ELEMENTS

OF

CHEMISTRY.

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TRANSLATED FROM THE FRENCH.

IN THREE VOLUMES.

VOL. I.

THE great experience of M. Chaptal, his unaffected candour, and the perspicuity which is seen in every part of the following treatise, cannot but render it extensively useful. I have been particularly careful not to diminish this last merit, by deviating in any respect from that scrupulous attention to accuracy which is indispensably required to give authority to the translation of a work of science.

London, April 1791.

W. NICHOLSON.

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FIRST VOLUME.

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OF

THE AUTHOR.

AGRICULTURE is no doubt the basis of public welfare, because it alone supplies all the wants which nature has connected with our existence. But the arts and commerce form the glory, the ornament, and the riches of every polished nation; since our refinement, and mutual dependence on each other, have created a new set of wants which require to be supplied. The cultivation of the arts is therefore become almost as necessary as that of the ground; and the true means of securing these two foundations of the reputation and

prospe-

prosperity of a state, consist in encouraging
the Science of Chemistry, which discovers
their principles. If this truth were not
universally acknowledged, I might on the
present occasion give an account of the suc-
cess with which my labours have been at-
tended in this province*. I might even call
upon the public voice ; and it would declare
that, since the establishment of lectures on
chemistry, between three and four hundred
persons have every year derived advantage
from instructions in this science. It is well
known that our ancient schools of medicine
and surgery, whose success and splendour
are connected with the general interest of
this province, are more flourishing and
more numerous since that period. And
with the same confidence I might appeal
to the Public, that our manufactures are
daily increasing in perfection ; that several
new kinds of industry have been introduced
into Languedoc ; that, in a regular succes-
sion, abuses have been reformed in the ma-
nufactories, while the processes of the arts
have been simplified ; that the number of
coal-mines actually wrought is increased ;

* Languedoc.

and

and that, upon my principles, and in confequence of my care and attention, manufactories of alum, of oil of vitriol, of copperas, of brown red, of artificial pozzolana, of cerufe, of white lead, and others, have been eftablifhed in feveral parts of the province.

Chemiftry is therefore effentially connected with the reputation and profperity of a ftate ; and at this peculiar inftant, when the minds of men are univerfally bufied in fecuring the public welfare, every citizen is accountable to his country for all the good which his peculiar fituation permits him to do. Every one ought to haften, and prefent to fociety the tribute of thofe talents which heaven has beftowed on him ; and there is no one who is not able to bring fome materials, and depofit them at the foot of the fuperb edifice which the virtuous adminiftrators are raifing for the welfare of the whole. It is with thefe views that I have prefumed to offer to my countrymen the work which I at prefent publifh ; and I entreat them to exercife their feverity upon the

inten-

intention of the author only, but to reserve all their indulgence to the work.

I publish these Elements of Chemistry with the greater confidence, because I have had opportunities myself of observing the numerous applications of the principles which constitute its basis to the phenomena of nature and art. The immense establishment of chemical products which I have formed at Montpellier, has allowed me to pursue the development of this doctrine, and to observe its agreement with all the facts which the various operations present to us. It is this doctrine alone which has led me to simplify most of the processes, to bring some of them to perfection, and to rectify all my ideas. It is therefore with the most intimate confidence that I propose it. I find no difficulty in making a public acknowledgment that I have for some time taught a different doctrine from that which I at present offer. I then believed it to be true and solid; but I did not on that account cease to consult nature. I have constantly entered into this research with a mind eager

for

for improvement. Natural truths were capable of fixing themselves with all their purity in my mind, becaufe I had banifhed prejudice ; and infenfibly I found myfelf drawn by the force of facts to the doctrine I now teach. Let other principles imprefs the fame conviction on my mind ; let the fame number of phenomena and facts exhibit themfelves in their favour ; the fame number of happy applications to the operations of nature and of art ; let them appear to my mind with all the facred characters of truth ; and I will publifh them with the fame zeal, and with the fame intereft. I condemn equally the man who, attached to the ancient notions, refpects them fo much as to reject without mature examination every thing which appears to oppofe them ; and him who embraces with enthufiafm, and almoft without reflection, the principles of any new doctrine. Both are worthy of compaffion if they grow old in their prejudices ; and both are worthy of blame if they perpetuate them.

I have been careful to banifh all difcuf-

fions

fions from my work. That fpirit of party
which but too often caufes a divifion be-
tween perfons who are purfuing the fame
objects, that tone of bitternefs which pre-
dominates in certain difputes, that want of
candour which is infenfibly produced by
the movements of felf-love, have but too
long retarded the progrefs of our know-
ledge. The love of truth is the only paf-
fion which a philofopher ought to indulge.
The fame object, the fame intereft, tend to
unite chemifts. Let the fame fpirit infpire
them, and direct all their labours. Then
we fhall foon behold chemiftry advancing
in a rapid progrefs; and its cultivators will
be honoured with the fuffrage and the grati-
tude of their countrymen.

I have endeavoured in this work to ex-
plain my ideas with clearnefs, precifion,
and method. I know by experience that
the fuccefs of any work, and its various de-
grees of utility, often depend on the form
under which the doctrine which it contains is
difplayed; and it has accordingly been my
intention to fpare no pains in exhibiting
the

the truths which form the bafis of this work in all the characters they are juftly entitled to.

In compofing thefe Elements of Chemiftry, I have availed myfelf with advantage of all the facts which I have found in the works of the celebrated chemifts who adorn this age. I have even made no fcruple to follow their method in drawing up certain articles; and have transferred into my own work, almoft without alteration, thofe facts which I have elfewhere found defcribed with a greater degree of precifion and perfpicuity than I might have been capable of beftowing on them. This proceeding, in my opinion, renders homage to authors, inftead of robbing them. If fuch a proceeding might juftify reclamations, Meffrs. Lavoifier, De Morveau, Berthollet, De Fourcroy, Sage, Kirwan, &c. might eafily declare againft me.

I was well aware that the pretenfion of knowing, difcuffing, and methodically diftributing the whole of our prefent fcience of chemiftry, was an enterprize beyond my ability. This fcience has made fo great a

progrefs,

progress, and its applications are so multiplied, that it is impossible to attend to the whole with the same care : and it appears to me that the writer of an elementary work ought at present to attend principally to the development of general principles, and content himself in pointing out the consequences, and their applications. In this way of proceeding we shall follow the method which has long been practised in the study of the mathematics ; the principles of which, nearly insulated, and separated from all application, form the first study of him who means to acquire them.

To obtain a thorough acquaintance with all the knowledge which has been acquired in chemistry until our time, the chemical part of the Encyclopédie Méthodique may be consulted. In this work, the celebrated author gives the most interesting account of the progress of the science. Here it is that he discusses the several opinions with that candour and energy which become the man of letters whose mind is directed to truth only. Here it is that he has made a precious deposit of all the knowledge yet acquired,

acquired, in order to prefent to us in the fame point of view all which has been done, and all which remains to be done: and here, in a word, it is that Mr. De Morveau has rendered the moft ftriking homage to the truth of the doctrine we now teach ; becaufe, after having combated fome of its principles in the firft volume, he has had the courage to recant, the moment the facts feen in a better point of view, and repeated experiments, had fufficiently enlightened him. This great example of courage and candour is doubtlefs honourable to the learned man who gives it ; but it cannot fail to add ftill more to the confidence which may be placed in the doctrine which is its object.

The development of the principles upon which the New Nomenclature is eftablifhed, may be found in the Elementary Treatife of Chemiftry of Mr. Lavoifier; and I refer likewife to this excellent work for the figure and explanation of all the apparatus I fhall have occafion to fpeak of. I take this ftep the more earneftly, becaufe, by affociating my own produc-

productions to thofe of this celebrated che-
mift, I entertain the hope of fecuring their
fuccefs, and can deliver them into the hands
of the public with greater confidence.

PRELIMINARY DISCOURSE.

IT appears that the ancient nations pof-
feffed fome notions of chemiftry. The
art of working metals, which dates from the
moft remote antiquity; the luftre which
the Phœnicians gave to certain colours; the
luxury of Tyre; the numerous manufac-
tures which that opulent city included
within its walls—all announce a degree of
perfection in the arts, and fuppofe a confi-
derable extent and variety of chemical
knowledge. But the principles of this
fcience were not then united into a body of
doctrine; they were concentrated in the
workfhops of the manufacturers, where
they had their origin: and obfervations
alone, tranfmitted from one operator to ano-
ther,

ther, enlightened and conducted the fteps
of the artift. Such, no doubt, has been the
origin of all the fciences. At firft they pre-
fented unconnected facts ; truths were con-
founded with error ; time and genius alone
could clear up the confufion ; and the pro-
grefs of information is always the fruit of
flow and painful experiment. It is difficult
to point out the precife epocha of the origin
of chemical fcience ; but we find traces of
its exiftence in the moft remote ages. Agri-
culture, mineralogy, and all the arts which
are indebted to it for their principles, were
cultivated and enlightened. We behold the
original nations, immediately fucceeding the
fabulous ages, furrounded by all the arts
which fupplied their wants ; and we may
compare chemiftry to that famous river
whofe waters fertilize the lands they inun-
date, but whofe fources are ftill to us un-
known.

Egypt, which appears to have been the
nurfe of chemiftry reduced to principles,
was not flow in turning the applications of
this fcience towards a chimerical end. The
firft feeds of chemiftry were foon changed
by

by the paſſion of making gold. In a moment all the labours of operators were directed towards alchemy alone; the great object of ſtudy became fixed on an endeavour to interpret fables, alluſions, hieroglyphics, &c.; and the induſtry of ſeveral centuries was conſecrated to the enquiry after the philoſopher's ſtone. But though we admit that the alchemiſts have retarded the progreſs of chemiſtry, we are very far from being diſpoſed to any outrage on the memory of theſe philoſophers: we allow them the tribute of eſteem to which on ſo many accounts they are entitled. The purity of their ſentiments, the ſimplicity of their manners, their ſubmiſſion to Providence, and their love for the Creator, penetrate with veneration all thoſe who read their works. The profoundeſt views of genius are every where ſeen in their writings, allied with the moſt extravagant ideas. The moſt ſublime truths are degraded by applications of the moſt ridiculous nature; and this aſtoniſhing contraſt of ſuperſtition and philoſophy, of light and darkneſs, compels us to admire them, even at the inſtant that

we

we cannot withhold our cenfure. We muſt not confound the fect of alchemiſts, of whom we ſhall proceed to ſpeak, with that crowd of impoſtors, that ſordid multitude of operators at the furnace, whoſe reſearches were directed to the diſcovery of minds capable of being impoſed on, who fed the ambition of ſuch weak minds by the deceitful hope of increaſing their riches. This laſt claſs of vile and ignorant men has never been acknowledged by the true alchemiſts; and they are no more entitled to that name, than the vender of ſpecifics on the ſtage to the honourable name of Phyſician.

