſubſtances, which contain only the principles of alum, are much more common than the foregoing, and require previous preparation. It is neceſſary either to calcine them, or to expoſe them to the air, according to their reſpective nature. The aluminous ſhiſti muſt be calcined, in order to burn the bitumen which colours them, and to decompoſe the pyrites, which afford the alum. Bergman found, that this ſhiſtus does not afford a particle of alum by waſhing with water before it is calcined. Expoſure to air produces the ſame effect on pure pyrites, ſprinkled with water. The ſpontaneous decompoſition of theſe ſubſtances produces vitriolic acid, which unites with the clay, and forms alum. The pyrites, fallen into effloreſcence, are lixiviated with water, and the iron it contains is ſuffered to ſubſide; after which it is evaporated, and ſet to cryſtallize in caſks: the ſalt is depoſited in large cryſtals. Strong ſoap lye is ſome-

ſometimes uſed to forward the cryſtallization. Such is the proceſs uſed in many manufactories; but theſe alums obtained from pyrites always contain iron; that which is extracted from ſtones, in which it exiſts ready formed, as the Roman alum, is much purer. The alum formed by the direct combination of the vitriolic acid with clay, is often mixed with a certain quantity of iron, becauſe the coloured clay uſed in the preparation always contains a portion of that metal.

Alum, regularly cryſtallized, is a perfect octahedron, conſiſting of two tetrahedral pyramids, united at their baſes. This form varies greatly, according to the circumſtances in which the cryſtallization is performed; the octahedron being more or leſs truncated irregular, acute, flattened, and the cryſtals are often joined, and as it were included one within another. Mr. Romé de Liſle has carefully deſcribed all theſe varieties, in the late edition of his Cryſtallographie.

Alum melts with a mild heat, emitting abundance of aqueous vapours, at the ſame time that it ſwells up, and becomes converted into a very large light maſs, of an opake white, with a great number of cavities. This phenomenon is produced, as in borax, by the diſengagement of water, whoſe vapour blows up and extends the ſaline maſs. The alum in this ſtate is called calcined

cined alum, and weighs little more than half its former weight. It is ſomewhat altered; reddens the ſyrup of violets; has a ſtronger taſte; and appears to have its acid more concentrated or diſengaged. If it be diſſolved in water, a ſmall quantity of earth precipitates: it may be cryſtallized, but it ſcarcely ſwells at all on being calcined a ſecond time, as Mr. Baumé obſerves. If alum be calcined in an apparatus for diſtillation, water is obtained, which, towards the end, becomes acid; but it cannot be intirely decompoſed, ſince Geoffroy kept it in a retort in a fire of the utmoſt violence for three days and three nights, without producing any remarkable alteration. Yet there is reaſon to think, that the changes produceable in alum by a long continued heat have not yet been properly examined into.

Alum ſlowly effloreſces in the air, and loſes its water of cryſtallization. This ſalt is not very ſoluble in cold water, ſince two pounds of that fluid diſſolved no more than fourteen drachms of alum, according to Mr. Baumé; but boiling water diſſolves more than half its weight, eight ounces of water in this ſtate diſſolving five ounces of the ſalt. It cryſtallizes very well by cooling. Its cryſtals are triangular pyramids, with truncated angles. When they are depoſited on threads in the middle of the ſolution, very regular octahedrons are formed, whoſe pyramids

ramids are obliquely truncated at the middle, between the vertex and the baſe.

Siliceous earth does not ſenſibly affect this ſalt. It may, however, be united to a much larger quantity of pure clay than it commonly contains.* By this addition, its properties approach to thoſe of clay, as Mr. Baumé has obſerved. To ſaturate alum with its earth, a ſolution of this ſalt muſt be boiled with very pure clay, and the mixture kept heated till it has loſt the ſtyptic taſte of alum. If the combination be well made, its taſte is inſipid, ſweetiſh, and earthy. Mr. Baumé obſerves, that by evaporation it affords leaves, or plates, reſembling mica. The Duc de Chaulne having expoſed for a long time to the air a lixivium of alum, ſaturated with its earth, found very regular cubical cryſtals at the end of ſome months. It is found that alum, ſaturated with its earth, cannot be eaſily reduced to its original ſtate of alum.

Alum is decompoſable by ponderous earth and magneſia, which have a ſtronger affinity than clay to the vitriolic acid. Ponderous ſpar and Epſom ſalt are produced in theſe decompoſitions.

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* The clay is here ſuppoſed to be very pure, and ſeparated by waſhing from the ſiliceous earth, which it often contains in ſuch large quantities, as to compoſe more than half its weight, as we have obſerved in the hiſtory of this earth. Note of the Author.

Lime-water poured on a ſolution of this neutral ſalt precipitates its argillaceous baſe; fixed and volatile alkalis have likewiſe the property of decompoſing it. Cretaceous tartar, cretaceous ſoda, cretaceous ammoniacal ſalt, chalk, and efferveſcent magneſia, likewiſe ſeparate the clay, which retains a portion of the cretaceous acid, if the precipitation be made in the cold. But I have obſerved, that the mixture of a hot ſolution of alum with hot ſolutions of cretaceous alkalis, is attended with efferveſcence and diſengagement of cretaceous gas.

Earth of alum precipitated by theſe different ſubſtances very gradually, has the form of flocks. When gently dried, it is very white; and decrepitates or flies to pieces in the fire, like clays. A ſtrong heat gives it a very conſiderable degree of hardneſs, at the ſame time cauſing it to contract much in all its dimenſions. It is not fuſible in the ſtrongeſt heat, not excepting that of the focus of the lens of the garden De l'Infante. It retains the laſt portions of moiſture with ſuch force, as not to be deprived of it, but by the moſt violent heat. It may be formed into a paſte with water, which may be baked into porcelain of an excellent quality. Aluminous earth has therefore all the characters of argillaceous earths, and is the pureſt clay which can be procured, as Macquer obſerves.

The effects of ponderous earth, magneſia, lime,

lime, and pure alkalis, on the earth of alum, are not well known: it is probable that theſe ſubſtances, eſpecially the laſt, would convert it into a vitreous frit by fire. Mr. Achard has made a ſeries of experiments, which prove this aſſertion. The colour, tranſparency, hardneſs, and all the properties of this kind of glaſs vary according to the relative proportions of the ſubſtances which enter into its compoſition, as the diſſertation of that chemiſt ſhews.

The vitriolic acid readily diſſolves the earth of alum when moiſt, and newly obtained, but does not act with equal rapidity when it is dry. This ſolution in the quantity of many ounces affords cryſtals of alum, mixed with ſmall plates or ſcales, ſimilar to thoſe of mica. Mr. Baumé adds, that if this experiment be made in the ſmall way, the ſcaly ſubſtance only is obtained, and ſcarcely any alum; other acids likewiſe diſſolve this earth, and form ſalts little known, which we ſhall mention in the following articles.

The action of aluminous earth on neutral ſalts, has not been enquired into. But the moſt ſingular property it exhibits, is that of combining by exceſs to alum, and of giving it new characters, as we have already obſerved. Mr. Baumé, the diſcoverer of this fact, boiled a ſolution of alum with the earth precipitated from another portion of alum, by by means of fixed alkali; the earth was diſſolved with efferveſcence, the filtrated ſolution had no longer the taſte of alum, but that of a hard water, did not redden the tincture of turnſole, but converted ſyrup of violets to a green. By ſpontaneous evaporation it afforded cryſtals, ſcaly and ſoft to the touch like mica. Mr. Baumé compares them to ſelenite; it is not eaſy to compoſe alum by adding vitriolic acid to this ſaturated ſalt, the mixture becoming acid, but not ſtyptic. However, after ſpontaneous evaporation for three months, the ſolution afforded cryſtals of alum mixed with ſome micaceous ſcales, ſimilar to thoſe afforded by alum ſaturated with its earth. Theſe are the reſults of the experimental enquiry of Meſſrs. Macquer and Baumé into the nature of the earth of alum.

Alum heated with combuſtible matters forms a ſubſtance which takes fire on expoſure to air, and is called the phoſphorus of Homberg. This chemiſt, who publiſhed an account of the pyrophorus, in the year 1711, made experiments on human excrement for the purpoſe of obtaining a colourleſs oil poſſeſſing the property of fixing mercury into fine ſilver; the enquiry produced many diſcoveries; the reſidue of this animal ſubſtance diſtilled with alum, took fire on expoſure to the air. Homberg repeated this experiment a number of times, and always with

with ſucceſs. Lemery the younger, in the years 1714 and 1715, publiſhed two Memoirs, in which he affirms, that pyrophorus may be made with a great number of vegetable and animal ſubſtances heated with alum. But he did not ſucceed in his attempts to form it, with many other vitriolic ſalts. Theſe two chemiſts, who ſuppoſed alum to be a combination of the vitriolic acid and calcareous earth, imagined that the latter being converted into lime attracted the humidity of the air, and produced a degree of heat ſufficient to ſet fire to the ſulphur formed by the vitriolic acid and inflammable ſubſtances.

Since the time of theſe chemiſts, Le Jay de Savigny, Doctor of Medicine, has publiſhed excellent Memoirs concerning Pyrophorus, in the third volume of the Memoires de Sçavans Etrangers; wherein he deſcribes a great number of experiments by which pyrophorus was made, not only with alum and different combuſtible bodies, as Lemery has done, but likewiſe with moſt ſalts that contain the vitriolic acid. This phyſician likewiſe propoſed a theory of the inflammation of pyrophorus expoſed to air, which has been univerſally received till very lately. He thinks that pyrophorus contains glacial oil of vitriol, which attracting the humidity of the air, and becoming ſtrongly heated,

heated, inflames the ſulphur, and produces the ſpontaneous inflammation.

Pyrophorus is uſually prepared by melting three parts of alum with one of ſugar, honey, or flour, in an iron ladle. The mixture is dried till it becomes blackiſh, and has ceaſed to ſmell. It is then pulverized, and put into a matraſs or phial ſtopped with earth, which is placed in a crucible filled with ſand. Heat is applied till a blueiſh flame appears to iſſue out of the neck of the phial. After this has continued ſeveral minutes, the crucible is taken out of the fire; and when the whole is cool, the pyrophorus is poured quickly into a dry bottle, which is immediately well cloſed. This pyrophorus on expoſure to air takes fire the more quickly in proportion as the air is more humid. The combuſtion is haſtened by any humid vapour, ſuch as that of the breath. If the pyrophorus be heated for too long a time, it will not take fire. When kept in an imperfectly cloſed veſſel, it gradually attracts humidity, and loſes its power of ſpontaneous inflammation; but this may be reſtored by calcining it again with the precautions before-mentioned.

Such was the ſtate of our knowledge before the Memoirs of Mr. Prouſt were publiſhed in Journal de Medicine, for July, 1778. This chemiſt having met with a great number of pyrophoric reſidues, in

which

which the exiſtence of the vitriolic acid could not be ſuſpected, concluded that the ſpontaneous inflammation of pyrophorus is not occaſioned by that acid. By a very ſimple experiment he ſhews, that it does not contain a particle of diſengaged vitriolic acid at liberty, ſince he finds that the addition of water does not produce heat. From the enumeration of the different pyrophori which he obtained, it appears that all ſubſtances which after this decompoſition leave a carbonaceous reſidue, divided by an earth or metallic calx, are ſuſceptible of inflammation by expoſure to air. But it cannot be ſaid that any part of Mr. Prouſt's experiments, which he has yet communicated, point out the cauſe of the inflammation of Homberg's pyrophorus, which according to him, differs from thoſe he has obſerved. His memoirs, in fact, teach us nothing concerning the ſubſtance we are treating of.

Mr. Bewly, an Engliſh ſurgeon, attributes the inflammation of pyrophorus to a ſubſtance capable of attracting the nitrous acid of the atmoſphere. He adopted this opinion on diſcovering, that ſpirit of nitre immediately inflames pyrophorus which has not been ſufficiently calcined, or is loaded with moiſture. But on the one hand, it is not proved that the nitrous acid exiſts ready formed in the atmoſphere; and on the other hand Mr. Prouſt has diſcovered that the

the inflammation of pyrophorus by the ſpirit of nitre ariſes from the coal contained in the former, ſince that acid detonates with all dry carbonaceous matters in a ſtate of extreme diviſion, as we ſhall more amply explain at the article charcoal. Mr. Bewly's theory does not therefore appear more ſatisfactory than that of the chemiſts who preceded him.

The cauſe of this phenomenon can only be diſcovered by an accurate inquiry into the chemical nature of Homberg's pyrophorus. It appears to contain earth of alum, carbonaceous matter in a ſtate of extreme diviſion afforded by the honey, ſugar, &c. a ſmall quantity of fixed alkali and ſulphur, partly united to the earth of alum, and partly to fixed alkali. When pyrophorus is ſtrongly heated in the pneumato-chemical apparatus, a large quantity of hepatic gas is obtained; and when deprived of this, it is found to be no longer inflammable on expoſure to air. If pyrophorus be immerſed in a veſſel of vital or dephlogiſticated air, it burns rapidly with a very brilliant red flame. By waſhing this ſubſtance in warm water, a true liver of ſulphur is afforded, and carbonaceous matter with earth of alum are left on the filtre: the pyrophorus is then decompoſed. Pyrophorus after combuſtion is found to be increaſed by the pure air abſorbed: it then affords alum, becauſe the ſulphur burned by the action of the air forms vitriolic acid, which

which unites to the aluminous earth; but this ſalt is found to be alum ſaturated with its earth.

The Journal de Phyſique for November, 1780, contains obſervations on pyrophorus; in which it is affirmed, 1. That this ſubſtance owes its combuſtibility to a certain quantity of phoſphorus formed by the acid of mucilaginous matters. 2. That pyrophorus, by diſtillation, affords from five to ſeven grains of phoſphorus. 3. That pyrophorus may be immediately formed by triturating in an iron mortar fifty-four grains of flowers of ſulphur, thirty-ſix of very dry charcoal of willow, and three of common phoſphorus. The particulars of this analyſis does not perfectly juſtify the concluſions; becauſe it does not ſhew that true phoſphorus was obtained. But the Memoir contains many intereſting facts which cannot but be uſeful to chemiſts, who propoſe to undertake a courſe of experiments on the nature of pyrophorus.

Alum is of very extenſive uſe in medicine; it is employed as an aſtringent, but it ought not to be internally adminiſtered without great precaution; it is moſt commonly applied externally as a powerful ſtyptic and deſiccative, with which intention it is uſed in the compoſition of plaſters, collyriums, &c.

Alum is one of the moſt uſeful ſalts in the arts.

arts. The makers of candles mix it with tallow to render that ſubſtance firm and hard. Printers rub their balls with calcined alum, that they may take the ink. Wood impregnated with a ſolution of alum is not burned without great difficulty, for which reaſon it has been propoſed as a means of ſecuring edifices from the effects of fire; it has the ſame effect on paper, which, however, becomes yellow, and alters in a ſhort time.

Bleachers throw a ſmall quantity of alum into water, to render it clear. Mr. Baumé ſuppoſes that the ſalt becomes charged with a portion of the earth ſuſpended in that fluid, and forms an inſoluble compound, which precipitates. Some uſe this method of rendering water clear for drinking. It is alſo uſed in the preparation of ſkins, and to impregnate paper and cloths, which are intended to be printed.

A ſolution of alum retards the putrefaction of animal ſubſtances, and affords a very uſeful as well as œconomical means of preſerving the natural productions imported from foreign countries. Earth of alum is the body or ſolid matter of paſtils or crayons. Laſtly, it is the ſoul of the art of dying, as Macquer calls it; it augments the intenſity and brilliancy of colours, and gives ſolidity to colouring extractive matters, which would elſe be periſhable, and eaſily diſcharged by water. This laſt mentioned action

action of alum on vegetable colouring matters ſhall be examined in the hiſtory of thoſe ſubſtances; where it will be ſeen that alum gives them ſolidity, by changing their nature, decompoſing them, and rendering them inſoluble in water.

Species II. ARGILLACEOUS NITRE, OR NITROUS ALUM.

Mr. Baumé affirms that the nitrous acid completely diſſolves the earth of alum. This ſolution is limpid, and much more aſtringent than that of alum. By ſpontaneous evaporation it affords ſmall pyramidal cryſtals very ſtyptic and deliqueſcent. The other properties of this ſalt have not yet been examined; and it is only known, that the ſame intermediums decompoſe this ſalt and alum. It has not yet been found in nature, but is always produced by art.

Species III. ARGILLACEOUS MARINE SALT, OR MARINE ALUM.

The marine acid diſſolves clay and earth of alum more readily than the nitrous acid. This ſaturated ſolution is gelatinous, and cannot be filtered without dilution in a large quantity of water. Its taſte is ſaline and ſtyptic; it reddens ſyrop of violets, and afterwards converts them to a green. By ſpontaneous

taneous evaporation it affords very ſtyptic cryſtals, whoſe form has not been examined. Lime-water decompoſes it. It is deliqueſcent, and is always produced by art; its other properties have not yet been diſcovered.

Species IV. ARGILLACEOUS BORAX.

The combination of ſedative ſalt with the earth of alum, which we call argillaceous borax, and may likewiſe be diſtinguiſhed by the name of aluminous borax, has not yet been obſerved. It is only known, that if a ſolution of borax be added to a ſolution of alum, a light and fleecy precipitate is formed. The vitriolic acid quits the clay to unite with the mineral alkali of the borax. This earth combines with the ſedative ſalt, which is at the ſame time ſeparated, and the new ſalt is gradually re-diſſolved. The liquid precipitated by fixed alkali, affords by evaporation, a viſcid and aſtringent maſs, in which Glauber's ſalt and argillaceous borax are confounded together. This ſpecies of borax is decompoſable by the ſame ſubſtances as alum: its properties have not yet been examined with ſufficient care.

Species V. SPARRY CLAY.

By this name we indicate the combination of ſparry acid with pure clay, or the baſe of alum.

alum. This neutral ſalt is not known. Scheele, Boulanger, and Bergman, ſay nothing of this combination.

Species VI. CRETACEOUS CLAY, or ARGILLACEOUS CHALK.

Though the union of the cretaceous acid with clay has been hitherto ſcarcely examined, yet it is certain that a portion of this acid combines with aluminous earth; becauſe, 1. According to the remark of Bergman, when a ſolution of alum is precipitated by the cretaceous alkali, the filtered liquor depoſits, at the end of a certain time, a ſmall quantity of earth, which was held in ſolution by the cretaceous acid, and is ſeparated in proportion as that acid flies off. 2. This precipitation, when made in the cold, is not attended with efferveſcence, and a portion of the cretaceous acid ſeparated from the alkali, appears to combine with the clay, while another portion becomes diſſolved in the fluid.

It is likewiſe acknowledged, from the analyſis of many argillaceous earths, by modern chemiſts, that they contain the cretaceous acid; for they efferveſce, when diſſolved in the vitriolic or marine acids.

CHAPTER X.

GENUS VI. Neutral Salts with Baſe of Ponderous Earth.

PONderous earth forms, with acids, neutral ſalts different from all ſuch as we have hitherto examined, not only in their form, taſte, and ſolubility, but likewiſe in the laws of their decompoſition. The earthy alkaline baſe, which conſtitutes them, has a ſtronger affinity than the three alkalies and the other earths with acids. It is therefore neceſſary that theſe alkaline ſubſtances ſhould be united with the cretaceous acid, in order to ſeparate this baſe, and decompoſe ponderous ſalts. Theſe ſalts are ſix in number, namely, ponderous ſpar, ponderous nitre, ponderous marine ſalt, ponderous borax, ſparry ponderous earth, and ponderous clay. This nomenclature of the ponderous ſalts, is abſolutely vicious, becauſe theſe ſalts are not heavier than moſt others, if we except ponderous ſpar. Mr. de Morveau having ſubſtituted the word barytes (barote) inſtead of ponderous earth, diſtinguiſhes theſe ſalts by the names of barytic ſalts, barytic vitriol, barytic nitre, barytic marine ſalt or muriate, barytic

barytic borax, barytic fluor, and barytic chalk, or mephitis.

Species I. PONDEROUS SPAR, or BARYTIC VITRIOL.

Ponderous ſpar, hitherto conſidered as a ſtone, becauſe it has neither taſte nor ſolubility, is the reſult of a combination of the vitriolic acid with ponderous earth. This ſpar has hitherto been confounded with fluor ſpar, by many naturaliſts, and in fact it breaks in the ſame manner, and does not efferveſce with acids; but its form, its imperfect tranſparency, and eſpecially its great weight, are ſufficient to diſtinguiſh it. A ſingle chemical character likewiſe anſwers this purpoſe; for if a ſmall quantity of oil of vitriol be poured on this ſpar reduced to powder, no vapour of any kind is diſengaged, nor ſmell perceived; whereas the fluor ſpar, if treated in the ſame manner, gradually emits a penetrating vapour, which forms a white ſmoke when it comes into contact with air, and is eaſily known to be the ſparry acid. Other naturaliſts have confounded it with the ſelenitic ſpar; but this laſt has neither the ſame form, nor the ſame inſolubility, and is decompoſed by pure or cauſtic fixed alkalies; whereas ponderous ſpar is not altered by thoſe ſalts.

Ponderous

Ponderous ſpar is found in large quantities. It moſt commonly accompanies metallic ores; it is either cryſtallized, or in irregular maſſes, but is always diſpoſed in layers of various thickneſs and extent. Its hardneſs is conſiderable, though it does not give fire with ſteel. Its principal varieties are the following.

Varieties.

1. White ponderous ſpar, ſemi-tranſparent, cryſtallized in ſix ſided priſms, two ſides very large, four very ſmall, terminated by dihedral ſummits. Theſe cryſtals are obliquely placed on maſſes of the ſame nature; they reſemble long ſquare plates, whoſe four ſides have been cut diamond wiſe. They are often covered with rhomboidal yellow cryſtals. This ſpecimen, as well as the following, is called ponderous ſpar in tables.
2. Ponderous ſpar, of a milky white, in tables, without chamfered edges. It is not regularly cryſtallized, but is formed of thick layers placed on each other; it is often incruſted with a red powder of ſilver ore, or pyrites.
3. Ponderous ſpar rounded, and ſemi-chatoyant. Bologna ſtone. It is compoſed of many converging fibres, which unite into laminæ, applied on each

each other. This variety is the moſt known on account of its phoſphoric property, it has evidently been worn round by water.

4. Octahedral ponderous ſpar; it is cryſtallized like alum, the ſummits of the pyramids being often truncated, which form a decahedron. The length of its ſides, or the truncature of its angles, likewiſe exhibits other varieties.
5. Dodecahedral ponderous ſpar; it has the form of ſome garnets and pyrites, and is more rare than the former.
6. Pyramidal ponderous ſpar. This variety, as well as the foregoing, is indicated in Daubenton's table.

I have conſidered as a variety of ponderous ſpar, the ſpar called pearly (perlé) which was formerly claſſed, like moſt of the foregoing, among the ſelenites. This ſpar is formed of ſmall rhomboidal plates, uſually brilliant, and placed obliquely one over the other. It is opake, brilliant, as it were micaceous, and ſprinkled on calcareous ſpar, or quartz, or on the firſt variety we have deſcribed. It is of a yellow or dirty green colour, and ſometimes of a ſilvery white. According to the Abbé Hauy, it is a true calcareous ſpar.

Margraf, who examined many varieties of ponderous ſpar, ſuch as the Bologna ſtone, and white opake ponderous ſpar, ſuppoſed it it to be a true ſelenite, mixed with a ſmall quantity of clay, which rendered it inſoluble; but Gahn, Scheele, and Bergman, find that it contains a peculiar earth, which they have diſtinguiſhed by the name of ponderous earth. Mr. Monnet likewiſe found, that its baſe differs from calcareous earth, by the ſalts it forms with acids; but that chemiſt admits it to contain ſulphur ready formed, and conſiders ponderous ſpar as an earthy liver of ſulphur in a cryſtallized ſtate.

Ponderous ſpar melts by a violent heat, ſuch as that of the porcelain furnace, &c. and affords a coloured glaſs. A low heat does not at all change it. If it be taken into the dark, after it has been heated rather ſtrongly, it exhibits a vivid blueiſh light. Lemery reports, that an Italian ſhoe-maker, named Vincenzo Caſciarolo, firſt diſcovered the phoſphoric property of the Bologna ſtone. 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 phenomenon, and have varied the method of calcining the Bologna ſtone in many reſpects. The works

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of La Poterie, Montalban, Mentzel, Lemery, Homberg, Dufay, and Margraf, contain many proceſſes of this nature.

It is now known that this property is common to all the varieties of ponderous ſpar. The proceſs conſiſts in heating them red hot in a crucible, reducing them to powder in a glaſs mortar, and forming the ſame into a paſte, with a ſmall quantity of mucilage, of gum trugacanth, in pieces of the thickneſs of the blade of a knife. Theſe being dried, are ſtrongly calcined by placing them in the middle of the coals of a furnace which draws well. When the coal is all conſumed, and the furnace grown cold, the pieces are cleanſed from the aſhes by means of a bellows. If theſe be expoſed to the light for a few minutes, and afterwards carried into an obſcure place, they ſhine like a burning coal. They even ſhine when immerſed in water. They loſe this property by degrees, but recover it on being again heated. Many other ſubſtances likewiſe exhibit this appearance. Magneſia, chalk, ſelenite, vitreous or fluor ſpar, &c. become luminous after having been heated. Macquer obſerved the ſame property in earth of alum, vitriolated tartar, Briançon chalk, black flint calcined, which proves, that the preſence of an acid is not abſolutely neceſſary for the production of this phenomenon, though

though it ſeems in ſome reſpect to contribute to its intenſity.

Ponderous ſpar, heated in a retort, afforded no product, and was not at all altered by the operation, as Margraf affirms.

This ſalt is perfectly inſoluble in water, and is not acted on by earths or ſalino-terreſtrial ſubſtances. Pure fixed alkalis do not decompoſe it. This laſt is one of its moſt ſingular properties. In fact, the other earthy and ſalino-terreſtrial ſubſtances have leſs affinity than fixed alkalis to the vitriolic acid; but ponderous earth, on the contrary, has more. Whence we have obſerved, after Bergman, that this earth decompoſes vitriolated tartar and Glauber's ſalt, as it does likewiſe ſalt containing the volatile alkali.

Mineral acids have no action on ponderous ſpar, becauſe the vitriolic acid adheres more ſtrongly than any other to the earth, which forms the baſe of this ſpar. Neither do neutral ſalts produce any change in it, if we except cretaceous tartar and cretaceous ſoda, which produce a decompoſition by double affinity. The ponderous earth is ſeparated from the vitriolic acid, becauſe it is attacked by the cretaceous acid, at the ſame time that one of the alkalis ſeizes the vitriolic acid. To produce this decompoſition, a mixture of two parts of fixed ſalt of tartar, well ſaturated with cretaceous acid, and one part of of ponderous ſpar reduced to powder, are ſtrongly heated in a crucible. The matter which is ſemi-vitrified is to be waſhed in diſtilled water; and the liquid, after filtration and evaporation, affords vitriolated tartar: the ſubſtance which remains on the filtre is cretaceous ponderous earth; which, when well waſhed, is in the form of a very white and fine pulverulent matter, but uſually impure, becauſe it always contains a portion of ponderous ſpar, which has eſcaped the decompoſition.

Combuſtible ſubſtances having the property of decompoſing ponderous ſpar, may likewiſe be employed to obtain its baſe. When pulverized ſpar is expoſed to a red heat in a crucible, together with one eighth of its weight of charcoal in powder, if the matter be poured into diſtilled water, it immediately communicates a yellow colour to the fluid, together with every other character of a ſolution of liver of ſulphur. The charcoal having deprived the vitriolic acid of its vital air, the ſulphur, ſet at liberty by this decompoſition, unites to the ponderous earth, which reduces it to the ſtate of an hepar. The ſulphur is precipitated from this ſolution by means of an acid. The marine acid is preferred, becauſe it forms with ponderous earth a ſoluble ſalt, whereas the vitriolic acid would re-compoſe the inſoluble ponderous ſpar. The liquid is then filtered, and the

ſulphur

ſulphur ſeparated. The barytic marine ſalt contained therein is decompoſed by a ſolution of cretaceous tartar; and the ponderous earth combining with the cretaceous acid, is precipitated. The latter may be ſeparated by calcination. This proceſs, which I have performed a great number of times, affords but a very ſmall quantity of ponderous earth; and the quantity of ſulphur on the filter is likewiſe very inconſiderable, unleſs the ponderous ſpar has been ſtrongly heated. The decompoſition of this earthy ſalt is greatly accelerated, by the addition of about one-fourth of fixed ſalt of tartar, to the mixture of ponderous ſpar and coal. By this means the fuſion is rendered much more complete, and the quantities of ſulphur and ponderous earth are increaſed accordingly.

From the ſe proceſſes for the decompoſition of ponderous ſpar, as well as from every other property of this ſalt, it is evident how much the earth, or ſalino-terreſtrial ſubſtance, which conſtitutes its baſe, differs from other earthy ſubſtances, namely, clay, lime, and magneſia.

Ponderous ſpar is not applied to any uſe.*

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* Dr. Withering, in the Philoſophical Tranſactions for 1784, Part II. points out a valuable chemical purpoſe, to which ſalited ponderous earth, or the barytic marine ſalt, may be applied; namely, the purification of the marine acid from the admixture of vitriolic acid, by which it is often adulterated. The ſolution of this ſalt cauſes the vitriolic acid to fall to the bottom, together with the earth, in the form of ponderous ſpar.

Species II. NITRE WITH BASE OF PONDEROUS EARTH, OR BARYTIC NITRE.

The nitrous acid readily unites with ponderous earth, and produces a neutral ſalt, in large hexagonal cryſtals, or ſmall irregular ones, according to Mr. D'Arcet. It is not obtained in the cryſtalline form without conſiderable difficulty.

Nitre, with baſe of ponderous earth, is decompoſed by fire, and affords vital air.

It attracts the moiſture of the air, and nevertheleſs requires a conſiderable quantity of water to hold it in ſolution.

Neither pure alkalis, nor ſand, clay, lime, or magneſia, decompoſe it.

The vitriolic acid, poured on a ſolution of barytic nitre, immediately precipitates ponderous ſpar; the ſparry acid likewiſe ſeizes its baſe.

Cretaceous alkaline neutral ſalts decompoſe it by double affinity.

This ſalt is hitherto very little known.

Species III. MARINE SALT WITH BASE OF PONDEROUS EARTH, OR BARYTIC MARINE SALT.

This ſalt has not been more examined than the foregoing. Bergman affirms, that it is cryſtallizable, and of difficult ſolution; its cryſtals are ſquare and long, much reſembling ponderous ſpar in tables.

Sand, clay, lime, magneſia, or pure alkalis, have no action on this ſalt, and do not precipitate its principles.

The vitriolic and ſparry acids decompoſe this ſalt by combining with its baſe.

Cretaceous tartar and cretaceous ſoda precipitate the ponderous earth combined with the cretaceous acid.

Bergman reckons ponderous marine ſalt among the moſt ſenſible re-agents, and propoſes it for detecting the ſmalleſt poſſible quantity of vitriolic acid contained in any mineral water. One or two drops of a ſolution of this ſalt poured into about three pounds of water, containing twelve grains of cryſtals of Glauber ſalt, immediately produce white ſtriæ of ponderous ſpar, formed by the double decompoſition of theſe two ſalts: the vitriolic acid forming ponderous ſpar with the earth, and common marine ſalt remains diſſolved in the liquid. All vitriolic ſalts are equally affected by this reagent, which decompoſes them, and affords a precipitate of ponderous ſpar.

Species IV. Borax with Base of Ponderous Earth, or Barytic Borax.

The combination of ſedative ſalt with ponderous earth is not at all known.

Bergman affirms that the acid of borax is one of thoſe which has the leaſt affinity with this ſalino-terreſtrial ſubſtance, and places it in his table below moſt of the vegetable and animal acids.

Species V. PONDEROUS EARTH COMBINED WITH THE SPARRY ACID, OR BARYTIC FLUOR.

This ſalt is not more known than the foregoing, and, with many other ſaline ſubſtances not yet examined, affords matter for experimental inquiry.

Bergman, in his diſſertation on elective attractions, affirms, that the fluor acid poured on a ſolution of nitre, or marine ſalt, with baſes of ponderous earth, occaſions a precipitate; and that this precipitate effervеſces with the vitriolic acid, which diſengages the acid of ſpar.

This experiment proves, that the fluor acid has a ſtronger affinity than the nitrous and marine acids with ponderous earth, and that it forms with this ſalino-terreſtrial ſubſtance a ſalt much leſs ſoluble than barytic nitre or marine ſalt.

Species VI. CRETACEOUS PONDEROUS EARTH, OR BARYTIC CHALK.

Ponderous earth is capable of uniting with the cretaceous acid, and forms a kind of neutral

neutral ſalt poſſeſſed of peculiar properties, and which ſeems in ſome reſpects to reſemble clay.

It has already been obſerved, that ponderous ſpar, and all the ſalts of which this earth is the baſe, are decompoſed by cretaceous alkalis, by virtue of the affinity of the ponderous earth with the cretaceous acid. In theſe decompoſitions barytic chalk, called aerated ponderous earth by Bergman, is precipitated. This ſpecies of ſalt is likewiſe obtained by expoſing a ſolution of pure ponderous earth to the air. The ſurface becomes ſlowly covered with a pellicle, which effervеſces with acids; a phenomenon which ariſes from the cretaceous acid of the atmoſphere combining with the earth, and rendering it leſs ſoluble; in the ſame manner as lime is ſeparated from lime-water. This fact exhibits a ſtriking analogy between theſe two ſalino-terreſtrial ſubſtances, which differ ſo much from each other in many other reſpects.

Barytic chalk, when expoſed to heat, loſes its acid. If it be heated in a retort, or in a matraſs, to which a pneumato-chemical apparatus is adapted, the acid is obtained in its natural or gaſeous form. The laſt portions are not ſeparated without great difficulty, and by an extreme heat.

All the mineral acids decompoſe this ſalt, and diſengage the cretaceous acid, with a ſtrong effervеſcence, which diſtinguiſhes it from pure ponderous earth. Bergman eſtimates that this ſalt contains in the hundred, ſeven parts of cretaceous acid, ſixty-five of ponderous earth, and eight of water.