The hope of the alchemiſt may indeed be founded on a ſlender baſis; but the great man, the man of genius, even at the time when he is purſuing an imaginary object, knows how to profit by the phenomena which may preſent themſelves, and derives from his labours many uſeful truths which would have eſcaped the penetration of ordinary men. Thus it is that the alchemiſts have ſucceſsively enriched pharmacy and the arts with moſt of their compoſitions. The ſtrong deſire of acquiring riches has in all

all times been a paffion fo general, that this fingle motive has been fufficient to lead many perfons to the cultivation of a fcience which has more relation than any other to metals; which ftudies their nature more particularly, and appears to facilitate the means of compofing them. It is known that the Abdarites did not begin to confider the fciences as an occupation worthy a rea-fonable man, until they had feen a celebrated philofopher enrich himfelf by fpeculations of commerce; and I do not doubt but that the defire of making gold has decided the voca-tion of feveral chemifts. We are therefore indebted to alchemy for feveral truths, and for feveral chemical profeffors: but this ob-ligation is fmall, in comparifon to the mafs of ufeful truth which might have been af-forded during the courfe of feveral centu-ries; if, inftead of endeavouring to form the metals, the operations of chemifts had been confined to analyfing them, fimplifying the means of extracting them, combining them together, working them, and multiplying and rectifying their ufes.

The rage for making gold was fucceeded

by

by the seductive hope of prolonging life by means of chemistry. The persuasion was easily admitted, that a science which affords remedies for all disorders, might without effort succeed in affording a universal medicine. The relations which have been handed down to us of the long life of the ancients, appeared to be a natural effect of their knowledge in chemistry. The numerous fables of antiquity obtained the favour of being admitted among established facts; and the alchemists, after having exhausted themselves in the search after the philosopher's stone, appeared to redouble their efforts to arrive at an object still more chimerical. At this period the elixirs of life, the arcana, the polychrest medicines, had their origin; together with all those monstrous preparations, of which a few have been handed down even to our days.

The chimera of the universal medicine agitated the minds of most men in the sixteenth century; and immortality was then promised with the same effrontery as a Charlatan now announces his remedy for every disease. The people are easily seduced by these

these ridiculous promises; but the man of knowledge can never be led to think that chemistry can succeed in reversing that general law of nature which condemns all living beings to renovation, and a continual circulation of decompositions and successive generations. This sect gradually became an object of contempt. The enthusiast Paracelsus, who, after having flattered himself with immortality, died at the age of forty-eight at an inn at Saltsburg, completed its disgrace. From that moment the scattered remains of this sect united themselves, never more to appear again in public. The light which began to shine forth on all sides, rendered it necessary that they should have recourse to secrecy and obscurity; and thus at length chemistry became purified.

James Barner, Bohnius, Tachenius, Kunckel, Boyle, Crollius, Glaser, Glauber, Schroder, &c. appeared on the ruins of these two sects, to examine this indigested aggregate, and separate from the confused mass of phenomena, of truth and of error every thing which could tend to enlighten the science. The sect of the adepts, urged on

by the madnefs of immortality, had difco-
vered many remedies ; and pharmacy and
the arts then became enriched with for-
mulæ and compofitions, whofe operations
required only to be rectified, and their ap-
plications better eftimated.

Nearly at the fame time appeared the
celebrated Becher. He withdrew chemif-
try from the too narrow limits of pharmacy.
He fhewed its connection with all the phe-
nomena of nature ; and the theory of the
formation of metals, the phenomena of fer-
mentation, the laws of putrefaction, were
all comprehended and developed by this
fuperior genius. Chemiftry was then di-
rected to its true object : and Stahl, who fuc-
ceeded Becher, reduced to certain general
principles all the facts with which his prede-
ceffor had enriched the fcience. He fpoke a
language lefs enigmatical ; he claffed all the
facts with order and method ; and purged
the fcience of that alchemic infection, to
which Becher himfelf was too much at-
tached. But if we confider how great are
the claims of Stahl, and how few the addi-
tions which have been made to his doc-
trine

trine until the middle of this century, we cannot but be aftonifhed at the fmall progrefs of the fcience. When we confult the labours of the chemifts who have appeared fince the time of Stahl, we fee moft of them chained down to the fteps of this great man, blindly fubfcribing to all his ideas; and the labour of thinking appeared no longer to exift among them. Whenever a well-made experiment threw a gleam of light unfavourable to his doctrine, we fee them torment themfelves in a ridiculous manner to form a delufive interpretation. Thus it was that the increafe of weight which metals acquire by calcination, though little favourable to the idea of the fubtraction of a principle without any other addition, was neverthelefs incapable of injuring this doctrine.

The almoft religious opinion which enflaved all the chemifts to Stahl, has no doubt been pernicious to the progrefs of chemiftry. But the ftrong defire of reducing every thing to firft principles, and of eftablifhing a theory upon incomplete experiments, or facts imperfectly feen, did not admit of the fmalleft obftacles. From the

moment that analysis had shewn some of the principles of bodies, the chemist thought himself in possession of the first agents of nature. He considered himself as authorized to regard those bodies as elements which appeared no longer susceptible of being decomposed. The acids and the alkalis performed the principal part in natural operations: and it appeared to be a truth buried in oblivion, that the term where the artist stops is not the point at which the Creator has limited his power; and that the last result of analysis does indeed mark the limits of art, but does not fix those of nature. We might likewise reproach certain chemists for having too long neglected the operations of the living systems. They confined themselves in their laboratories, studied no bodies but in their lifeless state, and were incapable of acquiring any knowledge but such as was very incomplete: for he who, in his researches, has no other object in view than that of ascertaining the principles of a substance, acts like a physician who should suppose he had acquired a complete notion of the human body by confin-

confining his studies to the dead carcase. But we must likewise observe that, in order to form a proper notion of the phenomena of living bodies, it is necessary to possess the means of confining the gaseous principles which escape from bodies; and of analysing these volatile and invisible substances which combine together. Now this work was impossible at that time; and we ought to beware of imputing to men those errors which arise from the state of the times in which they lived.

It may perhaps be demanded, on this occasion, why chemistry was sooner known, and more generally cultivated, in Germany and in the North than in our kingdom. I think that many reasons may be given for this. In the first place, the scholars of Stahl and of Becher must have been more numerous, and consequently their instruction farther extended. Secondly, the working of mines having become a resource necessary to the governments of the North, has been singularly encouraged; and that chemistry which enlightens mineralogy must necessarily

sarily

farily have participitated in its encouragements *.

The ftudy of chemiftry did not begin to be cultivated to advantage in France until the end of the laft century. The firft wars of Louis XIV. fo proper to develope the talents of the artift, the hiftorian, and the military man, appeared little favourable to

* Since the French government has facilitated the ftudy of mineralogy by the moft fuperb eftablifhments, we have beheld the tafte for chemiftry revive, the arts which have the working of metals for their object have been rendered more perfect, and the mines which have been wrought are more numerous. Mr. Sage has been more particularly affiduous and zealous to turn the favour of government towards this object. I have been a witnefs to the laborious attention of this chemift to effect this revolution. I have beheld the perfonal facrifices he made to bring it forward. I have applauded his zeal, his motives, and his talents. The fame fentiments ftill occupy my mind; and though I teach a doctrine at prefent which is different from his, this circumftance arifes from the impoffibility of commanding opinions. The philofopher who is truly worthy of this name, is capable of diftinguifhing the friend of his heart from the flave of his fyftem : and, in a word, every one ought to write according to his conviction ; the moft facred axiom of the fciences being, " Amicus Plato, fed magis amica veritas."

the

the peaceable study of nature. The naturalist who in his researches sees union and harmony around him, cannot be an indifferent spectator of the continual scenes of disorder and destruction; and his genius is crushed in the midst of troubles and agitations. The mind of the great Colbert, deeply penetrated with these truths, quickly endeavoured to temper the fire of discord, by turning the minds of men towards the only objects which could secure the peace and prosperity of the state. He exerted himself to render trade flourishing: he established manufactories: learned men were invited from all parts, encouraged, and united together, to promote his vast projects. Then it was that the ardour of enquiry replaced for a time the fury of conquest; and France very soon stood in competition with all nations for the rapid progress of the sciences, and the perfection of the arts. Lemery, Homberg, and Geoffroy arose nearly at the same time; and other nations were no longer entitled to reproach us for the want of chemists. From that moment the existence of the arts appeared to be well assured. All the

the fciences which afford their firft prin-
ciples, were cultivated with the greateft fuc-
cefs : and it will fcarcely be credited that,
in the fpace of a few years, the arts were
drawn from a ftate of non-entity ; and car-
ried to fuch a degree of perfection, that
France, which had before received every
thing from foreign countries, became in pof-
feffion of the glory of fupplying its neigh-
bours with models and with merchandizes.

Chemiftry and natural hiftory, however,
at the beginning of this century, were culti-
vated only by a very fmall number of per-
fons ; and it was then thought that the
ftudy of thefe fciences ought to be confined
to the academies. But two men, whofe
names will be ever famous, have rendered
the tafte general under the reign of Louis
XV. The one poffeffed that noble fpirit
which is a ftranger to the power of preju-
dice, that indefatigable ardour which fo ea-
fily overcomes every obftacle, that opennefs
of character which infpires confidence, and
transfufed into the minds of his pupils that
enthufiafm of which he himfelf felt the force.
While Rouelle enlightened the fcience of
chemiftry,

chemiftry, Buffon prepared a revolution ftill more aftonifhing in natural hiftory. The naturalifts of the North had fucceeded in caufing their productions to be read by a fmall number of the learned ; but the works of the French naturalift were foon, like thofe of nature, in the hands of the whole world. He poffeffed the art of diffufing through his writings that lively interest, that enchanting colouring, and that delicate and vigorous touch, which influence, attach, and fubdue the mind. The profundity of his reafoning is every where united to all that agreeable illufion which the moft brilliant imagination can furnifh. The facred fire of genius animates all his productions ; his fyftems conftantly exhibit the moft fublime profpects in their totality, and the moft perfect correfpondence in their minute parts : and, even when he exhibits mere hypothefes, we are inclined to perfuade ourfelves that they are eftablifhed truths. We become like the artift who, after having admired a beautiful ftatue, ufed his efforts to perfuade himfelf that it refpired, and removed every thing which could

could diffipate his illufion. We take up his work with a pleafure refembling that of the man who turns again to fleep, in hopes of prolonging the deception of an agreeable dream.

Thefe two celebrated men, by diffufing the tafte for chemiftry and natural hiftory, by making their relations and ufes better known, conciliated the favour of government towards them; and from that moment every one interefted himfelf in the progrefs of both fciences. Thofe perfons who were beft qualified in the kingdom, haftened to promote the revolution which was preparing. The fciences foon infcribed in their lift of cultivators the beloved and refpected names of La Rochefoucault, Ayen, Chaulnes, Lauraguais, Malefherve, &c.; and thefe men, diftinguifhed by their birth, were honoured with a new fpecies of glory, which is independent of chance or prejudice. They enriched chemiftry with their difcoveries, and affociated their names with all the other literati who purfued the fame career. They revived in the mind of the chemift that paffion for glory, and that ar-

dour

dour for the public good, which continually
excite new efforts. The man of ambition
and intrigue no longer endeavoured to de-
prefs the modeft and timid man of genius.
The credit of men in place ferved as a de-
fence and fupport againft calumny and per-
fecution. Recompences were affigned to
merit. Learned men were difpatched into
all parts of the world, to ftudy the arts,
and collect their productions. Men of the
firft merit were invited to inftruct us with
regard to our own proper riches; and eftab-
lifhments of chemiftry which were made
in the principal towns of the kingdom, dif-
fufed the tafte for this fcience, and fixed
among us thofe arts which we might in vain
have attempted to naturalize, if a firm bafis
had not been firft laid. The profeffors
eftablifhed in the capital, and in the pro-
vinces, appeared to be placed between the
academies and the people, to prepare the
latter for thofe truths which flow from fuch
refpectable affociations. We may confider
them as a medium which refracts and mo-
difies the rays of light that iffue from thofe
various luminous centres; and directs them
towards

towards the manufactories, to enlighten and improve their practice. Without these favours, without this consideration and these recompences, could it have been expected that the most unassuming among philosophers would have exerted himself to promote the reputation of a people to whom he was unknown? Could a man so situated reasonably hope to succeed in carrying a discovery into effect? Is it probable that he should have possessed a sufficient fortune to work in the large way, and by this means alone to overcome the numberless prejudices which banish men of science from manufactories? The contemplative sciences demand of the sovereign repose and liberty only; but experimental sciences demand more, for they require assistance and encouragement. What indeed could be hoped in those barbarous ages, wherein the chemist scarcely durst avow the nature of the occupation which in secret constituted his greatest pleasure. The title of Chemist was almost a reproach: and the prejudice which confounded the professors of this science with such wretched projectors as are entitled

titled only to pity, has probably kept back
the revival of the arts for feveral centuries;
for chemiftry alone can afford them a proper
bafis. If the princes of paft times had been
friends of the arts, and jealous to acquire a
pure and durable reputation; if they had
been careful to honour the learned, to collect
their valuable labours, and to tranfmit to us
without alteration the precious annals of
human genius; we fhould have been dif-
penfed from labouring among the rubbifh of
early times, to confult a few of thofe remains
which have efcaped the general wreck; and
we fhould have been fpared the regret of al-
lowing, after many ufelefs refearches, that
the mafter-pieces of antiquity which re-
main anfwer fcarcely any other purpofe
than to give us an idea of that fuperiority
to which the earlier nations had arrived.
Time, the fword, fire, and prejudice have
devoured all; and our refearches ferve only
to add to our regret for the loffes which the
world has fuftained.

The fcience of chemiftry poffeffes the
glory, in our days, not only of having ob-
tained the protection of government, but it
<div align="right">may</div>

may likewife boaft of another equally ele-
vated. This fcience has fixed the attention,
and formed the occupation, of various men
in whom the habit of a profound ftudy of
the accurate fciences had produced a ne-
ceffity of admitting nothing but what is
proved, and of attaching themfelves only to
fuch branches of knowledge as are fufcep-
tible of ftrict proof. Meffrs. De la Grange,
Condorcet, Vander Monde, Monge, De
la Place, Meufnier, Coufin, the moft cele-
brated mathematicians of Europe, are all
interefted in the progrefs of this fcience, and
moft of them daily add to its progrefs by
their difcoveries.

So great a mafs of inftruction, and fuch
ample encouragement, could not but effect
a revolution in the fcience itfelf; and we are
indebted to the combined efforts of all thefe
learned men for the difcovery of feveral
metals, the creation of various ufeful arts,
the knowledge of a number of advantage-
ous proceffes, the working of feveral mines,
the analyfis of the gafes, the decompofition
of water, the theory of heat, the doctrine of
combuftion; and a mafs of knowledge fo ab-
folute

folute and fo extended, refpecting all the phenomena of art and of nature, that in a very fhort time chemiftry has become a fcience entirely new. We might now fay with much more truth what the celebrated Bacon affirmed of the chemiftry of his time: " A new philofophy," fays he, " has iffued " from the furnaces of the chemifts, which " has confounded all the reafonings of the " ancients."

But while difcoveries became infinitely multiplied in chemiftry, the neceffity of re-medying the confufion which had fo long prevailed, was foon feen, and indicated the want of a reform in the language of this fcience. There is fo intimate a relation be-tween words and facts, that the revolution which takes place in the principles of a fcience ought to be attended with a fimilar revolution in its language: and it is no more poffible to preferve a vicious nomen-clature with a fcience which becomes en-lightened, extended, and fimplified, than to polifh, civilize, and inftruct uninformed man without making any change in his na-tural language. Every chemift who wrote on

on any subject was struck with the inaccuracy of the words in common use, and considered himself as authorized to introduce some change ; insomuch that the chemical language became insensibly longer, more confused, and more unpleasant. Thus the carbonic acid has been known, during the course of a few years, under the names of Fixed Air, Aerial Acid, Mephitic Acid, Cretaceous Acid, &c. ; and our posterity may hereafter dispute whether these various denominations were not applied to different substances. The time was therefore come in which it was necessary to reform the language of chemistry: the imperfections of the ancient nomenclature, and the discovery of many new substances, rendered this revolution indispensable. But it was necessary to defend this revolution from the caprice and fancy of a few individuals ; it was necessary to establish this new language upon invariable principles : and the only means of insuring this purpose was doubtless that of erecting a tribunal in which chemists of acknowledged merit should discuss the words received without prejudice and with-

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out interest; in which the principles of a new nomenclature might be established and purified by the severest logic; and in which the language should be so well identified with the science, the word so well applied to the fact, that the knowledge of the one should lead to the knowledge of the other. This was executed in 1788 by Messrs. De Morveau, Lavoisier, Berthollet, and De Fourcroy.

In order to establish a system of nomenclature, bodies must be considered in two different points of view, and distributed into two classes; namely, the class of simple substances reputed to be elementary, and the class of combined substances.

1. The most natural and suitable denominations which can be assigned to simple substances, must be deduced from a principal and characteristic property of the substance intended to be expressed. They may likewise be distinguished by words which do not present any precise idea to the mind. Most of the received names are established on this last principle, such as the names Sulphur, Phosphorus, which do not convey

any fignification in our language, and pro-
duce in our minds determinate ideas only,
becaufe ufage has applied them to known
fubftances.   Thefe words, rendered facred
by ufe, ought to be preferved in a new no-
menclature ; and no change ought to be
made, excepting when it is propofed to rec-
tify vicious denominations.   In this cafe
the authors of the New Nomenclature have
thought it proper to deduce the denomina-
tion from the principal characteriftic pro-
perty of the fubftance.   Thus, pure air
might have been called Vital Air, Fire Air,
or Oxigenous Gas ; becaufe it is the bafis
of acids, and the aliment of refpiration and
combuftion.   But it appears to me that this
principle has been in a fmall degree departed
from when the name of Azotic Gas was
given to the atmofpherical mephitis—
1. Becaufe, none of the known gafeous fub-
ftances excepting vital air being proper for
refpiration, the word Azote agrees with
every one of them except one ; and confe-
quently this denomination is not founded
upon an exclufive property, diftinctive and
characteriftic of the gas itfelf.   2. This de-
nomination

nomination being once introduced, the ni-
tric acid ought to have been called Azotic
Acid, and its combinations Azotates; be-
cause the acids are propofed to be denoted
by the name which belongs to their radical.
3. If the denomination of Azotic Gas does
not agree with this aëriform fubftance, the
name of Azote agrees ftill lefs with the
concrete and fixed fubftance; for in this
ftate all the gafes are effentially azotes. It
appears to me therefore that the denomina-
tion of Azotic Gas is not eftablifhed accord-
ing to the principles which have been
adopted; and that the names given to the
feveral fubftances of which this gas confti-
tutes one of the elements, are equally re-
moved from the principles of the Nomen-
clature. In order to correct the Nomen-
clature on this head, nothing more is ne-
ceffary than to fubftitute to this word a de-
nomination which is derived from the gene-
ral fyftem made ufe of; and I have prefumed
to propofe that of Nitrogene Gas. In the
firft place, it is deduced from the characte-
riftic and exclufive property of this gas,
which forms the radical of the nitric acid.

By this means we fhall preferve to the combinations of this fubftance the received denominations, fuch as thofe of the Nitric Acid, Nitrates, Nitrites, &c. In this manner the word which is afforded by the principles adopted by the celebrated authors of the Nomenclature, caufes every thing to return into the order propofed to be eftablifhed.

2. The method made ufe of to afcertain the denominations fuitable to compound fubftances, appears to me to be fimple and accurate. It has been thought that the language of this part of fcience ought to prefent the analyfes; that the words fhould be only the expreffion of facts; and that confequently the denomination applied by a chemift to any fubftance which has been analyfed, ought to render him acquainted with its conftituent parts. By following this method, the Nomenclature is as it were united, and identified with the fcience; and facts and words agree together. Two things are therefore united, which until this time appeared to have no mutual relation, the word, and the fubftance which

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it reprefented ; and by this means the ftudy
of chemiftry is fimplified. But when we
apply thefe inconteftable principles to the
various objects of chemiftry, we ought to
follow the analyfis ftep by ftep, and upon
this ground alone eftablifh general and in-
dividual denominations. We ought to ob-
ferve that it is from this analytical method
that the various denominations have been
affigned, and that the methodical diftribu-
tions of natural hiftory have been at all
times made. If man were to open his eyes
for the firft time upon the various beings
which people or compofe this globe, he
would eftablifh their relation upon the com-
parifon of their moft evident properties, and
no doubt would found his firft divifions
upon the moft fenfible differences. The
various modes of exiftence, or their feveral
degrees of confiftence, would form his firft
divifion ; and he would arrange them under
the heads of folid, liquid, or aëriform bo-
dies. A more profound examination, and
a more connected analyfis of the individuals,
would foon convince him that the fub-
ftances which certain general relations had

induced

induced him to unite in the same class, under a generic denomination, differed very essentially among each other, and that these differences necessarily required subdivisions. Hence he would divide his solid bodies into stones, metals, vegetable substances, animal substances, &c.; his liquids would be divided into water, vital air, inflammable air, mephitic air, &c. When he proceeded to carry his researches on the nature of these substances still farther, he would perceive that most of the individuals were formed by the union of simple principles; and here it is that his applications of the system to be followed, in assigning a suitable denomination to each substance, would begin. To answer this purpose, the authors of the New Nomenclature have endeavoured to exhibit denominations which may point out the constituent principles. This admirable plan has been carried into execution as far as relates to substances which are not very complicated, such as the combinations of the principles with each other; the acids, earths, metals, alkalis, &c. And this part of the Nomenclature appears to me to

<div align="right">leave</div>

leave nothing more to be desired. The expla-
nation may be seen in the work published on
this subject by the authors, and in the Elemen-
tary Treatise of Chemistry of Mr. Lavoisier.
I shall therefore do nothing more in this
place than present a sketch of the method I
have followed; taking for example the com-
binations of acids, which form the most nu-
merous class of compounds.

The first step consisted in comprehending
under a general denomination the combi-
nation of an acid with any given basis; and
in order to observe a more exact arrange-
ment, and at the same time to assist the me-
mory, one common termination has been
given to all words which denote the combi-
nation of an acid. Hence the words Sul-
phates, Nitrates, Muriates, are used to de-
note combinations of the sulphuric, nitric,
and muriatic acids. The kind of combina-
tion is denoted by adding to the generic
word the name of the body which is com-
bined with the acid; thus, the sulphate of
pot-ash expresses the combination of the
sulphuric acid with pot-ash.

The modifications of these same acids,

c 4 dependant

dependant on the proportions of their con-
stituent principles, form salts different from
those we have just spoken of; and the au-
thors of the New Nomenclature have ex-
pressed the modifications of the acids by
the termination of the generic word. The
difference in the acids arises almost always
from the greater or less abundance of oxi-
gene. In the first case, the acid assumes the
epithet of Oxigenated; hence the oxigen-
ated muriatic acid, the oxigenated sulphuric
acid, &c. In the second case, the termina-
tion of the word which denotes the acid,
ends in *ous*; hence the sulphureous acid, the
nitrous acid, &c. The combinations of
these last form sulphites, nitrites, &c.; the
combinations of the former compose oxigen-
ated muriates, oxigenated sulphates, &c.