Water does not diſſolve cretaceous ponderous earth in any ſenſible quantity; but when the fluid itſelf is ſaturated with cretaceous acid, it diſſolves about the 1550th of its weight. Hence we may perceive, that cretaceous ponderous earth is leſs ſoluble in water, than when pure or cauſtic, ſince in the laſt mentioned ſtate about the 900th part is taken up according to Bergman. In this reſpect, therefore, it reſembles chalk; from which, nevertheleſs, it differs in a great number of other properties, as we have already ſeen.

Barytic chalk is not applied to any uſe.*

C H A P. XI.

Concerning ſeveral Mineral Acids lately diſcovered.

HAving given the hiſtory of all ſaline matters which are well known, we think it

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* Withering, in his valuable paper on the native aerated ponderous earth, (Phil. Tranſ. for 1784) obſerves (1) That it reſembles a lump of alum, but is compoſed of ſpiculæ. (2) That its ſpecific gravity is from 4,300 to 4,338.

(3)

proper to add ſome account of certain acids, whoſe properties have not yet been ſufficiently examined, to juſtify the claſſing of them with the acids treated of in the foregoing pages.

Mr. Scheele having obſerved that the nitrous acid diſtilled from many ſubſtances of the three kingdoms, whoſe properties were little known, cauſed them to paſs to the ſtate of acids more or leſs fixed, conſidered theſe ſalts as of a peculiar and ſpecific kind. We ſhall in this place mention only ſuch as belong to the mineral kingdom; theſe are the acids of molybdena, of tungſten, of arſenic, and of Pruſſian blue. As we purpoſe to ſpeak largely concerning the two laſt in the hiſtory of metallic ſubſtances, we ſhall in this place treat only of the acids of molybdena and of tungſten.

CONCERNING MOLYBDENA AND ITS ACID.

Molybdena ought not to be confounded with common black lead which is uſed in

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(3) That 100 parts contain 78,6 parts of pure ponderous earth; 6 vitriolated ponderous earth, and 20,8 fixed air. (4) That it will not burn to lime, as the artificial terra ponderoſa aerata does; but when urged by heat, becomes firſt opake, and afterwards melts; a peculiarity, which the Doctor thinks, ariſes from water not being preſent. The many other curious and intereſting facts contained in the Diſſertation cannot be abridged into a note, but they are well worthy the reader's attention. T.

drawing, and is at preſent diſtinguiſhed by the peculiar name of plumbago. This confuſion is no doubt one cauſe of the differences between the chemical reſults of ſuch as have examined this ſubſtance from Pott and Scheele. It muſt be obſerved that plumbago or black lead being much more common than molybdena, which is not uſually to be met with, except in cabinets of natural hiſtory, French chemiſts, and more eſpecially Mr. de Liſle, have made their experiments with that ſubſtance, and not with the latter, as we ſhall ſhew in the hiſtory of combuſtible matters.

True molybdena is not eaſily diſtinguiſhed from plumbago by its external characters. It is, however, ſomewhat greaſy to the touch; it is formed of ſcaly laminæ of various magnitude, ſcarcely adhering to each other. It ſoils the fingers, and leaves traces of a blackiſh grey on paper. When reduced to powder, which is difficult to do, on account of the elaſticity of its laminæ, it has a blueiſh colour; it yields to the knife; is not at all brittle, and is not of a granulated texture like plumbago.

To reduce molybdena into powder, according to the proceſs of Mr. Scheele, it muſt be triturated in a mortar with a ſmall quantity of vitriolated tartar, which may afterwards be waſhed away with water. This ſubſtance, expoſed to the action of

fire

fire in open veſſels, gives out a ſmall quantity of ſulphur, and evaporates almoſt entirely; when urged by the blow-pipe in a ſilver ſpoon, it emits a white fume, which, on touching it with the blue point of the flame, takes that colour. The ſublimed white part is the peculiar acid of molybdena; but as no more than a very ſmall quantity can be collected by this proceſs, recourſe muſt be had to other means for obtaining it.

Thirty ounces of diluted nitrous acid being diſtilled from one ounce of molybdena at five ſucceſſive times; that is to ſay, ſix ounces of the acid at each time, a large quantity of nitrous gas is diſengaged, and a white powder remains in the retort, which muſt be waſhed with a ſufficient quantity of cold diſtilled water, to carry off the foreign acid ſoluble at that temperature. After this edulcoration, ſix drachms and a half of pure acid of molybdena remain. Mr. Scheele, the author of this diſcovery, thinks that the nitrous acid ſeizes the phlogiſton, and eſcapes in red vapours, burning at the ſame time the ſulphur of the molybdena; from which laſt circumſtance, the water uſed in waſhing the molybdena contains the vitriolic acid, which may be obtained in a concentrated ſtate by evaporation. The liquid then aſſumes a brilliant blue colour, ariſing from the portion of the acid of molybdena likewiſe in the ſolution. We are of opinion, in this operation,

operation, as well as in all others, where the nitrous acid being diſtilled from any ſubſtance reduces it to the ſtate of an acid, that the former is decompoſed, and that the ſeparation of vital air from the ſpirit of nitre, and its fixation in the molybdena, produce the diſengagement of nitrous gas, and the formation of the acid of molybdena.

This acid, obtained by the proceſs laſt deſcribed, has the form of a white powder of a ſlightly acid and metallic taſte. When heated by the blow-pipe in the ſpoon, or in a crucible with contact of air, it is volatilized into a white ſmoke, and partly melts on the ſides of the crucible. Notwithſtanding the edulcoration, it retains a portion of ſulphureous acid, which a ſtrong heat completely diſengages. This acid is ſoluble in boiling water. Scheele diſſolved a ſcruple in twenty ounces of water; in which ſtate its taſte was peculiarly acid, and almoſt metallic; it reddened tincture of turnſole, decompoſed ſolution of ſoap, and precipitated liver of ſulphur; the ſolution becomes blue and conſiſtent by cooling.

This acid earth, as Mr. Scheele calls it, is very ſoluble in oil of vitriol heated. The ſolution has a beautiful blue colour, and becomes thick by cooling; theſe two phenomena diſappear again when the acid is heated, and return in proportion as it gradually becomes cold. If this combination be ſtrongly heated

heated in a retort, the vitriolic acid is volatilized, and the acid of molybdena remains in a dry ſtate at the bottom of the veſſel.

Nitrous acid has no action on the acid of molybdena.

Common marine acid diſſolves a large quantity. The ſolution affords a reſidue of a deep blue colour, when diſtilled to dryneſs. If the fire be raiſed, the reſidue affords white flowers, and a blueiſh ſublimate; a grey matter remaining in the retort. The flowers and ſublimate are deliqueſcent, and give a blue colour to metals; the marine acid paſſes over in the dephlogiſticated ſtate. It is eaſy to conceive, that in this operation the marine acid takes a portion of the vital air from the molybdenic acid, and that a portion of this laſt acid paſſes again to the ſtate of molybdena.

The molybdenic acid decompoſes nitre and marine ſalt by diſengaging their acids, and forming neutral ſalts with their baſes, whoſe properties Mr. Scheele has not perfectly aſcertained. This acid likewiſe diſengages the cretaceous acid from the alkalis, with which it combines and forms neutral ſalts.

Though Mr. Scheele has not diſcovered all the properties of theſe ſalts, he has, nevertheleſs, pointed out three, which are ſufficient to diſtinguiſh the neutralized ſtate. He has obſerved, 1. That fixed alkali renders the acid earth of molybdena more ſoluble in water.

water. 2. That this ſalt prevents the molybdenic acid from being volatilized by heat. 3. That the combination of this acid with vegetable alkali, precipitates, by cooling, in ſmall grains or cryſtals.

The molybdenic acid precipitates nitre and marine ſalts with baſes of ponderous earth; the molybdenous barytic ſalt formed in theſe operations is ſoluble in water.

The molybdenic acid appears partly to decompoſe vitriolated tartar, and diſengages a ſmall quantity of vitriolic acid by a ſtrong heat.

The molybdenic acid diſſolves ſeveral metals, and aſſumes a blue colour, in proportion as it communicates to them part of its vital air. It precipitates many metallic ſolutions, &c. as we ſhall more particularly exemplify in the hiſtory of metals.

Perfect molybdena ſlightly detonates with nitre; the reſidue contains molybdenic tartar and calx of iron. From the experiments of Mr. Scheele, molybdena appears to conſiſt of a peculiar combuſtible matter and iron. The nature of the combuſtible matter is not yet perfectly known. Mr. Hielm, a diſciple of the celebrated Bergman, appears to have ſucceeded in converting it into a regulus. Mr. Pelletier affirms, that he has had the ſame ſucceſs; but the properties of this new metal have not yet been examined into.

The molybdenic acid appears to be a metallic

tallic acid. Its weight, its ſtyptic and auſtere taſte, its dry and pulverulent form, its fuſibility, its inſolubility, the colour it aſſumes by action of flame and combuſtible matters, its precipitation by nut-galls, and by the acid of Pruſſian blue, ſhew that it is ſomewhat ſimilar to the arſenical acid.

Such is the preſent ſtate of our knowledge reſpecting molybdena and its acid. This ſubſtance is ſo rare in France, that no chemiſt, except Mr. Pelletier, has had an opportunity of making a regular ſeries of experiments upon it. It is greatly to be wiſhed that they ſhould be continued, eſpecially with a view of deciding whether the molybdenic acid be truly different from all others. For I cannot avoid thinking, notwithſtanding its peculiar characters, that a ſubſtance, which does not become acid but by the aſſiſtance of thirty parts of weak nitrous acid, and is with ſo much difficulty brought to aſſume the ſaline ſtate, ought not to be conſidered as an acid truly peculiar. But I ſhall enlarge on this ſubject in other parts of this work.

CONCERNING TUNGSTEN AND ITS ACID.

The tungſten of the Swedes has been called heavy ſtone, lapis ponderoſus by ſeveral naturaliſts, and in particular by Bergman, in his Sciagraphia. Cronſtedt conſidered it as a ſpecies a ſpecies of iron ore, and called it Ferrum calciforme, terrâ quâdam incognita intimè mixtum. Moſt German naturaliſts claſs it among tin ores, under the name of white cryſtals of tin, or zinn ſpath; and it is arranged as ſuch in moſt cabinets of natural hiſtory.

The Swediſh word tungſten has the advantage of diſtinguiſhing this ſaline ſubſtance from ponderous earth and ponderous ſpar, with which the denomination of Bergman ſeems to confound it.

An accurate analyſis of this ſubſtance was not attempted before the time of Scheele, and it was almoſt generally conſidered as an ore of tin. Scheele examined this pretended ore, and diſcovered that it conſiſts of lime united to a peculiar acid. Bergman, who likewiſe examined the ſame ſubſtance, had reſults which confirmed thoſe of Scheele. This diſcovery was made in the year 1781. Meſſrs. De Luyart, of the Royal Biſcayan Society; M. Angulo of the Academy of Valladolid, and Mr. Crell, have repeated and confirmed the reſults of the Swediſh chemiſt.

Before we proceed to deſcribe the properties of tungſten and its acid, we muſt obſerve that this ſubſtance has been rarely met with till lately; that it is found in the iron mines of Bitzberg, in the tin mines in Schleckenwalde in Bohemia, and that moſt of the white cryſtals of Sanberg near Ehrenfriederſdorf, are tungſten: ſo that by aſſaying the cryſtals diſtinguiſhed by this name by the methods we ſhall point out, ſome ſpecimens may be found of this ſubſtance, which were not before ſuſpected to be ſuch.

Tungſten is not ſenſibly altered by heat; it decrepitates and is reduced to powder by the blow-pipe, but it does not melt. The blue flame ſlightly colours it, and nitre takes away the colours.

Boiling water has no action on tungſten in powder. The effects of air, earths, the ſalino-terreſtrial ſubſtances, and cauſtic alkalis on tungſten, have not been inquired into.

The vitriolic acid heated and diſtilled from tungſten paſſes without alteration, the reſidue is of a bluiſh colour. A ſmall quantity of ſelenite is obtained by waſhing it with boiling water. A proof that this ſubſtance contains lime, and that the vitriolic acid decompoſes only a very ſmall part.

Weak nitrous acid aſſiſted by heat, acts on tungſten without ſenſible effervеſcence. The acid converts it to a yellow colour, which diſtinguiſhes it from a true ore of tin. The acid diſſolves the calx; about twelve parts of nitrous acid in the ſtate of aqua fortis being required completely to decompoſe one part of tungſten. Mr. Scheele repeated this

this operation ſeveral ſucceſſive times; after the action of three parts of weak nitrous acid on one of tungſten had taken effect, he added two parts of cauſtic volatile alkali. The powder which was changed to a yellow by the nitrous acid, became white by the alkali; and he repeated the ſucceſſive application of the two agents, till the whole of the tungſten was diſſolved. From four ſcruples treated in this manner, he had three grains of a reſidue, which ſeemed to him to be quartz. By adding firſt the Pruſſian, and afterwards the common vegetable alkali, to the nitrous acid employed in the operation, he obtained two grains of Pruſſian blue, and fifty-three grains of chalk. The volatile alkali added to the nitrous acid afforded an acid precipitate. In this experiment the nitrous acid decompoſes the tungſten by ſeizing the lime, and the tungſtenic acid, diſengaged by this decompoſition, is ſeized by the volatile alkali. The ammoniacal ſalt, formed by this laſt ſolution, is decompoſed by the nitrous acid, whoſe affinity to the volatile alkali is greater than that of the tungſtenic acid; and as the latter acid is much leſs ſoluble than the ammoniacal tungſten, it is precipitated in the form of a white powder. This powder is waſhed with cold diſtilled water, in order that the acid may be had very pure.

This acid may be likewiſe obtained by another proceſs, which Mr. Scheele has employed

ployed with equal ſucceſs. One part of pulverized tungſten is fuſed in an iron crucible, with four parts of cretaceous tartar. This maſs is lixiviated with twelve parts of boiling water, and nitrous acid is added till it no longer produces any effervescence. The undiſſolved part is again fuſed with four parts of cretaceous tartar, lixiviated with water, and treated with nitrous acid, till the effervescence ceaſes. The reſidue then conſiſts of a ſmall quantity of quartz, the whole of the tungſten being decompoſed. For the fixed vegetable alkali during the fuſion combines with the tungſtenic acid, and forms a peculiar neutral ſalt; while the cretaceous acid unites with the lime, which it converts into chalk. When the melted maſs is lixiviated, the water diſſolves the tungſtenic tartar, and the inſoluble chalk remains. The nitrous acid which is applied, after the water, diſſolves the chalk with effervescence, without acting on the portion of tungſten, which the cretaceous fixed alkali in the firſt melting did not decompoſe. In the ſecond operation, the tungſten being completely decompoſed by the additional alkali, the nitrous acid takes up the whole of the chalk; ſo that by the ſucceſſive application of eight parts of cretaceous fixed alkali, and a ſmall quantity of aqua fortis, the component parts of the tungſten are completely ſeparated; its acid uniting with the alkali, and its lime combining with the nitrous acid. By precipitating the calcareous nitre by means of vegetable alkali, the quantity of lime contained in the tungſten is known. The tungſtenic acid remains to be ſeparated from its alkali, which is effected by the proceſs deſcribed in the firſt method. A ſufficient quantity of nitrous acid is poured into the water made uſe of in waſhing the melted tungſten. The lixivium becomes turbid by the precipitation of the tungſten acid, which is diſengaged in conſequence of the combination that takes place by ſtronger affinity between the nitrous acid and the alkali. The precipitate is waſhed with cold water, and conſiſts of the pure tungſten acid in the form of a white powder, as in the former operation. This laſt proceſs is to be preferred as the leaſt troubleſome and expenſive.

The marine acid acts on tungſten in the ſame manner as the nitrous, and decompoſes it. As it produces a deeper yellow colour, Bergman recommends it for aſſaying or diſcovering this earthy ſalt.

The tungſtenic acid, or white powder obtained by any of theſe three proceſſes, becomes yellow, brown, and black, when urged by the blow-pipe; but neither melts, nor becomes volatilized.

It is ſoluble in twenty parts of boiling water; the ſolution has an acid taſte, and reddens turnſole.

The

The tungſten acid appears to form with ponderous earth a ſalt abſolutely inſoluble in water, and with magneſia another ſalt of very difficult ſolubility.

When a ſolution of this acid is poured into lime-water, a precipitation is obſerved to begin, which is greatly augmented by heat, and conſiſts of regenerated tungſten, according to Scheele.

The tungſten acid, ſaturated with fixed vegetable alkali, affords a ſalt which precipitates in very ſmall cryſtals, whoſe form has not been aſcertained. Mr. Scheele does not ſpeak of its combination with the alkali of ſoda. According to him, it forms with the volatile alkali a ſal ammoniac in the form of very ſmall needles. This ammoniacal tungſten expoſed to heat in a retort, ſuffers the volatile alkali to eſcape, and the tungſten acid remains in the form of a dry yellowiſh powder. The ſame ſalt decompoſes calcareous nitre, and again forms tungſten.

The tungſten acid heated with the vitriolic acid aſſumes a blueiſh colour: with the nitrous and marine acids it becomes of a citron yellow like tungſten; it precipitates liver of ſulphur of a green colour. Mr. Scheele has not determined the cauſe of thoſe changes.

That chemiſt having obſerved that the tungſtenic acid is eaſily coloured by combuſtible bodies, and gives a blue colour to vitreous fluxes, as borax, &c. heated the acid

acid with linſeed oil in a crucible, but he did not obtain any metal, the acid only being blackened. Bergman, from the conſiderable weight of this acid, the colour it takes with inflammable bodies, and its precipitation by the Pruſſian alkali, thinks it is of metallic origin.

Meſſrs. De Luyarts have partly confirmed this conjecture by the analyſis of wolfram, a ſubſtance conſidered by moſt naturaliſts as a meagre ore of iron, from which, by treatment with marine acid, they obtained the tungſten acid, and ſucceeded in reviving it into a peculiar regulus. The wolfram they examined was procured from the tin mine of Zinnwald. It is cryſtallized into hexahedral flat priſms, with the metallic brilliancy of a leafy fracture, and may be cut with a knife. From the centenary of this ſubſtance they obtained 22 parts of black calx of manganeſe, a ſemi-metal hereafter to be deſcribed; 12 calx of iron, 64 of the yellow tungſtenic acid, and 2 of quartz. They have likewiſe analyzed the tungſten from the tin mines of Schleckenwald in Bohemia, and obtained 68 pounds of yellow tungſtenic acid, and 30 of lime per hundred. They likewiſe ſucceeded in combining wolfram with metals, and producing alloys.

As this mineral is very rare, no chemiſt that I know of has yet repeated and confirmed

firmed the experiments of Meſſrs. De Luyarts.

This ſhort account ſhews how much remains to be done, in order to diſcover the nature and properties of tungſten and its acid; more eſpecially the combinations it forms with other bodies, which have as yet been ſcarcely attended to.*

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* It does not appear from the text, that the ingenious author had ſeen more than an abſtract of the excellent Memoirs of Meſſrs. De Luyarts, which is printed in the Tranſactions of the Royal Biſcayan Society of Friends to their Country, for the year 1783; and was publiſhed in the year 1785 in London, by Charles Cullen, Eſq.; together with the papers of Scheele and Bergman, in the Engliſh language. From this valuable pamphlet the following facts are ſelected: 1. The white powder or acid obtained by Scheele in the humid way, is a triple ſalt, compoſed of tungſten calx or acid, nitrous acid, and volatile alkali. 2. The white matter obtained in the dry way, is likewiſe a triple ſalt, containing tungſten calx or acid, nitrous acid, and fixed alkali. 3. The laſt mentioned ſalt being repeatedly boiled with nitrous acid, and calcined in a cupelling furnace, becomes of a yellow colour, and inſipid; not ſoluble in water, though it forms an emulſion with that fluid, which does not ſubſide for ſome months; not acted on by, nor forming an emulſion with, the vitriolic, nitrous, or marine acids; coloured blue, by acetous acid; combinable with alkalis, and colouring vitreous fluxes. 4. The yellow matter treated with charcoal in a violent heat, affords a button, containing a congeries of metallic globules of a ſteel-like fracture and ſpecific gravity of 17,6. 5. This metal is more difficult of fuſion than mangaeſe; becomes converted into the yellow matter by calcination, at the ſame time that its abſolute weight is augmented; and forms peculiar alloys with the other metals. 6. The diſcoverers call this metal wolfram. T.

CHAP. XII.

Recapitulation of Facts, and Compariſon of the Mineral Salts with each other.

AFTER having exhibited the ſtate of our knowledge, as far as it reſpects the properties of all the known mineral ſalts, we think it neceſſary to give a ſhort account of their leading characters, properties, and mutual attractions.

I. Salts are diſtinguiſhed by four general properties, taſte, tendency to combination, ſolubility, and incombuſtibility. Theſe properties have very different degrees of energy, and theſe degrees conſtitute the moſt eſſential differences that exiſt between them.

II. All ſalts may be reduced to four orders or principal genera. 1. The ſalino-terreſtrial ſubſtances, which unite the earthy to the ſaline properties. 2. Alkalis, which have an urinous taſte, and change the colour of many tables from blue to green. 3. Acids known by their ſour taſte, and the red colour they produce with blue vegetable ſubſtances. 4. Mean, or neutral ſalts, which differ from the foregoing by their weaker taſte, which is mixed, bitter, &c. leſs degree of ſolubility, &c.

III. There are three ſalino-terreſtrial ſubſtances;

ſtances; ponderous earth or barytes, magneſia, and lime. Their properties are known, but not their compoſition. No chemiſt has yet ſucceeded in ſeparating their component parts, and forming them again by combination. They are therefore ſimple or elementary ſubſtances, with reſpect to the preſent ſtate of ſcience, though we may perhaps ſucceed hereafter in our attempts to decompoſe them.

IV. Three alkaline ſalts are known; the fixed vegetable alkali, called ſalt of tartar or pot aſh; the mineral alkali, likewiſe called the marine alkali or ſoda; and the volatile alkali. The two firſt are dry, ſolid, cauſtic, fuſible, deliqueſcent, &c. not diſtinguiſhable from each other when pure, but eaſily known by their combinations. No experiment has yet ſhewn their intimate compoſition; their principles have not been ſeparated, neither have they yet been formed by any combination.

That opinion which regards alkalis as an union of water and earth, is merely an ingenious hypotheſis, which cannot be maintained, becauſe ſupported by no plauſible fact. Volatile alkali differs from the two foregoing, becauſe it exiſts in the form of an elaſtic fluid of a very penetrating ſmell, &c. It is at preſent more than ſuſpected, that it is a compound of two gaſes, inflammable gas and atmoſpheric mephitis; that it is decompoſed in many operations, and formed again in others.

V. The well known acids are ſix in number; the cretaceous, the marine, the ſparry, the nitrous, the vitriolic, and the ſedative. All have peculiar and diſtinctive properties. The cretaceous, marine, and ſparry acids, aſſume the elaſtic or aeriform ſtate very readily; the vitriolic and nitrous acids do not aſſume it with equal facility; the ſedative acid is concrete and cryſtalline. The acids of molybdena and tungſten, which we have treated of in a ſupplementary chapter, are concrete, but pulverulent, and without a regular cryſtalline form.

VI. We begin to be acquainted much better than formerly with the nature of acids. It is proved, that the hypotheſis, which conſidered them as an intimate union of water and earth, is no longer probable. It is demonſtrated, that vital air enters into their compoſition; that this vital air is often united with a combuſtible body, as charcoal in the cretaceous acid, ſulphur in the vitriolic acid, nitrous gas in the nitrous acid. The formation of a great number of peculiar acids by the action of the nitrous acid on combuſtible bodies, confirms this aſſertion reſpecting the neceſſity of vital air to conſtitute acids; for which reaſon Mr. Lavoiſier diſtinguiſhes vital air by the name of the oxyginous or acidifying principle.

VII. Acids unite, without decompoſition, with clay, ponderous earth, magneſia, lime, and the alkalis. From theſe combinations reſult a great number of ſalts, called compound, middle, or neutral ſalts. Subſtances, which neutralize acids in ſaline compounds, are called baſes.

VIII. Middle, or neutral ſalts, have properties which differ from thoſe of their component parts. In moſt of them, we cannot diſtinguiſh the character either of the acid or baſe. The latter, however, rather than the acid, appears to communicate certain general properties to neutral ſalts; for which reaſon we have diſtinguiſhed neutral ſalts by their baſes.

IX. On this principle there are ſix genera of neutral ſalts, whoſe order, compoſition, and nomenclature, are as follow.

Genus I. NEUTRAL SALTS, WITH BASE OF FIXED ALKALI.

Species I. Vitriolic acid, and vegetable fixed alkali; vitriolated tartar, or rather vitriol of pot-aſh.

Species II. Vitriolic acid and mineral fixed alkali; Glauber's ſalt, or rather vitriol of ſoda.

Species III. Nitrous acid and vegetable fixed alkali; nitre, or nitre of pot-aſh.

Species IV. Nitrous acid and mineral

fixed alkali; rhomboidal nitre, cubic nitre, or rather nitre of ſoda.

Species V. Marine acid and vegetable fixed alkali; febrifuge ſalt of Sylvius, or rather muriate of ſoda.

Species VI. Sedative acid and vegetable fixed alkali; borax of pot-aſh.

Species VII. Sedative acid and mineral fixed alkali; common borax, borax of ſoda.

Species VIII. Sparry or fluor acid, and vegetable fixed alkali; ſparry tartar, or rather fluor of pot-aſh.

Species IX. Fluor acid and fixed mineral alkali; ſparry ſoda, or rather fluor of ſoda.

Species X. Cretaceous acid and fixed vegetable alkali; cretaceous tartar, or rather chalk of pot-aſh.

Species XI. Cretaceous acid and fixed mineral alkali; cretaceous ſoda, or rather chalk of ſoda.

Genus II. NEUTRAL AMMONIACAL SALTS.

Species I. Vitriolic acid and volatile alkali; ammoniacal vitriol.

Species II. Nitrous acid and volatile alkali; ammoniacal nitre.

Species III. Marine acid and volatile alkali; ſal ammoniac, or rather ammoniacal muriate.

Species IV. Sparry acid and volatile alkali; ammoniacal fluor.

Species V. Sedative acid and volatile alkali; ammoniacal borax.

Species VI. Cretaceous acid and volatile alkali; ammoniacal chalk.

Genus III. CALCAREOUS NEUTRAL SALTS.

Species I. Vitriolic acid and lime; plaſter, gypſum, ſelenite, or rather calcareous vitriol.

Species II. Nitrous acid and lime; calcareous nitre.

Species III. Marine acid and lime; calcareous marine ſalt, or rather calcareous muriate.

Species IV. Fluor acid and lime; vitreous ſpar, cubic ſpar, fuſible or fluor ſpar, ſparry fluor, or rather calcareous fluor.

Species V. Sedative acid and lime; calcareous borax.

Species VI. Cretaceous acid and lime; chalk, calcareous ſpar, or rather calcareous chalk.

Genus IV. MAGNESIAN NEUTRAL SALTS.

Species I. Vitriolic acid and magneſia; Epſom ſalt, or rather magneſian vitriol.

Species II. Nitrous acid and magneſia; magneſian nitre.

Species III. Marine acid and magneſia; marine ſalt of magneſia, or rather magneſian muriate.

Species IV. Fluor acid and magneſia; magneſian fluor.

Species V. Sedative acid and magneſia; magneſian borax.

Species VI. Cretaceous acid and magneſia; effervefcent magneſia, or rather magneſian chalk.

Genus V. NEUTRAL ARGILLACEOUS SALTS.

Species I. Vitriolic acid and clay; alum, or rather argillaceous vitriol.

Species II. Nitrous acid and clay; aluminous nitre, nitrous alum, or rather argillaceous nitre.

Species III. Marine acid and clay; argillaceous marine ſalt, aluminous ſalt, or rather argillaceous muriate.

Species IV. Fluor acid and clay; ſparry clay, or rather argillaceous fluor.

Species V. Sedative acid and clay; argillaceous borax.

Species VI. Cretaceous acid and clay; effervefcent clay, or rather argillaceous chalk.

Genus

Genus VI. NEUTRAL SALTS, WITH BASE OF PONDEROUS EARTH, OR BARYTIC NEUTRAL SALTS.

Species I. Vitriolic acid and barytes; ponderous ſpar, or rather barytic vitriol.

Species II. Nitrous acid and barytes; ponderous nitre, or rather barytic nitre.

Species III. Marine acid and barytes; ponderous marine ſalt, or rather barytic muriate.

Species IV. Fluor acid and barytes; barytic fluor.

Species V. Sedative acid and barytes; barytic borax.

Species VI. Cretaceous acid and barytes; cretaceous ponderous earth, or rather barytic chalk.

X. To theſe ſalts may be joined ſuch as are formed by the acids of molybdena and tungſten; the former of which may be diſtinguiſhed by the terms molybdena of pot-aſh, of ſoda, ammoniacal, calcareous, magneſian, argillaceous, barytic; and the latter, tungſten of pot-aſh, of ſoda, ammoniacal, &c.

XI. Each peculiar ſalt, whether it be ſimple or compound, poſſeſſes diſtinguiſhing characters, by which it may be known from every other. Theſe characters conſiſt in their

their taſte, their figure, and their habitudes, with reſpect to fire, air, the earths, and ſalts. They cannot be well diſtinguiſhed, but by a careful attention to all their properties, by comparing them with each other, and eſpecially by attending to ſuch properties as are the moſt peculiar.

XII. Though moſt of the ſimple ſalts in common uſe, more eſpecially the neutral, are produced by art, yet nature offers them in large quantities, either at the ſurface, or at ſmall depths in the earth. Neither pure barytes, nor magneſia, have yet been found. Quick-lime exiſts in the neighbourhood of volcanos. Fixed alkalis are never cauſtic at the ſurface of the earth, but are combined with acids. The cretaceous acid is contained in the atmoſphere, fills ſeveral ſubterraneous cavities, and is diſengaged from many waters. The marine acid appears to be at liberty at the ſurface of the ſea. The ſparry acid is always found combined with lime. The nitrous acid is found amongſt putrified matters. The vitriolic acid has been found cryſtallized, by Mr. Baldoſtari, in a grotto at the baths of St. Philip in Italy; and by Mr. Dolomieu, in a grotto near Mount Ætna. Mr. Vandelli has alſo obſerved, in the neighbourhood of Sienna and Viterbo, the vitriolic acid diſſolved in water iſſuing from amongſt rocks. The ſulphureous acid is continually diſengaged

gaged in volcanic places. The ſedative acid is diſſolved in the water of many of the lakes in Tuſcany, according to Mr. Hoefer.

XIII. Among the forty-two ſpecies of neutral ſalts, the following only have been found at the ſurface of the globe, in the waters, or among the fluids of organized bodies, in the genus of perfect neutral ſalts, with baſe of fixed alkali: vitriolated tartar in vegetables; Glauber's ſalt, diſſolved in water, and exiſting in certain plants; nitre in the juices of vegetables, and in earths impregnated with putrid matters; febrifuge ſalt in water and marine plants; marine ſalt in earth, water, ſea plants, and animal fluids; cretaceous tartar in vegetables; cretaceous ſoda in efflorеſcence, on the ſurface of the earth, on ſtones, and in the animal fluids. It is not well determined whether borax is ever found native.* Cubic nitre, fluor of pot-aſh, fluor of ſoda, and borax of pot-aſh, are always produced by art.

XIV. Among the ammoniacal ſalts, none are found in nature, excepting ſal ammoniac, in the neighbourhood of volcanos, and ammoniacal chalk in putrified animal matters. Ammoniacal vitriol, ammoniacal nitre,

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* Mr. Grill Abrahamſon ſent ſome borax to Sweden, in the year 1772, in a cryſtalline form, as dug out of the earth, in the kingdom of Thibet, where it is called pounxa, my poun, and houi poun. Kirwan's Mineralogy, page 206. T.

ammoniacal fluor, and ammoniacal borax, are always produced by art.

XV. Neutral calcareous ſalts are abundantly found, there being but one of the ſix ſpecies we know, which is not produced in nature. Calcareous vitriol, or ſelenite, forms conſiderable beds in mountains: chalk, or calcareous ſubſtances, conſtitute a great part of the external cruſt of the earth: calcareous nitre conſtantly accompanies common nitre in the places where it is produced; calcareous marine ſalt, or calcareous muriate, is likewiſe conſtantly found to accompany ſal-gem, or the ſalt diſſolved in waters. Fluor ſpar is abundantly found in mines.

XVI. Magneſian ſalts are much more rarely found in nature, Epſom ſalt, and marine magneſian ſalt, being only found diſſolved in certain waters. Magneſian nitre likewiſe exiſts but in very ſmall quantities. Nature has not yet been found to afford magneſian borax, magneſian fluor, and magneſian chalk; the latter, however, appears to exiſt, or is combined, in many ſtones.

XVII. Among the ponderous or barytic neutral ſalts, ponderous ſpar is the only one met with; it is found in the clefts of mountains, and always in the vicinity of mines. Nitre, marine ſalt, borax, fluor, and chalk, with baſe of barytes, have not yet been diſcovered in a natural ſtate.*

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* For native aerated ponderous earth, ſee Phil. Tranſ. for 1784. T.

XVIII. Argillaceous, or aluminous ſalts, are nearly as ſcarce; alum is almoſt the only ſalt of this genus which is found ready formed. It exiſts in volcanos, and volcanized earths; in efflореſcence, on decompoſed lavas; and is alſo contained in pyrites which have fallen into effloreſcence.

Nitre, muriate, borax, and fluor, with baſes of clay, are mere artificial products: clay is frequently combined with cretaceous acid, there not being any earth of this ſpecies from which that acid may not be ſeparated by the application of a ſtronger.

CHAP. XIII.

An Examination of certain peculiar Properties of Salts, particularly their Cryſtallization, Fuſibility, Effloreſcence, or Deliqueſcence, Solubility, &c.

THE properties of ſimple and neutral ſalts, which we have conſidered in each ſingly, require to be again attended to, in a comparative view, in order to deduce ſeveral uſeful general reſults; with this intention, we ſhall proceed to treat of their cryſtallization, fuſibility, effloreſcence, deliqueſcence, and ſolubility in water.