The combinations of the various bodies
which compose this globe are not all as
simple as those here mentioned; and it may
be immediately perceived how long and
troublesome the denominations would be, if
attempts were made to bestow a single deno-
mination which should denote the consti-
tuent principles of a body formed by the
union

union of five or fix principles. In this cafe, the preference has been given to the received appellation, and no other changes have been admitted but fuch as were neceffary in order to fubftitute proper appellations inftead of thofe which afforded notions contrary to the nature of the objects they were applied to.

I have adopted this Nomenclature in my lectures, and in my writings; and I have not failed to perceive how very advantageous it is to the teacher, how much it relieves the memory, how greatly it tends to produce a tafte for chemiftry, and with what facility and precifion the ideas and principles concerning the nature of bodies fix themfelves in the minds of the auditors. But I have been careful to infert the technical terms ufed in the arts, or received in fociety, together with thefe new denominations. I am of opinion that, as it is impoffible to change the language of the people, it is neceffary to defcend to them, and by that means render them partakers of our difcoveries. We fee, for example, that the artift is acquainted with the fulphuric acid by
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Preliminary Discourse.

no other name than that of Oil of Vitriol,
though the name of the Vitriolic Acid has
been the language of chemists for a century
past. We cannot hope to be more happy
in this respect than our predecessors ; and,
so far from separating ourselves from the
artist by a peculiar language, it is proper that
we should multiply the occasions of bring-
ing us together ; so far from attempting to
enslave him by our language, we ought ra-
ther to inspire his confidence by learning
his terms. Let us prove to the artist that
our relations with him are more extended
than he imagines ; and let us by this inti-
macy establish mutual correspondence, and
a concurrence of information, which cannot
but redound to the advantage of the arts
and of chemistry.

After having explained the principal ob-
jections which have retarded the improve-
ment of chemistry, and the causes which
in our time have accelerated its progress, we
shall endeavour to point out the principal
applications of this science ; in which at-
tempt, we think, we shall succeed best by
casting a general retrospect over those arts
and

and fciences which receive certain principles from it.

Moſt of the arts are indebted to accident for their diſcovery. They are in general neither the fruit of reſearch, nor the reſult of combination, but all of them have a more or leſs evident relation to chemiſtry. This fcience therefore is capable of clearing up their firſt principles, reforming their abuſes, fimplifying their operations, and accelerating their progreſs.

Chemiſtry bears the ſame relation to moſt of the arts, as the mathematics have to the feveral parts of fcience which depend on their principles. It is poſſible, no doubt, that works of mechaniſm may be executed by one who is no mathematician; and ſo likewiſe it is poſſible to dye a beautiful ſcarlet without being a chemiſt : but the operations of the mechanic, and of the dyer, are not the leſs founded upon invariable principles, the knowledge of which would be of infinite utility to the artiſt.

We continually hear in manufactories of the caprices and uncertainty of operations; but it appears to me that this vague expreſſion

fion owes its birth to the ignorance of the workmen with regard to the true principles of their art. For nature itfelf does not act with determination and difcernment, but obeys invariable laws; and the inanimate fubftance which we make ufe of in our manufactures, exhibits neceffary effects, in which the will has no part, and confequently in which caprices cannot take place. Render yourfelves better acquainted with the materials you work upon, we might fay to the artifts; ftudy more intimately the principles of your art; and you will be able to forefee, to predict, and to calculate every effect. It is your ignorance alone which renders your operations a continual feries of trials, and a difcouraging alternative of fuccefs and difappointment.

The public, which continually exclaims that experience is better than fcience, encourages and fupports this ignorance on the part of the artift; and it will not be remote from our object to attempt to afcertain the true value of thefe terms. It is very true, for example, that a man who has had a very long experience may perform operations

with

with exactnefs; but he will always be con-
fined to the mere manipulation. I would
compare fuch a man to a blind perfon who
is acquainted with the road, and can pafs
along it with eafe, and perhaps even with
the confidence and affurance of a man who
fees perfectly well; but is at the fame time
incapable of avoiding accidental obftacles,
incapable of fhortening his way or taking
the moft direct courfe, and incapable of lay-
ing down any rules which he can communi-
cate to others. This is the ftate of the artift
of mere experience; however long the du-
ration of his practice may have been, as the
fimple performer of operations.

It may perhaps be replied, that artifts have
made very important difcoveries in confe-
quence of affiduous labour. This is indeed
true, but the examples are very fcarce; and
we have no right to conclude, becaufe we
have feen men of genius without any ma-
thematical theory execute wonderful works
of mechanifm, that the mathematics are not
the bafis of mechanics, or that any one has
a right to expect to become a great mecha-
nic

nic without a profound ftudy of mathema-
tical principles.

It appears to be generally admitted at pre-
fent, that chemiftry is the bafis of the arts;
but the artift will not derive from chemiftry
all the advantages he has a right to expect,
until he has broken through that powerful
barrier which fufpicion, felf-love, and pre-
judice have raifed between the chemift and
himfelf. Such philofophers as have at-
tempted to pafs this line, have frequently
been repelled as dangerous innovators; and
prejudice, which reigns defpotically in ma-
nufactories, has not even permitted it to be
thought that the proceffes were capable of
improvement.

It is eafy to fhew the advantages which
the arts might obtain from chemiftry, by
cafting a retrofpect over its applications to
each of them in particular.

1. It appears, from the writings of Co-
lumella, that the ancients poffeffed a confi-
derable extent of knowledge refpecting agri-
culture, which was at that time confidered
as the firft and nobleft occupation of man.
                                        But

But when once the objects of luxury prevailed over thofe of neceffity, the cultivation of the ground was left to the mere fucceffion of practice, and this firft of the arts became degraded by prejudices.

Agriculture is more intimately connected with chemiftry than is ufually fuppofed. It muft be admitted that every man is capable of caufing ground to bear corn ; but what a confiderable extent of knowledge is neceffary to caufe it to produce the greateft poffible quantity ! It is not enough, for this purpofe, to divide, to cultivate, and to manure any piece of ground : a mixture is likewife required of earthy principles fo well afforted, that it may afford a proper nourifhment ; permit the roots to extend themfelves to a diftance, in order to draw up the nutritive juices ; give the ftem a fixed bafe ; receive, retain, and afford upon occafion, the aqueous principle, without which no vegetation can be performed. It is therefore effential to afcertain the nature of the earth, the avidity with which it feizes water, its force of retaining it, &c. ; and thefe requifites point to ftudies which will afford principles

ciples not to be obtained by mere practice but flowly and imperfectly.

Every grain requires a peculiar earth. Barley vegetates freely among the dry remains of granite ; wheat grows in calcareous earth, &c. And how can it be poffible to naturalize foreign products, without a fufficient ftock of knowledge to fupply them with an earth fimilar to that which is natural to them ?

The diforders of grain and forage, and the deftruction of the infects which devour them, are objects of natural hiftory and chemiftry : and we have feen in our own times the effential art of drying and preferving grain, and all thofe details which are interefting in the preparation of bread, carried by the labours of a few chemifts to a degree of perfection which feemed difficult to have been attained.

The art of difpofing ftables in a proper manner, that of chufing water adapted for the drink of domeftic animals, the œconomical proceffes for preparing and mixing their food, the uncommon talent of fupplying a proper manure fuited to the nature of foils, the

the knowledge neceffary to prevent or to repair the effects of blights—all come within the province of chemiftry; and without the affiftance of this fcience our proceeding would be painful, flow, and uncertain.

We may at prefent infift upon the neceffity of chemiftry in the various branches of agriculture with fo much the more reafon, as government does not ceafe to encourage this firft of arts by recompences, diftinctions, and eftablifhments; and the views of the ftate are forwarded by the propofal of means to render this art flourifhing. We fee, with the greateft fatisfaction, that, by a happy return of reflection, we begin to confider agriculture as the pureft, the moft fruitful, and the moft natural fource of our riches. Prejudices no longer tend to opprefs the hufbandman. Contempt and fervitude are no longer the inheritance received for his inceffant labours. The moft ufeful and the moft virtuous clafs of men is likewife that whofe ftate is moft minutely confidered; and the cultivator of the ground in France is at laft permitted to raife his hands in a ftate

of freedom to Heaven, in gratitude for this
happy revolution.

2. The working of mines is likewise
founded upon the principles of chemiftry.
This fcience alone points out and directs
the feries of operations to be made upon a
metal, from the moment of its extraction
from the earth until it comes to be ufed in
the arts.

Before the chemical analyfis was applied
to the examination of ftones, thefe fubftances
were all denoted by fuperficial characters,
fuch as colour, hardnefs, volume, weight,
form, and the property of giving fire with
the fteel. All thefe circumftances had given
rife to methods of divifion in which every
other property was confounded; but the
fucceffive labours of Pott, Margraaff, Berg-
mann, Scheele, Bayen, Dietrich, Kirwan,
Lavoifier, De Morveau, Achard, Sage, Ber-
thollet, Jerhard, Erhmann, Fourcroy, Mon-
gez, Klaproth, Crell, Pelletier, De la Metherie,
&c. by inftructing us concerning the confti-
tuent principles of every known ftone, have
placed thefe fubftances in their proper fitua-
tions, and have carried this part of chemiftry

to

stances have been discovered, individuals have opened mines in the provinces; and we have become familiar with a species of industry which seemed foreign, and almost incompatible with, our soil and our habits. Steel and the other metals have received in our manufactories that degree of perfection which had till lately excited our admiration, and humiliated our self-love. The superb manufacture of Creufot has no equal in Europe. Most of our works are supported by pit-coal; and this new combustible substance is so much the more valuable, as it affords us time to repair our exhausted woods, and as it is found almost every where in those barren soils which repel the ploughshare, and prohibit every other kind of industry. The eternal gratitude of this country is therefore due to Messrs. Jars, Dietrich, Duhamel, Monet, Genfanne, &c. who first brought us acquainted with these true riches. The taste for mineralogy, which has diffused itself within our remembrance, has not a little contributed to produce this revolution; and it is in a great measure owing to those collections of natural

tural hiftory, againft which fome perfons have fo much exclaimed, that we are indebted for this general tafte. Our collections have the fame relation to natural hiftory, as books bear to literature and the fciences. The collection frequently is nothing more than an object of luxury to the proprietor; but in this very cafe it is a refource always open to the man who is defirous of beholding, and inftructing himfelf. It is an exemplar of the works of nature, which may be confulted every moment; and the chemift who runs over all thefe productions, and fubjects them to analyfes to afcertain their conftituent principles, forms the precious chain which unites nature and art.

3. While the chemift attends to the nature of bodies, and endeavours to afcertain their conftituent principles, the natural philofopher ftudies their external characters, and as it were their phyfiognomy. The object of the chemift ought therefore to be united to that of the philofopher, in order to acquire a complete idea of a body. What in fact fhall we call Air or Fire, without the

d 3 inftruction

inftruction of the chemift ? Fluids more or
lefs compreffible, ponderous, and elaftic.
What are the particulars of information
which natural philofophy affords us con-
cerning the nature of folids ? It teaches us
to diftinguifh them from each other, to
calculate their weight, to determine their
figure, to afcertain their ufes, &c.