Cryſtallization, conſidered in general in all

all the bodies which poſſeſs that property, conſiſts in a tendency to aſſume a regular form under certain circumſtances. Moſt minerals poſſeſs it; but it is more eminent in ſaline ſubſtances than in any others. The circumſtances which favour its exiſtence, (and without which it cannot take place) are reducible to the two following, as far as relates to ſalts: 1. The particles muſt be divided, and ſeparated from each other, ſo that they may afterwards tend to unite, by the application of ſuch ſides or faces as have the ſtrongeſt affinity with each other. 2. It is neceſſary that this approach of the parts take place gradually, by the gradual ſubſtraction of the fluid. Hence it is eaſily conceived, that cryſtallization is effected by virtue of an attraction between the particles, or the affinity of aggregation, which tends to bring them together. Theſe conſiderations afford reaſon to think, that the integrant parts of a ſalt have a peculiar form, and that the different form affected by each ſaline ſubſtance in its cryſtallization, is a conſequence of this figure. And we are equally led to conclude, that the ſmall polyhedral figures of the particles of ſalt, having ſome faces more extended than others, may have a tendency to approach and unite by ſuch faces as are the largeſt. This being ſuppoſed, it will eaſily be conceived, that when the fluid which kept them aſunder, is ſubſtracted, they

they will unite by ſuch faces as are the beſt adapted, or have the ſtrongeſt affinity to each other; and that if the fluid be withdrawn gradually, ſo as to afford time for the ſaline particles to arrange themſelves in the beſt manner, the cryſtallization will be regular: but on the contrary, that a too ſpeedy privation of the fluid will cauſe them to approach ſuddenly, and to unite by the faces which firſt preſent themſelves; in which caſe the cryſtallization will be irregular, and the form not eaſily determined: or if the evaporation be ſtill more ſudden, the ſalt will take the form of a concrete maſs, of an appearance ſcarcely, if at all, cryſtalline.

The art of cryſtallizing ſaline matters is founded on theſe fundamental truths. All ſalts are cryſtallizable, though with different degrees of facility; ſome cryſtallize ſo readily, that we conſtantly ſucceed in procuring them in their regular form; others require more care and precaution; others again are ſo difficultly obtained in this ſtate, that it has not yet been accompliſhed. To ſucceed in attempts of this nature, it is neceſſary to pay great attention to the particular properties of each ſalt. The firſt ſtep is to diſſolve the ſaline ſubſtance in water: but there are ſome diſſolved with ſo much difficulty, by the means we poſſeſs, that it is almoſt impoſſible to obtain the regular approach of the particles; ſuch are ſelenite, calcareous ſpar, and fluor ſpar. Nature continually preſents theſe neutral terreſtrial ſalts, in very regular cryſtals, not imitable by art, but after long time: and many eminent philoſophers ſtill doubt the poſſibility of this proceſs, which we give on the authority of Mr. Achard; it conſiſts in paſſing water, which has ſtood a long time on ſalts of difficult ſolubility, through a very narrow aperture, and procuring a very ſlow evaporation. On the contrary, other ſaline matters are ſo ſoluble, and unite ſo ſtrongly with water, that they are not ſeparated but with great difficulty, and are ſcarcely to be obtained in a regular form: this is the caſe with all deliqueſcent ſalts, ſuch as the calcareous and magneſian nitres and marine ſalts.

It cannot be doubted, but that each ſalt has its peculiar mode of cryſtallization; or, which is the ſame thing, that its integrant parts have a determinate form, differing from that of every other ſalt: ſuch is doubtleſs the cauſe of the remarkable varieties among cryſtals. Simple ſalts, from the ſalino-terreſtrial ſubſtances to the moſt powerful acids, have not in general any diſtinguiſhing form; there are but few circumſtances which, without intirely deſtroying their peculiar ſaline properties, cauſe them to aſſume a cryſtalline form, as is the caſe with the dephlogiſticated or aerated marine acid, and

and glacial oil of vitriol. Mr. Bertholet, however, affirms, that cauſtic alkalis cryſtallize in ſcales; and that the acid of borax univerſally exhibits that form. Notwithſtanding this apparent conformity among ſimple ſalts, few of them do take a regular form in our laboratories; whether it be that they are not really ſuſceptible of it, or whether our methods be inſufficient for the purpoſe. But the neutral or middle ſalts all affect a regular form, which may be produced or deſtroyed in moſt of them at pleaſure. When we reflect on this property, ſo different from that of ſimple ſalts, it becomes an object of inquiry, whether it depends on the acids, or on the baſes by which thoſe acids are neutralized. It does not ſeem excluſively to depend either on the one or the other, ſince the ſame acids form ſalts very differently figured, with various baſes; and the ſame baſe, combined with different acids, preſents a like diſſimilarity in its cryſtals. The diverſity of forms in compounds, muſt therefore be attributed to the total change of properties which ariſes from combination.

There are three methods generally uſed in cryſtallizing ſalts in chemical laboratories: 1. Evaporation, which conſiſts in heating a ſaline ſolution, ſo as to diſſipate the water which kept the particles aſunder. The ſlower this evaporation is, the more regular will be the cryſtals obtained. Vitriolated tartar, marine ſalt, febrifuge ſalt, ſelenite, and magneſian chalk, are cryſtallized in this way. Their form is irregular, if the evaporation be performed too quickly, as for example, by a boiling heat; but by a ſand heat, of about 150 degrees, theſe ſaline ſolutions afford very regular and beautiful cryſtals. There is ſcarcely any ſalt which may not be had in a very diſtinct form by this proceſs, if ſkilfully conducted. 2. Cooling is ſucceſsfully employed with ſuch ſalts, as are more ſoluble in hot than in cold water. It is eaſy to conclude that a ſalt of this kind muſt cryſtallize, becauſe it is leſs ſoluble in water, whoſe temperature is diminiſhed. The portion which remained in ſolution, in conſequence of the heat, will be ſeparated in proportion as the fluid becomes cool; and when it is intirely cold, no more of the ſalt will remain diſſolved than the portion which cold water is capable of ſuſtaining. In this proceſs, as in the former, the more ſlowly the water cools, the more accurately will the ſaline particles approach each other, and in the moſt natural poſitions. For this reaſon, all ſuch ſaline ſolutions muſt be kept for ſome time at a certain degree of heat, which muſt be afterwards gradually diminiſhed to the freezing point, if neceſſary. It muſt be obſerved, in fact, that all ſalts, which may be cryſtallized by this proceſs,

proceſs, are in general much more ſoluble than thoſe which are cryſtallized by the former proceſs; that a ſudden refrigeration cauſes the exceſs of ſalt to be depoſited in an irregular maſs; and that regular cryſtals can only be obtained by gradual cooling. In this method, beautiful cryſtals of Glauber's ſalt, nitre, cretaceous ſoda, cretaceous tartar, ſal ammoniac, &c. may be obtained.

3. The third method of cryſtallizing ſalts, is by ſpontaneous evaporation. With this intention, a pure ſaline ſolution is expoſed to the temperature of the air, in capſules of glaſs, or earthen ware, covered with gauze, to prevent duſt from falling into it, without impeding the evaporation of the water: a ſeparate chamber, or loft, uſed for no other purpoſe, is beſt adapted to this operation. The ſolution is to be left till cryſtals are perceived, which in ſome ſalts does not happen in four or five months, or longer. This proceſs, in general, ſucceeds better than any other, for obtaining very regular cryſtals of conſiderable magnitude; and ought to be employed with all ſalts, if time permit, as it is a method of obtaining them perfectly pure. Rhomboidal nitre, marine ſalt, borax, alum, Epſom ſalt, ammoniacal vitriol, and ammoniacal nitre, &c. may be treated in this manner. In ſome circumſtances, more than one of theſe proceſſes are advantageouſly uſed at the ſame time; more eſpecially

cially when the very deliqueſcent ſalts, ſuch as calcareous nitre and muriate, magneſian nitre and muriate, &c. are to be cryſtallized. Theſe ſolutions are ſtrongly evaporated, and immediately expoſed to an intenſe cold; this method, however, affords only irregular cryſtals, and ſometimes concrete maſſes, of an indeterminate figure. The want of ſucceſs, in cryſtallizing a conſiderable number of neutral ſalts, ariſes from its not being preciſely determined to what ſtate of concentration each ſolution ought to be brought, in order to afford cryſtals. The work, which is eaſy, and only requires time and patience, has not been completely followed by chemiſts. This uſeful piece of knowledge conſiſts in the ſpecific gravities of the ſaline ſolutions: its advantages have already been perceived in ſeveral manufactories where ſaline matters are treated in the large way; an areometer or hydrometer being uſed to determine the requiſite degree of denſity or concentration of the ſaline ſolutions.

Beſides theſe different methods of cryſtallizing ſalts, there are ſeveral circumſtances which aſſiſt their operation, whoſe influence it is neceſſary to bring into the account. A ſlight motion is ſometimes uſeful in producing cryſtallization: thus we find, that by carrying from place to place the cups containing ſaline ſolutions, the cryſ-

tallization

tallization is completed a few inſtants after the ſlighteſt agitation. I have already obſerved, that this phenomenon takes place more eſpecially in nitre and calcareous muriate. The contact of air is likewiſe indiſpenſably neceſſary for the formation of cryſtals. It frequently happens, that a ſolution, evaporated to the requiſite degree for affording cryſtals, remains fluid throughout, in a well cloſed bottle; though the ſame ſolution cryſtallizes readily, if expoſed to the air in a cup: this obſervation was very accurately made by Rouelle the elder. The form of the veſſels, and the immerſion of foreign bodies in ſaline ſolutions, greatly influence their cryſtallization. The firſt modifies the figure of the cryſtals, and produces a very great variety: for this reaſon it is, that threads, or ſmall ſticks, are placed with great advantage in the cups containing the ſaline ſolution. For the cryſtals which adhere to the threads, having baſes of inconſiderable magnitude, are commonly of the moſt regular form; while ſuch as fix themſelves to the oblique, irregular, and unequal ſides of the veſſels commonly employed for this uſe, are more or leſs truncated and irregular. Foreign bodies, plunged in ſaline ſolutions, have likewiſe another advantage; they promote the formation of cryſtals, which would otherwiſe have been much more ſlowly effected. Thus it is, that a piece of wood, or a ſtone, thrown into a ſalt ſpring, becomes a baſe, on which the water depoſits cryſtals of marine ſalt. From the obſervation of this phenomenon, ſome chemiſts have propoſed to add a ſaline cryſtal to the ſolution of a ſalt which does not readily cryſtallize; and many have affirmed, that the cryſtallization of ſalts, which it is very difficult to obtain in a regular form, is greatly favoured by this means. Such are the principal cauſes which influence the cryſtallization of ſalts: there are doubtleſs many others, which the future obſervation and inquiries of chemiſts will make known.

The ſeparation of any ſalt from water, which holds it in ſolution, cannot be effected in a regular form, unleſs the ſalt retains a portion of the fluid. This may be ſhewn, in a convincing manner, by diſſolving in water a ſalt reduced to powder by heat, ſuch as calcined alum, or borax, or Glauber's ſalt fallen into effloreſcence, which will be found ſometimes increaſed to double in their cryſtallization; that is to ſay, an ounce of the ſalt treated in this manner, will afford two ounces of cryſtals. Whence it is concluded by chemiſts, that a well cryſtallized ſalt, contains more water than the ſame ſalt deprived of the cryſtalline form by the action of fire or air. They have called this water by the name of water of cryſtallization, becauſe it is in fact one of the elements of ſaline cryſtals, which loſe their tranſparency and regular form when deprived of it. Various ſalts contain very different quantities of the water of cryſtallization. Some contain the half of their weight, as Glauber's ſalt, cretaceous ſoda, and alum; others retain only a ſmall quantity as nitre, marine ſalt, &c.

The relative quantity of water of cryſtallization in all cryſtallizable ſalts, has not been well determined. It may be abſtracted from ſalts without their eſſential properties being in any reſpect altered, and is itſelf perfectly pure and ſimilar to diſtilled water.

As we have ſeen that various ſaline ſubſtances do not cryſtallize by the ſame proceſſes, or in circumſtances preciſely ſimilar, it is clear that this property may be advantageouſly uſed as the means of ſeparating them from each other. In this manner a ſalt cryſtallizable by cooling, may be obtained ſeparate from another ſalt, which is cryſtallizable only by continuing the evaporation; as is obſerved in the ſalt ſprings of Lorraine, which contain common ſalt and Glauber's ſalt. Notwithſtanding this, it frequently happens, that two ſalts diſſolved in the ſame water, however different their manner of cryſtallization may be, do nevertheleſs vitiate each other's cryſtals, and cannot be obtained ſeparate, but by repeated ſolutions and cryſtallizations. This obſervation applies

applies ſtill more ſtrongly to ſuch ſalts as cryſtallize nearly at the ſame time, which are more difficult to ſeparate from each other, eſpecially if they be numerous. For example, if the ſame water contain four ſalts alike cryſtallizable by evaporation, or cooling, it will be impoſſible to ſeparate them by one or two ſucceſſive cryſtallizations; and theſe operations muſt be multiplied a conſiderable number of times, that the ſlight differences between their manner of cryſtallization may produce the deſired effect: for it muſt be remarked, that no two ſalts are preciſely alike as to their manner of cryſtallization by cooling or evaporating. If ſuch exiſted they would always cryſtallize together, and could never be obtained ſeparate by this method; a circumſtance which in fact happens with ſuch ſalts as greatly reſemble each other in this property. There are other ſalts which are not ſeparable by cryſtallization, becauſe they adhere or combine together; ſuch in general are the neutral ſalts formed by the ſame acid, and cryſtallizable by the ſame proceſs as Epſom ſalt and ammoniacal vitriol. But theſe ſingular adheſions of neutral ſalts have not yet been ſufficiently examined, though the ſubject well deſerves the attention of chemiſts.

Laſtly, to conclude this ſhort hiſtory of the cryſtallization of ſalts, we muſt add, that there is another method of obtaining them,

them, which conſiſts in precipitating them from their ſolutions by the addition of a ſubſtance which has a ſtronger affinity for water. Thus, for example, ſpirit of wine poured into a ſaline ſolution, produces this effect on moſt neutral ſalts; thoſe only excepted which are ſoluble in that menſtruum. The ſame phenomenon of the precipitation of ſaline cryſtals takes place in the mixture of ſome ſalts, whoſe ſolubility is very different, and even ſometimes by the mixture of ſeveral ſaline ſolutions with each other. Thus we find that Epſom ſalt diſſolved in water appears to precipitate a ſolution of ammoniacal vitriol in the form of cryſtals; but the other facts, which accompany theſe ſingular admixtures, have not been ſufficiently aſcertained to juſtify any attempt towards forming a theory.

The fuſibility of ſalts by heat having been treated of under each particular article, we ſhall here take a comparative view of this property. Two kinds of fuſibility are diſtinguiſhable in ſalts; the one produced by the water they contain, and called the aqueous fuſion; the other, properly belonging to the ſaline matter, and termed the igneous fuſion. The aqueous fuſion depends entirely on the water of cryſtallization being in ſufficient quantity to diſſolve the ſalt at a certain temperature. The cryſtalline form then diſappears, and the ſalt is really diſſolved;

ſolved; a fact which is ſufficiently proved by continuing the application of heat for a ſufficient time to a ſalt of this nature, ſuch as Glauber's ſalt, borax, alum, &c. which become dry, and no longer appear melted after the water of ſolution is diſſipated. The apparent or aqueous fuſion likewiſe appears to be independent of the true igneous fuſion, from the circumſtance of this laſt appearing in all thoſe ſalts which are ſuſceptible of the other. When Glauber's ſalt or borax, for inſtance, have paſſed the aqueous fuſion, and become dry, they may be again melted by a ſtrong heat. The true igneous fuſion is not produced in all ſalts by the ſame degree of heat; there are ſome that melt as ſoon as they become red, as nitre and marine ſalt; others require a moſt violent degree of heat to fuſe them, as vitriolated tartar, and Glauber's ſalt. Laſtly, there are others whoſe fuſibility is ſuch, that they communicate the ſame property to the moſt refractory bodies; in this manner it is that fixed alkalis combine with and melt quartz, ſand, and all other ſiliceous earths which are not fuſible alone. Theſe ſalts are called fluxes from this property, and becauſe they are uſed to facilitate the fuſion of earthy and metallic ſubſtances. We have elſewhere remarked, that volatility is the extreme of fuſibility; and we may here add, that all ſaline matters are more or leſs volatile, no ſalt being ſufficiently

ciently fixed to withſtand the action of a violent heat.

The alterations to which cryſtallized ſalts are ſubject by expoſure to air, are not all alike. Some experience no ſenſible change; others loſe their tranſparent form, either gradually becoming fluid with an increaſe of weight, or becoming pulverulent by the loſs of a part of their maſs. The firſt of theſe changes is called deliqueſcence, and the latter effloreſcence.

The phenomenon termed deliqueſcence, takes its name from the ſaline matter becoming liquid: it is likewiſe ſaid that a ſalt falls into deliquium, when it melts in this manner by the contact of air. It appears to be the conſequence of a true elective attraction, which is ſtronger between the ſalt and the water, than between the latter and the air of the atmoſphere. All ſalts do not deliqueſce with equal rapidity, nor attract equal quantities of water from the atmoſphere. Fixed alkalis, alkaline gas, marine acid gas, and concentrated vitriolic acid, ſeize the water of the atmoſphere, and render it very dry, by abſorbing more than their own weight of that fluid. The appearance is more eſpecially remarkable in vitriolic acid congealed by cold, and dry cauſtic fixed alkali of tartar. Theſe two ſalts firſt become ſoft, and ſoon acquire a denſe fluidity ſimilar to that of certain oils, which has occaſioned

occaſioned the firſt to be called oil of vitriol, and the ſecond oil of tartar; though theſe names are far from being ſignificant, and may lead beginners into miſtakes. Others, though not ſo greedy of moiſture, nevertheleſs attract it very ſtrongly; as for example, calcareous nitre and marine ſalt, nitre, and marine ſalt of magneſia. Laſtly, there are ſome which become ſlightly moiſt, and do not completely deliqueſce; ſuch as rhomboidal nitre, febrifuge ſalt, ammoniacal vitriol, &c.

Efflореſcence was ſo denominated from the ſalts, which are ſuſceptible of it, becoming covered with a white ſubſtance, ſimilar to that which is known in chemiſtry by the name of flowers. This property is the reverſe of deliqueſcence; for as that happens by the decompoſition of the humid atmoſphere, by the ſtronger elective attraction of ſaline cryſtals for moiſture; ſo on the other hand, in effloreſcence the ſaline cryſtals are decompoſed, becauſe the air has a ſtronger affinity with water than thoſe cryſtals have. Effloreſcence is, therefore, a loſs of the water of cryſtallization, in conſequence of which the ſalts loſe their tranſparency and conſiſtence, and become lighter. It is of importance to be obſerved, that ſaline cryſtals which effloreſce, are ſubjected to the ſame alteration as would be produced by fire in a much ſhorter time; that is to ſay, they are ſlowly calcined, and loſe

loſe exactly the ſame weight as drying by heat would deprive them of: to this we muſt likewiſe add, that effloreſcent ſalts are of the moſt ſoluble claſs which cryſtallize by cooling their ſolutions.

Efflоreſcence, like deliqueſcence, is a property which greatly varies in the ſeveral neutral ſalts. Some ſalts, ſuch as borax, and cretaceous ſoda, readily effloreſce, and continue to fall in pieces, till the whole becomes a fine white powder; and as they loſe by this means half their weight, it may be concluded, that their property of effloreſcing ſo completely, is a conſequence of a large quantity of water which enters into their cryſtals: and in fact, we find that ſalts which effloreſce very little, ſuch as borax, alum, and Epſom ſalt, do not contain ſo large a quantity of that fluid in their cryſtals. If effloreſcence depend on a ſtronger elective attraction, between air and water, than between water and the ſalt, the phenomenon will take place more readily and effectually when the atmoſphere is very dry, while air loaded with moiſture will not have the ſame action on them. This aſſertion may be confirmed, by ſprinkling a ſmall quantity of water on cryſtals capable of effloreſcence; for the atmoſphere ſeizing this water, and becoming ſaturated, does not act on, or alter the cryſtals; but if this operation be not repeated from time to time, the air combines with the water of cryſtallization, and the efloreſcence takes place. This is daily obſerved by druggiſts, who find it neceſſary to moiſten Glauber's ſalt with a ſmall quantity of water, that the form of the cryſtals may be well preſerved.

The diſſolution of ſalts in water, is a phenomenon which highly deſerves the attention of chemiſts. Some perſons having obſerved that this is effected without any ſenſible motion or effervеſcence, ſuch as accompanies the ſolution of metals in acids, have propoſed to diſtinguiſh the latter by the word ſolution, and the former by that of diſſolution. But there is no difference in the ſenſe of either of theſe terms; and the mutual action of acids and metals being intirely different from the ſolution of ſalts in water, and depending on peculiar cauſes, hereafter to be explained, no advantage would be derived from this diſtinction. The ſolution of ſalts in water has been conſidered by ſome philoſophical chemiſts as a ſimple mechanical diviſion of the ſaline particles; but there is an intimate penetration, which takes place between theſe two bodies, attended with a change of temperature; and it ſeems that a true combination takes place between the ſalts and the water, which can by no means be explained, on the ſuppoſition of the ſaline particles being ſimply divided. This is proved, not only by the change of temperature, but likewiſe by the practicability of ſeparating

parating any ſalt from its ſolution, by the addition of another; as fixed alkali precipitates vitriolated tartar, and chalk, from waters which hold them in ſolution. The precipitations of ſalts by each other are far from being all known; and the ſcience of chemiſtry would derive great advantage from a connected ſeries of experiments on this ſubject. It may be obſerved, in the particular hiſtory of each ſaline ſubſtance, that they all poſſeſs different degrees of ſolubility, from conſtant fluidity, ſuch as exiſts in the vitriolic and nitrous acids, to almoſt perfect infuſibility; as ponderous ſpar. Many chemiſts have publiſhed tables of the different ſolubility of ſalts; but theſe tables will be inaccurate and imperfect, till experiments have been ſufficiently multiplied to eſtabliſh the exact proportions between the different ſolubilities. We muſt here add, that all ſimple ſalts, whether alkaline or acid, conſtantly produce heat, when diſſolved in water; whereas cold is always produced during the ſolution of neutral ſalts. The meaſure of theſe changes of temperature is not well aſcertained in all kinds of ſalts, but this phenomenon is more attended to at preſent than formerly. It will doubtleſs lead the way to valuable diſcoveries: we already begin to perceive certain truths, whoſe exiſtence was formerly not ſo much as ſuſpected. For example, when we obſerve, that neutral ſalts, which produce the greateſt cold in their ſolution, as Glauber's ſalt, nitre, ſal ammoniac, are much more ſoluble in hot than in cold water, may we not conclude, that this ſolubility depends on the water then poſſeſſing a more conſiderable quantity of heat, which it is neceſſary they ſhould abſorb, to become melted, and take the liquid ſtate? This exceſs of heat, being eaſily carried off by the air and ſurrounding bodies, a part of the ſalt is precipitated in the cryſtalline form during the cooling.

CHAP. XIV.

Concerning the Elective Attractions which take place between the ſeveral Saline Subſtances.

THE diſcoveries made in conſequence of the numerous experiments made by chemiſts, on ſaline matters, ſince the middle of the preſent century, have ſhewn, that ſaline ſubſtances have very different degrees of affinity, or elective attraction, among each other. Geoffroy is the firſt who compared them; but later diſcoveries have ſhewn, that his table contains many errors. Bergman has corrected them, and has added a much greater number

number of elective attractions between all the ſalts: however, on conſulting the ſeveral articles of the table of this celebrated Swediſh chemiſt, we find that many of them are not yet eſtabliſhed on a ſufficient number of accurate experiments, and that he himſelf acknowledges their uncertainty. Without extending the theory of elective attractions to ſo large a number of baſes as Bergman has done, we ſhall confine ourſelves to the preſent ſtate of chemiſtry, in our examination of the affinities which are exerted between thoſe ſaline matters, whoſe nature and properties are beſt known.

Among the ſix ſpecies of acids we have examined, the vitriolic appears to be the ſtrongeſt in its elective attractions; that is to ſay, it deprives other acids of moſt of their alkaline ſalino-terreſtrial baſes. Thus it decompoſes nitrous ſalts, marine ſalts or muriates, fluor ſalts, boraxes, and chalks, by diſengaging their acids.

The nitrous acid in general occupies the ſecond rank, yielding the alkaline baſes to the vitriolic acid, but depriving the four following acids of them.

To ſhew the different affinities which obtain between the mineral acids and the ſaline baſes of the ſame kingdom, to the beſt advantage, we ſhall exhibit them in the order or arrangement of Bergman; by conſidering, 1ſt, Each acid, with reſpect to the different baſes

baſes it can unite with; 2d, Each alkaline matter, with reſpect to the acids which ſaturated it, and the degree of adheſion with which it unites to thoſe ſalts.

I. The elective attractions of the vitriolic acid, for the different baſes, are diſpoſed, by Bergman, in the following order, beginning with that to which it moſt ſtrongly adheres.

VITRIOLIC ACID.*

Pure ponderous earth.
Pure vegetable fixed alkali.
Pure mineral fixed alkali.
Quick-lime.
Volatile alkali.
Magneſia.
Clay.

Though the nitrous and marine acids have the ſame order of elective attractions for alkaline baſes, we ſhall nevertheleſs exhibit them at length.

NITROUS ACID.

Pure ponderous earth.
Pure vegetable fixed alkali.

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* We have already exhibited the order of the affinities of acids, with the baſes, in the hiſtory of each; but we think proper to repreſent them here in columns, as is uſually done in tables of affinities, that they may be ſeen and compared on inſpection. F.

Pure mineral fixed alkali.
Quick-lime.
Volatile alkali.
Magneſia.
Clay.

MARINE ACID.

Pure ponderous earth.
Pure vegetable fixed alkali.
Pure mineral fixed alkali.
Quick-lime.
Magneſia.
Clay.

Ponderous earth has therefore a ſtronger affinity with the vitriolic, nitrous, and marine acids, than every other baſe, and decompoſes all the neutral ſalts formed by theſe acids, and other alkaline matters. Bergman places magneſia before the volatile alkali, becauſe, he affirms, that this ſalino-terreſtrial ſubſtance decompoſes ammoniacal ſalts. We muſt obſerve, that volatile alkali decompoſes magneſian ſalts more completely; in fact, all the magneſia is not precipitated by this alkali, the fluid retaining in ſolution mixed or triple ſalts, formed by the union of the magneſian with the ammoniacal ſalts. We apprehend, notwithſtanding our reſpect for the authority of Bergman, that there is a ſtronger elective attraction between the acids and volatile alkali, than between the ſame ſalts and magneſia, becauſe the latter does not decompoſe ammoniacal ſalts by diſtillation; and for that reaſon we have placed the volatile alkali before magneſia, and think the correction is neceſſary to be made in Bergman's table.

II. The elective attractions of the fluor acid for alkaline baſes, are very different from thoſe of the three foregoing. Alkalis yield this acid to lime, and the two other ſalino-terreſtrial ſubſtances. A ſolution of barytic fluor in hot water is precipitated by lime-water, which immediately forms ſparry fluor. The ſame thing happens with other fluor neutral ſalts; lime ſeizing the acid at the eighth column of Bergman's table, decompoſed hereunder denotes.

FLUOR ACID.

Quick-lime.
Ponderous earth.
Magneſia.
Vegetable fixed alkali.
Mineral fixed alkali.
Volatile alkali.
Clay.

The ſame phenomena take place by the dry way; for fluor ſpar is not decompoſed by pure and cauſtic fixed alkalis, though it it is by cretaceous tartar and cretaceous ſoda.

III. Bergman, in his tenth column, exhibits the affinities of the acid of borax, in the ſame order as thoſe of the acid of fluor; becauſe, when borax is heated in water with quick-lime, the latter ſeizes its acid, forming the ſcarcely ſoluble calcareous borax, and leaves the marine alkali in a ſtate of purity. As to the other baſes, he has diſpoſed them by analogy, and conſiders the diſpoſition as nothing more than a probable conjecture.*

ACID OF BORAX.

Quick-lime.
Ponderous earth.
Magneſia.
Vegetable fixed alkali.
Mineral fixed alkali.
Volatile alkali.
Clay.

IV. The elective attractions of the cretaceous acid are ſomewhat different from theſe. It adheres more ſtrongly to ponderous earth, and after that to lime, than to any other ſubſtance. Its combination with magneſia is likewiſe deſtroyed by the cauſtic vola-

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* Quod idem accidat cum alkali vegetabili, acido boracis ſaturato, hactenus tantum probabilis eſt conjectura, æque ac terræ ponderoſæ, & magneſiæ poſitura.

tile alkali, as Bergman has proved by accurate experiments. The following extract of the twenty-fifth column of the table of this celebrated chemiſt, expreſſes the order of the attractions of the cretaceous acid for the ſeveral ſaline baſes.

CRETACEOUS ACID.

Ponderous earth.
Quick-lime.
Vegetable fixed alkali.
Mineral fixed alkali.
Magneſia.
Volatile alkali.
Clay.

V. The ſeven earthy, or alkaline baſes, whoſe combinations with the mineral acids we have examined, have different elective attractions for thoſe acids, when compared together; five of them, namely, the two fixed alkalis, volatile alkali, lime, and clay, reſemble each other in the order of their affinities. All the five adhere to acids in the following order: the vitriolic, nitrous, marine, fluor borax, and cretaceous acids; but ponderous earth and magneſia have different affinities from the foregoing, though they agree with each other.

Bergman diſpoſes the elective attractions of ponderous earth and magneſia, with reſpect

ſpect to the mineral acids, in the following manner.

PONDEROUS EARTH AND MAGNESIA.

Vitriolic acid.
Fluor acid.
Nitrous acid.
Marine acid.
Acid of borax.
Cretaceous acid.

There is no difference between this order of affinities, and that of the other five baſes, except that the fluor acid is before the nitrous and marine acids, which ſhews, that nitre, and the barytic and magneſian muriates, are decompoſed by the fluor acid; while the barytic and magneſian fluors do not yield their baſes to the nitrous and muriatic acids.

VI. The elective attractions we have exhibited, ſhew the order of ſimple decompoſitions, which take place on the mixture of three ſaline bodies; but it is equally neceſſary that the chemiſt ſhould attend to the double affinities, or decompoſitions which take place when four ſubſtances are mixed together.

It muſt be recollected, that by double affinity is underſtood a combined force, by virtue of which, a compound of two bodies, which cannot be ſeparated neither by a third nor a fourth body, preſented ſeparately, is nevertheleſs decompoſed with the greateſt facility, when the two laſt are combined together. This double elective attraction is very often exerted between neutral ſalts. In this manner it is, that the vitriolic, nitrous, and marine calcareous ſalts, are not decompoſed by volatile alkali, or by the cretaceous acid alone; becauſe the firſt of theſe bodies has a leſs affinity than lime with the vitriolic, nitrous, or marine acids, while the ſecond has a leſs affinity than lime with the ſame acids: but when a compound of volatile alkali and cretaceous acid is preſented to theſe calcareous ſalts, the adheſion of their principles will be deſtroyed. I have ſhewn, in the firſt volume of this work, where affinities are generally treated of, that the cauſe of this phenomenon might be explained, by aſſuming numbers to expreſs the different degrees of elective attraction. I have attempted to apply this idea to ſaline ſubſtances; but as the nature and combinations of the acids of fluor, and of borax, are not yet well known, I have conſidered only the vitriolic, nitrous, marine, and cretaceous acids, with reſpect to the ſaline mineral baſes. The numbers I have aſſumed to expreſs the different degrees of adheſion to thoſe baſes, are founded on the reſult of ſimple decompoſitions. It muſt be noted, that they are not perhaps accurately proportioned

to

to the forces of affinity, but are chiefly deſigned to explain the cauſe of double elective attractions.

I ſhall, in this place, firſt give a table of numbers, expreſſing the affinities of the four acids above-enumerated, with ſix baſes: I do not comprehend ponderous earth, becauſe its ſeveral ſaline combinations are not yet ſufficiently known. After which, I proceed to exhibit the known effects of double affinity among neutral ſalts, according to the method of diſpoſition invented by Bergman, which I have already deſcribed in the general chapter on affinities. I muſt here repeat, that in this ingenious diſpoſition, to which I have only added the numerical expreſſion, the ſum of the two vertical numbers, which denote the divellent attractions, muſt exceed that of the horizontal numbers, which indicate the quieſcent attractions, in order that a double decompoſition may follow.

TABLE of the Degrees of Attraction between Four Acids and Six Baſes, expreſſed in Numbers.

FIRST COLUMN.

The vitriolic acid has an affinity of combination with	Vegetable fixed alkali equal to	8
	Mineral fixed alkali	7
	Quick-lime	6
	Volatile alkali	4
	Magneſia	$3\frac{1}{2}$
	Clay	2

SECOND COLUMN.

The nitrous acid has an affinity of combination with	Vegetable fixed alkali equal to	7
	Mineral fixed alkali	6
	Quick-lime	4
	Volatile alkali	3
	Magneſia	2
	Clay	1

THIRD COLUMN.

The marine acid has an affinity of combination with	Vegetable fixed alkali equal to	6
	Mineral fixed alkali	5
	Quick-lime	3
	Volatile alkali	2
	Magneſia	1
	Clay	$\frac{1}{2}$

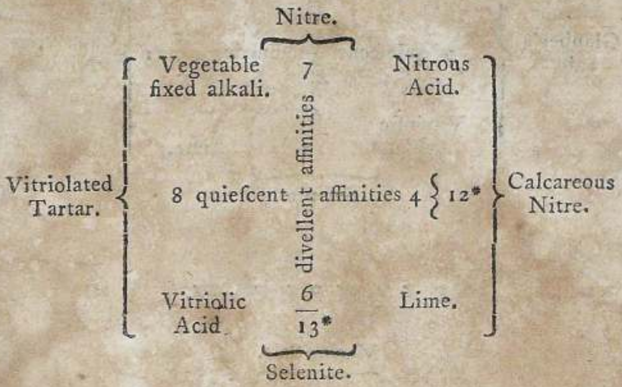
FOURTH COLUMN.

The cretaceous acid has an affinity of combination with	Vegetable fixed alkali equal to	3
	Mineral fixed alkali	2
	Quick-lime	1
	Volatile alkali	$\frac{3}{4}$
	Magneſia	$\frac{1}{3}$
	Clay	$\frac{1}{4}$

TABLE

TABLE of Ten Decompoſitions by Double Affinity, which take place between ſeveral Neutral Salts, and are expreſſed by Numbers, taken from the foregoing Table.

EXAMPLE I.



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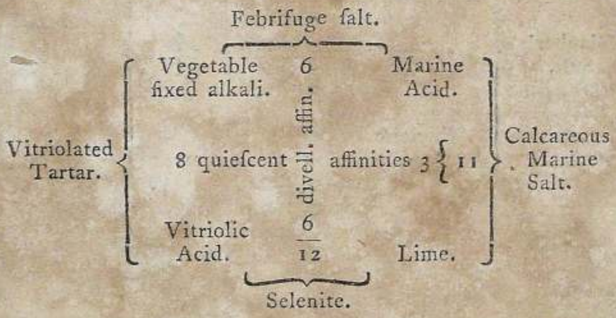

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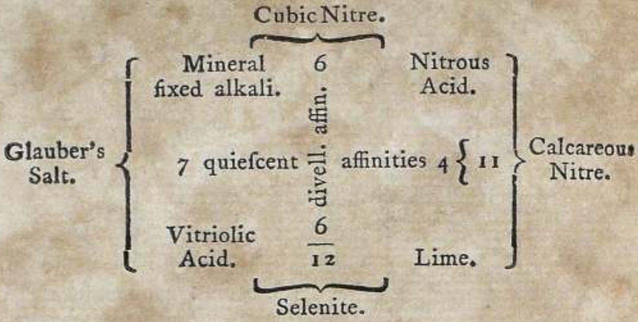
* Theſe numbers denote the ſums of the quieſcent and divellent affinities.

EXAMPLE

EXAMPLE III.



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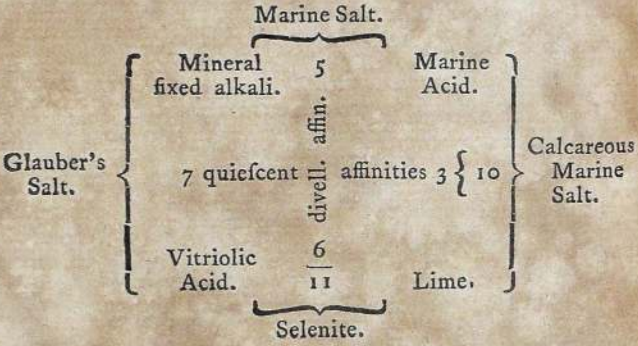
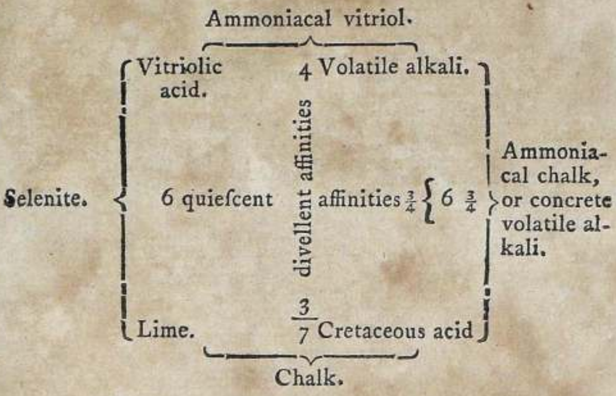


EXAMPLE

EXAMPLE V.



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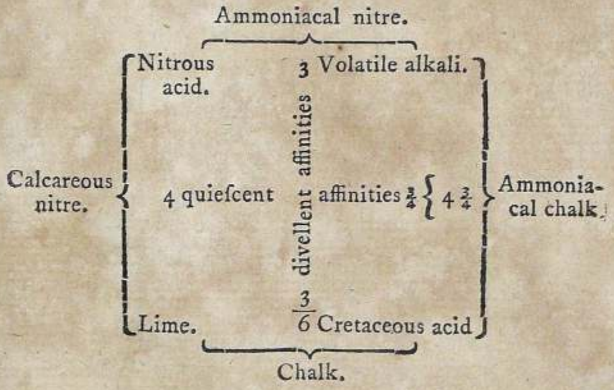

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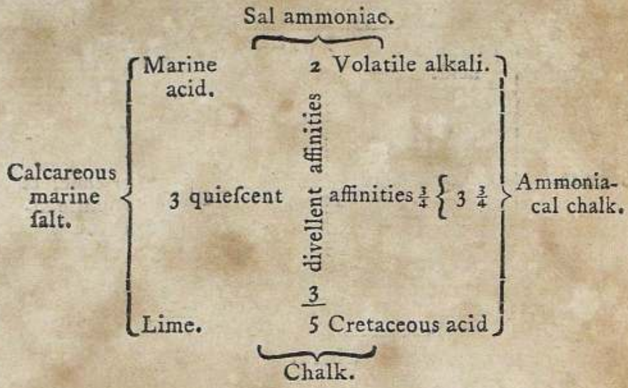
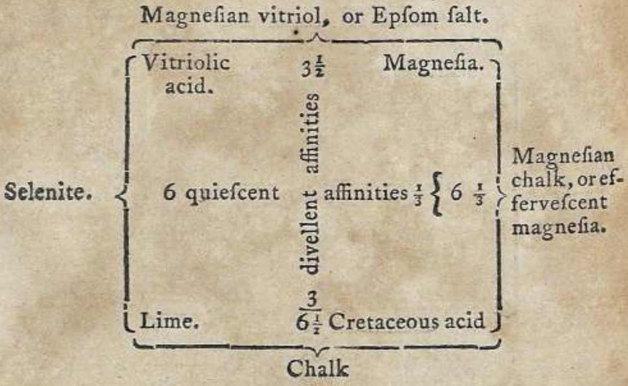
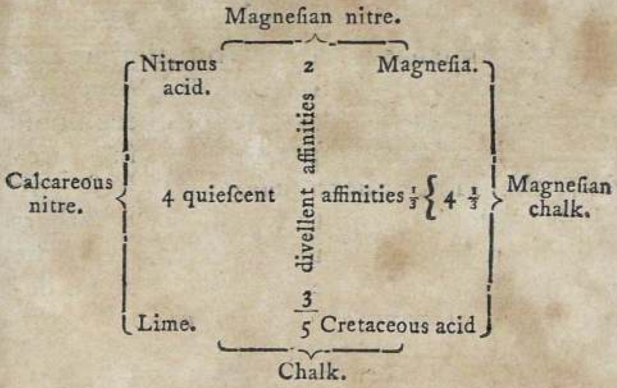


EXAMPLE VIII.

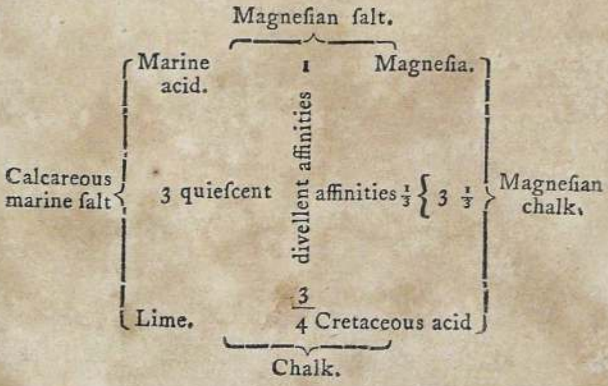


EXAMPLE

EXAMPLE IX.



EXAMPLE X. AND LAST.



Theſe ten examples of double affinity are not the only inſtances of this kind of decompoſition which takes place among the neutral ſalts we have examined. We have ſeen, for inſtance, that barytic ſalts are not decompoſed by pure fixed alkali, while cretaceous tartar and cretaceous ſoda decompoſe them; that vitreous ſpar, or fluor ſpar preſent the ſame phenomenon. Theſe two kinds of double affinity, and perhaps others which are not yet known, among ſalts, are not repreſented in the foregoing table, becauſe the elective attractions of ponderous earth and fluor acid are not yet ſufficiently aſcertained to be expreſſed by numbers. When the neceſſary inquiries have been made, theſe numbers will doubtleſs require to be changed, but the method will remain unchanged, and is capable of improvement only in point of accuracy.

PART II.

MINERALOGY.

SECTION III.

COMBUSTIBLE BODIES.

CHAP. I.

Concerning Combuſtible Bodies in general.

WE have already ſpoken of combuſtion in the hiſtory of air. The order we have adopted requires a ſhort recapitulation in this place of the doctrines there maintained.

A combuſtible body, according to Stahl, is a compound which contains fixed fire or phlogiſton; combuſtion, according to his theory, conſiſts in its diſengagement, and its tranſition to the ſtate of liberty; which are manifeſted by light and heat. When this proceſs is intirely finiſhed, the body enters the claſs of incombuſtible matters, and may regain its original combuſtibility by receiving its phlogiſton, or by becoming again united to the matter of fire transferred to it from another body. We have taken notice of four principal difficulties in this theory: 1. The impoſſibility of aſcertaining the preſence of phlogiſton. 2. The augmentation of weight by combuſtion, which cannot be imagined to ariſe from the loſs of a principle. 3. The loſs of weight which a body ſuſtains when it paſſes from the incombuſtible to the inflammable ſtate, by the addition of phlogiſton. 4. The little attention Stahl paid to the neceſſity of air in combuſtion.

A more accurate obſervation of this laſt phenomenon, and the augmentation of weight which combuſtible bodies acquire by being burned, has given birth to the following theory.

Bodies are combuſtible, becauſe they tend ſtrongly to combine with pure air, and combuſtion is the proceſs by which this combination is effected. The four following facts conſtitute the baſis of this opinion. 1. Bodies cannot burn without air. 2. The purer the air, the more rapid the combuſtion. 3. By combuſtion air is abſorbed, and the weight of the burned body augmented. 4. Laſtly, the body burned in the atmoſphere contains the portion of air which the atmoſphere loſt; and this portion

tion may in ſome caſes be extracted by different methods hereafter to be deſcribed.

Macquer united this theory with that of Stahl, by conſidering fixed light as phlogiſton, and admitting pure air as the precipitant of light. He ſuppoſed that in every combuſtion the phlogiſton was ſeparated, in the form of light, by the pure air which occupied its place in the combuſtible body; and he conſidered theſe two ſubſtances, light and vital air, as mutual precipitants of each other. So that when fixed light paſſes from a combuſtible body into a body already burned, he ſuppoſed that this tranſition is made only in proportion as the vital air united with the burned body gives place to the matter of light, and becomes itſelf transferred into the other ſubſtance from which the light eſcapes.

M. Lavoiſier has propoſed a different theory from the two foregoing. He thinks that vital air is compoſed of a fixable baſe, which he calls the oxyginous principle, held in ſolution in the ſtate of elaſtic fluidity by the matter of fire or light. When a combuſtible body is heated in this fluid, it decompoſes the vital air by ſeizing its baſe; the matter of fire being at the ſame time ſet at liberty, and eſcaping with the appearance of its diſtinguiſhing characters, namely, heat and light, which conſtitute flame. According to this hypotheſis, pure air is the true and only combuſtible body. This theory does not reject the preſence of phlogiſton, which is here exhibited in the form of light; but it differs from that of Stahl, by the place allotted to phlogiſton or fixed fire, which M. Lavoiſier admits in the body which maintains the combuſtion; while Stahl imagined it to exiſt in the combuſtible body. The ſame objection may likewiſe be made againſt the oxyginous principle of vital air, as has been urged againſt the phlogiſton of Stahl. In fact, this principle has not yet been exhibited in an inſulated or pure ſtate, ſince it always exiſts, either combined with the matter of fire in vital air, or with combuſtible bodies after they have been burned. Like phlogiſton, it is only perceived to paſs from one body to another, and to change its combination, without being capable of a ſeparate exhibition in a ſtate of purity.

The different combuſtible bodies vary greatly in their reſpective tendency to combine with the baſe of vital air; and the greater or leſs degree of combuſtibility appears to depend on theſe variations: ſo that a table of the order of their combuſtibility or affinity with vital air may be hence conſtructed.

This variety of affinity between combuſtible bodies and the oxyginous principle, is the cauſe of the different phenomena they preſent

preſent during their combination with that fluid: four kinds of combuſtion may therefore be diſtinguiſhed.

1. Combuſtion attended with flame and heat, ſuch as, for example, the combuſtion of ſulphur.

2. Combuſtion attended with heat, but without flame, as that of ſeveral metals.

3. Combuſtion with flame, but without heat, as that of phoſphorus, &c.

4. Slow combuſtion, without apparent heat or flame, ſuch as takes place by the contact of certain combuſtible bodies with air.

It muſt be obſerved, that the phenomena of combuſtion differ likewiſe in many other reſpects, peculiar to each combuſtible body. The rapidity, colour, and magnitude of the flame; the ſmell which accompanies it; the quantity of air abſorbed; the form, the colour, the weight, and other properties of the reſidue; together with other concomitant circumſtances, which it is needleſs to explain in this place, becauſe they will be treated with that attention which the importance of the ſubject demands, in the account of each combuſtible body, ſerve to eſtabliſh eſſential differences, well adapted to characterize bodies belonging to this claſs.

When we conſider the great variety of phenomena exhibited by combuſtible bodies, we cannot but admit that the cauſe of this phenomenon

phenomenon is ſtill unknown, and that important diſcoveries remain to be made in this part of chemical theory. The different degrees of affinity which appear to exiſt between combuſtible bodies and vital air, or the oxyginous principle, are already ſufficient to account for ſome of the facts. It is natural to believe, that a body, which has a ſtrong attraction for the oxyginous principle, will exhibit more heat, motion, and light; becauſe this laſt will be ſeparated with more energy, whether from the combuſtible body, according to Macquer's theory, or from the vital air, according to that of M. Lavoiſier, or from both at once. But this hypotheſis does not explain the cauſe of the various colours of flame in combuſtible bodies; why, for example, copper burns green, &c.; neither does it explain how certain combuſtible matters burn without apparent flame, unleſs we adopt the opinion of many philoſophers, that the matter of light and of heat are one and the ſame, and differ only in the degree of condenſation. The difficulties attending this opinion are ſufficiently known. If it could be proved, that light is combined in combuſtible bodies, and that it is diſengaged during combuſtion, it might be imagined, that this ſubſtance is differently combined in different bodies: that in ſome, for example, the whole of its ſeven rays, or principles, is fixed; that others contain only the

the orange-coloured ray, as nitrous gas; and others the yellow or green, as zink and copper. But this hypotheſis, which has already been mentioned in the hiſtory of combuſtion, when treated of under the article air, has not yet been confirmed by facts; and we can ſcarcely avoid thinking, when we reflect on the phenomena of combuſtion, that light appears rather to be contained in the vital air, than in the combuſtible bodies. In fact, how can we conceive, that a body ſo divided, and ſo elaſtic, as light, can become fixed and ſolid? Is it not more natural, and conformable to the notions of ſound philoſophy, to conclude, that, far from being capable of aſſuming the ſolid form, light is rather adapted to deſtroy it in ſuch bodies as poſſeſs it, and that it is the cauſe of elaſticity in all aeriform fluids, which ſeem to be ſubſtances naturally ſolid, but united with light? I muſt confeſs, that the hypotheſis at preſent admitted by many philoſophers, that elaſtic fluids owe their ſtate, as ſuch, to the matter of fire or light, appears to me infinitely more probable than that which admits the preſence of this, incoercible ſubſtance, in matters of ſo fixed and ſolid a nature as metals.

It appears therefore, that difficulties ſtill remain to be cleared up in the hiſtory of combuſtion; but that it is well eſtabliſhed, that combuſtible bodies, after having been burned,

burned, acquire a different nature, becoming more heavy by the addition of the oxyginous principle; and that this principle has aſſumed a more ſolid form than it before poſſeſſed, when combined with light, in the ſtate of vital air.

We ſhall divide mineral combuſtible bodies into ſix genera; namely, diamond, inflammable gas, ſulphur, plumbago, metallic ſubſtances, and bitumens.

CHAP. II.

Genus I. DIAMOND.

DIAMOND is a ſingular ſubſtance; it is uſually reckoned among ſtones, becauſe of its hardneſs, inſipidity, and inſolubility: it is, beſides, the moſt tranſparent and the hardeſt of all minerals. This hardneſs is ſuch, that the beſt tempered ſteel has no effect on it; and it can only be worn away by rubbing one diamond againſt another.

Diamonds are found in the Eaſt Indies, particularly in the kingdoms of Golconda and Viſapour: they likewiſe come from the Brazils; but theſe laſt appear to be of an inferior quality, and are known in commerce

commerce by the name of Portugueze diamonds.

Diamonds are uſually found in an ochreous yellow earth, under rocks of grit-ſtone and quartz; they are likewiſe found detached in torrents, which have carried them from their beds. Diamonds are ſeldom found above a certain ſize. The ſovereigns of India reſerve the largeſt, in order that the price of this article may not fall. Diamonds have no brilliancy when dry out of the earth, but are covered with an earthy cruſt, which incloſes a ſecond cruſt, of the nature of calcareous ſpar, according to Mr. Romé de Liſle. Bright diamonds are occaſionally found in waters.

Diamonds very often have no regular form, but are flat, or worn round. Sometimes they are regularly cryſtallized in octahedrons, formed by two quadrangular pyramids, united at their baſes; they are likewiſe found with twelve, twenty-four, and forty-eight faces.

Some diamonds are perfectly tranſparent; others are ſpotted, veined, clouded, and are of much leſs price. Some are uniformly and beautifully tinged with yellow, red, blue, and black; the latter are very rare.

Diamonds appear to be compoſed of laminæ, laid upon each other; and they are eaſily divided, by ſtriking them in the direction of theſe laminæ with a good ſteel inſtrument.

ſtrument. There are, however, ſome diamonds which do not appear to be formed of diſtinct laminæ, but of twiſted fibres, like thoſe of knots in wood. Theſe laſt are exceedingly hard, and cannot be wrought; lapidaries call them diamonds of nature.

The tranſparency, the hardneſs, and the regular cryſtalline form of the diamond, induced naturaliſts to claſs it among vitrifiable ſtones. They conſidered it as the pureſt and moſt homogeneous rock-cryſtal. They ſuppoſed it unchangeable by fire, becauſe jewellers are in the habit of heating, and even of igniting, diamonds ſpotted with yellow; the ſpots becoming black by this proceſs, and incapable of affecting the brilliancy of the reſt of the ſtone. It was neverthele ſs known, that diamond is much heavier and harder than rock-cryſtal, and that it poſſeſſes a ſtrong electric property; but theſe were attributed to its extreme purity.

It is known, that all earthy or ſaline bodies refract the light nearly in the direct ratio of their denſity, but that tranſparent combuſtible bodies refract it about twice as much. The diamond produces nearly three times the refraction it would have produced, according to the ratio of its denſity; and as the refraction of light, from the poſterior ſurfaces of bodies, is greater in this ratio, the ſingular luſtre of the diamond muſt depend on this property. As it is exceedingly tranſparent,

tranſparent, and the light is ſtrongly refracted and reflected by its ſurfaces, every one of the facets emits a very brilliant pencil of light. For which reaſon, ſuch diamonds as are cut into facets on every part of their ſurface, emit a much ſtronger light than ſuch as are cut only on one ſide; whence the lapidaries diſtinguiſh the firſt by the name of brilliants, and call the ſecond roſes.

Boyle affirmed, that fire altered diamonds, and diſengaged acrid vapours; but the fact firſt mentioned by this philoſopher was not attended to. However, Coſmo the Third, Grand Duke of Tuſcany, in the years 1694 and 1695, ſaw diamonds deſtroyed, at Florence, by the burning mirror; and many years afterwards, the Emperor Francis I. was a witneſs of their deſtruction by the ſimple fire of a furnace.

Mr. D'Arcet, in his valuable experiments on the deſtruction of ſtony ſubſtances, expoſed to the heat of a violent and long continued fire, did not forget the diamond. He aſſerted, that it is evaporated in the direction of its laminæ, and that if the evaporation be deſignedly interrupted, the remainder is not at all altered, but conſiſts of a diamond of leſs magnitude.

Mr. D'Arcet, being deſirous of determining whether the evaporation of the diamond be any thing elſe but a ſimple decrepitation, thought proper to treat them in veſſels, cloſed

cloſed by various methods. He took a ſphere of porcelain clay, and after having cut it in two, he placed a diamond in the centre, and then cloſed the two hemiſpheres together, in ſuch a manner, as that the diamond formed its own bed in the clay, without any other cavity. This ſphere, being placed in the furnace till it was baked, was then broken, and the diamond was found to be evaporated, the ſpace in which it was lodged being empty, without the leaſt perceptible crack in the ball.

Mr. D'Arcet varied this experiment, by ſometimes uſing balls of porcelain clay, and at other times baked crucibles of porcelain, cloſed with a ſtopper of the ſame ſubſtance, covered with a fuſible matter, which, vitrifying in the fire, formed an hermetical cloſure. Mr. D'Arcet always found that the diamond diſappeared, and concluded that it is evaporable without the acceſs of air.

Meſſrs. D'Arcet and Roux have ſince obſerved, that it is not neceſſary to uſe ſo violent a heat to volatilize diamonds; and in the year 1770, Mr. Roux volatilized one, at the School of Medicine, in five hours, in a cuppelling furnace.

In the year 1771, Macquer obſerved a new phenomenon relative to the deſtruction of this ſubſtance. Having a diamond to volatilize, he uſed the furnace of Pott, with ſome improvements of his own. This furnace,

nace, with the addition of a tube, or chimney, of ten or twelve feet in height, produces a degree of heat equal to that of a furnace for hard porcelain. Macquer, having placed a muffle in the centre of this furnace, which at that time had only two feet of chimney, put a brilliant-cut diamond, weighing three-ſixteenths of a carrat, in a cuppel, which he firſt placed near the mouth of the red hot muffle, into which he gradually removed it, that the diamond might not fly in pieces by the too ſudden heat. At the end of twenty minutes, having obſerved the diamond, he found it increaſed in volume, and much more brilliant than the capſule in which it was placed; and laſtly, he obſerved a light, and apparently phoſphoric flame, forming a very evident glory round the ſtone; but he perceived no acrid vapours, as Boyle mentioned. The diamond having been replaced under the muffle, intirely diſappeared at the end of thirty minutes, without leaving any trace behind. Macquer, therefore, volatilized, in leſs than an hour, a diamond weighing near four grains, and found that it burned with a ſenſible flame, in the ſame manner as other combuſtible bodies.

This fact, publiſhed by Macquer, has been verified ſeveral times ſince. In the year 1775, Bucquet volatilized a diamond of about three grains and a half. He uſed the furnace of Macquer, but without the chimney; and the muffle remained open almoſt the whole time of the operation, in order to obſerve what paſſed during the combuſtion of the diamond. It remained about fifteen minutes before it inflamed, and in leſs than twenty-five minutes afterwards it was intirely diſſipated.

None of theſe experiments proving what became of the diamond, Meſſrs. Macquer, Lavoiſier, and Cadet, reſolved to make ſome experiments in cloſe veſſels. They diſtilled twenty grains of diamonds in a ſtone-ware retort, with a proper apparatus for collecting the product, if any paſſed over. A fire of the greateſt violence was uſed, and nothing was obtained. The diamonds were found intire, but had loſt ſome of their weight. It was therefore ſuſpected, that this loſs depended on the diamond's having been partly burned, by means of a ſmall quantity of air included in the veſſels. The diamonds were, beſides, covered with a blackiſh and coaly film, which was quickly taken off by the mill.

While theſe chemiſts were buſied in reſearches into the nature of diamond, the lapidaries ſtill retained their belief of its abſolute indiſtructability by fire. One of them, Mr. Le Blanc, brought a diamond to Mr. Rouelle to be expoſed to the fire, but choſe to incloſe it in his own way.

He placed it in a crucible, with a cement of chalk and powder of charcoal. This crucible was incloſed in another, with a cover, and luted. It remained in the fire during four hours, as well as ſeveral other diamonds, on which Mr. Rouelle was making experiments. At the end of this time, the diamonds of Mr. Rouelle, as well as that of Mr. Le Blanc, were found to have diſappeared. Mr. Maillard, another lapidary, waited on Mr. Cadet, with whom Meſſrs. Macquer and Lavoiſier were then at work; he produced three diamonds, which he propoſed to expoſe to the fire, cemented in his own way.

He filled the bowl of a tobacco pipe with pounded charcoal, well preſſed in, the diamonds being placed in the centre; he covered the pipe with an iron plate, luted on with founders ſand. The pipe was included in a crucible, ſurrounded with chalk, and covered with a bed of ſand, moiſtened with ſalt water. The whole was placed in Macquer's furnace, and the heat ſo raiſed, that at the end of two hours it appeared ſoftened, and ready to melt. After the operation, the crucible was found to be vitrified, and had loſt its figure; it was broken with care, and the pipe was found perfectly whole, the charcoal as black as ever, and the diamonds not at all diminiſhed in weight. They were only blackened on their ſurface, and became white and

and brilliant by friction on the mill. Macquer repeated this experiment, with equal ſucceſs, in the large furnace, in which the hard porcelain of Seve is baked; yet, as the iron which covered the pipe was melted, and part reached the diamond, it was ſcorified on that ſide, but the other ſide remained perfect. The fire laſted twenty-four hours.

Mr. Mitouard having had opportunities of treating many diamonds in cloſed veſſels, and with different cements, found that charcoal is the moſt effectual in preventing the deſtruction of this body.

All chemiſts were convinced, from theſe facts, that the diamond burns in the ſame manner as other combuſtible bodies, and like charcoal is not deſtroyed, but in proportion to the contact of air. Neverthe-leſs, the well conducted and accurate experiments of Mr. D'Arcet ſeem to ſhew the contrary. To clear up this matter, Mr. Macquer filled ſeveral balls of baked porcelain and ſeveral crucibles of unbaked porcelain clay, with powder of charcoal; the charcoal was reduced to aſhes, and the aſhes even became vitrified in the unbaked veſſels, while that in the baked veſſels remained unchanged. Whence this chemiſt concluded, that there is a great difference between theſe two kinds of veſſels; he thinks that cracks are made during the baking of the porcelain, which are ſufficient to facilitate the combuſtion,

buſtion, though they afterwards diſappear by the contraction of the porcelain in cooling.

Mr. Lavoiſier has made other experiments, which prove, that diamond does not burn, but in proportion to the quantity of air it is in contact with. He expoſed diamonds to the focus of Mr. Tradaine's lens, after having covered them with a bell, under which he cauſed water or mercury to riſe by extracting the air. This chemiſt, in his experiments on the effects of the burning glaſs made together with Meſſrs. Macquer, Cadet, and Briſſon, had already obſerved, that if diamonds be ſuddenly heated, they ſplit and fly about very ſenſibly; but that this does not happen when they are ſlowly and gradually heated. He likewiſe obſerved, that the diamonds melted and flowed in certain parts. The ſurface of thoſe which remained a certain time expoſed to the focus of the lens, appeared full of little cavities like a pumice-ſtone. By heating them in the ſaid pneumato-chemical apparatus he aſcertained that the diamond burns only for a certain time, proportioned to the quantity of air contained under the veſſel; and that the air, after the combuſtion of the diamond, is abſolutely ſimilar to that which remains after the combuſtion of other inflammable bodies; that is to ſay, deprived of the portion of vital air required to maintain that proceſs. It muſt be noted, that this reſidual air, after the combuſtion of the diamond, contained cretaceous acid, as appeared by its precipitating lime-water.

To ſhew ſtill more evidently the nature of the diamond, Mr. Lavoiſier attempted to burn it under glaſs veſſels filled with cretaceous acid. The diamond ſuffered a ſmall loſs, doubtleſs owing to a portion of air mixed with the cretaceous acid. This chemiſt thinks, that great part of the loſs likewiſe depends on the volatilization of the diamond; and he thinks that this ſtone might be entirely ſublimed in cloſe veſſels, if a ſufficient degree of heat could be applied. Mr. Lavoiſier having made the ſame experiments on charcoal, found the ſame events take place, both with reſpect to combuſtion and volatilization. He likewiſe obſerved, that the diamond always became black at its ſurface.

From theſe different facts it follows, that the diamond is a ſubſtance not at all reſembling ſtones; but is on the contrary a true combuſtible body, capable of burning with a flame, whenever it is ignited with contact of air. In a word, that it is a true combuſtible volatile ſubſtance, which leaves no fixed reſidue; perfectly reſembling charcoal by its habitudes in the fire, though greatly differing from that ſubſtance in tranſparency, weight, hardneſs, and many other properties. All theſe experiments, as well as the art of ſplitting the diamond, ſhew that it is formed of laminæ placed one on the other; that there is ſometimes between the layers a foreign colouring matter, which perhaps cauſes the carbonaceous film, with which diamonds become covered when heated, eſpecially in cloſe veſſels. This coloured ſtratum, being placed at different depths, may be the cauſe why the proceſs uſed by lapidaries to render clouded diamonds tranſparent, does not always ſucceed. If its depth be inconſiderable, it may be eaſily deſtroyed, and the diamond will become clear. If, on the contrary, it be far within the ſtone, it cannot be removed but by the ſucceſſive deſtruction of the laminæ placed over it, which in that caſe would require the diamond to be almoſt entirely deſtroyed before the imperfection could be removed. Notwithſtanding all theſe experiments, we are ſtill unacquainted with the compoſition of the diamond; and in the preſent ſtate of our knowledge muſt conſider it as a peculiar combuſtible body different from all others.

The diamond is of little uſe but as an ornament; but its property of refracting the rays of light, decompoſing them, and exhibiting the moſt lively and brilliant colours, renders it truly precious without the aſſiſtance of the caprice of faſhion. Its exceſſive hardneſs, by which its exquiſite poliſh remains unalterable, its rarity, and the labour of cutting it, add ſtill to its value. It is advantageouſly uſed to engrave on glaſs and hard

hard ſtones, or to cut them into convenient ſizes.

Diamond powder is uſed in poliſhing diamonds.

CHAP. III.

Genus II. INFLAMMABLE GAS.

THE gas called inflammable air by Dr. Prieſtley, is an elaſtic fluid, poſſeſſing all the apparent properties of air. It is about thirteen times lighter than the air of the atmoſphere, does not maintain combuſtion, and quickly deſtroys animal life by producing ſtrong convulſions. It has a very evident and peculiar ſmell. Its characteriſtic property is to take fire when in contact with air, by the application of a body already ignited, or by the electric ſpark.

Inflammable gas has been long known, as a product both of nature and art. Mines, coal-pits, the ſurface of waters, and putrified animal or vegetable ſubſtances, exhibited a great number of inſtances of vapours naturally combuſtible; and vapours of the ſame nature have long been artificially produced, in the ſolution of ſeveral metals in the vitriolic and marine acids, and in the diſtillation of animal and vegetable ſubſtances.

ſtances. But no one before Dr. Prieſtley thought of collecting them in receivers, and examining their properties. This philoſopher diſcovered, that they conſtitute a kind of permanently elaſtic fluid.

Inflammable gas exhibits all the phenomena of combuſtible bodies, in a moſt eminent degree. Like them, it cannot be burned without acceſs of air. Its flame is more or leſs red when pure, and blue or yellow when it is united to a ſubſtance capable of modifying its properties. It frequently crackles, and produces ſmall brilliant ſparks during its combuſtion, with a noiſe ſimilar to that of nitre, when it detonates. A ſtrong heat is excited during its combuſtion.

It burns more rapidly, in proportion as it is environed with a larger quantity of air. As theſe two fluids have a like aggregation, it is poſſible to mix them in ſuch a manner, as that every particle of each ſhall be contiguous to a particle of the other, in which caſe it will burn with great rapidity. This is evident, when a mixture of two parts of common, and one of inflammable air is ſet on fire: the combuſtion is inſtantaneous, and attended with a ſtrong exploſion, reſembling that of gunpowder; whereas inflammable gas, not mixed, but expoſed to common air, when ſet on fire, burns gently, and at the ſurface.

It may in the ſame manner be burned in an an inſtant, and with much more vehemence, if two or three parts be mixed with one of vital air: the exploſion is then much more conſiderable than in the foregoing experiment.

Mr. Cavendiſh, many years ago, remarked, that whenever inflammable gas is burned, drops of water are always produced. Inflammable gas being burned in a veſſel full of vital air, over mercury, a vacuum is produced in the apparatus; the mercury riſes, and the ſides of the glaſs are covered with a large quantity of drops of water, which increaſe in proportion as the combuſtion goes on. Mr. Lavoiſier in this manner combined a ſufficient quantity of the two elaſtic fluids to obtain ſeveral drachms of water. Both theſe fluids were previouſly paſſed through a glaſs cylinder, filled with very dry cauſtic fixed alkali, in order to deprive them of the portion of water they might contain. The water obtained by the combuſtion, agreed perfectly in weight with the elaſtic fluids made uſe of; whence he concluded, that water is compoſed of ſix parts by weight of vital, and one of inflammable air. The water obtained in this experiment was found to contain a few grains of nitrous acid. To account for the formation of this acid, it muſt be recollected, that Mr. Cavendiſh produced it, by combining, with the aſſiſtance of the electric ſpark, ſeven parts of vital air, and three of atmoſpheric mephitis. Now, the vital air uſed by Mr. Lavoiſier, in his experiment, having been obtained from red precipitate, the nitrous acid, uſed in making that ſubſtance, might afford a ſmall quantity of the atmoſpheric mephitis, which enters into its compoſition. This portion of acid, therefore, does not affect the reſult, nor the aſſertions of Mr. Lavoiſier concerning the production of water. If we compare this capital experiment, with that in which the ſame chemiſt decompoſed water, by cauſing it to fall on red hot iron, zink, and charcoal, as well as on boiling oils, and in which he obtained inflammable gas, in proportion to the combuſtion which took place in theſe different bodies, we ſhall be convinced, that this theory of the nature of water is built on as firm a foundation as any that has been propoſed reſpecting chemical facts.

The nature of inflammable gas remains then to be determined. Is it a ſimple ſubſtance, always identical? And may we conſider it as the phlogiſton of Stahl, according to the opinion of many Engliſh chemiſts, eſpecially Mr. Kirwan?