If we caft our attention upon the nume-
rous particulars which chemiftry has lately
taught us refpecting air, water, and fire, we
fhall perceive how much the connection of
thefe two fciences has been ftrengthened.
Before this revolution, natural philofophy
was reduced to the fimple difplay of ma-
chines ; and this coquetry, by giving it a
tranfient glare, would have impeded its
progrefs, if chemiftry had not reftored it
to its true deftination. The celebrated
chancellor Bacon compared the natural ma-
gic, or experimental philofophy, of his time,
to a magazine in which a few rich and va-
luable moveables were found among a heap
of toys. The curious, fays he, is ex-
hibited inftead of the ufeful. What more
is required to draw the attention of great
men,

men, and to form that transient fashion of
the day which ends in contempt?

The natural philosophy of our days no
longer deserves the reproaches of this cele-
brated philosopher. It is a science founded
on two bases equally solid. On the one
part, it depends on mathematical science for
its principles; and, on the other, it rests
upon chemistry. The natural philosopher
will attend equally to both sciences.

The study of chemistry, in certain de-
partments, is so intimately connected with
that of natural philosophy, that they are in-
separable; as, for example, in researches
concerning air, water, fire, &c. These
sciences very advantageously assist each
other in other respects; and while the che-
mist clears minerals from the foreign bodies
which are combined with them, the philo-
sopher supplies the mechanical apparatus ne-
cessary for exploring them. Chemistry is
inseparable from natural philosophy even in
such parts as appear the most independent
of it; such, for example, as optics, where
the natural philosopher can make no pro-
gress

grefs but in proportion as the chemift fhall bring his glafs to perfection.

The connection between thefe two fciences is fo intimate, that it is difficult to draw a line of diftinction between them. If we confine natural philofophy to enquiries relative to the external properties of bodies, we fhall afford no other object but the mere outfide of things. If we reftrain the chemift to the mere analyfis, he will at moft arrive at the knowledge of the conftituent principles of bodies, and will be ignorant of their functions. Thefe diftinctions in a fcience which has but one common purpofe, namely the complete knowledge of bodies, cannot longer exift; and it appears to me that we ought abfolutely to reject them in all objects which can only be well examined by the union of natural philofophy and chemiftry.

At the period of the revival of letters, it was of advantage to feparate the learned, as it were, upon the road to truth; and to multiply the workfhops, if I may ufe the expreffion, to haften the clearing away. But

at prefent, when the various points are re-united, and the connection between the whole is feen, thefe feparations, thefe divi-fions, ought to be effaced; and we may flatter ourfelves that, by uniting our efforts, we may make a rapid progrefs in the ftudy of nature. The meteors, and all the phe-nomena of which the atmofphere is the grand theatre, can be known only by this re-union. The decompofition of water in the bowels of the earth, and its formation in the fluid which furrounds us, cannot but give rife to the moft happy and the moft fublime applications.

4. The connection between chemiftry and pharmacy is fo intimate, that thefe two fciences have long been confidered as one and the fame ; and chemiftry, for a long time, was cultivated only by phyficians and apothecaries. It muft be allowed that, though the chemiftry of the prefent day is very different from pharmacy, which is only an application of the general principles of this fcience, thefe applications are fo nume-rous, the clafs of perfons who cultivate phar-macy is in general fo well informed, that

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it is not at all to be wondered at, that moſt apothecaries ſhould endeavour to enlighten their profeſſion by a ſerious ſtudy of che-miſtry, and by the happieſt agreement unite the knowledge of both parts of ſcience.

The abuſes which, at the beginning of the preſent century, were made of the ap-plications of chemiſtry to medicine, have cauſed the natural and intimate relations of this ſcience with the art of healing to be miſtaken. It would have been more pru-dent, no doubt, to have rectified its ap-plications; but unfortunately we have too much ground to reproach phyſicians for going to extremes. They have, without re-ſtriction, baniſhed that which they before received without examination; and we have ſeen them ſucceſſively deprive their art of all the aſſiſtance it might obtain from the auxiliary ſciences.

In order to direct with propriety the ap-plications of chemiſtry to the human body, proper views muſt be adopted relating to the animal economy, together with accurate notions of chemiſtry itſelf. The reſults of the laboratory muſt be conſidered as ſubor-dinate

dinate to phyfiological obfervations. We
fhould endeavour to enlighten the one by
the other, and to admit no truth as eftab-
lifhed which is contradicted by any of thefe
means of conviction. It is in confequence
of a departure from thefe principles that the
human body has been confidered as a life-
lefs and paffive fubftance; and that the ftrict
principles obferved in the operations of the
laboratory have been applied to this living
fyftem.

In the mineral kingdom, every thing is
fubjected to the invariable laws of the affini-
ties. No internal principle modifies the ac-
tion of natural agents ; and hence it arifes
that we are capable of foretelling, producing,
or modifying the effects.

In the vegetable kingdom, the action of
external agents is equally evident ; but the
internal organization modifies their effects,
and the principal functions of vegetables
arife from the combined action of external
and internal caufes. It was no doubt for
this reafon that the Creator difpofed the
principal organs of vegetation upon the fur-
face of the plant, in order that the various
functions

functions might at the same time receive
the impressions of external agents, and that
of the internal principle of the organiza-
tion.

In animals, the functions are much less
dependant on external causes; and nature
has concealed the principal organs in the
internal part of their bodies, as if to with-
draw them from the influence of foreign
powers. But the more the functions of an
individual are connected with its organi-
zation, the less is the empire of chemistry
over them; and it becomes us to be cau-
tious in the application of this science to all
the phenomena which depend essentially
upon the principles of life.

We must not however consider chemis-
try as foreign to the study and practice of
medicine. This science alone can teach us
the difficulty and art of combining reme-
dies. This alone can teach us to apply them
with prudence and firmness. Without the
assistance of this science, the practitioner
would scarcely venture to apply those power-
ful remedies from which the chemical phy-
sician knows the means of deriving such

great

great advantage. Chemiftry alone, in all probability, is capable of affording means of combating epidemic diforders, which in moft cafes are caufed by an alteration in the air, the water, or our food. It will be only in confequence of analyfis that the true remedy can be found againft thofe ftony concretions which form the matter of the gout, the ftone, the rheumatifm, &c.; and the valuable particulars of information which we now poffefs refpecting refpiration, and the nature of the principal humours of the human body, are likewife among the benefits arifing from this fcience.

5. Chemiftry is not only of advantage to agriculture, phyfic, mineralogy, and medicine, but its phenomena are interefting to all the orders of men: the applications of this fcience are fo numerous, that there are few circumftances of life in which the chemift does not enjoy the pleafure of feeing its principles exemplified. Moft of thofe facts which habit has led us to view with indifference, are interefting phenomena in the eyes of the chemift. Every thing inftructs and amufes him; nothing is indifferent

ferent to him, becaufe nothing is foreign to
his purfuits ; and nature, no lefs beautiful in
her moft minute details than fublime in the
difpofition of her general laws, appears to
difplay the whole of her magnificence only
to .the eyes of the chemical philofopher.

We might eafily form an idea of this
fcience, if it were poffible to exhibit in this
place even a fketch of its principal applica-
tions. We fhould fee, for example, that
chemiftry affords us all the metals of which
the ufes are fo extenfive ; that chemiftry af-
fords us the means of employing the parts
of animals and of plants for our ornament ;
that our luxuries, and our fubfiftence, are
by this fcience eftablifhed as a tax upon all
created beings ; and that by this power we
are taught to fubject nature to our wants,
our tafte, and even to our caprices. Fire,
that free independent element, has been col-
lected and governed by the induftry of the
chemift ; and this agent, deftined to pene-
trate, to enliven, and to animate the whole
of nature, has in his hands become the agent
of death, and the prime minifter of deftruc-
tion.

tion. The chemifts who in our time have taught us to infulate that pure air which alone is proper for combuftion, have placed in our hands, as it were, the very effence of fire ; and this element, whofe effects were fo terrible, becomes the agent of ftill more terrible confequences. The atmofphere, which was formerly confidered as a mafs of homogeneous fluid, is now found to be a true chaos, from which analyfis has obtained principles fo much the more interefting to be known, as nature has made them the principal agents of her operations. We may confider this mafs of fluid in which we live as a vaft laboratory, in which the meteors are prepared, in which all the feeds of life and of death are developed, from which nature takes the elements of the compofition of bodies, and to which their fubfequent decompofition returns the fame principles which were before extracted.

Chemiftry, by informing us of the nature and principles of bodies, inftructs us perfectly concerning our relation to the objects around us. This fcience teaches us, as it were, to live with them ; and impreffes a true life

life upon them, since by this means each body has its name, its character, its uses, and its influence, in the harmony and arrangement of this universe.

The chemist, in the midst of those numerous beings which the common race of men accuse nature of having vainly placed upon our globe, enjoys the prospect as it were in the centre of a society, all whose members are connected together by intimate relations, and concur to promote the general good. In his sight, every thing is animated, every being performs a part on this vast theatre ; and the chemist who participates in these interesting scenes, is repaid with usury for his first exertions to discover the relations existing between them.

We may even consider this commerce, or mutual relation between the chemist and nature, as very proper to soften the manners, and to impress on the character that freedom and firmness of principle so valuable in society. In the study of natural history, no cause ever presents itself to complain of inconstancy or treachery. An attachment

tachment is eafily contracted for objects which afford enjoyment only; and thefe connections are as pure as their object, as durable as nature, and ftronger in propor- tion to the exertions which have been re- quired to eftablifh them.

From all thefe confiderations, there is no fcience which more eminently deferves to enter into the plan of a good education than chemiftry. We may even affirm that the ftudy of this fcience is almoft indifpenfably neceffary to prevent us from being ftrangers in the midft of the beings and phenomena which furround us. It is true indeed that the habit of beholding the objects of na- ture may produce a knowledge of fome of their principal properties. We may even in this way arrive at the theory of fome of the phenomena. But nothing is more proper to check the pretenfions of young perfons who are elevated by fuch imperfect acqui- fitions, than to fhew them the vaft field of which they are ignorant. The profound fentiment of their ignorance will be fe- conded by the natural defire of acquiring new knowledge. The wonderful proper-

ties of the objects prefented to them will
engage their attention. The interefting na-
ture of the phenomena will tend to excite
their curiofity. Accuracy of experiment, and
ftrictnefs of refult, will form their reafoning
powers, and render them fevere in their
judgment. By ftudying the properties of
all the bodies which furround him, the
young fcholar learns to know their relation
with himfelf; and by fucceffively attending
to all objects, he extends the circle of his
enjoyment by new conquefts. He becomes
a partaker in the privileges of the Creator,
by uniting and difuniting, by compounding
and deftroying. We might even affirm
that the Author of nature, referving to him-
felf alone the knowledge of his general laws,
has placed man between himfelf and matter,
that it may receive thefe laws from his
hands, and that he may apply them with
proper modifications and reftrictions. In
this view, therefore, we may confider man
as greatly fuperior to the other beings which
compofe this living fyftem. They all fol-
low a monotonous and invariable procefs;
receive the laws, and fubmit to effects
without

without modification. Man alone poffeffes
the rare advantage of knowing a part of
thefe laws, of preparing events, of predict-
ing refults, of producing effects at pleafure,
of removing whatever is noxious, of appro-
priating whatever is beneficial, of compofing
fubftances which nature herfelf never forms;
and, in this laft point of view, himfelf a
Creator, he appears to partake with the Su-
preme Being in the moft eminent of his
prerogatives.