With reſpect to the firſt queſtion, chemiſts are not agreed on the pretended identity of inflammable gas, obtained from very different ſubſtances, and which ſeems to have various properties.

Some,

Some, and even the greater number of chemiſts, think, that there are really ſeveral ſpecies of inflammable air; ſuch, for example, are the inflammable gas obtained, by means of water, from iron and zink, which burns with a red flame, and detonates with pure air; that which Mr. Delaſſone obtained from Pruſſian blue, and from the reduction of flowers of zink by charcoal, which burns without detonating with air; the inflammable gas of marſhes, which burns with a blue flame, and does not detonate; and likewiſe that obtained from the diſtillation of organic matters, which reſembles the gas of marſhes. An accurate analyſis has, it is true, ſhewn, that the two laſt are compounds of pure detonating inflammable gas with the cretaceous acid, in different proportions; and that by lime-water and cauſtic alkalis, they may be brought to the ſtate of pure inflammable gas of the firſt kind. We were therefore inclined to think, with the illuſtrious Macquer, in the year 1782, that it is one ſubſtance, capable of various modifications, by its combinations with different matters. Nevertheleſs, Mr. Lavoiſier, in a memoir on the combuſtion of alum with various carbonaceous ſubſtances, inſerted among thoſe of the academy for the year 1777, thinks, that there are three kinds of inflammable gaſes, the vitriolic, marine, and cretaceous. It is this laſt which he obtained by by the re-action of alum on carbonaceous ſubſtances. The characters by which he diſtinguiſhes them is, that each, by inflammation, becomes converted into an acid ſimilar to that from which it was obtained. Thus vitriolic inflammable gas, after combuſtion, affords oil of vitriol; marine inflammable gas, ſpirit of ſalt; and the third, the cretaceous acid. This chemiſt thinks, that the inflammable gas, obtained during the preparation of pyrophorus, is formed by the charcoal itſelf, reduced into vapour, and combined with the pure air of the vitriolic acid, which, by the loſs of that principle, is converted into ſulphur. In fact, Mr. Lavoiſier, ſince the publication of that memoir, has aſcertained, that the inflammable gas, obtained when metals are diſſolved in acids, is produced by the water which accompanies thoſe ſalts, and is decompoſed by the metallic ſubſtances: and from this circumſtance, it is more probable, at preſent, that there is but one kind of inflammable air, in all caſes produced by the decompoſition of water, compoſing it again by uniting with vital air, more or leſs inflammable, and producing different colours, when burned, accordingly as it is combined with other bodies.

As to the ſecond queſtion, though the opinion of Bergman and the Engliſh chemiſts, who conſider inflammable gas as the phlogiſton of Stahl, appears to agree with a certain

certain number of facts, yet there is a greater number which prevent our adopting it. It appears, in fact, that inflammable gas is not always produced by bodies in which Stahl admitted the preſence of his phlogiſton, but that water almoſt always contributes to its formation. Mr. Kirwan, who has been employed for ſome years in the examination of this important queſtion, has not yet, that we know, diſcovered any fact which poſitively decides it. We ſhall take care to explain, in ſeveral other articles of this work, our opinion of the inflammable air, which this celebrated chemiſt has obtained from an amalgam of zink, as well as of another experiment brought in ſupport of this new theory, by Mr. De Morveau, who appears to have adopted it. We ſhall not here enter into any detail of the objections which may be made, becauſe they might not be underſtood by ſuch as have only read the preceding part of this work, but ſhall reſerve our objections till we come to treat of metallic ſubſtances, phoſphorus, &c. However, we muſt here admit, that the phenomena of chemiſtry may be explained in as ſatisfactory a manner, by admitting inflammable gas to be the phlogiſton, as by all the other theories; and that, if we at preſent appear to doubt the identity of theſe two ſubſtances, it is becauſe we are deſirous of adhering to that ſcrupulous exactneſs, which we have endeavoured

deavoured to preſerve with reſpect to all the facts we have hitherto related. Laſtly, whatever part may be taken in the various opinions held forth, it is ſtill a fact, that no chemiſt has yet ſucceeded in ſeparating the principles of inflammable gas, and conſequently, that it is a ſimple ſubſtance, in the preſent ſtate of our knowledge, which appears to combine totally with pure air, and to form water. We take no notice of the theories of thoſe who affirm, that inflammable gas is a compound of air and the matter of fire, or that it is a modification of light, fire, electricity, &c.; for theſe aſſertions are all too vague, and bear too great a reſemblance to the inaccurate and uncertain language of the infancy of natural philoſophy, and are beſides too far removed from experiment and proof to merit diſcuſſion. It cannot, however, be doubted, but that inflammable gas contains much ſpecific heat, perhaps the matter of light; and that the former is ſeparated from this gas, whenever it loſes its elaſtic ſtate, and paſſes into liquid combinations.

Inflammable gas does not unite with water, but may be preſerved a long time over that fluid without alteration; though at laſt it ceaſes to be inflammable. Dr. Prieſtley has not determined what kind of change is produced, either in the inflammable gas or in the water; but it is probable, that this experiment,

experiment, carefully made, would tend greatly to explain the nature of that combuſtible body.

Inflammable gas does not appear to act on earths, nor on the three ſalino-terreſtrial ſubſtances; excepting, however, that it deſtroys the white colour of ponderous earth, and renders it dark.

The change which alkalis and acids might cauſe in this ſubſtance, and themſelves be ſubjected to by it, are not known. It is probable, that it would decompoſe certain acids, eſpecially the vitriolic and the dephlogiſticated marine acids, by ſeizing their pure air, or oxyginous principle, and forming water: as to the vitriolic acid, it may be ſuſpected, that it would experience this decompoſition, becauſe the baſe of vital air has a ſtronger affinity with inflammable gas; the latter not decompoſing water, as we ſhall hereafter ſee. The dephlogiſticated marine acid has ſo large a quantity of ſuperabundant vital air, which adheres ſo weakly, that it may be preſumed it would unite with the inflammable gas, and form water.

Inflammable gas does not appear to act on neutral ſalts; its action on ſaline ſubſtances in general has been little attended to. It is become a ſubſtance of greater importance, in the eyes of the ſcientific world, ſince it has been applied to the filling of aeroſtatic machines, diſcovered by

Meſſrs. Montgolfier. Its ſpecific levity, which is thirteen times more conſiderable than that of common air, is the cauſe of the aſcenſion of theſe machines. It is more than probable, that this fluid has a conſiderable ſhare in the production of meteors; that it exiſts in large quantities in the atmoſphere, where, being ſet on fire by the electric ſpark, it forms water. Perhaps it may be carried by the winds, like a kind of natural aeroſtat.

Attempts have been made to ſubſtitute this fluid, inſtead of other combuſtible matters, for the ordinary purpoſes of life; to give light and heat, to charge fire-arms, &c. Mr. Volta has conſidered it in this laſt point of view, and has propoſed ſeveral methods of applying it. Mr. Neret, in the Journal de Phyſique for January 1777, has given a deſcription of a chafing-diſh heated by inflammable air. Meſſrs. Furſtenberger of Baſil; Brander, mechanic at Augſburg; Ehrmann, Lecturer in Natural Philoſophy at Straſburg; have deſcribed lamps which may be lighted in the night by the electrical ſpark. Laſtly, very pretty artificial fires are made, with glaſs tubes, bent in different directions, and pierced with a great number of ſmall apertures. The inflammable gas is introduced into theſe tubes, from a bladder filled with that fluid, and fitted with a copper cock. When the bladder is preſſed, the inflam-

inflammable air being made to paſs into the tube, iſſues out of all the ſmall apertures, and is ſet on fire by a lighted taper.

CHAP. IV.

Genus III. SULPHUR.

SULPHUR is a combuſtible, dry, very brittle body, of a lemon yellow, which has no ſmell, unleſs heated, and whoſe taſte is very weak, though ſufficiently perceptible. It becomes electric by friction; if a piece of a conſiderable ſize be expoſed to a ſudden though gentle heat, as for example, by holding it in the hand, it breaks to pieces, with a crackling noiſe. Sulphur is found naturally in great quantities, ſometimes pure, and ſometimes in a ſtate of combination. We ſhall in this place ſpeak only of the firſt: the following are the varieties of form in which it is found pure.

Varieties.

1. Tranſparent ſulphur, cryſtallized in octahedrons, whoſe two pyramids are truncated: it is depoſited by water, moſt commonly upon the ſurface of calcareous ſpar. Such is that of Cadiz.

2. Tranſ-

2. Tranſparent ſulphur in irregular pieces; from Switzerland.
3. Whitiſh pulverulent ſulphur, depoſited in ſiliceous geodes: flints filled with ſulphur are found in Franche Comté, &c.
4. Pulverulent ſulphur, depoſited at the ſurface of mineral waters; ſuch as thoſe of Aix la Chapelle, of Enghien near Paris, &c.
5. Cryſtalline ſulphur, ſublimed; it is tranſparent, and found in the neighbourhood of volcanos.
6. Pulverulent ſulphur, ſublimed by volcanic fires, without any regular form, and often interpoſed between ſoft ſtones, as is obſerved at Solfatara, near Naples.
7. Stalactites of ſulphur, formed by volcanic fires.

Beſides theſe ſeven varieties of pure mineral ſulphur, this combuſtible ſubſtance is found combined with different matters. It is uſually combined with metals, which it converts into pyrites, or ores. It is ſometimes united to calcareous earth, in the form of an earthy liver of ſulphur. The hepatic calcareous ſtones, the fetid ſpar, and ſwine ſtone, appear to be of this nature.

Late diſcoveries have added to the foregoing varieties. Sulphur ſeems to be continually formed in vegetable and animal matters which begin to putrify. Though theſe ſpecies of ſulphur do not appear eſſentially to belong to the mineral kingdom, yet we think it proper to join them with the preceding varieties, to render its natural hiſtory more complete.

Varieties.

8. Cryſtallized ſulphur, formed by the ſlow decompoſition of accumulated animal matters; ſuch as that which has been found in the ancient layſtall*, near the gate of St. Antoine.
9. Pulverulent ſulphur, formed by the vapours diſengaged by animal ſubſtances in a ſtate of putrefaction. It is collected on the walls of ſtables, privies, &c.
10. Sulphur obtained from many vegetables, eſpecially the root of the baſtard rhubarb, (Lapathum), the ſpirit of cochlearia, &c. This diſcovery, as well as the following, was made by Mr. Deyeux, member of the college of pharmacy, and lecturer in chemiſtry.
11. Sulphur, obtained in the analyſis of animal matters, particularly white of egg.

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* A lay-ſtall (voierie) is a place appropriated, by the chief of a lordſhip, for the reception of mud, and other filth.

12. Sul-

12. Sulphur, obtained from horſe-dung. A lady of the acquaintance of the Duc de la Rocheſoucauld found this combuſtible body at the inſtant of its being emitted. It is probable, that ſubſequent inquiries will diſcover this body in a great number of animal ſubſtances.

None of theſe ſulphurs are uſed in the arts. The ſulphur of commerce is extracted, by diſtillation, from metallic ſubſtances, called pyrites. In Saxony, and in Bohemia, this mineral is put into earthen tubes, placed on a long furnace; the ends of the tubes, which iſſue out of the furnace, are received in ſquare iron veſſels, containing water; the ſulphur is collected in theſe receivers, but is very impure. In order to purify it, it is melted in an iron ladle; the earthy and metallic parts ſubſide to the bottom. It is then poured into a copper boiler, where it makes another depoſit of the foreign matters which contaminated it. After having been kept a certain time in fuſion, it is poured into cylindrical wooden moulds, which give it the form it uſually has in commerce; that which is precipitated to the bottom of the boiler during the fuſion, is grey, and impure: it is very improperly called ſulphur vivum. In other countries, as at Rammelſberg, the ſulphur is extracted from pyrites, in a more ſimple manner.

The ſulphur, which is found melted among the maſſes of pyrites, roaſted in the open air, is taken away with ladles, and purified by a ſubſequent fuſion.

Sulphur is not altered by the contact of light; heated in cloſe veſſels, it becomes ſoft, melts, and in cooling often aſſumes a red, brown, and greeniſh colour, and needled form. To ſucceed in this cryſtallization, it muſt, according to the proceſs of Rouelle, be ſuffered to congeal at its ſurface; and the fluid portion, which is underneath the cruſt, muſt be poured off. The under ſurface of the congealed part preſents needles of ſulphur, croſſing each other in different directions.

If ſulphur be gently heated when in fuſion, it is volatilized in ſmall pulverulent parcels, of a bright lemon yellow, called flowers of ſulphur. As the part which riſes conſiſts of the pureſt ſulphur, this is the beſt proceſs for obtaining it free from foreign matters. For this purpoſe, common ſulphur, in powder, is put into an earthen cucurbit, to which pots are adapted, which mutually cover each other, and are called aludels. The upper is terminated by a reverſed funnel, whoſe opening forms a ſlight communication with the air; the cucurbit is heated till the ſulphur melts, at which time it ſublimes, and adheres to the ſides of the aludels.

Flowers of ſulphur, prepared in the large way, often contain a ſmall quantity of vitriolic acid, formed by the combuſtion of the ſulphur, which is effected by the air contained in the veſſels: it is thoroughly purified by waſhing: ſulphur ought to be prepared in this way for medical, and the nicer chemical purpoſes.

Sulphur, heated with contact of air, takes fire ſoon after it is melted, and burns with a blue flame, if the heat to which it has been ſubjected be not conſiderable; or with a white, brilliant flame, when the heat is ſtronger. In the firſt of theſe combuſtions, it emits a ſuffocating ſmell; and if the vapour which exhales be collected, it is found to conſiſt of a very ſtrong ſulphureous acid. In the rapid combuſtion, it has no ſmell, and its reſidue is not ſulphureous acid, but oil of vitriol.

Stahl, who imagined that ſulphur was a compound of that acid and phlogiſton, ſuppoſed, that during combuſtion it loſt its inflammable principle, and conſequently became reduced to the ſtate of acidity. The collection of proofs, brought by him in ſupport of this opinion, was well calculated to cauſe it to be adopted by all ſucceeding chemiſts. However, ſince experiments have been made with a view to aſcertain the influence of air in combuſtion, to which Stahl does not appear to have attended, ſome chemiſts,

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ſtruck with the difficulty hitherto experienced in the attempt to exhibit phlogiſton alone, and the facility with which all the objections to this doctrine are anſwered by the late diſcoveries reſpecting air, have adopted an opinion intirely oppoſite to that of Stahl, concerning ſulphur and its combuſtion.

The facts on which the new opinion is founded are theſe: Hales obſerved that ſulphur abſorbs a great quantity of air when burned. M. Lavoiſier has demonſtrated that ſulphur in this reſpect reſembles all other combuſtible bodies: 1. That it cannot burn without acceſs of air. 2. That it abſorbs the pureſt portion of this fluid during its combuſtion. 3. That the reſidue of the air is incapable of maintaining a new combuſtion. 4. That the vitriolic acid produced exceeds the quantity of ſulphur from which it was produced, by the weight the air has loſt. 5. That conſequently ſulphur combines with the baſe of pure air, to form oil of vitriol. This acid is therefore a compound of the oxyginous principle and ſulphur; and the latter, inſtead of being a compound, is one of the principles of oil of vitriol, which requires only to be united with the baſe of air to form that acid, a proceſs that takes place during combuſtion. Heat is neceſſary, becauſe it divides and deſtroys the aggregation, and favours its combination

bination with the oxyginous principle. When it is once burned or combined with the latter principle, it is no longer capable of being inflamed, but enters into the claſs of incombuſtible bodies.

According to the manner in which it is burned, it abſorbs different quantities of the oxyginous principle, and becomes more or leſs acid. Such is the theory of the difference which exiſts between the ſlow and rapid combuſtions of ſulphur, and the ſulphureous and vitriolic acids reſulting from each. Stahl ſuppoſed, that when ſulphur is ſlowly burned it does not loſe all its phlogiſton, and that the vitriolic acid retaining a portion of that principle, preſerves its ſmell and volatility: but it is now proved by experiment, that when ſulphur burns ſlowly, it does not abſorb as much of the baſe of air as it is capable of uniting with; whereas in the rapid combuſtion, it becomes ſaturated with that principle, and conſtitutes vitriolic acid. The ſulphureous acid combined with alkaline matters becomes gradually converted into the common vitriolic acid, by abſorbing the baſe of vital atmoſpheric air.

It will be eaſy to form a clear notion, according to this theory, of what happens when ſulphur is formed with the vitriolic acid and certain combuſtible matters, as we have obſerved with reſpect to the vitriols of pot-aſh, of ſoda, the ammoniacal, calcareous,

magneſian,

magneſian, argillaceous, and barytic vitriols heated with charcoal. According to the doctrine of Stahl, the phlogiſton of the coal united with the vitriolic acid of the ſalts, forms ſulphur; according to the modern theory, the coal ſeizes the oxyginous principle contained in the vitriolic acid, and conſequently leaves the ſulphur, which is its other principle. Whenever, therefore, the vitriolic acid is changed into ſulphur by any combuſtible body, the latter is always reduced to the ſtate of a body which has ſuffered combuſtion, as we ſhall obſerve in the hiſtory of many metallic ſubſtances. For this reaſon likewiſe it is, that a large quantity of cretaceous acid is obtained during the artificial production of ſulphur, namely, by the tranſition of the oxyginous principle from the vitriolic acid to the carbonaceous matter. It muſt be recollected, that the preſence of the baſe of pure air is eaſily demonſtrated in the vitriolic acid.

Sulphur is not at all changeable by expoſure to air, nor ſoluble in water. If it be held a certain time in fuſion, and poured into that fluid, it becomes red, and preſerves a certain degree of ſoftneſs, ſo that it may be kneaded; but it loſes theſe properties in a few days. Water, let fall drop by drop into burning ſulphur, is not decompoſed, and does not maintain the combuſtion, which proves that the baſe of vital air,

or

or the oxyginous principle, has a ſtronger affinity with inflammable gas without ſulphur. This aſſertion may be confirmed by the action of inflammable gas on the vitriolic acid, which it appears to deprive of the oxyginous principle.

Sulphur has no action on ſiliceous earth, and does not unite with clay, without difficulty. The latter, however, when exceedingly divided, appears to reduce ſulphur to the hepatic ſtate, as is ſeen in the preparation of pyrophorus.

The general name of ſulphureous hepar, or liver of ſulphur, has been given to a compound formed of ſulphur, with ſome alkaline ſubſtance. This compound conſidered in general, is of a brown colour, reſembling that of the liver of animals; decompoſable by vital air; ſoluble in water, in which ſtate of ſolution it emits a fetid ſmell; precipitable in part by acids, which diſengage a peculiar gas, called hepatic gas. There are ſix kinds of liver of ſulphur produced by ponderous earth, magneſia, lime, and the three alkalis. The properties of each require to be particularly examined.

Pure ponderous earth does not appear to act ſtrongly on ſulphur; when theſe are boiled together with water, the liquid becomes in a ſmall degree hepatic; but it combines much more intimate in the dry way. When a mixture of eight parts of ponderous ſpar in powder

der with one part of charcoal, is ſtrongly heated in a crucible, a coherent maſs is obtained without fuſion, which readily diſſolves in hot water, and has the ſmell and every other characters of a hepar. The ſolution is of a golden or orange colour. I have diſcovered that it cryſtallizes by cooling; it is then of a yellowiſh white. Expoſure to air decompoſes it, when it attracts moiſture, and becomes of deeper colour; ſulphur being precipitated, and ponderous ſpar regenerated. This liver of ſulphur gives out on the addition of any acid, an elaſtic fluid, known by the name of hepatic gas, whoſe properties we ſhall hereafter examine. When the barytic hepar is precipitated by vitriolic acid, ſulphur and ponderous ſpar fall down; if nitrous or marine acid be uſed, the barytic nitre or muriate remains in ſolution, and the ſulphur is depoſited alone.

Sulphur combines with pure magneſia, by the aſſiſtance of heat. The ſalt, which we have called aerated magneſia, is commonly uſed for this purpoſe, becauſe more diffuſable in water. A pinch of magneſia, with a like maſs of the flowers of ſulphur, is put into a bottle with diſtilled water; this veſſel being perfectly filled, and well ſtopped, is expoſed to the heat of a water-bath for ſeveral hours. The water being then filtered, has a fetid ſmell of rotten eggs; ſtrongly colours metallic ſolutions, and affords ſmall cryſtalline needles by ſpontaneous evaporation: in a word, it is a true magneſian liver of ſulphur; the magneſia being precipitable by fixed alkali, which has a ſtronger affinity with the ſulphur. As to the latter combuſtible ſubſtance, its preſence is eaſily aſcertained by the addition of an acid, which ſeparates it under the form of a white powder. Such was the kind of liver of ſulphur which Mr. Le Roi, phyſician at Montpellier, diſſolved in pure water, to imitate the hepatic mineral waters; but it is now known, that moſt of thoſe waters do not contain a true hepar, but are mineralized ſimply by impregnation with hepatic gas.

Lime unites much more readily with ſulphur than the two ſalino-terreſtrial ſubſtances before-mentioned. If water be poured by a little at a time on a mixture of quick lime and flowers of ſulphur, the heat produced by the action of the water on the lime is ſufficient to promote the combination between it and the ſulphur. If more water be added, it becomes reddiſh, and emits a fetid or hepatic odour, being in fact a ſolution of ſulphur combined with lime. This hepar is not well prepared, but by the humid way, and it is often neceſſary to aſſiſt the combination by the application of a gentle heat, when the lime is not freſh. This compound is of a red colour; and the more cauſtic the lime, the deeper the red. When it

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is highly ſaturated, I have obſerved that it depoſits, by cooling, a layer of ſmall needled cryſtals of an orange yellow, diſpoſed in tufts, which appeared to me to conſiſt of flattened tetrahedral priſms, terminated by dihedral ſummits. Theſe cryſtals gradually loſe their colour by expoſure to air, and become white and opake, without any alteration in their form. Calcareous liver of ſulphur moiſtened with a ſmall quantity of water, and diſtilled in the pneumato-chemical apparatus, is partly decompoſed, and affords a large quantity of hepatic gas: if it be evaporated to dryneſs, and calcined in an open crucible till it emits no more fumes, the reſidue conſiſts of ſelenite formed by the lime and the vitriolic acid, produced by the ſlow combuſtion of the ſulphur. Calcareous liver of ſulphur is quickly changed by expoſure to air, loſing its ſmell and colour, in proportion as the hepatic gas is diſſipated. When diſſolved in a large quantity of water, the ſame alteration takes place, eſpecially when it is agitated, as Mr. Monnet obſerves, in his Treatiſe on Mineral Waters. Selenite remains after thoſe changes. When preſerved in bottles, not quite full, it depoſits a black incruſtation on the glaſs, pellicles being at the ſame time formed, which fall to the bottom of the liquor. If the veſſel which contains it be well cloſed, it may be kept a long time without change, as I have often obſerved in my my laboratory. Calcareous liver of ſulphur is decompoſed by pure fixed alkalis, which have a ſtronger affinity than lime to the ſulphur. Acids precipitate the ſulphur in the form of a very ſubtle white powder, which has been called magiſtery of ſulphur. The cretaceous acid effects this ſeparation as well as the others; but the action of neutral ſalts on calcareous liver of ſulphur is not known.

The two pure or cauſtic fixed alkalis, have a very ſtrong action on ſulphur; they form the true hepars, which are leſs decompoſeable, and more permanent, than the other. I have diſcovered, that the dry fixed cauſtic alkalis act on ſulphur when in the cold. The pure fixed alkali and the ſulphur in powder muſt be triturated in a mortar; the moiſture of the air attracted by the alkali favours the re-action of the ſalt on the ſulphur. The mixture becomes ſoft, aſſumes an yellow colour, emits a fetid ſmell, and is converted into hepar; but when this hepar is diſſolved in water, the ſolution is of a pale yellow colour, and is found to contain a leſs quantity of ſulphur than the ſame hepar prepared by heat. The alkaline hepar is prepared in laboratories in two methods, by the dry, or by the moiſt way; the firſt proceſs is performed by melting equal parts of dry lapis cauſticus and flowers of ſulphur in a crucible: as ſoon as the mixture is intirely melted, it is to be poured out

out on a marble ſlab, and appears when cool to be of a red brown colour, reſembling that of the liver of animals. Mr. Gengembre, who has communicated to the Academy a ſeries of very valuable experiments concerning hepatic gas, makes an important obſervation on the alkaline hepar prepared by the dry way; namely, that this compound is not fetid, and does not emit hepatic gas while it is dry; its ſmell not becoming perceptible till it has attracted moiſture from the atmoſphere, or is diſſolved in water: a fact which proves that water diſengages hepatic gas, as we ſhall more fully explain. The two pure and cauſtic fixed alkalis act abſolutely in the ſame manner on liver of ſulphur, and are equally capable of diſſolving it by the dry way. Theſe combinations of cauſtic alkalis with ſulphur have hitherto been little attended to; liver of ſulphur having almoſt always been made with fixed alkalis, ſaturated with the cretaceous acid. Yet there are remarkable differences between theſe two kinds of hepar; thoſe made with the cretaceous fixed alkalis require a longer time for their preparation, becauſe theſe ſalts are much leſs active. But the moſt important difference we have had occaſion to obſerve between the livers of ſulphur made with cauſtic or dry alkalis in the dry way, is the comparative ſtate of their ſaturation. In fact, the firſt are brown, and more

more fetid when diſſolved, and the gas they afford is much more hepatic and inflammable than that of the ſecond. Theſe laſt are of a paler colour, often of a greeniſh grey; their ſmell is weaker, and their compoſition leſs durable. The cretaceous fixed alkalis appear to preſerve their acid in their union with ſulphur, the gas of theſe hepars not being inflammable till it has been deprived of its cretaceous acid, by waſhing it in lime-water. The cauſe of the differences between livers of ſulphur made with cauſtic alkalis, and with thoſe made with mild alkalis, conſiſts therefore in the preſence of the acid in the latter, which diminiſhes the effect of the alkali.

Solid alkaline liver of ſulphur made with either of the fixed alkalis, is very fuſible, and, like calcareous liver of ſulphur, is decompoſed by heating in cloſe veſſels, after having been moiſtened with a ſmall quantity of water, in which circumſtance it gives out much heat. It is capable of aſſuming a cryſtalline form when it becomes ſolid after fuſion; but this form has not yet been well deſcribed. While hot and dry it has a brown colour; in proportion as it cools and attracts the humidity of the air, it loſes its colour, and becomes paler. The contact of the air ſoon gives it a greeniſh yellow colour; after which it is rendered liquid by the moiſture it attracts, and is

ſlowly

ſlowly decompoſed, ſo as to become converted at the end of a certain time into vitriolated tartar, or Glauber's ſalt. It diſſolves readily in water, immediately aſſuming a peculiar fetid ſmell; the hepatic gas being formed by the re-action of the water: this ſolution is of a deep red colour, if the liver of ſulphur has been recently prepared, but otherwiſe a green. The livers of ſulphur prepared in the humid way, by heating a ſolution of either of the cauſtic fixed alkalis in water, with half their weight of powdered ſulphur, exhibit the ſame properties as the ſolution here mentioned: we may therefore deſcribe both under the common name of alkaline liquid hepar.

The liquid alkaline liver of ſulphur, when very ſtrong, depoſits irregular needle-formed cryſtals by cooling. It is decompoſable by the action of heat. When diſtilled in the pneumato-chemical apparatus, it affords hepatic gas: expoſure to air likewiſe decompoſes it, ſo that it becomes turbid; pellicles are then formed, and ſulphur depoſited. Bergman and Scheele thought that this decompoſition is produced by the vital air of the atmoſphere; a ſmall quantity of liquid liver of ſulphur being placed under a glaſs veſſel with vital air, the latter is entirely abſorbed, and the hepar decompoſed. Mr. Scheele has even propoſed the application of this fact to eudiometrical purpoſes; and it is in fact

fact one of the beſt methods of aſcertaining the purity of the air.

Earths, and ſalino-terreſtrial ſubſtances, have no action on alkaline liquid hepar when very pure; but if it has been prepared with a cretaceous alkali, it becomes turbid by the addition of lime-water. Acids decompoſe it, by uniting with the alkali, and precipitating the ſulphur in the form of a very fine white powder, called magiſtery of ſulphur. Spirit of nitre, poured on ſolid liver of ſulphur in fuſion, produces a detonation. According to Mr. Prouſt, all the acids decompoſe alkaline liver of ſulphur, diſengaging at the ſame time gas, which may be collected in the pneumato-chemical apparatus, and deſerves to be particularly examined.

To obtain this gas, an acid muſt be poured on pulverized ſolid alkaline liver of ſulphur; a ſtrong effervefcence is produced, which does not take place in the ſame manner, if the acid be poured into a ſolution of the hepar. This phenomenon, which has ſcarcely been attended to by chemiſts, depends on two circumſtances: 1. Solid alkaline hepar, according to the obſervation of M. Gengembre, does not contain hepatic gas ready formed; but when an acid is poured on it, the water, which holds this laſt ſalt in ſolution, contributes to its formation. As the quantity inſtantly produced is very conſiderable, and the gas does not find a body which

which may retain it in ſolution, it eſcapes, occaſioning a ſtrong effervеſcence; ſo that when the experiment is made in a bottle, to which a tube is adapted, the gas may be eaſily collected over mercury. 2. The ſolution of alkaline liver of ſulphur contains a conſiderable quantity of hepatic gas ready formed; though a part of the gas was diſengaged during the act of its ſolution; and when an acid is added, the portion of gas which is diſengaged becomes diſſolved in the water, ſo as not to produce a ſenſible effervеſcence; or at leaſt the effervеſcence is very inconſiderable, and the quantity of gas collected is but ſmall.

This gas, which is the ſame in all livers of ſulphur, and is their diſtinguiſhing characteriſtic, has been long known by its fetid ſmell, and by its action on metals and metallic calces, particularly thoſe of lead and biſmuth, which it renders intirely black. Its ſmell is inſupportable; it ſuddenly deſtroys animal life, renders ſyrup of violets green, and burns with a very light blue flame: if it be ſet on fire in a large and very clean glaſs veſſel, it depoſits on the ſurface of the glaſs certain clouds, which are found to be ſulphur. This gas is decompoſed by vital air, and depoſits its ſulphur whenever it comes in contact with atmoſpheric air; it is from this cauſe that ſulphur is found floating in the form of flowers on the ſulphureous waters, which it mineralizes,

mineralizes, though they do not contain true liver of ſulphur. The ſulphur depoſited from the waters of Aix-la-Chapelle, Enghien, &c. has the ſame origin. From this cauſe likewiſe, ſulphureous depoſitions are made on that part of bottles which contain livers of ſulphur. Bergman attributes this decompoſition to the ſtrong affinity of pure air with phlogiſton. He conſiders hepatic gas as a combination of ſulphur, phlogiſton, and the matter of heat; when one of theſe principles is ſeparated, the other two become diſunited. M. Gengembre, ſtruck with the obſervation, that hepars do not give out gas when water is not preſent, concluded that this fluid, by its decompoſition, contributes to the formation of the gas; that its vital air unites with a part of the ſulphur, and its inflammable gas diſſolves a ſmall portion, which ſolution conſtitutes hepatic gas. He imitated the formation of this gas by melting ſulphur over mercury in a jar containing inflammable gas, by the ſolar focus of a lens of nine inches in diameter: part of the ſulphur became diſſolved in the inflammable gas, which aſſumed all the characters of hepatic gas; but as the ſulphur alone cannot decompoſe water, and the oxyginous principle has a ſtronger affinity with aqueous inflammable gas, than with that combuſtible ſubſtance, M. Gengembre thinks that the alkali favours the decompoſition of water by ſulphur, by reaſon of its tendency to unite with the combination of ſulphur with the oxyginous principle; that is to ſay, with the vitriolic or ſulphureous acid. To ſupport this theory, M. Gengembre obſerves, that the quantity of hepatic gas diſengaged from liver of ſulphur, is in proportion to the force with which the acid made uſe of retains its oxyginous principle; becauſe the water is in that caſe decompoſed, rather than the acid. Such, according to him, is the reaſon why the marine acid affords one half more hepatic gas than the nitrous, as obſerved by Meſſrs. Scheele and Sennebier. Laſtly, the proceſs of Mr. Scheele for obtaining a large quantity of hepatic gas, which conſiſts in diſſolving pyrites in artificial ſpirit of vitriol, compoſed of three parts of iron, and one of ſulphur, tends greatly to eſtabliſh this opinion. It therefore appears, that the vital air decompoſes hepatic gas, by uniting and forming water with the inflammable gas, while the ſulphur precipitates.

Water diſſolves hepatic gas with conſiderable facility. This ſolution, which has all the properties of that aeriform fluid, is a perfect imitation of ſulphureous mineral waters.

Earths and alkaline ſubſtances do not appear to act on this gas.

The vitriolic acid does not decompoſe hepatic

patic gas, becauſe the oxyginous principle has a ſtronger affinity with ſulphur than with the aqueous inflammable gas. The nitrous acid, in which the oxyginous principle is very weakly retained, quickly decompoſes hepatic gas, and precipitates the ſulphur. This acid is advantageouſly uſed as a teſt of the preſence of ſulphur in hepatic waters.

Alkaline liver of ſulphur decompoſes neutral ſalts, as well as metallic ſolutions, as we ſhall hereafter ſee.