ELEMENTS

OF

CHEMISTRY.

PART THE FIRST.

CONCERNING THE CHEMICAL PRINCIPLES.

INTRODUCTION.

Definition of Chemiſtry; its Object and Means.—Deſcription of a Laboratory, and the principal Inſtruments employed in chemical Operations, with a Definition of thoſe Operations.

CHEMISTRY is a ſcience, the object of which is to aſcertain the nature and properties of bodies.

The methods uſed to obtain this knowledge are reducible to two; analyſis and ſyntheſis.

The

The principal operations of chemiſtry are performed in a place called a Laboratory.

A laboratory ought to be extenſive and well aired, in order to prevent dangerous vapours from remaining, which are produced in ſome operations, or which may eſcape by any unfore-ſeen accident. It ought to be dry, becauſe otherwiſe iron veſſels would ruſt, and moſt of the chemical products would be liable to change. But the principal excellence of a laboratory conſiſts in its being furniſhed with all thoſe in-ſtruments which may be employed in the ſtudy of the nature of bodies, and in enquiries re-ſpecting their properties.

Among theſe inſtruments there are ſome which are of general uſe, and applicable to moſt operations ; and there are others which ſerve only for peculiar uſes. This diviſion im-mediately points out that, at the preſent inſtant, we can only treat of the former, and that we muſt deſcribe the others on ſuch occaſions as will render it neceſſary to treat of their uſes.

The chemical inſtruments moſt frequently employed are thoſe which preſent themſelves firſt to view upon entering a laboratory ; namely, the furnaces.

Theſe furnaces conſiſt of earthen veſſels ap-propriated to the various operations performed upon bodies by means of fire.

　　　　　　　　　　　　　A proper

A proper mixture of sand and clay is commonly the material of which these vessels are formed. It is difficult, and even impossible, to prescribe and determine, according to any invariable method, the proportions of these constituent parts; because they must be varied according to the nature of the earths made use of. Habit and experience alone can furnish us with principles on this subject.

The several methods of applying fire to substances under examination, has occasioned the construction of furnaces in different forms, which we shall at present reduce to the three following.

I. The evaporatory furnace.—This furnace has received its name from its use. It is used to reduce liquid substances into vapour by means of heat, in order to separate the more fixed principles from those which are more ponderous; and were mixed, suspended, compounded, or dissolved in the fluid.

The fire-place is covered by the evaporatory vessel. Two or three grooves, channels, or depressions are made in the sides of the furnace, near its upper edge, to facilitate the drawing of the fire.

The vessel which contains the substance to be evaporated, is called the evaporatory vessel.

These

Theſe veſſels are formed of earth, glaſs, or metal. Veſſels of unglazed earth are too porous, infomuch that liquids filtrate through their texture. Thoſe of porcelain biſcuit are likewiſe penetrable by liquids ſtrongly heated, and ſuffer gaſeous or aëriform ſubſtances to eſcape. The beautiful experiments of Mr. D'Arcet upon the combuſtion and deſtruction of the diamond, in balls of porcelain, are well known, and tend to illuſtrate this ſubject. I have confirmed theſe reſults by experiments in the large way, upon the diſtillation of aqua-fortis, which loſes as well in quality as quantity when the proceſs is carried on in veſſels of porcelain clay.

Glazed earthen veſſels cannot be uſed when the glaſs conſiſts of the calces of lead or copper ; becauſe thoſe metallic matters are attacked by acids, fats, oils, &c. Neither can earthen veſſels be uſed which are covered with enamel, becauſe this kind of opake glaſs is almoſt always full of ſmall cracks, through which the liquid would introduce itſelf into the body of the veſſel.

Earthen veſſels cannot therefore be uſed, excepting in operations of little delicacy, in which preciſion and accuracy are not indiſpenſably required.

Evaporatory

Evaporatory veſſels of glaſs are in general to be preferred. Thoſe which reſiſt the fire better than any others, are prepared in the laboratory, by cutting a ſphere of glaſs or a receiver into two equal parts with a red-hot iron. The capſules which are made in the glaſs-houſe are thickeſt at the bottom, and conſequently are more liable to break at that part when expoſed to the fire.

Evaporatory veſſels of metal are uſed in manufactories. Copper is moſt commonly employed, becauſe it not only poſſeſſes the property of reſiſting fire, but has a conſiderable degree of ſolidity, together with the facility of being wrought. Alembics are made of this metal, for the diſtillation of vinous ſpirits, and aromatic ſubſtances; as are alſo caldrons or pots for the cryſtallization of certain ſalts, and for ſeveral dying proceſſes, &c. Lead is likewiſe of conſiderable uſe, and is made choice of whenever operations are to be performed upon ſubſtances which contain the ſulphuric acid, ſuch as the ſulphates of alumine and of iron; and for the concentration and rectification of the oils of vitriol. Tin veſſels are alſo employed in ſome operations: the ſcarlet bath affords a more beautiful colour in boilers of this metal than in thoſe of any other. Capitals of

tin have already begun to be ſubſtituted in the room of thoſe of copper, in the conſtruction of alembics; and by this means the ſeveral products of diſtillation are exempted from every ſuſpicion of that dangerous metal. Boilers of iron are likewiſe uſed for certain coarſe operations; as, for example, in the concentration of the lixiviums of common ſalt, of nitre, &c.

Evaporatory veſſels of gold, of ſilver, or of platina, are to be preferred in ſome delicate operations; but the price and ſcarcity of theſe veſſels do not permit them to be uſed, eſpecially in the large way.

Moreover it is from the nature of the ſubſtance to be evaporated, that we muſt determine the choice of the veſſel moſt ſuitable to any operation. There is no particular kind of veſſel which can be adapted excluſively on all occaſions. It may only be obſerved, that glaſs preſents the greateſt number of advantages, becauſe it is compoſed of a ſubſtance the leaſt attacked, the leaſt ſoluble, and the leaſt deſtructible by chemical agents.

Evaporatory veſſels are known by the name of capſules, cucurbits, &c. according to their ſeveral forms.

Theſe veſſels ought in general to be very wide and ſhallow, in order that the diſtil-
lation

lation and evaporation may be speedy and œconomical. It is neceffary, 1. That the evaporatory veffel be not narrow at its upper part. 2. That the heat be applied to the liquid in all parts, and equally. 3. That the column or mafs of the liquid fhould have little depth, and a large furface of evaporation. It is upon thefe principles that I have conftructed, in Languedoc, boilers proper for diftilling brandy, which fave eleven-twelfths of the time, and four-fifths of the combuftibles.

Evaporation may be performed in three manners. 1. By a naked fire. 2. By the fand bath. 3. By the water bath.

Evaporation is made by a naked fire, when there is no fubftance interpofed between the fire and the veffel which contains the liquid intended to be evaporated ; as, for example, when water is boiled in a pot.

Evaporation is performed by the fand bath, when a veffel filled with fand is interpofed between the fire and the evaporatory veffel. The heat is in this cafe communicated more flowly and gradually ; and the veffels, which would otherwife have been broken by the immediate application of the heat, are enabled to refift its force. The heat is at the fame time more equally kept up; the refrigeration is more gradual ;

dual; and the operations are performed with a
greater degree of order, precifion, and facility.

If, inftead of employing a veffel filled with
fand, we ufe a veffel of water, and the evapo-
ratory veffel be plunged in the liquid, the eva-
poration is faid to be made on the water bath:
in this cafe, the fubftance to be evaporated is
only heated by communication from the water.
This form or method of evaporation is employed
when certain principles of great volatility, fuch
as alcohol, or the aromatic principles of plants,
are to be extracted or diftilled. It poffeffes the
advantage of affording products which are not
changed by the fire, becaufe the heat is tranf-
mitted to them by the intervention of a liquid:
it is this circumftance which renders the pro-
cefs valuable for the extraction of volatile oils,
perfumes, etherial liquids, &c. It poffeffes the
advantage of affording a heat nearly equal, be-
caufe the degree of ebullition is a term nearly
conftant; and this ftandard heat may be gradu-
ated or varied at pleafure, by adding falts to
the liquid of the water bath, becaufe this fingle
circumftance renders the ebullition more or lefs
quick and eafy. The fame effect may likewife
be produced by reftraining the evaporation;
for in this cafe the liquid may affume a degree
of heat much more confiderable, as is feen in
the

the digefter of Papin, fteam engines, eolipiles, and the boilers for ftriking the red tinge in cotton.

Sublimation differs from evaporation, becaufe the fubftance to be raifed is folid. The veffels ufed in this operation are known by the name of fublimatory veffels. Thefe are commonly globes terminating in a long neck : they are then called mattraffes.

In order to fublime any fubftance, a part of the ball of the mattrafs is furrounded with fand. The matter which is volatilized by the heat, rifes, and is condenfed againft the coldeft part of the veffel ; where it forms a ftratum or cake, that may be taken out by breaking the veffel itfelf. In this manner it is that fal ammoniac, corrofive fublimate, and other fimilar products, are formed for the purpofes of commerce.

Sublimation is ufually performed either for the purpofe of purifying certain fubftances, and difengaging them from extraneous matters; or elfe to reduce into vapour, and combine under that form, principles which would have united with great difficulty if they had not been brought to that ftate of extreme divifion.

II. The reverberatory furnace.—The name of the reverberatory furnace has been given to that

that conftruction which is appropriated to diftillation.

This furnace is compofed of four parts. 1. The afh-hole, intended for the free paffage of the air, and to receive the afhes or refidue of the combuftion. 2. The fire-place, feparated from the afh-hole by the grate, and in which the combuftible matter is contained. 3. A portion of a cylinder, which is called the laboratory, becaufe it is this part which receives the retorts employed in the operations or diftillations. 4. Thefe three pieces are covered with a dome, or portion of a fphere, pierced near its upper part by an aperture, which affords a free paffage to the current of air, and forms a chimney. The moft ufual form of the reverberatory furnace is that of a cylinder terminated by a hemifphere, out of which arifes a chimney of a greater or lefs length, to produce a fuitable degree of afpiration.

In order that a reverberatory furnace may be well proportioned, it is neceffary, 1. That the afh-hole fhould be large, to admit the air frefh and unaltered. 2. That the fire-place and laboratory together fhould have the form of a true ellipfis, whofe two foci fhould be occupied by the fire and the retort. In this cafe all

the

the heat, whether direct or reflected, will ſtrike the retort.

The reverberatory furnace is uſed for diſtillation. Diſtillation is that proceſs by which the force of fire is applied to diſunite and ſeparate the ſeveral principles of bodies, according to the laws of their volatility, and their ſeveral affinities.

Diſtilling veſſels are known by the name of retorts.

Retorts are formed of glaſs, of ſtone-ware, of porcelain, or of metal; theſe ſubſtances being reſpectively uſed, according to the nature of the bodies intended to be expoſed to diſtillation.

Whatever be the nature of the material, the forms of retorts are the ſame. This figure reſembles an egg, terminating in a beak or tube, which diminiſhes inſenſibly in diameter, and is ſlightly inclined or bended.