The cauſtic volatile alkali, or volatile alkaline ſpirit, has ſcarcely any action on concrete ſulphur; though Boerhaave affirms that this fluid, by long ſtanding on flowers of ſulphur, afforded him a golden tincture. To combine theſe bodies, they muſt be preſented to each other in a ſtate of vapour. With this intention, a mixture of equal parts of quick lime and ſal ammoniac, with half a part of flowers of ſulphur, are diſtilled in the apparatus of Woulfe, obſerving to put no greater quantity of water in the bottle, than is neceſſary to diſſolve the doſe of alkaline gas to be produced. In this diſtillation, which muſt be carefully conducted, a reddiſh yellow alkaline liquor is obtained of a penetrating ſmell, and ſomewhat hepatic. In a word, a true volatile liver of ſulphur, which has the property of emitting whitiſh fumes, when in contact with air, whence it is called the fuming liquor of Boyle. This liver of ſulphur is decompoſed by heat. At the end of a certain time, a large quantity of ſmall rainbow-coloured needles, one or two lines in length, are formed, which appear to be the concrete and cryſtallized volatile liver of ſulphur. A light, blackiſh, and frequently golden-coloured cruſt, is depoſited on the ſides of the bottles. Lime and fixed alkalis decompoſe the fuming liquor; acids likewiſe precipitate the ſulphur with great facility, and diſengage a very inflammable hepatic gas. The ammoniacal ſalts, produced in theſe decompoſitions, differ according to the nature of the acid made uſe of. A miſtake made in one of my lectures, produced an accidental diſcovery, which deſerves to be mentioned. Being deſirous of precipitating the fuming liquor of Boyle, I took a bottle, placed on my table, with the title of ſpirit of vitriol; it contained only a very ſmall quantity of the fluid, which prevented me from perceiving that it was pure oil of vitriol. I poured a few drops into the fuming liquor; a rapid inteſtine motion was inſtantly excited, a very denſe white cloud iſſued out of the veſſel in which the mixture was made, and a noiſe, reſembling that of a large fuſee, immediately followed. The liquor flew out of the glaſs, the veſſel became very hot, and broke into a great number of pieces; nothing

thing remaining but a yellowiſh thick magma, reſembling ſulphur, on ſome of the fragments. I have carefully repeated this experiment a great number of times, conſtantly with the ſame reſult. The whole mixture is thrown out, after a violent commotion; but the different phenomena ſucceed each other with ſuch rapidity, that it is impoſſible to avoid confounding them together. The moſt fuming ſpirit of nitre did not appear to produce the ſame effect on the fuming liquor prepared ſome time before; the mixture is ſtrongly agitated; much heat and ebullition is produced; a white cloud of ammoniacal nitrous ſalt riſes, but no exploſion follows, as is produced by oil of vitriol on the ſame hepatic liquor, though made a long time before. Mr. Prouſt affirms, that nitrous acid, poured on two drachms of the fuming liquor of Boyle, produces a report equally violent with that of the ſame quantity of fulminating powder. This phenomenon does not appear to take place, but with the volatile hepar recently prepared.

The cretaceous ammoniacal ſalt, or concrete volatile alkali, likewiſe unites with ſulphur. Whenever theſe two bodies meet in the vaporous form, they unite, and compoſe a concrete volatile liver of ſulphur. It may be obtained, by diſtilling a mixture, of equal parts of cretaceous tartar, or chalk, and ſal-ammoniac, with half a part of the flowers of ſulphur. This liver of ſulphur is of a red brown, and cryſtallized; it emits ſome white vapours when diſſolved; is decompoſed by heat; is changed, and loſes its colour, by expoſure to air; is decompoſed by acids, &c. The hepatic gas which it affords contains cretaceous acid. It muſt be obſerved, that this concrete volatile hepar, is merely ammoniacal chalk, vitiated by a ſmall portion of the fuming liquor of Boyle; for it is impoſſible that the volatile alkali ſhould hold ſulphur in ſolution, while it is combined with the cretaceous acid, which has the property of precipitating the ſulphur very readily.

Several acids act upon ſulphur. If oil of vitriol be boiled on flowers of ſulphur, the acid aſſumes an amber colour, and a ſulphureous ſmell; the ſulphur melts, and floats like oil: in cooling, it forms concrete globules, of a green colour, which is deeper, in proportion to the time it has been expoſed to the action of the acid. The acid diſſolves a ſmall part of the ſulphur, which is precipitable by an alkali, as M. Baumé has ſhewn. This experiment, and many others of the like nature, convinced Mr. Bertholet, that the ſulphureous acid conſiſts of the vitriolic acid, which holds ſulphur in ſolution.

The ſmoking nitrous acid acts ſtrongly

on ſulphur. Mr. Prouſt was the firſt who obſerved, that a detonation and inflammation are produced when red nitrous acid is poured on melted ſulphur. Mr. Chaptal has made a ſeries of experiments relative to this ſubject; he ſucceeded in diſſolving and converting ſulphur into vitriolic acid, by diſtillation, with the addition of nitrous acid. Hence it appears, that vital air, or the oxyginous principle, has a ſtronger affinity with ſulphur, than with nitrous gas or atmoſpheric mephitis.

The common marine acid produces no change in this combuſtible ſubſtance; but the exceſs of the oxyginous principle, abſorbed by this acid, in the dephlogiſticated ſtate of Scheele, is capable of acting more ſtrongly on it. Experiments have not, however, been ſufficiently varied, to render it neceſſary for us to dwell longer on this ſubject.

Vitriolic neutral ſalts have no action on ſulphur; nitrous ſalts, on the contrary, cauſe it to burn with rapidity, even in cloſed veſſels. Nothing can be more ſimple than the theory of this important phenomenon. Nitre, decompoſed by heat, affords a very large quantity of vital air. Sulphur is a very combuſtible ſubſtance; that is to ſay, it has a ſtrong tendency to unite with the oxyginous principle: it therefore finds that, in the nitre which is neceſſary for its combuſtion, and does not therefore need the contact of atmoſpheric air for that purpoſe. The products are very different, according to the reſpective quantities of nitre employed. If a mixture of eight parts of ſulphur, and one of nitre, be ſet on fire in a cloſe veſſel, the ſulphur burns with a very brilliant white flame, and becomes converted into vitriolic acid. This method has been uſed in England, and in Holland, for more than twenty years, for preparing this acid, which was before obtained from vitriol. Very large glaſs veſſels, capable of holding about four or five hundred pints, having a large neck, were at firſt uſed in England. Theſe were placed beſide each other, on a bed of ſand, in two rows, at a ſufficient diſtance from each other to be conveniently come at. A few pounds of water were put into each of theſe veſſels. A ſtoneware pot was introduced into the neck of each veſſel, on which a ladle of iron, previouſly made red hot, was placed. Into this laſt, by means of another ladle of tin-ware, a mixture of ſulphur and nitre, in due proportion, was put; the aperture of the glaſs veſſel being immediately cloſed with a ſtopper of wood. The heat of the iron ladle ſet theſe ſubſtances on fire; the ſulphur became burned by the air of the nitre; and when the combuſtion was finiſhed, the veſſel was taken out, and the vapours ſuffered to condenſe. The ſame operation was made in each

each of the glaſs veſſels compoſing the two rows, ſo that the workman, after paſſing through the whole range, arrived at the firſt veſſel, at the time when the vapours were totally condenſed, and the veſſel conſequently in a ſtate to receive a new portion of the burning matter. When the water was ſufficiently charged with acid, it was taken out, and poured into glaſs retorts, and the acid concentrated, by diſtilling off the aqueous part, till a bottle, capable of holding an ounce of diſtilled water, would contain one ounce ſeven drachms and a half of the acid. Such was the method of preparing oil of vitriol in England, which was very expenſive, on account of the price and brittleneſs of the large glaſs veſſels. But ſulphur has been for ſome years burned for this purpoſe in iron grates, placed within large chambers, lined on all ſides with lead; the vitriolic acid being conducted by gutters, as it is condenſed, into a receiver. It is afterwards concentrated by the action of fire. This proceſs is uſed in the manufactory of Javelle, near Paris, the eſtabliſhment of which cannot but be very uſeful to the arts. It is proper to obſerve, that the oil of vitriol obtained by this proceſs, always contains a ſmall portion of ſulphur and vitriolated tartar, together with alum and vitriol of lead; but the quantity of theſe ſubſtances is ſo ſmall, as to have no ſenſible effects in in moſt of the uſes to which this ſaline matter is applied. It is, beſides, very eaſy to purify it for the nicer purpoſes of chemiſtry, by diſtilling it to dryneſs.

If, inſtead of burning ſulphur with the addition of one-eighth part of nitre, the doſe of the latter be augmented, ſo as to be equal to that of the ſulphur, vitriolated tartar, formed by the combination of the vitriolic acid with the fixed baſe of the nitre, will be obtained, inſtead of the diſengaged vitriolic acid. The ſalt obtained in this method, is called the polychreſt ſalt of Glaſer. It is prepared, by throwing a mixture of equal parts of ſulphur and nitre, into a red hot crucible; the reſidue is diſſolved in water, evaporated to a pellicle, afterwards filtered, and affords, by cooling, true vitriolated tartar, which has been diſtinguiſhed by the name of its inventor, Glaſer; though it does not at all differ from common vitriolated tartar.

A mixture of ſulphur and nitre with charcoal, compoſes gunpowder, whoſe terrible effects ariſe from its great combuſtibility. It is formed, for the moſt part, of nitre, with a much ſmaller proportion of charcoal, and ſtill leſs of ſulphur. One hundred pounds of gunpowder of Eſſone, near Corbeil, contain ſeventy-five pounds of nitre, nine pounds and a half of ſulphur, and fifteen of charcoal. This mixture is triturated

rated for ten or twelve hours, in wooden mortars, with peſtles of the ſame ſubſtance, a very ſmall quantity of water being added from time to time. When almoſt the whole of the fluid is evaporated, ſo that the powder will not ſoil an earthen plate, it is carried to be granulated. This is effected, by cauſing it to paſs through a number of ſieves of ſkin, which are moved backwards and forwards in a right line. The holes in theſe ſieves are of various ſizes, down to that of cannon powder. The duſt, or meal powder, is ſeparated from the grains by ſifting. The grains are then carried to the drying-houſe, which is a ſhed expoſed to the ſouth, with glaſs windows, ſo as to receive the rays of the ſun. Cannon powder receives no other preparation than we have here mentioned. Muſquet powder is glazed, that it may not ſoil the hands. To perform this operation, a caſk, mounted on an axis, and turned by a water wheel, is half filled with powder. The motion of the caſk excites continual friction, by which the grains of the powder are worn ſmooth. The duſt is ſeparated from this glazed powder by a ſieve, and the grains are likewiſe ſeparated by another ſieve, into a finer and a coarſer ſort. M. Baumé, in conjunction with the Chevalier D'Arcy, has made a very numerous ſet of experiments on the method of preparing gunpowder, on the reſpective forces of this compound,

pound, made with different proportions of the ingredients, and on the analyſis of this ſubſtance. Out of the many valuable circumſtances of information derived from theſe experiments, we ſhall ſelect the moſt important, and ſuch as have an immediate reference to chemical theory. 1. Good powder cannot be made without ſulphur, as has been propoſed by ſeveral perſons; this ſubſtance being found greatly to increaſe its force. 2. Every kind of charcoal, whether light or heavy, except animal coal, is equally fit for making gunpowder. 3. Charcoal is one of the moſt uſeful ingredients, a mixture of ſulphur and nitre not producing an effect to be compared with that of gunpowder. 4. The goodneſs of powder depends intirely on the accurate mixture and trituration, continued till the powder riſes in the form of duſt about the mortar. 5. Powder has a much greater effect when ſimply dried, than when grained. The moiſture neceſſary to grain the powder, cauſes the nitre to ſeparate, by cryſtallization, from the other ſubſtances; ſo that it may be obſerved, by a magnifier, in the internal part of grains of powder, cut in two. 6. Glazed, or muſquet powder, is leſs ſtrong than unglazed powder, becauſe the particles of the former are cloſer together, and conſequently leſs inflammable. As to the analyſis of gunpowder, M. Baumé performs it in a very ſimple manner:

manner: his proceſs conſiſts in waſhing the gunpowder, well pulverized, with diſtilled water, and evaporating the water, which of courſe affords the nitre in cryſtals; the reſidue contains the ſulphur and charcoal. Sublimation does not completely ſeparate the former, becauſe it appears to be partly more fixed by the charcoal. M. Beaumé, to ſeparate them, burned the ſulphur by heat not ſufficient to burn the charcoal. The latter, however, always retains a ſmall quantity of ſulphur, ſince, according to the obſervation of that chemiſt, it emits a ſulphureous ſmell till it is intirely reduced to aſhes. He eſtimates the ſulphur, retained by the charcoal, at one twenty-fourth of its weight. Gunpowder may likewiſe be deprived of its ſulphur, by expoſing it intire, and without previous waſhing, to the action of a gentle heat, as Mr. Robins, in his Treatiſe on Gunnery, written in the Engliſh language, has obſerved. The perſons who ſteal game have been long in the habit of deſulphurating gunpowder, by expoſing it in a tin diſh to the heat of a bed of aſhes. They are perſuaded, that the powder, in this ſtate, impells the ſhot to a much greater diſtance, and does not ſoil the piece ſo much.

Chemiſts and philoſophers have maintained various opinions reſpecting the violent effects of gunpowder; ſome have attributed them to water, reduced into vapour, and others to the ſudden dilation of air. M. Baumé ſuppoſed them to ariſe from a nitrous ſulphur, formed in the inſtant of combuſtion. For our part, we think this phenomenon may be very readily explained, by the application of the modern improvements in chemiſtry. To render our theory more perſpicuous, it muſt firſt be obſerved, that all the phenomena, which attend the inflammation of gunpowder, depend intirely on its great combuſtibility. The intimate mixture, which has ſo great an influence on the force of gunpowder, as M. Baumé's valuable experiments have ſhewn, is the only cauſe of its effects. The nitre is equally diſperſed among all the particles of very combuſtible matter: as its quantity is much the greateſt, each particle of ſulphur and charcoal is ſurrounded, and, as it were, covered with nitre. A much greater quantity of vital air, than is neceſſary for the complete combuſtion, will be produced; it being well aſcertained, that nitre affords that fluid in great quantities, by the application of heat. The ſame thing happens in this combuſtion, as is obſerved, when a combuſtible body is plunged in a veſſel filled with vital air; that is to ſay, it is burned with great vivacity, and in much leſs time than in the common atmoſpheric air. It follows, therefore, that the ſulphur and the charcoal muſt be burned in an inſtant, becauſe they are really plunged in an atmoſphere of vital air. Hence, the rapid inflammation of powder, its

its taking place in cloſe veſſels, and the terrible force with which it explodes and drives every obſtacle before it, may be eaſily conceived.

The effects of this mixture of nitre, ſulphur, and coal, are nothing, in compariſon with thoſe of another preparation, called fulminating powder. This is made, by triturating, in a hot marble mortar, with a wooden peſtle, three ounces of nitre, two ounces of very dry fixed ſalt of tartar or cretaceous tartar, and one ounce of flowers of ſulphur, till the whole is very accurately mixed. If a drachm of this powder be expoſed to a gentle heat, in an iron ladle, it melts, and ſoon after produces a detonation as loud as the report of a cannon. This phenomenon, which is ſo much the more aſtoniſhing, becauſe its effect is produced without incloſing the powder in any inſtrument, as is done with gunpowder, may be explained, by obſerving, 1. That it does not ſucceed, but by gradually heating the mixture, ſo as to melt it. 2. That if fulminating powder be thrown on ignited charcoal, it only detonates, like nitre, but with very little noiſe. 3. That a mixture of liver of ſulphur with nitre, in the proportion of one part of the former, and two of the latter, fulminates with more rapidity, and produces as loud a report, as the compoſition of ſulphur, nitre, and alkali: hence it appears, that when fulminating powder is heated, liver of ſulphur is formed before the detonation takes place; and this fact is ſufficient to explain the whole appearance. When cryſtallized nitre, and liver of ſulphur, are expoſed to the action of heat, inflammable or hepatic gas is diſengaged from the latter, while the ſalt gives out vital air. Now theſe two, which together are capable of producing a ſtrong inflammation, as we have obſerved in the hiſtory of inflammable gas, are ſet on fire by a portion of the ſulphur. But as the thick fluid they are obliged to paſs through preſents a conſiderable obſtacle, and as the whole takes fire at the ſame inſtant, they ſtrike the air with ſuch rapidity, that it reſiſts in the ſame manner as the chamber of a muſquet reſiſts the expanſion of gunpowder. A proof of this is obſervable in the effect the fulminating powder has on the ladle in which it explodes. The bottom of this veſſel is bulged outwards, and the ſides bent inwards, in the ſame manner as if it had been acted on by a force directed perpendicularly downwards, and laterally inwards.

Laſtly, we ſhall in this place conſider, that mixture of nitre and ſulphur, which is called powder of fuſion. It conſiſts of three parts of nitre, one of ſulphur, and one of ſaw-duſt. A ſmall quantity of this powder is put into a nut-ſhell, with a ſmall piece of copper money rolled up; the piece is covered with the ſame powder, which being ſet

ſet on fire, burns rapidly, and melts the coin, without burning the ſhell, which is only blacked. It is neceſſary, however, to plunge the whole in water as ſoon as the powder has ceaſed to burn. This experiment proves, in fact, that the powder is an effectual flux. But as the preſent appearance depends, in a great meaſure, on the action of the ſulphur on the metal, we ſhall again mention this fact in the hiſtory of metallic ſubſtances.

Marine and ſparry neutral ſalts, and the different ſpecies of borax, have no action on ſulphur. We have ſeen, that cretaceous alkaline ſalts unite with that ſubſtance, and render it ſoluble in water, by forming the alkaline hepars, which are not cauſtic.

Inflammable gas does not act, in any ſenſible manner, on ſulphur. It is proper to obſerve, that it was very natural for chemiſts to conſider theſe ſubſtances, as having a ſtrong analogy with each other. For it is certain that the vitriolic acid, in its combination with combuſtible bodies, affords inflammable gas, when it is diluted with water, and ſulphur, when it is concentrated. In all places where inflammable gas is produced, as for example, where large quantities of animal matters putrify, ſulphur is likewiſe formed; and the latter, combined with alkaline ſubſtances, appeared to become changed into inflammable or hepatic gas. Laſtly, inflammable gas alone acts on a great number of bodies, nearly in the ſame manner as ſulphur. It might therefore have been rationally concluded, that there is a ſort of identity in theſe two bodies, if it were not at preſent known, that inflammable gas is almoſt always produced by the decompoſition of water, and that ſulphur does not enter into that fluid.

Sulphur is capable of combining with many other ſubſtances; but as thoſe ſubſtances have not yet been treated of, we ſhall poſtpone the conſideration of their properties to the enſuing part of this work.

Sulphur is an excellent remedy in pituitous diſorders of the lungs, and eſpecially in cutaneous diſorders. It is very ſucceſsfully employed in the humid aſthma, and in ſcorbutic eruptions. It is adminiſtered in the form of flowers of ſulphur, or in lozenges prepared with ſugar. An ointment is made with fat ſubſtances, with which cutaneous eruptions are rubbed. Liver of ſulphur has been propoſed in obſtructions, numbneſs, palſies, foulneſſes of the ſkin, &c. Though ſome phyſicians have ſuppoſed that ſulphur is not ſoluble in the animal fluids, it is nevertheleſs certain, that it penetrates to the extremities of the minuteſt veſſels, ſince the perſpiration, the urine, and the ſaliva, of ſuch as uſe it, are manifeſtly impregnated. The hepatic gas, diſſolved in mineral waters, as in thoſe of Cauterez, Aix la Chapelle, Bereges, and Enghien, communicates to them diſcuſſive properties, of great ſervice in diſorders of the ſkin, the lungs, the joints, palſies, &c.

Sulphur is not leſs uſeful in the arts. We have ſeen its utility in making gunpowder and fire-works. It is uſed to take fine impreſſions of engraved ſtones, to make matches, to bleach ſilks, and to deſtroy certain colours; to impede or ſtop the progreſs of fermentation in wines, &c. It has been propoſed to be uſed in fixing iron in ſtones, &c.

CHAP. V.

Genus IV. PLUMBAGO.

PLUMBAGO was not known as a peculiar combuſtible matter, different from molybdena, till the experiments of Scheele were publiſhed, in the Memoirs of the Academy of Stockholm for the year 1779: before the time of this celebrated chemiſt, it was confounded with molybdena. Pott is one of the firſt who proved, that neither of theſe ſubſtances, which by Pliny and Dioſcorides are confounded with lead ores, do contain that metal.

The

The many names by which plumbago and molybdena have been diſtinguiſhed, ſerve to increaſe, or at leaſt to perpetuate, theſe errors. Both, without diſtinction, were called lead ore, Engliſh crayon, plomb de mer, black ceruſe, mica of the painters, crayon of lead, falſe galena, talc-blende, potelot; this laſt name has been adopted by Mr. Daubenton, to denote molybdena, and diſtinguiſh it from plumbago, which he calls black crayon.

Plumbago is found in mountains, often between beds of quartz, felt ſpar, clay, or calcareous earth, in the form of roundiſh irregular pieces, of different magnitudes; the largeſt of which weigh from eight, to ten or eleven pounds: it is likewiſe found diſſeminated in much ſmaller fragments, and ſometimes even in beds or ſtrata. The inhabitants of Bleoux, a village near Curvan, in Upper Provence, find plumbago in ſtrata, four feet thick, between two ſtrata of clay. This is ſold at Marſeilles. Mr. De la Peyrouſe reckons plumbago among the minerals of the Pyrenean mountains. It is likewiſe found in Spain and Germany; and alſo in the county of Cumberland, in England, where it is made into pencils, which are highly eſteemed. North America, and the Cape of Good Hope, likewiſe afford ſome ſpecimens.

Plumbago is of a ſhining blue black, of a greaſy

greaſy feel, and tuberculated fracture; whereas the fracture of molybdena is lamellated. Its unctuous and ſaponaceous quality, cauſed ſome naturaliſts to conſider it as a ſpecies of impure clay. It ſoils the hands, and makes a black trace on paper, which is very well known to every one.

Plumbago is not altered in cloſe veſſels. Mr. Pelletier, who has made experimental inquiries on this ſubſtance, which confirm the reſults of Mr. Scheele, expoſed 200 grains in a porcelain crucible, accurately cloſed, to the heat of the furnace of the manufactory of Seve. The loſs was no more than 10 grains. But when it is heated with contact of air, it becomes calcined, without leaving ſcarcely any reſidue. Meſſrs. Quiſt, Gahn, and Hielm, obſerved, that 100 grains, treated in this manner, in a muffle, left only 10 grains of ferruginous earth. This calcination is a ſlow combuſtion, not eaſily performed. It does not ſucceed in a common crucible: a thin layer of plumbago muſt be expoſed, in a ſhallow veſſel, to the action of a ſtrong fire, and the ſurfaces muſt be often renewed, by ſtirring the matter.

Air, water, and earthy ſubſtances, have no action on plumbago.

Alkalis act ſtrongly on this ſubſtance. If one part of plumbago, with two parts of dry cauſtic fixed alkali, or lapis cauſticus, be expoſed to heat in a retort, with the pneumatomato-chemical apparatus, the ſmall quantity of water contained in the ſalt is ſufficient to favour the combuſtion: inflammable gas is obtained, the alkali is charged with cretaceous acid, and the plumbago is found to have diſappeared. This experiment, as well as the detonation with nitre, hereafter to be mentioned, cauſed Mr. Scheele to conclude, that this matter is a kind of ſulphur, compoſed of the cretaceous acid and phlogiſton. This theory ſhall be diſcuſſed, after we have examined the other phenomena, exhibited by this combuſtible body with acids and neutral ſalts.

The vitriolic acid has no action on plumbago, according to Scheele. Mr. Pelletier has obſerved, that 100 grains of plumbago, and four ounces of oil of vitriol, being digeſted for ſeveral months in the cold, the acid acquired a green colour, and the property of congealing, by a very ſlight degree of cold. This acid, diſtilled from plumbago, paſſes to the ſulphureous ſtate, by burning part of that ſubſtance.

The nitrous acid has no effect whatſoever on plumbago. The marine acid diſſolves the clay and the iron, and ſerves to purify it, according to Bertholet. Mr. Pelletier uſed the ſame proceſs, in order to obtain plumbago in a ſtate of purity. As to the clay, which the marine acid takes from plumbago, Mr. Scheele obſerves, that that which

which he obtained in his analyſis, came from the crucible in which he had before treated that ſubſtance.

Plumbago, fuſed with four parts of vitriolated tartar, and of vitriol of ſoda, produces a liver of ſulphur, and is intirely decompoſed.

Nitre detonates by the addition of this mineral, ten parts of the ſalt being neceſſary for the complete combuſtion of one part of plumbago. The fixed alkali, which remains after this operation, effervеſces ſtrongly with acids, and contains a ſmall quantity of martial ochre. The ſame effect follows, when rhomboidal nitre, or ammoniacal nitre, is uſed. Mr. Pelletier has obſerved, that in this laſt operation, the volatile alkali is diſengaged, in combination with a portion of the cretaceous acid.

Plumbago does not act on the muriate of pot-aſh, nor on the muriate of ſoda.

When diſtilled with ſal ammoniac, it affords martial ammoniacal flowers; heated with ſulphur in a retort, the ſulphur ſublimes alone, without affecting the plumbago in the leaſt.

All theſe facts prove, that plumbago is a peculiar combuſtible matter; but the theory of Scheele, who conſiders it as a combination of the cretaceous acid and phlogiſton, cannot be ſaid to be proved; 1. Becauſe that chemiſt did not aſcertain the quantity of acid produced. 2. Becauſe he has not artificially

artificially produced plumbago, by combining the cretaceous acid with a combuſtible ſubſtance. Moreover, the two ſubſtances, by the addition of which Mr. Scheele changed plumbago into cretaceous acid, appear to effect this converſion, by affording vital air, which, combining with the inflammable matter of that ſubſtance, produces the cretaceous acid by the fixation of the oxyginous principle; for ſuch is the proceſs by which the nitrous acid converts tungſten, arſenic, and ſugar, into acids. The cauſtic fixed alkali likewiſe converts plumbago into cretaceous acid, moſt probably in conſequence of the water that alkali always contains, and which burns the combuſtible matter, as it does iron and zink. This opinion is confirmed, by the inflammable gas obtained during the reciprocal action of the alkali and the plumbago; and it might be ſtill more confirmed, by paſſing the vapour of water over plumbago, made red hot in a tube of copper, in the ſame manner as the experiment is made with iron and zink. And though this has not yet been tried, I think I may venture to predict, that all the plumbago would be deſtroyed, and converted into cretaceous acid; and that the product of this operation would conſiſt of inflammable gas, mixed with a large quantity of cretaceous acid, formed by combination of the oxyginous principle of the water with the plumbago.

bago. It would therefore ſeem natural to conclude, that the cretaceous acid is a compound of plumbago and the oxyginous principle. But as we know, by many other experiments, that this acid is very abundantly produced by combining charcoal with pure air, it follows, that there is a very ſtrong analogy between charcoal and plumbago: a few leading circumſtances will ſhew this more evidently.

The charcoal of many vegetable matters is brilliant, and of a metallic aſpect, like plumbago; ſoils the hands, and leaves traces on paper; is brittle, and of a granulated fracture. The moſt brilliant charcoals, ſuch as thoſe of certain animal ſubſtances, are as difficult to burn as plumbago, which requires to be frequently ſtirred, at the ſame time that it is expoſed to a ſtrong heat, with contact of air: both contain iron; and, laſtly, both are ſuſceptible of being changed into cretaceous acid by combuſtion. May we not from hence conſider plumbago, as charcoal formed in the interior part of the globe, or buried in the earth? May we not even ſuppoſe, that this matter is formed by the combination of certain mineral principles, though almoſt all chemiſts have concluded, that organic bodies only are convertible into charcoal? Theſe ideas may be confirmed, or deſtroyed, by a connected inquiry into the ſtate of plumbago in nature, the circumſtances of its and its formation, the changes to which it is ſubjected. Plumbago is of conſiderable uſe. Pencils are made of it; the beſt come from England. The Engliſh black lead comes from Keſwick, in the county of Cumberland. It is cut into thin plates, the edge of which being fitted into a groove, in a ſemi-cylinder of wood, it is then ſawed off, ſo as to leave the cavity intirely filled. The mineral is retained in its place, by the other half of the cylinder, which is glued on. The powder of plumbago ſerves to make pencils of an inferior quality; great numbers of which are ſold in Paris. It is either mixed with gum-water, or fuſed with ſulphur. Theſe inferior pencils are known, either by their taking fire at the flame of a candle, or their falling into powder, by moiſtening in water. German plumbago is likewiſe uſed to make pencils, with the addition of various foreign ſubſtances, ſuch as charcoal, ſulphur, &c.

The very fine powder of plumbago is uſed in England inſtead of greaſe, to facilitate the motion of the axes of certain mechanical inſtruments, which it effects by its unctuous quality.

One of the principal uſes of plumbago, is to cover iron which is to be defended from ruſt. The pipes of ſtoves, chimney-plates, and other utenſils, expoſed to the action of fire and air, are covered with plumbago, applied

plied to their ſurface by ſimple friction with with a bruſh. Homberg, in the year 1699, deſcribed a proceſs for giving a leaden colour to iron utenſils. It conſiſts in mixing eight pounds of lard, melted with four ounces of camphire, together with a ſufficient quantity of plumbago; the iron is to be ſmeared with this compoſition, when it is almoſt too hot to retain it, and muſt be rubbed with a cloth when cold.

The makers of ſmall ſhot poliſh and blacken its ſurface, by agitating or rolling it in a caſk, with powder of plumbago. This mineral likewiſe enters into the compoſition for razor ſtraps. Laſtly, it is an ingredient in certain black pottery, and in crucibles made at Paſſaw in Saxony. Mr. Pelletier, who has well deſcribed the ſeveral uſes of plumbago, prepares a lute or coating, after Pott, conſiſting of one part of plumbago, three of common clay, and a ſmall quantity of cow dung, chopped very ſmall. This coating ſupports glaſs retorts ſo well, that they ſometimes may be even melted without producing any change in its form.

CHAP. VI.

Genus V. METALLIC SUBSTANCES IN GENERAL.

METALLIC ſubſtances conſtitute an order of bodies, of the greateſt importance and utility in the different purpoſes of ordinary life, as well as in chemiſtry and medicine. They eſſentially differ from earthy and ſaline matters, by their phyſical characters, and their chemical properties.

Before we proceed to the examination of each particular metallic ſubſtance, it will be proper to conſider them in general. We ſhall do this in order, under ſeveral heads; namely, 1. We ſhall ſpeak of their phyſical properties. 2. Their natural hiſtory. 3. The art of aſcertaining their nature and quantity, which is uſually called the docimaſtic art, or art of aſſaying. 4. The art of working metals in the large way, or metallurgy. 5. Their chemical properties. 6. The method of diſtinguiſhing them from each other, and the diviſions which it is neceſſary to eſtabliſh among them.

§ I. Concerning the phyſical properties of metallic ſubſtances.

Metallic ſubſtances are abſolutely opake; a circumſtance in which they differ greatly from ſtony ſubſtances: for the moſt opake ſtone, being divided into thin portions, has a ſort of tranſparency; whereas the thinneſt plate of metal, is as perfectly opake as the moſt ſolid piece.* The opacity of metallic ſubſtances, renders them exceedingly proper to reflect the rays of light, no bodies poſſeſſing this property in ſo eminent a degree. Thus we obſerve, that looking-glaſſes do not ſtrongly reflect the ſpecies of objects, unleſs they be coated with metal. The metallic brilliancy ariſes from the ſame property, and is always greater, in proportion as the denſity and hardneſs of the metal permits it to take a finer poliſh. White metallic ſubſtances reflect a greater quantity of light, and are more brilliant than thoſe which are coloured.

Metallic ſubſtances have a much greater ſpecific gravity than all other bodies. A cubic foot of marble weighs only 252 pounds; a cubic foot of tin, which is the lighteſt of metals, weighs 516 pounds; and a cubic

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* This has not been well inquired into. Gold in leaf, which is about the $\frac{1}{282000}$ of an inch in thickneſs, tranſmits light of a lively green colour, and is tranſparent. Silver leaf, which is about the $\frac{1}{150000}$ of an inch thick, is perfectly opake; and ſo likewiſe is leaf braſs, or Dutch gold, whoſe thickneſs is $\frac{1}{60000}$ of an inch. Other metals have not been extended in this way, and whether any of them are capable of it in any conſiderable degree, is not known. T.

a cubic foot of gold weighs 1326 pounds. This exceſſive weight, ſo much beyond that of other earthy ſubſtances, doubtleſs depends on their great denſity, to which their perfect opacity and brilliancy are likewiſe owing.

Moſt metallic ſubſtances may be extended, by repeated percuſſion, or ſtrong preſſure. This property, peculiar to metallic matters, and which for that reaſon we have not had occaſion to notice in any of the ſubſtances we have yet examined, is termed ductility. We think it ought to be diſtinguiſhed into two kinds; the one, ductility under the hammer, or malleability, conſiſts in the property of being extended into thin plates, without cracking; lead and tin poſſeſs this kind of ductility only: the other conſiſts in the ſucceſſive, and almoſt extreme lengthening of certain metallic matters into wire. This ductility, which is eminently obſervable in iron, copper, and gold, is likewiſe called tenacity. It is of much more conſequence to make a proper diſtinction between theſe two ſorts of ductility, becauſe they appear to be really very different from each other. Metallic ſubſtances, which are very malleable, have often ſcarcely any tenacity; and many of thoſe which are very ductile, when in the hand of the wire-drawer, are not very malleable. The tenacity of metals is very accurately expreſſed, by the quantity of weight a metallic wire, of a known diameter, is capable of ſuſtaining without

without breaking: both theſe properties appear to depend on the peculiar form of the integrant parts of each metal. Metals, which are extended into thin plates by percuſſion, ſeem to be formed of ſmall laminæ, which, when compreſſed, ſlide on each other, and are increaſed in breadth, in proportion as their thickneſs is diminiſhed; while ſuch as are capable of being drawn into fine wire, have a kind of fibrous texture, whoſe filaments are cauſed to approach each other, and become lengthened, by the ſtrong preſſure they ſuffer in the drawing. The ductility of metals is limited. It is obſerved, that when a metal, even of the moſt ductile kind, has received ſeveral ſtrokes of the hammer, it becomes hard, and cracks, inſtead of extending; it is then ſaid to be hammer-hardened: a metal in this ſtate, recovers its former ductility, by being heated, and gradually cooled. The parts ſeem to extend under the hammer, only while the ſpace between each particle is ſuch, that they may yield before the hammer. It may eaſily be conceived, that theſe parts, being once brought ſufficiently near each other to leave ſcarcely any interval, can no longer yield or eſcape before the ſtroke of the hammer; and in that caſe, the impulſe will be exerted in deſtroying the texture, or breaking the metal. Heat, by dilating, cauſes the parts to ſeparate, and produces new ſpaces between them, which conſequently allow of their being again brought together, by reiterated ſtrokes.

As ductility is a property of certain metallic ſubſtances only, chemiſts and naturaliſts have availed themſelves of it as a diſtinctive character. They call thoſe which have the metallic weight and brilliancy, together with ductility, metals; and thoſe which, with the metallic appearance, are not ductile, they call ſemi-metals. But this diſtinction, though conſiderably accurate, is not ſufficient to ſeparate all metallic matters into two claſſes, ſince the difference between the extreme ductility of gold, and the ſingular brittleneſs of arſenic, is connected by inſenſible degrees in the other metals; there being perhaps a greater difference, in this reſpect, between gold and lead, which are reckoned metals, than between lead and zink; the latter of which is reckoned among the ſemi-metals, or between zink and arſenic: the difference between one body and another being almoſt imperceptible.

Metals, conſidered with reſpect to their ductility, may be arranged in the following order. Gold is the moſt malleable, and is ſucceeded, in order, by ſilver, copper, iron, tin, and lead. The ſemi-metals have been conſidered as poſſeſſing no ductility. We ſhall, however, ſee, that this property exiſts, in a certain degree, in zink and mercury.

cury. As to tenacity, gold poſſeſſes it in the higheſt degree, and is ſucceeded by iron, copper, ſilver, tin, and lead. The tenacity of platina is not well known.

Metallic ſubſtances are ſuſceptible of a regular figure, either naturally, or by art. Naturaliſts have long acknowledged this property in native biſmuth, virgin ſilver, and ſome other metals. The alchemiſts have carefully obſerved the ramified, or ſtellated figures, which are formed at the ſurface of regulus of antimony and biſmuth. Mr. Baumé, in his chemiſtry, affirms, that metallic matters, after being well fuſed, aſſume a ſymmetrical arrangement, by gradual cooling, &c. The Abbé Mongez, regular canon of St. Genevieve, has made a continued ſeries of experiments on the cryſtallization of all metallic ſubſtances. Mr. Brongniart, lecturer of chemiſtry, at the king's garden, has likewiſe made experiments relative to this inquiry, which have been repeated by many chemiſts. The general reſult is, that all metals are capable of cryſtallizing, and that though many of them apparently differ, yet the greateſt number preſents the ſame octahedral form, with ſome modifications.

Certain metallic matters have a ſenſible taſte and ſmell, as lead, copper, iron, regulus of arſenic, and regulus of antimony. Theſe properties are conſtantly obſerved in ſuch

ſuch metallic ſubſtances as are moſt ſubject to change. They ſometimes exiſt in ſo eminent a degree, as to be capable of corroding, and intirely deſtroying, the organs of animals.

§ II. The Natural Hiſtory of Metallic Subſtances.

Metallic ſubſtances exiſt in the earth in four different ſtates: the firſt is that of virgin, or native metal; that is to ſay, poſſeſſed of all its properties. Gold is always found in this ſtate; ſilver, copper, mercury, biſmuth, and arſenic, often; but iron ſeldom: and lead, zink, regulus of antimony, &c. ſtill more rarely.

The ſecond ſtate in which metallic ſubſtances are found, is that of earth, or calx; that is to ſay, without the metallic aſpect, and rather reſembling ochres, or the ſtony ſubſtances called ſpars; in which caſe theſe minerals are called ſpathoſe ores. Copper is often found in the ſtate of green or blue calx; iron in the ſtate of ruſt, or white, or coloured ſpar, ſometimes cryſtallized; lead in the ſtate of cryſtallized calx, or white, red, or green ſpar; tin alſo has ſometimes the metallic form; zink in the ſtate of calamine; cobalt in red flowers; arſenic in a white calx, &c.

The third natural ſtate, and the moſt common in which metals are found, conſtitutes

ores,

ores, or mineralized metals. The metallic ſubſtance is found combined with a combuſtible matter, which deprives it of its metallic properties, and requires to be ſeparated before thoſe properties can be again manifeſted. This matter, which is called the mineralizer, is either ſulphur, or ſome metal. Some chemiſts even affirm that ſulphur is the moſt common mineralizer. It is united to ſilver in the vitreous ore; ores of copper almoſt always contain much ſulphur; iron is combined with this mineral in the martial pyrites, lead in the galena, mercury in cinnabar, zink in blend, the regulus of antimony in antimony; and laſtly, it is ſometimes united with biſmuth, and often with arſenic.

It is proper to obſerve, that metals have not all the ſame affinity with ſulphur. There are ſome metals which contain large quantities, and readily part with it, their metallic ſtate appearing ſcarcely altered; ſuch are copper, lead, and regulus of antimony. Others contain it in very ſmall quantities, but ſtrongly adherent, and cauſing almoſt all the metallic qualities to diſappear; as is obſervable in cinnabar.

Metals are occaſionally found alloyed with other metals, but arſenic is the moſt uſual mineralizer. Iron, tin, and cobalt, are frequently united to arſenic. Sometimes the metal is combined both with arſenic and with ſulphur, as in the red ore of antimony,

and

and the red ſilver ore. Laſtly, there are metallic ores compoſed of many metals and many mineralizers; ſuch as the grey copper ore, the grey ſilver ore, and ſome others.

The fourth ſtate in which metals are found, is in combination with ſaline ſubſtances, almoſt always acids. The vitriolic acid is moſt frequently found combined with metals; as for example, zink, lead, copper, and iron. The cretaceous acid is likewiſe a common mineralizer; and the arſenical and phoſphoric acids have likewiſe been diſcovered in minerals within the laſt few years.

Metallic ſubſtances are much leſs abundant than ſtony matters; they are formed in mountains in veins or clefts, which interſect the ſtrata of earths and ſtones with various degrees of obliquity. This is the moſt uſual ſtate of mineralized metals; ſuch as are in the ſtate of calx, or of ſalts, are often found in maſſes depoſited by water, and ſometimes cryſtallized. Metallic ores are alſo found in large irregular maſſes; in this caſe, their formation ariſes from peculiar cauſes.

The metallic veins are accompanied with ſtony matters, which ſeem to have been formed at the ſame time. Theſe ſtones are uſually quartz and ſpar. The layer on which the ore is placed is called the bed or floor of the mine; the other which covers it is called the roof. Stones conſtitute what is called the gangue or matrix of the ore, and muſt

muſt not be confounded with the mineralizer; for this laſt is combined with the metal, ſo as not to be ſeparated but by chemical methods; whereas the gangue may be ſeparated by mechanical means. Neither muſt the gangue, which is formed of cryſtallized ſtones, be confounded with the rock which forms the maſs of the mountain wherein the metallic veins are formed. The veins are divided into rich, or poor; large, or ſmall; ſtraight, or crooked; continued, or interrupted.

Metallic ſubſtances appear to be all formed by water. The greater part, in fact, are found cryſtallized, or mixed with ſubſtances incapable of ſuſtaining the action of fire without change; as calcareous ſtones and ſulphur. Bodies are likewiſe found among them which have the animal or vegetable organization; a certain proof that they have not paſſed the fire. There may, perhaps, exiſt certain ores, whoſe formation may be attributed to fire; as for example, the ſpecular iron ore of Mont D'or, in Auvergne; but theſe inſtances are rare.

Ores are more commonly found in mountains than in plains; and almoſt always in ſuch mountains as form continued chains. It is obſerved that the plants which grow on the ſurface of metalliferous mountains, are dry; the trees are ſinuous, and deformed; ſnow melts almoſt immediately when

when it falls in theſe regions, and the ſands often exhibit metallic colours. Mineral metallic ſprings are found in the vicinity; by the examination of which, and of the ſands over which they flow, good indications of the metallic matters in the neighbourhood may be obtained. When metallic veins appear at the ſurface of the earth, the ground may be broken into with probability of advantage, and the boring inſtrument bringing up the ſubſtances which compoſe the internal parts of the mountain, together with the metallic mineral ſubſtance, ſerves to ſhew the nature of that ſubſtance, as well as the reſiſtance which may be expected in digging.

§ III. The Art of Aſſaying Ores, or Docimaſia.

When a certain quantity of any ore has been extracted, it is neceſſary to make an aſſay, that its nature and produce may be known. Theſe aſſays form one of the moſt important parts of chemiſtry, and require to be varied according to the nature of the ore under examination; though there are certain general principles to be followed in all aſſays.

Specimens of the ore are to be taken from the richeſt, the pooreſt, and that which is of a middle quality. This precaution is very neceſſary; becauſe if the aſſay were made with a rich ſpecimen, it might excite too flattering expectations; or if with a very poor one, it might produce diſcouragement. The ores being finely powdered, muſt afterwards be thoroughly waſhed with water, which carries off the pulverized gangue, while the more ponderous mineral remains at the bottom of the veſſel. The waſhed ore muſt then be carefully roaſted, in order to drive off, by ſublimation, as large a quantity as poſſible of the mineralizer. The roaſting ought to be performed in a ſmall ſhallow earthen diſh, covered with a veſſel of the ſame kind. This precaution is neceſſary, becauſe certain ores decrepitate in the fire, and would fly out of the capſule in which they are roaſted, and by that means render the reſult uncertain. As the roaſting made in the open air uſually leaves the metal in the ſtate of a calx, and may even diſſipate a part, if it be of a volatile nature; we prefer the roaſting of ores in an earthen retort. This operation has the advantage of exhibiting the nature and property of the mineralizer, and of affording a much more accurate analyſis of the mineral. When the ore has been kept red hot for a certain time, and no longer emits any vapour, the roaſting is finiſhed. The ore being weighed before and after the waſhing, determines the quantity of the gangue; a ſecond weighing after the roaſting

roaſting ſhews how much it loſes by that operation.

The roaſted ore muſt then be fuſed. For this purpoſe, it is mixed with three parts of black flux, and a ſmall quantity of decrepitated marine ſalt, and put into a crucible cloſed with its cover, and placed in a good melting furnace. The alkali of the black flux fuſes the metal, and abſorbs the portion of mineralizer which remains in the ore. The coal of the tartar which exiſts in the black flux ſerves to reduce the calcined part of the metal. The marine ſalt prevents the mixture from ſuffering any loſs during the fuſion; becauſe that ſalt, being lighter than the other matters, occupies the upper part of the crucible, and covers the mixture. The fuſion being performed, the crucible muſt be ſuffered to cool very gradually. When the fuſion has been properly made, the metal is found in a ſingle button with a convex ſurface, and ſo metallic grains are diſcovered in the ſcoriæ; the ſcoriæ themſelves being vitreous, compact, and uniform, covered with a bed of common ſalt melted into a ſolid maſs. The metallic button muſt be accurately weighed, and ſhews the proportion of metal contained in the ore.

Some ores are harder, and more refractory; to theſe muſt be added, a larger quantity of the moſt active fluxes, ſuch as borax, pounded glaſs, fixed alkalis, &c. It frequently

happens,

happens, that the ſame mineral contains the perfect metals mixed with the imperfect; theſe are ſeparated by heating the metallic button with contact of air. The imperfect metal is diſſipated by calcination, and leaves the perfect metal in a ſtate of purity. The perfect metal almoſt always conſiſts of gold and ſilver mixed together. Theſe are ſeparated by diſſolving the ſilver in a menſtruum, which does not act upon the gold, the operation being called parting. The reſidues of all theſe proceſſes muſt be weighed with the aſſay balance.

Theſe proceſſes, accurate as they may ſeem, are often leſs uſeful to thoſe who undertake to work mines than an aſſay leſs carefully conducted would be; becauſe in the large way, neither the ſame expenſive materials are uſed, nor the ſame minute accuracy obſerved. It is therefore proper to attempt to fuſe the ore among the coals of a melting furnace. The charcoal reduces the metallic calx; and the fixed alkali produced in the combuſtion of the coal, abſorbs a portion of the mineralized ſubſtance. It is ſometimes neceſſary to add a ſmall quantity of iron filings or ſcoriæ, or glaſs gall, to facilitate the fuſion of the more refractory ores.

There is likewiſe a method of aſſaying in the humid way, which may be practiſed when it is required to know what metals are contained in ſpecimens intended to be preſerved in cabinets of natural hiſtory. A ſmall piece of the ore is taken, which is digeſted in acids, that diſſolve the metal, and ſeparate the mineralizer; the ſalt produced by the union of the metal to the acid, ſhews the quality of the metal: but this kind of aſſay is not applicable to every ore, becauſe they are not all capable of being attacked by acids. Bergman has written a very valuable diſſertation on this method of analyſis, which may be conſulted.*

§ IV. Concerning the Art of extracting and purifying Metals in the large Way; or Metallurgy.

When by the aſſay of an ore it is aſcertained that it is worth working, the operation is conducted in the following manner: A ſquare perpendicular well, or cavity is dug in the earth, of ſufficient magnitude to contain ladders, by means of which the workmen may deſcend and aſcend. Over this is uſually erected ſome ſimple apparatus for drawing up veſſels loaded with the mineral; and ſometimes pumps are erected to draw up the water which may iſſue from the earth into the cavity. If the ore is too deep for one ſingle well, or ſhaft, to lead to the floor of the vein, a horizontal drift is dug, at

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* See Bergman's Eſſays, tranſlated by Cullen.

the end of which a new ſhaft is ſunk, and this is done repeatedly, till the works are carried to the required depth.

If the rock in which theſe operations are carried on be very hard, it will not be neceſſary to ſupport it; but if it be crumbly, as when the work is carried on through earths, the drifts muſt be properly ſupported, and the ſhafts lined with planking properly fixed.

It is of great conſequence to renew the air in mines. When it is practicable to open an adit from the bottom of a ſhaft, ſo as to communicate horizontally with the plane below, a current of air is eaſily produced; but where this cannot be done, a new ſhaft is ſunk, ſo as to communicate with the end of the gallery, fartheſt from the original ſhaft. When one of theſe two ſhafts is lower than the other, the air circulates readily; but if both open at the ſame level above, no current of air will be produced. In this laſt caſe, a fire is lighted in a furnace at the mouth of one of the ſhafts, and the air being rarified by the heat, paſſes through the combuſtible matters, and is continually renewed in the gallery.

Water is likewiſe productive of great inconvenience in mines. If it iſſues by a little at a time from the earths, the miners attempt to convey it to ſome lower ground, or to the neareſt river, by a ſloping drift.

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If it is collected in larger quantities, pumps are uſed to draw it off. It ſometimes happens, in piercing the rock, that a prodigious quantity of water, capable of filling all the drifts, iſſues out in an inſtant. The workmen are aware of this, by the particular kind of noiſe produced, in ſtriking their inſtruments againſt the rock. In this caſe, they conſtruct a door, or gate, in one of the galleries; a workman breaks the rock to give vent to the water, and quickly retires, ſhutting the door after him; by which means, he has time to eſcape before the water gains too much.

Vapours of cretaceous acid, and inflammable gas, are often diſengaged, or formed in mines, by the re-action of mineral and metallic matters on each other. The fires which the workmen are obliged to light for the purpoſe of ſoftening or ſplitting the rock, favour the diſengagement of theſe gaſes; whoſe dangerous effects can only be prevented by rapid currents of air, or by detonation.

The ore extracted from the earth is pounded, waſhed, roaſted, ſmelted, and refined. The ore is in ſome caſes pounded under large peſtles, moved by water; and the pounded ore is waſhed on inclined planes or tables, by the current of water which carries off the gangue. Ores that contain much ſulphur muſt be roaſted in the open air; ſuch as contain but little,

little, may be roaſted in the furnaces, which afterwards ſerve to fuſe them. Some ores are fuſible alone; others require to be melted in contact with charcoal, and with different fluxes. The melting furnaces vary in different countries, and according to the nature of the ore. The refining furnaces do not eſſentially differ from thoſe uſed in melting; and ſometimes the ſame furnace ſerves for both operations. When the metals have been reduced in this manner, they almoſt always conſiſt of ſeveral united together. The methods of ſepárating them are intirely chemical, and will be ſpoken of when we come to treat of each metal individually.

§ V. Concerning the Chemical Properties of Metallic Subſtances.

All the chemical properties of metallic ſubſtances ſeem to prove, that they are ſimple, and not decompoſable. The changes they are ſubject to by the action of heat, air, and ſaline ſubſtances, always ariſe, as we ſhall ſee, from combinations; none of theſe changes reſembling an analyſis, as we ſhall prove by a particular explanation of the phenomena which accompany them.

Light appears to alter the colour and the brilliancy of ſome metallic ſubſtances. Though well cloſed in tranſparent veſſels, they

they become tarniſhed by a change of colour, which gradually increaſes till the metallic brilliancy no longer remains. This kind of alteration has not been obſerved to any farther extent.

Heat only produces certain changes of aggregation, with various degrees of facility in each. All metallic ſubſtances heated in well cloſed veſſels become fluid, or melt; ſome long before the red heat, others at the inſtant of ignition; and others long after. No two metals perfectly agree in fuſibility. If they be ſuffered to cool gradually, after having been melted, they cryſtallize. If the fire be greatly urged, they boil after the manner of fluids, and are reduced into vapours. Theſe properties have long been known in mercury; many goldſmiths have aſſured me that they have obſerved gold and ſilver to boil when in fuſion. M. de Buffon obſerved, that when plates of ſilver are expoſed to the focus of a large concave mirror, a white fume is emitted from their ſurface. Meſſrs. Macquer and Lavoiſier, having placed cuppelled ſilver in the focus of the lens of Tſchirnhauſen, obſerved, that this metal exhales in the form of ſmoke. A plate of gold expoſed to this fume was perfectly ſilvered. Gold placed in the ſame focus likewiſe emitted fumes, which perfectly gilded a plate of ſilver expoſed to them. The chimneys of goldſmiths and aſſayers are filled with fumes of of gold and ſilver. Copper, tin, lead, zink, regulus of antimony, biſmuth, and arſenic, are volatilized with conſiderable facility.

All melted metals appear convex on their ſurface, and form perfect ſpheres when their quantity is ſmall. This effect depends on the force of aggregation, which cauſes the metallic parts to approach each other, and likewiſe on their ſmall tendency to combine with the body which ſupports them. This property is general in all fluids, and may be obſerved in oil, ſurrounded with water, or water ſurrounded by any fat ſubſtance.

Metals expoſed to the action of fire with contact of air, are very ſenſibly altered; but the time required to produce thoſe alterations is exceedingly different in the ſeveral metals. Such as are not ſenſibly changed, are called perfect metals; and ſuch as are intirely deprived of their metallic properties by theſe properties, are called imperfect metals. This change, to which metallic ſubſtances are liable, is called calcination, and is a true combuſtion; which cannot be performed without the acceſs of air, and when performed in a certain quantity of air, cannot be continued, unleſs that air be occaſionally renewed. The air in which metals have been burned becomes mephitic. The combuſtion of metallic ſubſtances is accompanied with a flame more or leſs ſtrong, which is very ſenſible in zink, regulus of arſenic, iron,

iron, gold, ſilver; and even in lead, tin, and regulus of antimony, when ſtrongly heated. Metals in a more eminent degree loſe their metallic properties, the longer they are expoſed to heat in contact with air. Some approach in their characters to earthy matters, in which ſtate they have been called metallic earths. The name of metallic calx ought to be preferred to this laſt term, becauſe it is now aſcertained that thoſe burned metals are not earths, as was till within a few years paſt believed. Metallic calces do not retain the brilliancy they poſſeſſed when in the form of metals, and have no affinity with metals; not excepting even the ſpecies from which they were made. When urged by fire, they are either volatilized, or flow into glaſs; which is the more tranſparent and refractory, the more perfect the calcination. Metallic calces or glaſſes unite with ſaline and earthy matters. Several of them have the ſaline character. Arſenic, well calcined, becomes a peculiar acid, whoſe properties have been examined by Scheele and Bergman. Meſſrs. Rouelle have informed us, that the calx of antimony, like that of arſenic, is ſoluble in water.

Some metallic calces, expoſed to the action of heat, are reduced to the metallic form, affording at the ſame time an aeriform fluid, which is the pureſt vital air we know. We are indebted to Mr. Bayen for the firſt information reſpecting this ſubject. He obſerved, that the calces of mercury heated in cloſe veſſels give out much air, and are reduced into running mercury. Dr. Prieſtley having examined this air, perceived that it was much purer than the air of the atmoſphere; and from this diſcovery it is, that we may date the epocha of the commencement of that accurate knowledge we at preſent poſſeſs, reſpecting the calcination of metals. Let us take a ſhort review of the phenomena of this calcination: A metal never becomes calcined, but when in contact with air; the more extenſive this contact, the larger is the quantity of metal which becomes calcined. A given quantity of air can ſerve for the calcination of no more than a given quantity of metal; as Mr. Lavoiſier has ingeniouſly proved by calcining lead with a reflecting mirror in a glaſs veſſel, containing a known bulk of air. The metal, during its calcination, abſorbs a portion of the air which ſurrounds it, as is proved by the aſcent of the mercury during the proceſs. The increaſe of weight acquired by the metallic calces, is owing to this portion of air abſorbed during calcination; for when it is extracted from the calces of mercury, they loſe the exceſs of weight in their return to the metallic ſtate; and this exceſs is accurately found in the air they afford by diſtillation. From all

all theſe phenomena, it appears to be demonſtrated, that calcination is merely the combination of the metal with the baſe of pure of air contained in the atmoſphere. This combination is often made by the ſimple contact of air, in metals which calcine or ruſt. The neceſſity of heating moſt metals, in order to calcine them, ariſes from the force of affinity or combination being increaſed in the ſame proportion as the force of aggregation is diminiſhed; whence the change intended to be effected is greatly promoted. Heat, therefore, in this operation, as in many others, is only an acceſſary. The air, which has ſerved the purpoſe of calcination, cannot maintain combuſtion, becauſe it is deprived of that pure portion, or vital principle of the ancients, which alone is capable of maintaining combuſtion and life. The greater the quantity of pure air contained in the atmoſphere, the better adapted it is to calcine a given quantity of metal in a ſhorter time. I have often obſerved, that a much greater quantity of calx of lead, bitumen, &c. may be obtained by plunging theſe melted metals into a veſſel filled with vital air, than would have been produced in the ſame time in the open air. All theſe facts, and many others, which will be found in the particular hiſtory of each metal, are well calculated to prove, that a metallic calx is merely a chemical

mical combination of metal, and the baſe of pure air; that calcination is ſimply the act in which this combination takes place; and that the air of the atmoſphere is decompoſed during the proceſs.

The reduction of metals, by the addition of combuſtible matters, likewiſe elucidates, and greatly tends to confirm, this theory. When a calx is to be reduced to the metallic ſtate, it is often neceſſary to heat it in cloſe veſſels, with ſome combuſtible matter, as greaſe, oil, charcoal, &c. In all theſe caſes the metallic calx is decompoſed, by depriving it of the baſe of the air, which produced the calciform ſtate. This operation may be explained, by obſerving, 1. That metals are not the moſt combuſtible ſubſtances in nature, or, which is the ſame thing, their affinity with the baſe of vital air is not the greateſt poſſible. 2. That combuſtible animal, or vegetable ſubſtances, have a ſtronger affinity with this oxyginous baſe than metallic ſubſtances have. 3. That, conſequently, when a metallic calx is reduced by the addition of charcoal, the latter being more combuſtible than the metal, or having a ſtronger affinity with the oxyginous principle, ſeizes it, and decompoſes the metallic calx, which conſequently paſſes to the metallic ſtate. Theſe operations, therefore, do not ſucceed well but in cloſed veſſels, becauſe the combuſtible matter, being exclud-

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ed from the contact of air, can only burn by the aſſiſtance of that of the calx. Hence, alſo, the portion of this inflammable ſubſtance, which ſeizes the oxyginous principle of the metallic calx, is found to be converted into cretaceous acid, and aſhes, after the reduction. While we are explaining the hiſtory of metallic calcination, according to the modern theory, we muſt not forbear to mention the doctrine of Stahl, which was almoſt univerſally adopted, till the time of the lateſt diſcoveries reſpecting air and combuſtion. Stahl conſidered metallic ſubſtances, as compounds of peculiar earths and phlogiſton. Calcination, according to him, conſiſts in the diſengagement of phlogiſton; and the reduction reſtores to the metallic calces, the principle they loſt during their calcination. This theory, we may obſerve, is abſolutely contrary to that of the moderns; as it holds metals to be compound ſubſtances, while the pneumatic theory conſiders them as ſimple. According to Stahl, they loſe a principle in their calcination; and the modern doctrine proves, that during this operation they combine with a new ſubſtance. Laſtly, this great chemiſt imagined, that during reduction, the metallic calces reſumed the phlogiſton they had loſt, by the action of fire; and the moderns, on the contrary, believe, that reduction is nothing more than the ſeparation of the oxyginous prin-

principle, which combined with them during calcination.

After this ſlight compariſon of the two theories, let us endeavour to aſcertain which is ſupported by the greateſt number of facts. Stahl is intirely taken up in attempting to prove the exiſtence of phlogiſton in metals, but ſeems to have forgotten the influence of air in calcination: nevertheleſs, Becher, John Rey, Boyle, and ſeveral other chemiſts, ſuſpected, before him, that the principal circumſtance depended upon that element. The theory of Stahl, however ſatisfactory it may have appeared before the time of the modern diſcoveries concerning air, could not therefore agree with all the facts which demonſtrate the neceſſity and action of that fluid in calcination. And we accordingly obſerve many phenomena not explicable, by that theory, and even contradictory to it. Such, for example, is the increaſed weight of metallic bodies, beyond that of the metals before their calcination. We can never form any conception, how a body can become heavier by loſing one of its conſtituent parts; and as weight is one of the properties by which the preſence of matter is proved, the ingenious explanation, given by M. De Morveau, in his diſſertation on phlogiſton, relative to this phenomenon, cannot be admitted as intirely ſatisfactory; more eſpecially ſince the exiſtence of air in metallic calces

calces has been proved. From theſe facts it therefore appears, that the pneumatic theory has great advantages over that of Stahl. Yet Macquer, guided by that philoſophical caution, which cannot be too ſtrongly recommended to every cultivator of ſcience, has thought proper to connect the modern diſcoveries with the doctrine of phlogiſton, and was even of opinion that they tended to confirm that doctrine. According to this celebrated chemiſt, metals cannot loſe their phlogiſton, and become calcined, but in proportion as the pure air of the atmoſphere precipitates, and becomes united to them, diſengaging, at the ſame time, the light they contain; and, on the contrary, they are not reducible, until light, aſſiſted by heat, ſeparates the pure air, and takes its place: ſo that theſe two bodies are mutually precipitated by each other.

As it is clearly demonſtrated, at preſent, that metallic calces are compounds of metals and the oxyginous principle, it becomes an important ſubject of inquiry, to aſcertain the various elective attractions, which exiſt between this principle and metallic ſubſtances. Mr. Lavoiſier has already made ſome progreſs in this intereſting reſearch; but experiments have not yet been ſufficiently multiplied, and the accuracy of their reſult is not well enough aſcertained, to allow of our entering into the ſubject at full length.

Metallic ſubſtances are changed by expoſure to the air, their ſurface being tarniſhed, and ſome of them becoming covered with ruſt. We ſhall have frequent occaſion to re-conſider this ſubject, and to ſhew, that the vapour of water calcines many metals, and that the cretaceous acid of the atmoſphere unites with them after calcination.

Water diſſolves ſome metals, and has no action on others. In the vaporous form, it ſingularly favours the production of ruſt, in ſuch metals as are ſuſceptible of that modification. The recent diſcoveries of Mr. Lavoiſier have ſhewn, that it calcines with great facility ſuch metals as are moſt combuſtible, as for example, zink and iron; and that it is itſelf decompoſed into the oxyginous principle, which unites to the metals and inflammable gas which is diſengaged.

Earthy matters do not appear to act on metallic ſubſtances; but they unite, by fuſion, with their calces.

The action of the ſalino-terreſtrial ſubſtances on the metals, is not known.

Alkalis diſſolve certain metals, though they act but feebly on moſt of them. The water which is always united to alkalis, appears to contribute greatly to the calcination they produce in many metals.

Acids act ſtrongly on metals, and diſſolve them

them with various degrees of facility. The vitriolic acid produces either inflammable gas, or ſulphureous gas, accordingly as it is united to water, or concentrated. In the firſt caſe, the water is decompoſed, and affording its oxyginous principle to the metal, produces inflammable gas: in the ſecond, the acid itſelf is decompoſed; and its oxyginous principle becoming partly fixed in the metallic ſubſtances, leaves the ſulphur ſtill united with a portion of that principle, and conſequently in the ſtate of ſulphureous gas. The vitriolic acid, ſaturated with metallic calces, in either circumſtance forms vitriols, which, when cryſtallized, muſt be conſidered as compounds of four bodies; namely, metal, the oxyginous principle, vitriolic acid, and water. Theſe metallic vitriols are variouſly coloured, cryſtallizable, ſoluble in water, decompoſable by heat, &c.

The nitrous acid appears to act on metals with more rapidity than the vitriolic, though it in general adheres to them much more ſlightly. A large quantity of nitrous gas is produced; the metal is more or leſs calcined, and either falls down, or remains united to the acid. Stahl attributed this effect to the diſengagement of the phlogiſton of metals. *All chemiſts, at preſent, think it is produced by the decompoſition of the nitrous acid, and the ſeparation of the vital air and nitrous gas, which they conſider as

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the two principles of this acid. Nitrous metallic ſolutions are more or leſs decompoſable by heat, by air, and by water. Alkalis ſeparate the metallic calces. The nitrous, as well as the vitriolic acid, has various degrees of attraction for the different metals. Mr. Prouſt has diſcovered, that ſeveral metallic ſubſtances take fire by the contact of this acid.

The marine acid, in general, acts with very little energy on metals. The water with which it is united, calcines them, and diſengages inflammable air. The muriatic ſolutions of metals, are in general more permanent, and more difficultly decompoſed by heat, than thoſe which are made in the vitriolic or nitrous acids. Some afford cryſtals by heat; but in general they do not cryſtallize without difficulty. The marine acid has a ſtronger affinity, than the vitriolic or nitrous, with ſeveral metallic ſubſtances, and decompoſes their ſolutions.

The dephlogiſticated, or aerated marine acid, calcines moſt metals with the greateſt facility, by means of the exceſs of the oxyginous principle it contains, and which is not ſtrongly united with it. It diſſolves them without efferveſcence, in the ſame manner as water diſſolves ſalt.

The cretaceous acid acts weakly on metals, though it is capable of combining with moſt of them, as Bergman has ſhewn. Combinations

binations of metals with this acid are often found in nature; they are ſometimes cryſtallized, and are known by the name of ſpathoſe ores, of which iron and lead are inſtances.

The acids of fluor, and of borax, likewiſe unite with metals; but the compounds they form are little known.

Among the various combinations of metals with acids, ſome are capable of cryſtallizing, while others aſſume no regular form. Some are decompoſed by fire, and others, on the contrary, are not at all changed by that agent. The greater number are changed by expoſure to air. All are more or leſs ſoluble in water, and may be, for the moſt part, decompoſed by that fluid, as Macquer obſerved. All are precipitated by clay, ponderous earth, magneſia, lime, and alkalis, which have a ſtronger affinity with acids.

When certain metals, which have a ſtronger affinity with acids than others, are uſed to ſeparate the latter from their acid ſolutions, the precipitated metals appear with the metallic form and brilliancy, becauſe the oxyginous principle, which was united to them in their ſtate of ſolution, is ſeparated, and becomes combined with the precipitant, which becomes diſſolved in the acid in its turn. For this reaſon, Mr. Lavoiſier conſiders the precipitations of metals by each other,

other, as effects of their ſeveral affinities with the oxyginous principle.

Neutral ſalts are very little changed by the action of metals in the humid way; but if a mixture of theſe ſalts with metals be ſtrongly heated, many of them are decompoſed. Several vitriolic ſalts form ſulphur in theſe circumſtances. Mr. Monnet is the only chemiſt who has mentioned this decompoſition with the regulus of antimony. In a ſeries of experiments relative to this inquiry, I have diſcovered ſeveral other metals, ſuch as iron, zink, &c. which decompoſe vitriolated tartar, &c.

Nitre detonates with moſt metallic ſubſtances, and calcines them more or leſs. This phenomenon depends on the greater affinity of the oxyginous principle with many of theſe ſubſtances, than it has with the atmoſpheric mephitis. Metals calcined by this ſalt, are called metals fixed by nitre. The alkaline baſe of this ſalt often diſſolves part of the metallic calces.

Sal ammoniac is decompoſed by many metals, and by the calces of moſt metallic ſubſtances. Bucquet, who made many experiments relative to this ſubject, has obſerved, that all metals, on which the marine acid is capable of acting immediately, are capable of completely decompoſing ſal-ammoniac; that inflammable gas is diſengaged during theſe decompoſitions; and that they

they do not take place in the ſame manner, with ſuch metals as are not ſoluble in the ordinary marine acid. The volatile alkali, obtained by theſe decompoſitions, is always very cauſtic and pure.

Almoſt all mineral combuſtible bodies unite gradually with metals. Inflammable gas gives them a deeper colour, and reduces ſome of their calces, becauſe it has a ſtronger affinity with the oxyginous principle, as is proved by ſeveral very ingenious experiments of Dr. Prieſtley. Theſe reductions of metallic calces are accompanied with the production of a certain quantity of water, formed by the combination of this gas with the oxyginous principle of the calces.

Sulphur unites with moſt metals; its combinations form a kind of artificial ores; when they are moiſtened, or expoſed to a moiſt air, they become gradually vitriolized. The hepars of ſulphur diſſolve all the metals. Hepatic gas colours them, and decompoſes their calces, which it cauſes to reſume the metallic ſtate, by abſorbing the oxyginous principle they were united to.

Metals combine with each other with various degrees of facility, and produce alloys, whoſe reſpective properties render them very uſeful in the arts.

§ VI. Methodical arrangement of metallic ſubſtances.