The oval portion of the retort, which is called its belly, is placed in the laboratory of the furnace, and is ſupported upon two bars of iron, which ſeparate the laboratory from the fire-place; while the beak or neck of the retort iſſues out of the furnace through a circular aperture formed in the edges of the dome and of the laboratory.

A veſſel intended to receive the product of the

the diftillation is fitted to the neck of the re-
tort.   This veffel is called the recipient, or
receiver.

The receiver is commonly a fphere w th two
apertures ; the one of confiderable magnitude,
to receive the neck of the retort ; the other
fmaller, to afford vent for the vapours.   This
part is called the tubulure of the receiver ;
whence the terms tubulated receiver, or re-
ceiver not tubulated, &c.

Though the reverberatory furnace be parti-
cularly adapted to diftillation, this operation
may be performed on the fand-bath ; and here,
as in other cafes, it depends fingly on the in-
telligence of the artift to vary his apparatus ac-
cording to the neceffity of circumftances, and
the nature of the fubftances upon which he
operates.

The conftruction of thefe furnaces may like-
wife be varied ; and the chemift will find it ne-
ceffary to learn the art of availing himfelf of
every apparatus he poffeffes, to carry his ope-
rations into execution : for if he fhould per-
fuade himfelf that it is impoffible to proceed in
chemical refearch, excepting in a laboratory
provided with all fuitable veffels, he may let
the moment pafs in which a difcovery might be
made, but which may not again return.   And
                                                        it

it may be truly be faid, that he who treads fer-
vilely in the paths of others who have gone be-
fore him, will never attain to the difcovery of
new truths.

III. The forge furnace.—The forge furnace is
that in which the current of air is determined
by bellows. The afh-hole, the fire-place, and
the laboratory are here all united together ; and
this affemblage forms only a portion of a
cylinder, pierced near the lower angle by a
fmall hole, into which the tube of the bellows
enters. This part is fometimes covered with a
hemifphere or dome, to concentrate the heat
with greater efficacy, and to reflect it upon the
bodies expofed to it. The forge furnace is
employed in the fufion and calcination of me-
tals, and generally for all the operations which
are performed in crucibles.

By crucibles we underftand veffels of earth
or metal, which are almoft always of the form
of an inverted cone. A crucible ought to fup-
port the ftrongeft heat without melting : it
ought to refift the attacks of all fuch agents as
are expofed to heat in veffels of this kind.
Thofe crucibles which poffefs the greateft de-
gree of perfection, are made in Heffe or in
Holland. I have made very good ones by a
                                        mixture

mixture of raw and unbaked clay from Salavas in the Vivarais.

Our laboratories have been provided with crucibles of platina, which unite the moſt excellent properties. They are nearly infuſible, and at the ſame time indeſtructible by the fire.

The ſeveral earthen veſſels concerning which we have here treated, may be fabricated by hand, or wrought in the lathe. The firſt proceeding renders them more ſolid, the clay is better united, and it is the only method uſed in glaſs manufactories; but the ſecond method is more expeditious.

The agent of ſuch decompoſitions as are effected by means of furnaces, is fire. It is afforded by the combuſtion of wood, pit-coal, or charcoal.

Wood is only employed in certain large works; and we prefer charcoal in our laboratories, becauſe it does not ſmoke, has no bad ſmell, and burns better in ſmall maſſes than other combuſtibles. We chooſe that which is the moſt ſonorous, the drieſt, and the leaſt porous.

But, in the ſeveral operations we are about to deſcribe, it is neceſſary to defend the retorts from the immediate action of the fire; and alſo to coerce and reſtrain the expanſible vapours,

which

which are very elastic, and frequently corrosive. It is to answer these purposes that various lutes are employed.

1. A glass retort exposed to the action of the fire would infallibly break, if the operator were not to have recourse to the prudent precaution of coating it with earth.

I have found it advantageous for the coating of retorts, to use a mixture of fat earth and fresh horse dung: for this purpose, the fat earth is suffered to rot for some hours in water; and when it is moistened, and properly softened, it must be kneaded with the horse dung, and formed into a soft paste, which is to be applied and spread with the hand upon every part of the retort intended to be exposed to the action of the fire. The horse dung combines several advantages. 1. It contains a serous fluid, which hardens by heat, and strongly connects all the parts together: when this juice has been altered by fermentation or age, the dung does not possess the same virtue. 2. The filaments or stalks of hay, which are so easily distinguished in horse dung, unite all the parts of the lute together.

Retorts luted in this manner resist the impression of the fire very well; and the adhesion of the lute to the retort is such, that even should the

the retort fly during the operation, the distillation may be still carried on, as I have daily experience in works in the large way.

2. When it is required to coerce or oppose the escape of the vapours which are disengaged during any operation, it is no doubt sufficient if the joinings of the vessels be covered with paper glewed on, or with slips of bladder moistened with the lute of lime and white of egg, provided the vapours be neither dangerous nor corrosive; but, when the vapours are corrosive, it is necessary to use the fat lute to retain them.

Fat lute is made with boiled linseed oil mixed and well incorporated with sifted clay. Nut oil, kneaded with the same clay, forms a lute possessing the same properties. It is easily extended in the hand, and is used for defending the joinings of vessels, upon which it is afterwards secured by strips of linen, dipped in the lute of lime and white of egg. Before the application of heat in any distillation, it is necessary first to suffer the lutes to dry. Without this precaution, the vapours would rise and escape ; or otherwise they would combine with the water which moistens the lutes, and would corrode and destroy the bladder, the skin, the paper, and in a word every substance used to secure them in their places. The lute of lime and white of

<div align="right">egg</div>

egg dries very speedily, and must be used the moment it is made. This lute, likewise, opposes the greatest resistance to the escape of the vapours, and adheres the most intimately to the glass. It is made by mixing a small quantity of finely-powdered quick-lime with white of egg, and afterwards beating up the mixture to facilitate the combination. It must then be instantly applied on pieces of old linen, to be wrapped round the places of joining.

In the large works, where it is not possible to attend to all these minute details, the joinings of the retort and receiver are luted together with the same lute which is used to coat the retorts. A covering of the thickness of a few lines is sufficient to prevent the vapours of the marine or nitrous acid from escaping.

As in certain operations a disengagement takes place of so prodigious a quantity of vapours, that it is dangerous to confine them; and as, on the other hand, the suffering them to escape would occasion a considerable loss in the product; an apparatus has been contrived of great ingenuity and simplicity to moderate the issue, and to retain without risk such vapours as would otherwise escape. This apparatus is known by the name of its author, Mr. Woulfe, a famous English chemist. His most excel-

lent

lent procefs confifts in adapting the extremity
of a recurved tube to the tubulure of the re-
ceiver; the other end of which is plunged into
water, in a bottle half filled, and properly
placed for that purpofe. From the empty part
of this bottle iffues a fecond tube, which is in
like manner plunged in the water of a fecond
bottle. A number of other bottles may be ad-
ded, obferving the fame precautions; with the
attention, neverthelefs, to leave the laft open, to
give a free efcape to the vapours which are not
coercible: and, when the apparatus is thus dif-
pofed, all the joinings are to be luted. It will
eafily be imagined that the vapours which
efcape from the retort are obliged to pafs
through the tube adapted to the tubulure of the
receiver, and confequently muft pafs through
the water of the firft bottle: they therefore
fuffer a firft refiftance, which partly condenfes
them. But as almoft all vapours are more or lefs
mifcible and foluble in water, a calculation is
previoufly made of the quantity of water necef-
fary to abforb the vapours which are difengaged
from the mixture in the retort; and care is taken
to diftribute this proper quantity of water in the
bottles of the apparatus.

By this means we obtain the pureft and moft
concentrated products; becaufe the water, which

is

is always the receiver, and is the vehicle of these substances, becomes saturated with them. There is, perhaps, no other method of obtaining products always of an equal energy, and comparable in their effects; a circumstance of the greatest importance in the operations of the arts, as well as in philosophical experiments.

I have applied this apparatus to works in the large way; and I use it to extract the common muriatic acid, the oxigenated muriatic acid, ammoniac or volatile alkali, &c.

As it would very often happen, in this apparatus, that the pressure of the external air would cause the water of the outer vessels to pass into the receiver, in consequence of the simple refrigeration of the retort; this inconvenience has been obviated, by inserting a straight tube into the necks of the first and the second bottles, to such a depth, that its lower end is plunged into the water, while its other end rises several inches above the neck of the bottle. It may easily be conceived, as a consequence of this disposition, that when the dilated vapours of the receiver and retort are condensed by cooling, the external air will rush through these tubes to establish the equilibrium; and the water cannot pass from the one to the other.

Before the invention of this apparatus, it was
usual

ufual to drill a hole in the receiver, which was kept clofed, and only opened from time to time for the efcape of the vapours. This method was inconvenient in many refpects. In the firft place, and principally, becaufe, in fpite of all precautions, it was attended with the rifk of an explofion every moment, by the irregular difengagement of the vapours, and the impoffi-bility of calculating the quantity produced in a given time. A fecond inconvenience was, that the vapours which thus efcaped occafioned a confiderable lofs in the product, and even weak-ened the remainder ; becaufe this volatile prin-ciple confifted of the ftrongeft part. A third inconvenience was, that the vapours which did efcape incommoded the artift to fuch a degree, that it was impoffible to perform moft of the operations of chemiftry in the courfe of a lec-ture, where a confiderable number of auditors were prefent.

Thus it is that the apparatus of Woulfe unites a number of advantages: on the one hand, economy in the proceffes, and fuperiority in the product; on the other hand, fafety for the chemift and his affiftants : and in every point of view the author is entitled to the beft ac-knowledgments of chemifts, who were too of-ten fo much affected with thefe unwholefome exhalations,

exhalations, that their health was either totally destroyed, or they fell absolute victims to their zeal for the promotion of science.

It is necessary that a laboratory should be provided with balances of the utmost accuracy; for the chemist, who very frequently operates only upon small quantities, ought to be able by the strictness of his operations, and the accuracy of his apparatus, to produce results comparable with those of works in the large way. It frequently happens that the simple essay of a specimen of an ore determines the opening of a mine: and it scarcely need be pointed out, of how great consequence it is to remove every cause of error from the operations of chemistry; since the slightest error in the works of the laboratory may be attended with the most unhappy consequences, when the application of the principles is made to works in the large way.

We shall treat of other vessels and chemical apparatus, in proportion as we shall have occasion to make use of them; for it appears to us that, by thus connecting the description with their use, we shall succeed better in rendering them intelligible to the reader, at the same time that his memory will be less fatigued.

SECTION I.

Concerning the General Law which tends to
bring the Particles of Bodies together, and
to maintain them in a State of Mixture
or Combination.

THE Supreme Being has given a force of
mutual attraction to the particles of mat-
ter; a principle which is alone sufficient to pro-
duce that arrangement which the bodies of this
universe present to our observation. As a very
natural consequence of this primordial law, it
follows that the elements of bodies must have
been urged towards each other; that masses
must have been formed by their re-union; and
that solid and compact bodies must have in-
fensibly been constituted; towards which, as
towards a centre, the less heavy and less com-
pact bodies must gravitate.

This law of attraction, which the chemists
call Affinity, tends continually to bring prin-
ciples together which are disunited, and retains
with more or less energy those which are already
in combination; so that it is impossible to pro-
duce

duce any change in nature, without interrupting
or modifying this attractive power.