The number of metallic ſubſtances being con-

conſiderable, renders it neceſſary to eſtabliſh an arrangement, or order of claſſing them, by which ſuch as have ſimilar properties may be placed together, and ſuch as differ may be ſeparated. Ductility is a leading character. Metallic ſubſtances, which are not at all ductile, or at leaſt which poſſeſs but a very inconſiderable degree of ductility, are called ſemi-metals. Thoſe, on the contrary, which are very ductile, are called metals. The ſemi-metals are either very brittle under the hammer, or capable of a ſmall degree of extenſion, which affords another ſub-diviſion of theſe ſubſtances. The metals may likewiſe be ſub-divided, with reſpect to the action of fire upon them. In fact, ſome, when treated with the contact of air, become quickly calcined; others, on the contrary, treated in the ſame manner, experience no change. The firſt are the perfect, and the latter the imperfect, metals. In order to avoid multiplying diviſions, we ſhall here exhibit a Table, containing the metallic ſubſtances arranged according to the foregoing diſtinctions.

Metallic Subſtances are either

Scarcely ductile,	Or very ductile.
Sect. I.	Sect. II.
Semi-metals.	Metals.
Division I.	Division I.
Brittle under the hammer,	Eaſily calcined by heat, with acceſs of air.
	Imperfect Metals.
Arſenic,	Lead,
Cobalt,	Tin,
Biſmuth,	Iron,
Regulus of antimony,	Copper.
Nickel,	
Manganeſe.	
Division II.	Division II.
Poſſeſſing a ſmall degree of ductility under the hammer,	Not calcinable by mere heat with acceſs of air.
	Perfect Metals.
Zink,	Silver,
Mercury.	Gold,
	Platina.

CHAP.

CHAP. VII.

Concerning Arſenic.*

ARSENIC may be properly placed the firſt in the arrangement of ſemi-metals, becauſe it greatly reſembles ſalts. Kunckel conſidered it as a coagulated aqua-fortis; Beccher and Stahl reckoned it a ſaline matter: Scheele has proved, that it is capable of forming a peculiar acid; and on the other hand, Brandt and Macquer have proved, that it is a true ſemi-metal. Arſenic, when poſſeſſed of all its properties, has the characters of metallic ſubſtances; it is perfectly opake, ponderous, and brilliant.

Arſenic is often found native, in black heavy maſſes, ſcarcely brilliant. It has ſometimes the metallic luſtre, and reflects the colours of the rainbow; in its fracture, it appears to be more brilliant than at its ſurface, and ſeems compoſed of a great number of ſmall ſcales; when theſe ſcales appear externally, the ſpecimens are called teſtaceous

* We give the name of arſenic, to the ſemi-metallic ſubſtance uſually called regulus of arſenic: the latter denomination ought to be abandoned as improper. The ſubſtance called white arſenic, is a calx of the ſemi-metal.

arſenic,

arſenic, or improperly, teſtaceous cobalt; becauſe formerly, when the metallic character of arſenic was unknown, the teſtaceous arſenic was conſidered as an ore of cobalt, to which appellation the arſenical nature of moſt cobalt ores contributed.

Native arſenic is very eaſily known, when it has the metallic brilliancy and ſcaly texture; but when it is black, and of a cloſe-grained texture, it is only diſtinguiſhed by its great weight, and total diſſipation on hot coals, in white fumes of a garlick ſmell. This laſt is abundantly found mixed with grey ſilver ore at St. Marie-aux-Mines, and is likewiſe found among the ores of Saxony, and at Andrarum, in the province of Schonen in Sweden.

Arſenic is ſometimes naturally found in the form of a white calx, of a vitreous appearance, though more commonly in the form of flowers, or mixed with certain earths. This calx is alſo found at St. Marie-aux-Mines, and is known by the white fumes, and ſmell of garlick, which it exhales when thrown into the fire.

Arſenic is often combined with ſulphur, and then forms orpiment and realgar. Native orpiment is found in yellow, brilliant, and as it were, talcky maſſes, often mixed with realgar, and ſometimes of a greeniſh colour. Realgar is of a red colour, more or leſs lively and tranſparent, and often cryſtallized

cryſtallized in brilliant needles. It is found in great quantities at Quito, and near Mount Veſuvius. Theſe two ſubſtances appear to differ only in the degree of fire, by which they have been combined.

Miſpikel, or arſenical pyrites, is the laſt ore of arſenic, and contains that ſemi-metal combined with iron. Miſpikel is ſometimes cryſtallized in cubes, and is frequently without any regular form. Wallerius calls it white cubic ore of arſenic.

Arſenic is likewiſe found in the ores of cobalt, antimony, tin, iron, copper, and ſilver.

Pure arſenic, likewiſe called regulus of arſenic, is of a blackiſh grey, reflecting the colours of the rainbow. It is very ponderous and friable. Expoſed to heat in cloſe veſſels, it ſublimes without decompoſition, being one of the moſt volatile among metallic ſubſtances. When ſlowly ſublimed, it cryſtallizes into triangular pyramids. Arſenic, heated with contact of air, becomes very quickly calcined, and its calces are diſſipated in the form of white fumes, with a very ſtrong ſmell of garlic. The red ore of arſenic burns with a very perceptible flame, of a blueiſh colour. In this combuſtion, it combines with the baſe of vital air, and forms the compound, known by the name of white arſenic, or calx of arſenic; and by this proceſs it is, that the arſenical

arſenical ores of cobalt afford a large quantity of white fumes when in the furnace, which are condenſed in the chimney, in the form of a white, ſtratified, ponderous, ſemi-vitrified calx, known in commerce by the name of arſenic.

Calx of arſenic differs eſſentially from all other metallic calces. Its taſte is very ſtrong, and even cauſtic; and it is one of the moſt violent of poiſons. Expoſed to heat in cloſe veſſels, it riſes in the form of a white cryſtallized powder, called flowers of arſenic: if the heat be very ſtrong, a very tranſparent glaſs is produced, capable of cryſtallizing, in the form of a triangular ſolid, with truncated angles. This glaſs quickly tarniſhes in the air. None of the metallic calces, excepting that of arſenic, is volatile without addition. It is alſo very fuſible, and vitrifiable. Beccher attributed the weight and volatility of arſenic to a peculiar principle, which he called mercurial, or arſenical earth, the exiſtence of which Stahl was unable to prove.

Arſenic, in the reguline ſtate, does not act ſenſibly on combuſtible bodies; but the calx and glaſs of arſenic evidently alter them, and at the ſame time reſume the metallic ſtate. Stahl thought, that the phlogiſton loſt by the arſenic in calcination, is reſtored by the combuſtible body. The moderns, on the contrary, think, that the calx

calx of arſenic is a compound of arſenic and the baſe of vital air; and that the combuſtible body, by depriving it of this principle, cauſes the arſenic to reſume the metallic ſtate. To reduce the calx of this ſemi-metal, it is pulverized, and made into a paſte with ſoft ſoap, which is put into a matraſs on a ſand bath. A gentle heat is firſt given, to dry the oil; and when humid vapours are no longer exhaled, the fire is raiſed to ſublime the arſenic. The matraſs being broken, is found to contain, in its upper part, a maſs, poſſeſſing the metallic brilliancy; it is calx of arſenic. Moſt of the coal of the oil remains at the bottom of the matraſs.

Arſenic, expoſed to the air, becomes ſenſibly black. The vitrified calx of arſenic loſes its tranſparency, and aſſumes a milky colour.

Arſenic does not appear to be attacked by water, but its calces are ſoluble in this menſtruum, in a quantity ſomewhat greater when heated than when cold; the ſolubility of this ſubſtance likewiſe varies, accordingly as it has been more or leſs perfectly calcined. The calx of arſenic, by ſlowly evaporating its ſolution, affords yellowiſh cryſtals, in triangular pyramids. No metallic ſubſtance we are acquainted with, is ſo largely ſoluble in water: in this property, and alſo in its ſtrong taſte, it reſembles ſaline ſubſtances.

Calx of arſenic unites with earths by fuſion, becoming fixed with them, and accelerating their vitrification; but all the glaſſes, into which arſenic enters, have the bad quality of becoming tarniſhed, by the action of the air, in a ſhort time. The action of the ſalino-terreſtrial matters on arſenic, or its calx, is not known. Cauſtic fixed alkalis, which have no ſenſible action on arſenic, diſſolve its calx very well. Macquer, in his valuable Memoirs on this ſubject, publiſhed among thoſe of the Academy for the year 1746, has obſerved, that when the calx of arſenic, in powder, is boiled in a ſolution of fixed nitre, or of a vegetable alkali nearly cauſtic, it is diſſolved completely, and forms a brown gelatinous fluid, whoſe conſiſtence gradually increaſes. This compound, to which he gives the name of liver of arſenic, does not cryſtallize, but becomes hard and brittle; it is deliqueſcent and ſoluble in water, which precipitates ſome brown flocks. When urged by a ſtrong fire, the arſenic is diſſipated. It is decompoſed by acids. The mineral alkali exhibits the ſame phenomena; but its ſolution afforded Macquer irregular cryſtals, whoſe general form he found it impoſſible to deſcribe.

The vitriolic acid, even when concentrated, does not attack arſenic in the cold; but

but if it be boiled with this ſemi-metal, in a retort, much ſulphureous gas comes over, which is ſucceeded by a ſmall portion of ſulphur, and the arſenic is found calcined, but not diſſolved. Concentrated and boiling oil of vitriol likewiſe diſſolves the calx of arſenic, but it ſeparates in cooling, in the form of a precipitate. In this combination, it acquires a conſiderable fixity; but Bucquet affirms, that it reſumes all its qualities, when the acid is waſhed off by water.

The nitrous acid, applied to arſenic, ſtrongly attacks and calcines it; it likewiſe diſſolves a conſiderable quantity of the calx, by the aſſiſtance of a mild heat. Saturated with either of theſe ſubſtances, it preſerves its own peculiar ſmell; when ſtrongly evaporated, it forms a ſalt, which, according to Bucquet, has not a regular form, but is by Baumé affirmed to be partly cubical, and partly ſhaped to a point, like diamonds. Wallerius affirms, that its cryſtals reſemble lunar nitre. Nitre of arſenic ſtrongly attracts the humidity of the air; does not detonate on hot coals; is decompoſed neither by water nor by acids; and affords no precipitate on the addition of alkalis. The latter nevertheleſs decompoſe it, according to Bucquet; ſince nitre and neutral arſenical ſalt are obtained by evaporating the nitrous arſenical ſolution, with the previous addition of alkaline lixivium. We ſhall preſently ſee, that all chemiſts were for a time embarraſſed with the ſingular nature of the ſolutions of arſenic, and its calx, in acids, and attempted in vain to diſcover what happens in the combination of this calx with the nitrous acid, as they did not ſuſpect that the arſenical acid is produced.

The marine acid, aſſiſted by heat, diſſolves arſenic and its calces, according to Bucquet. Theſe combinations may be precipitated by fixed or volatile alkalis. Mr. Baumé affirms, that the regulus diſſolves in boiling marine acid, and that a yellow powder, reſembling ſulphur, is precipitated. Meſſrs. Bayen and Charlard, in their inquiries reſpecting tin, have aſcertained, that the marine acid does not act on arſenic in the cold, and ſcarcely at all when heated.

The action of other acids on arſenic, and its calx, are not known. This ſemi-metal, mixed with nitre, and thrown into a red hot crucible, produces a ſtrong detonation. The nitrous acid calcines and burns the ſemi-metal; and after the operation, the crucible is found to contain the fixed alkaline baſe of the nitre, and the arſenic, in the form of a calx and partly combined with the alkali.

If equal parts of calx of arſenic and nitre be mixed together, and expoſed to diſtillation in a retort, very red vapours of ſpirit of nitre come over. This acid cannot be condenſed,

denſed, but by a ſmall quantity of water put into the receiver, which gives it a blue colour. Beccher, Stahl, and Kunckel, have deſcribed this operation. Macquer, who carefully repeated it, having examined the reſidue to which theſe chemiſts did not attend, diſcovered, that it is formed by the combination of the calx of arſenic with the alkali. He called it neutral arſenical ſalt. Mr. de Morveau calls it arſeniate of pot-aſh. This ſalt diſſolved in water, and evaporated in the open air, affords very regular cryſtals in tetrahedral priſms, terminated by pyramids of four equal ſides; the form of theſe cryſtals, however, ſometimes varies.

Neutral arſenical ſalt expoſed to heat, melts readily, and remains in fuſion, without becoming alkalized, or any part of the calx of arſenic being driven off. It is not ſenſibly altered by the action of air. It is much more ſoluble in water than pure calx of arſenic, and diſſolves more plentifully in hot than in cold water.

It is not decompoſable by any pure acid, but its component parts may be ſeparated by the way of double affinity. If a ſolution of martial vitriol be added in a ſmall quantity to a ſolution of this ſalt, a double decompoſition takes place. The vitriolic acid quits the iron to unite with the alkali; and the calx of arſenic unites with that of iron.

Combuſtible matters readily decompoſe the neutral arſenical ſalt.

Calx of arſenic likewiſe decompoſes rhomboidal nitre by diſtillation, and forms with its baſe a neutral arſenical ſalt of ſoda; which, according to Macquer, does not greatly differ from the ſalt laſt ſpoken of, and cryſtallizes abſolutely in the ſame manner. This calx produces the ſame effect with ammoniacal nitre, conſtituting an arſenico-ammoniacal ſalt, with its baſe. It was formerly thought that this operation required to be conducted with great precaution, on account of the property of ammoniacal nitre, which detonates without addition in cloſe veſſels: but Mr. Pelletier has proved, that it may be made without danger even in the quantity of ſeveral pounds. The diſcovery of the arſenical neutral ſalt of Macquer, was a prelude to the diſcovery of the arſenical acid; that illuſtrious chemiſt having ſeen and obſerved that the calx of arſenic acts as an acid in this ſalt.

Calx of arſenic is not decompoſed by marine ſalt, and does not ſeparate the volatile alkali from ſal ammoniac, but with great difficulty; in which property it agrees with the regulus.

The action of combuſtible mineral matters on arſenic has not been examined. The calx ſeems reducible by inflammable gas and plumbago, which have a ſtronger affinity than arſenic with the oxyginous principle or baſe of air.

Calx of arſenic combines very well with ſulphur. When theſe two ſubſtances are melted together, a yellow or red volatile body is produced, which has a weaker taſte than pure arſenic, and is not ſoluble in water. This compound is called factitious orpiment, when it is yellow, and is capable of cryſtallizing in triangles like the glaſs of arſenic; when red it is called realgal, realgar, rizigal, or red arſenic. Some chemiſts have thought that the realgal does not differ from orpiment, but in the larger proportion of ſulphur it is ſuppoſed to contain: but Bucquet has proved, that the compound of ſulphur and calx of arſenic is red, when it has been melted; nothing more being neceſſary than to expoſe orpiment to a ſtrong heat, in order to convert it into realgar. I find that realgar is much leſs volatile than orpiment, ſince it remains at the bottom of the matraſs, in which the mixture of calx of arſenic and ſulphur has been ſublimed, where it has the form of porous red laminæ, which have been manifeſtly fuſed. The artificial orpiment and realgar, do not differ from the natural: they are decompoſed by lime and alkalis, which have a ſtronger affinity with ſulphur than the calx of arſenic has. This calx, nevertheleſs

leſs has, like acids, the property of decompoſing liver of ſulphur.

All the properties of the calx of arſenic prove, that this ſemi-metallic and combuſtible ſubſtance united to the baſe of vital air, aſſumes the characters of a ſalt. The theory we have explained in treating of ſalts in general, appears, therefore, to be confirmed by theſe experiments. Macquer, as I have already obſerved, took notice in the courſe of his valuable diſcoveries reſpecting the neutral arſenical ſalt, that the metallic calx performs the part of an acid in this ſalt. But it was difficult to conceive, why the calx of arſenic immediately diſſolved in alkali, ſhould differ ſo greatly from the ſame combination made by the decompoſition of nitre, by this calx. Mr. Scheele, reaſoning from the diſcovery of the marine acid, which he calls dephlogiſticated, imagined, that the ſame thing happens when nitre is diſtilled with calx of arſenic. He thinks that the nitrous acid ſeizes the phlogiſton ſtill remaining in the calx, and that the calx when deprived of this laſt portion, becomes converted into a peculiar acid, which he calls the arſenical acid. The Academicians of Dijon have adopted this opinion. The great chemiſt of Upſal confirmed his aſſertion, by preparing the arſenical acid by proceſſes ſimilar to thoſe uſed in obtaining the dephlogiſticated marine acid. One of theſe conſiſts in diſtilling a mixture of dephlogiſticated marine acid and calx of arſenic. The marine acid, according to him, ſeizes the phlogiſton of the calx, which then paſſes to the acid ſtate. The arſenical acid is likewiſe prepared by diſtilling ſix parts of nitrous acid from one of the calx. Much nitrous gas is produced, and the calx of arſenic aſſumes the characters of an acid; it muſt be expoſed for a conſiderable time to heat, in order to diſengage all the ſuperabundant nitrous acid. The facts here related, are greatly in favour of the modern doctrine. On the one hand, it is difficult, according to Stahl, to ſhew that calx of arſenic contains phlogiſton; and on the other, nothing is more eaſily conceived, according to the new theory, than the tranſition of this calx to the acid ſtate, by the action of ſpirit of nitre, or the dephlogiſticated marine acid of Scheele. The calx of arſenic appears to have a ſtrong affinity with the oxyginous principle, with which it is not ſaturated; when it is diſtilled with the nitrous, or with the dephlogiſticated or aerated marine acid, it ſeizes the oxyginous principle contained in either. The more of this principle it contains, the nearer it approaches to the nature of ſaline ſubſtances; and when it is intirely ſaturated, it aſſumes all the characters of acids, which, as we have proved, are combuſtible ſubſtances combined

combined with the baſe of vital air, to which they owe their ſaline properties. This theory very happily explains why the calx of arſenic not ſaturated with air, but in the ſtate of ſimple calcination by fire, does not form the neutral arſenical ſalt of Macquer; and why it cannot conſtitute that ſalt till it has been previouſly treated with acids; from which, by the aſſiſtance of heat, it takes the oxyginous principle.

The arſenical acid differs greatly from the common calx of arſenic. Its taſte is ſtronger; it is fixed in the fire; ſo that the difference with reſpect to volatility, affords a method of accurately ſeparating from this acid the portion of arſenical calx it may contain. Its fixity, when treated with the vitriolic acid, is doubtleſs a conſequence of its approach to the acid ſtate. It is capable of being converted into a tranſparent glaſs by fuſion; in which melted ſtate, it acts as a flux on earthy ſubſtances, and appears to be capable even of corroding glaſs. It ſlightly reddens blue vegetable colours. I have obſerved, that by expoſure to air, it loſes its tranſparency, and ſcales off in fragments, which are often pentagonal, and gradually attract humidity. It is ſoluble in two parts of water, and readily combines with lime, but more difficultly with ponderous earth and magneſia. When united with alkalis, it forms neutral ſalts, decompoſable by lime,

lime, according to Bergman. Barytes and magneſia appear likewiſe to have a ſtronger affinity with this acid than alkalis, according to the ſame chemiſt. Many experiments remain yet to be made for the diſcovering of all the properties of the arſenical acid. Mr. Pelletier has prepared this acid, by decompoſing ammoniacal nitre by calx of arſenic; the ammoniacal arſeniate which is produced, gives out its volatile alkali by heat; and by the continued action of fire the arſenical acid will remain pure and diſengaged at the bottom of the retort.

Bergman obſerves, that the ſpecific gravity of arſenic varies greatly from its metallic to its acid ſtate. The following are given by him: Regulus of arſenic, 8,308; glaſs of arſenic, 5,000; white calx of arſenic, 3,706; arſenical acid, 3,391.

Arſenic is uſed in ſeveral arts, more eſpecially in dying. The neutral arſenical ſalt is likewiſe uſed; and M. Baumé has long prepared it for manufactories. The facility with which the calx of arſenic diſſolves in water, and in all aqueous fluids, renders it the more dangerous, as it is highly poiſonous, and may be very eaſily conveyed in ſuch fluids. The following ſymptoms denote that a perſon has been poiſoned with arſenic: The mouth is dry, the teeth ſet on edge, and the throat contracted; the patient ſpits involuntarily, has a ſtrong ſenſe of pain at the ſtomach, great thirſt, ſickneſs, vomiting of mucous and bloody matter, excruciating cholics, cold ſweats, convulſions, and ſoon after, death. An examination of the ſuſpected food, will ſoon ſhew whether it contains the poiſon of arſenic. If a portion be previouſly dried, and thrown on hot coals, a white fume ariſes of a garlic-like ſmell.

It was formerly uſual to give mucilaginous drinks, or milk, or mild oils, in large doſes, to perſons poiſoned by arſenic, with the intention of relieving the viſcera, and carrying off the greater part of the arſenic. Navier, a phyſician of Chalons, who has made inquiries concerning the beſt remedies againſt the poiſon of arſenic, has diſcovered a ſubſtance which combines with it in the humid way, and deſtroys the greateſt part of its cauſticity. This ſubſtance is the calcareous or alkaline liver of ſulphur, and is ſtill better adapted to the intention, when it holds a ſmall quantity of iron in ſolution. When this martial hepar is poured into a ſolution of arſenic, it is decompoſed without emitting any ſmell; becauſe the arſenic combines with the ſulphur, and forms orpiment; and at the ſame time unites with the iron. Navier preſcribes a drachm of the liver of ſulphur in a pint of water, which he directs to be taken a glaſs at a time; or five or ſix grains of dry liver of ſulphur may be given in pills, a glaſs of warm water being

being taken after each pill. When the firſt ſymptoms are diſſipated, he adviſes the uſe of ſulphureous mineral waters; experience having ſhewn him, that they are very efficacious in removing the tremors and paralytic affections, which uſually remain after arſenic has been taken, and often bring on conſumptions, that terminate in death. Navier likewiſe approves the uſe of milk, becauſe it diſſolves arſenic as well as water does; but he condemns the uſe of oils for the contrary reaſon.

CHAP. VIII.

Concerning COBALT.

COBALT, or cobolt, is a ſemi-metal of a reddiſh white colour, and cloſe grain, ſo brittle as to be eaſily reduced into powder by the peſtle. Weighed in water, it loſes about the eighth of its weight; its ſpecific gravity is about 7,700, according to Bergman. It cryſtallizes in aggregates of needles placed one on the other.

Cobalt has never been found pure and native, but it is almoſt always calcined and united with arſenic, the arſenical acid, ſulphur, iron, &c. The following are the principal

principal ores of cobalt, diſtinguiſhed according to their component parts, by Bergman and Mongez.

1. Native cobalt, combined with arſenic. This ore is ſolid, grey, ponderous, has little brilliancy, and is granulated in its fracture. It gives ſparks with ſteel, and becomes black in the fire. The nitrous acid diſſolves it with effervеſcence; and it forms a ſympathetic ink with the muriatic acid.

2. Cobalt in the calciform ſtate. This ore, which appears to conſiſt of cobalt calcined by an acid, is uſually of a blackiſh grey, ſometimes ſimilar to lamp-black, often friable and pulverulent; it ſoils the fingers. When compact, its fracture preſents roſe-coloured ſpots; it ſometimes reſembles ſcoriæ or glaſs, whence it has been called vitreous ore of cobalt, by ſome naturaliſts. This ore does not contain arſenic when it is pure, but is frequently mixed with martial ochre.

3. Cobalt united to the arſenical acid: flowers of cobalt, red, roſe-coloured, or the colour of peach bloſſoms. The arſenical acid diſcovered in it by Bergman and Mongez, give it this colour. This ore is either in maſſes, in powder, in a ſtriated effloreſcence, or in four-ſided priſms, with ſummits of two faces. Its colour is deſtroyed by fire, in proportion as the arſenical acid is diſſipated.

4. Cobalt united to iron, and the vitriolic acid: ſpecular ore of cobalt; it is very improperly called ſulphureous cobalt, ſince it does not contain ſulphur, but a ſmall proportion of vitriolic acid. This ore is white, or grey, and very brilliant. It is the richeſt of any, and often gives fire with the ſteel.

5. Cobalt united to ſulphur, arſenic, and iron. This mineral is called white, or grey cobalt ore. It is of a whitiſh grey, cryſtallized in cubes, either intire, or truncated ſo as to form ſolids of fourteen, eighteen, or twenty-ſix facets. Its fracture is lamellated, and ſpathoſe; it ſometimes has dendrites on its ſurface, reſembling fern; in this ſtate it is called knit cobalt. The white ores of cobalt are frequently without any regular cryſtallization; but they are always known by their whitiſh grey colour, their weight, which is leſs than that of the preceding ores, and by the red efflореſcence they almoſt always have on their ſurface.

To aſſay cobalt ores, pounding, waſhing, and roaſting, muſt be uſed. The cobalt remains in a ſtate of black calx, more or leſs deep with reſpect to colour; this is mixed with three parts of black flux, and a ſmall quantity of decrepitated marine ſalt; the fuſion is performed by a forge heat in a covered crucible, which muſt be ſlightly agitated to precipitate the metal as ſoon as the

the fuſion is complete. The metallic button is ſometimes found to conſiſt of two diſtinct ſubſtances, cobalt being uppermoſt, and biſmuth beneath; a ſtroke of the hammer readily ſeparates them.

Modern mineralogiſts, eſpecially Bergman and Kirwan, propoſe to aſſay cobalt ores by the nitrous acid. The cobalt and the iron are by this means diſſolved, and are precipitated by the addition of cretaceous ſoda; the cobaltic precipitate is to be afterwards diſſolved by the acetous acid. Scheffer adviſes trying the colouring quality of cobalt ores, by fuſion with three parts of vegetable alkali, and five of powdered glaſs.

In the large works, cobalt is not extracted in the metallic form: after pounding and waſhing the cobalt ore, it is roaſted in a furnace, which terminates in a long horizontal flue, that ſerves inſtead of a chimney. In this flue, the calx of arſenic being ſublimed, becomes condenſed into the ſemi-vitrified ſubſtance, which is improperly called white arſenic. If the ore contain biſmuth, this very fuſible metal is collected at the bottom of the furnace; the cobalt remains in the ſtate of an obſcure, grey calx, called zaffre. The zaffre, in commerce, is never pure, but is mixed with three times its weight of pulverized flints. In this ſtate, if it be expoſed to a ſtrong fire, it melts into a glaſs, of a dark blue colour, called ſmalt. This is reduced to powder in mills, and mixed with water. The firſt portion which falls down, is the largeſt grained, and is called coarſe ſmalt: the turbid water being decanted off, affords a ſecond precipitate; and this decantation is repeated four times in the whole: the laſt depoſition, which is finer than the reſt, is improperly called azure of four fires. This azure is uſed in many arts, to give a blue colour to metals, glaſſes, &c.

The zaffre of commerce, fuſed with three times its weight of black flux, a ſmall quantity of tallow, and marine ſalt, affords the ſemi-metal, known by the improper name of regulus of cobalt. The reduction of zaffre is very difficult. A large quantity of flux muſt be uſed, and the crucible muſt be kept a conſiderable time in a white-red heat, that the matter may become very fluid, and that the ſcoria may be completely fuſed into a blue glaſs: at this period the cobalt ſinks to the bottom, in the form of a button.

Cobalt, expoſed to heat, does not melt till it is well ignited. This ſemi-metal appears to be very fixed in the fire, and it is not known whether it can be volatilized in cloſe veſſels. If it be ſuffered to cool ſlowly, it cryſtallizes in needle-formed priſms, placed one on the other, and united in bundles. It conſiderably reſembles maſſes of baſaltes,

baſaltes, which are ſeparated from each other, as Mr. Mongez obſerves. To ſucceed in this cryſtallization, the cobalt muſt be melted in a crucible, till it appears to boil; and when the ſurface of the ſemi-metal becomes fixed on withdrawing it from the fire, the veſſel is to be inclined. The metal, which ſtill remains fluid, runs out; and that portion which adheres to the ſides of the kind of geodes, formed by the cooling of the ſurface of the cobalt, is found to be covered with cryſtals.

Cobalt, melted and expoſed to the air, becomes covered with a dull pellicle, which is a calx of the ſemi-metal, formed by its combination with the baſe of vital air. A larger quantity of the calx of cobalt may be more eaſily had, by expoſing the pulverized ſemi-metal, in a ſhallow veſſel, under the muffle of a cuppelling furnace, and ſtirring it up, from time to time, to renew the calcining ſurface. This powder, after remaining ignited for ſome time, loſes its brilliancy, increaſes in weight, and becomes black. This calx requires a moſt violent heat to convert it into glaſs, which is then of a deep blue colour.

Cobalt becomes ſlightly tarniſhed by expoſure to air, and is not attacked by water. It does not unite with earths, but its calx combines with them, by fuſion, and forms a beautiful blue glaſs, extremely fixed in the fire.

fire. This property of the calx of cobalt, renders it of the greateſt uſe in the art of painting in enamel, on porcelain, &c.

The action of ponderous earth, magneſia, and lime, on cobalt, is not known. Alkalis manifeſtly alter it; but theſe changes have not been accurately deſcribed.

This ſemi-metal diſſolves in all the acids, but with different phenomena, according to its own ſtate and that of the acid.

Cobalt, in the metallic ſtate, is not ſoluble in vitriolic acid, unleſs it be concentrated and boiled. This ſolution is made in a glaſs phial, or retort: when the acid is almoſt intirely evaporated, in the form of ſulphureous gas, the reſidue muſt be waſhed; a portion diſſolves in the water, and communicates a roſy, or greeniſh colour: it is the vitriol of cobalt. The other part conſiſts of cobalt, calcined by the acid, whoſe oxyginous principle has combined with the ſemi-metal. M. Baumé affirms, that by ſufficiently evaporating the vitriolic ſolution of cobalt, two ſorts of cryſtals are obtained by cooling: the one white, ſmall, and cubical; the other greeniſh, quadrangular, ſix lines in length, and four in breadth. He conſiders theſe laſt as the vitriol of cobalt. The former are produced by certain foreign matters, united to the cobalt. The cryſtals of the vitriol of cobalt moſt commonly obtained,

tained, have the form of ſmall needles, deſcribed by Mr. Sage as tetrahedral-rhomboidal priſms, terminated by a dihedral ſummit, with rhombic faces. They are decompoſable by fire, and leave a calx of cobalt, not reducible alone. Ponderous earth, magneſia, lime, and the three alkalis, likewiſe decompoſe this ſalt, and precipitate the calx of cobalt. 100 grains of cobalt, diſſolved in the vitriolic acid, afford, by the addition of pure ſoda, about 140 grains of precipitate; and by cretaceous ſoda, 160 grains. This augmentation depends on the oxyginous principle of the vitriolic acid, which is united to the cobalt; and in the ſecond caſe, likewiſe on the cretaceous acid, which combines with the calx of cobalt. The vitriolic acid, diluted with water, acts on zaffre, and diſſolves a portion, with which it forms vitriol of cobalt.

The nitrous acid diſſolves the regulus of cobalt, with efferveſcence, by the aſſiſtance of a gentle heat; nitrous gas is diſengaged, in proportion as the oxyginous principle of the acid unites with the cobalt. When the ſolution is nearly ſaturated, it is either of a roſy brown, or bright green colour. By a ſtrong evaporation, it affords nitre of cobalt, in ſmall needles, joined together. This ſalt is very deliqueſcent, boils up on hot coals, without detonating, and leaves a deep red calx.

calx. It is decompoſed by the ſame ſaline intermediums as the vitriol of cobalt. If more alkali be added in theſe decompoſitions, than is neceſſary to precipitate the cobalt, the precipitate diſappears, by ſolution in the exceſs of alkali.

The muriatic acid does not diſſolve cobalt in the cold, but takes up a portion by the aſſiſtance of heat. This acid acts more ſtrongly on zaffre, forming a ſolution of a red brown, which becomes green when heated. By evaporation, it affords a cryſtallized ſalt, in ſmall needles, very deliqueſcent, which becomes green when heated, and is ſoon after decompoſed.

Aqua regia diſſolves cobalt rather more eaſily than the muriatic, but leſs ſo than the nitrous acid. This ſolution has been long known as a ſympathetic ink, which is not viſible unleſs heated, in which caſe it becomes of a beautiful ſea-green, that diſappears in proportion as the paper becomes cold. This property belongs to the ſolution of the cobalt in the muriatic acid; and the nitrous acid of the aqua regia only facilitates its ſolution and ſuſpenſion. It was formerly thought, that the green colour, produced by heat in the ſympathetic ink of cobalt, aroſe from the metallic ſalt being cryſtallized, and afterwards attracting a ſufficient quantity of water, from the cold air, to diſ-

ſolve

ſolve it, and cauſe it to diſappear intirely; but it is proved, that the marine ſalt of cobalt, diſſolved in water, aſſumes the ſame colour when expoſed to a certain degree of heat.

The acid of borax does not diſſolve cobalt immediately; but when a ſolution of borax is mixed with a ſolution of the ſemi-metal, in one of the foregoing acids, a double decompoſition takes place. The ſoda unites with the acid which held the metallic calx in ſolution, and the calx combining with the acid of borax, forms a precipitate, which may be ſeparated by filtration.

Cobalt has no action on moſt of the neutral ſalts. Heated with nitre, it becomes calcined. If a mixture of one part of cobalt, in powder, and two or three parts of dry nitre, be thrown into a red-hot crucible, a ſtrong detonation does not follow, but ſmall ſcintillations are very evidently ſeen. A portion of the cobalt is found, converted into a calx, of a red colour, more or leſs deep, and ſometimes of a green. This experiment, as well as many others, relating to the detonation of nitre with metallic ſubſtances, deſerves to be more particularly attended to.

Cobalt does not decompoſe ſal ammoniac. Bucquet, who made this experiment with great care, did not obtain a particle of volatile alkali; a circumſtance which no doubt depends on the ſmall degree of affinity, which

which exiſts between this ſemi-metal and the muriatic acid.

The action of inflammable gas on cobalt is not known. Sulphur unites very difficultly with this ſubſtance; liver of ſulphur favours this combination, and produces a kind of artificial ore, of a finer or cloſer grain, and of a whiter or yellower colour, in proportion to the quantity of ſulphur in the combination. M. Baumé, who has given an excellent account of this compound, in the ſecond volume of his Chemiſtry, obſerves, that it is not decompoſable by acid, and that fire is not capable of ſeparating all the ſulphur.

Cobalt is not uſed in its metallic ſtate; its calx, as we have obſerved, is applied to give a blue colour to glaſs, enamel, pottery, and other ſubſtances of the like nature.

END OF VOLUME THE SECOND.