It is natural, therefore, and even indifpenfa-
ble, that we fhould fpeak of the law of the affini-
ties before we proceed to treat of the methods of
analyfis.

Affinity is exercifed either between principles
of the fame nature, or between principles of a
different nature.

We may, therefore, diftinguifh two kinds of
affinity, with refpect to the nature of bodies.
1. The affinity of aggregation, or that which
exifts between two principles of the fame na-
ture. 2. The affinity of compofition, or that
which retains two or more principles of diffe-
rent natures in a ftate of combination.

Of the Affinity of Aggregation.

Two drops of water which unite together in-
to one, form an aggregate, of which each drop
is known by the name of an integrant part.

An aggregate differs from a heap; becaufe
the integrant parts fo this laft have no percep-
tible adhefion to each other; as, for example, a
heap of barley, of fand, &c.

An aggregate, and a heap, differ from a mix-
ture; becaufe the conftituent parts of this laft

are of a different nature; as, for example, in gun-powder.

The affinity of aggregation is ftronger, the nearer the integrant parts approach to each other; fo that every thing which tends to feparate or remove thefe integrant parts from each other, diminifhes their affinity, and weakens their force of cohefion.

Heat produces this effect upon moft known bodies: hence it is that melted metals have no confiftence. The caloric, or matter of heat, by combining with bodies, almoft always produces an effect oppofite to the force of attraction; and we might confider ourfelves as authorifed to affirm that it is a principle of repulfion, if found chemiftry had not proved that it produces this effect only by its endeavour to combine with bodies, and thereby necessarily diminifhing their force of aggregation, as all other chemical agents do. Befides which, the extreme levity of caloric produces the effect that, when it is combined with any given body, it continually tends to elevate it, and to overcome that force which retains it, and precipitates it towards the earth.

The mechanical operations of pounding, of hammering, or of cutting, likewife diminifh the affinity of aggregation. They remove the in-

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tegrant parts ro a diftance from each other ; and this new difpofition, by prefenting a lefs degree of adhefion, and a larger furface, facilitates the immediate action, and augments the energy, of chemical agents. It is for this purpofe that bodies are divided when they are to be analyfed, and that the effect of re-agents is facilitated by the action of heat.

The mechanical divifion of bodies is more difficult, the ftronger their aggregation.

Aggregates exift under different ftates ; they are folid, liquid, aëriform, &c.—See Fourcroy's Chemiftry.

Of the Affinity of Compofition.

Bodies of different kinds exert a tendency or attraction upon each other, which is more or lefs ftrong ; and it is by virtue of this force that all the changes of compofition or decompofition obferved amongft them, are effected.

The affinity of compofition exhibits invariable laws in all the phenomena it caufes. We may ftate thefe laws as general principles ; to which may be referred all the effects prefented to our obfervation by the action of bodies upon each other.

I. The

I. The affinity of compofition acts only between the conftituent parts of bodies.

The general law of attraction is exerted upon the maffes; and in this refpect it differs from the law of the affinities, which does not perceptibly act but on the elementary particles of bodies. Two bodies placed near each other do not unite; but, if they be divided and mixed, a combination may arife. We have examples of this when the muriate of foda, or common falt, is triturated with litharge; the muriate of ammoniac, or common fal ammoniac, with lime, &c. And it may be afferted that the energy of the affinity of compofition is almoft always proportioned to the degree of the divifion of bodies.

II. The affinity of compofition is in the inverfe ratio of the affinity of aggregation.

It is fo much the more difficult to decompofe a body, as its conftituent principles are united or retained by a greater force. Gafes, and efpecially vapours, continually tend to combination, becaufe their aggregation is weak: and nature, which is conftantly renewing the productions of this univerfe, never combines folid with folid; but, reducing every thing into the form of gas, by this means breaks the impediments of aggregation; and thefe gafes uniting together, form folids in their turn.

6   Hence,

Hence, no doubt, it arifes, that the affinity of compofition is fo much the more ftrong as bodies approach nearer to the elementary ftate; and we fhall obferve, on this fubject, that this law of nature is founded in wifdom : for if the force or affinity of compofition did not increafe in proportion as bodies were brought to this degree of fimplicity ; if bodies did not affume a decided tendency to unite and combine, in proportion as they approach to their primitive or elementary ftate; the mafs of elements would continually increafe by thefe fucceffive and uninterrupted decompofitions; and we fhould infenfibly return again to that chaos or confufion of principles, which is fuppofed to have been the original ftate of this globe.

The neceffity of this ftate of divifion, which is fo proper to increafe the force of affinity, has caufed it to be admitted as an inconteftable principle, that the affinity of compofition does not take place, unlefs one of the bodies be in the fluid ftate : *corpora non agunt nifi fint fluida.* But it feems to me that extreme divifion might be fubftituted inftead of diffolution ; for both thefe operations tend only to attenuate bodies, without altering their nature. It is by virtue of this divifion, which is equivalent to diffolution, that the decompofition of muriate of foda is
effected

effected by trituration with minium, as well as
the union of cold and dry alkali with antimony,
and the difengagement of volatile alkali by the
fimple mixture of fal ammoniac with lime.

III. When two or more bodies unite by
the affinity of compofition, their temperature
changes.

This phenomenon cannot be explained but
by confidering the fluid of heat as a conftituent
principle of bodies, unequally diftributed amongft
them; fo that, when any change is produced in
bodies, this fluid is difplaced in its turn, which
neceffarily produces a change of temperature.
We fhall return to thefe principles when we
fpeak of heat.

IV. The compound which refults from the
combination of two bodies, poffeffes properties
totally different from thofe of its conftituent
principles.

Some chemifts have affirmed, that the pro-
perties of compounds were intermediate be-
tween thofe of their conftituent parts. But this
term "intermediate" has no meaning in the pre-
fent cafe; for what intermediate qualities can
exift between four and fweet, or between water
and fire?

If we attend ever fo little to the phenomena
which are exhibited to us by bodies in their
                                    compofition,

compofition, we fhall perceive that their form, their tafte, and their confiftence, are changed in combination; and we cannot eftablifh any rule to indicate, *a priori*, all the changes which may arife, and the nature and properties of the body which fhall be formed.

V. Every individual fubftance has its peculiar affinities with the various fubftances prefented to it.

If all bodies had the fame degree of affinity with each other, no change could take place amongft them : we fhould not be able to dif-place any principle by prefenting one body to another. Nature has therefore wifely varied the affinities, and appointed to each body its re-lation with all thofe that can be prefented to it.

It is in confequence of this difference in the affinities that all chemical decompofitions are ef-fected : all the operations of nature and art are founded upon it. It is therefore of importance to be well acquainted with all the phenomena and circumftances which this law of decompo-fition can prefent to us.

The affinity of compofition has received diffe-rent names, according to its effects. It is divided into fimple affinity, double affinity, the affinity of an intermedium, reciprocal affinity, &c.

1. Two principles united together, and fepa-rated

rated by means of a third, afford an example of simple affinity : it confists in the difplacing of one principle by the addition of a third. Bergman has given it the name of Elective Attraction.

The body which is difengaged, or difplaced, is known by the name of the Precipitate. An alkali precipitates metals from their folutions; the fulphuric acid precipitates the muriatic, the nitric, &c.

The precipitate is not always formed by the difengaged fubftance. Sometimes the new compound itfelf is precipitated ; as, for example, when I pour the fulphuric or vitriolic acid on a folution of muriate of lime. Sometimes the difengaged body and the new compound are precipitated together ; as, for example, when the fulphate of magnefia or Epfom falt is diffolved in water, and precipitated by means of lime-water.

2. It often happens that the compound of two principles cannot be deftroyed either by a third or a fourth body feparately applied ; but if thefe two bodies be united, and placed in contact with the fame compound, a decompofition or change of principles will then take place. This phenomenon conftitutes the double affinity. An example will render this propofition more clear
and

and precise. The sulphate of pot-ash or vitriol-
ated tartar is not completely decomposed by the
nitric acid or by lime, when either of these
principles is separately presented; but, if the
nitric acid be combined with lime, this nitrate
of lime will decompose the sulphate of pot-ash.
In this last case the affinity of the sulphuric acid
with the alkali is weakened by its affinity to the
lime. This acid, therefore, is subject to two at-
tractions; the one which retains it to the alkali,
and the other which attracts it towards the lime:
Mr. Kirwan has named the first the Quiescent
Affinity, and the other the Divellent Affinity.
The same may be said respecting the affinities
of the alkali; it is retained to the sulphuric acid
by a superior force, but nevertheless attracted by
the nitric acid. Let us suppose, now, that the
sulphuric acid adheres to the alkali with a force
as 8, and to the lime by a force expressed by the
number 6; that the nitric acid adheres to the
lime by a force as 4, and tends to unite with the
alkali by a force as 7. It may then be perceived
that the nitric acid and the lime, separately ap-
plied to the sulphate of pot-ash, would not pro-
duce any change : but if they be presented in a
state of combination, then the sulphuric acid is
attracted on the one hand by 6, and retained
by 8 ; it has therefore an effective attraction

to

to the alkali as 2. On the other hand, the nitric acid is attracted by a force as 7, and retained by a force as 4; it therefore retains a tendency to unite with the alkali, which is denoted by the number 3; and consequently it ought to displace the sulphuric acid, which is retained only by a force as 2.

3. There are cases in which two bodies, having no perceptible affinity to each other, obtain a disposition to unite by the intervention of a third; and this is called the affinity of an intermedium. An alkali is the intermedium of union between oil and water; hence the theory of lixiviums, of washing, &c. &c.

If the affinities of bodies were well known, we might foretel the results of all operations : but it is obvious how difficult it must be to acquire this extensive knowledge of nature ; more especially since modern discoveries have exhibited to us an infinity of modifications in our processes, and have shewn that results may vary with such facility, that even the absence or presence of light will render them very different.

As long as chemistry was confined to the knowledge of a few substances, and was busied only in attending to a certain number of facts, it was possible to draw up tables of affinity, and to exhibit the result of our knowledge in one and the

the fame table. But all the principles upon which thefe tables have been conftructed, have received modifications; the number of principles has increafed; and we find ourfelves under the neceffity of labouring upon new ground. A fketch of this great work may be feen in the Effay on Affinities of the celebrated Bergman, and in the article Affinity in the *Encyclopédie Methodique*.

VI. The particles which are brought together and united by affinity, whether they be of the fame nature or of different natures, continually tend to form bodies of a polyhedral, conftant, and determinate form.

This beautiful law of nature, by which fhe impreffes on all her productions a conftant and regular form, appears to have been unknown to the ancients: and when chemifts began to difcover that almoft all bodies of the mineral kingdom affected regular forms, they at firft diftinguifhed them according to the inaccurate refemblance fuppofed to exift between them and other known bodies. Hence the denomination of cryftals in pyramids, needles, points of diamonds, croffes, fword blades, &c.

We are more particularly indebted to the celebrated Linnæus for the firft precife ideas of thefe geometrical figures. He took notice of

the conſtancy and uniformity of this character; and this celebrated naturaliſt thought himſelf authoriſed to make it the baſis of his method of claſſification of the mineral kingdom.

Mr. Romé de Liſle has proceeded ſtill far-ther : he has ſubjected all the forms to a ſtrict examination ; he has, as it were, decompoſed them ; and is of opinion that he can diſtinguiſh in the cryſtals of all analogous or identical ſub-ſtances, the ſimple modifications and ſhades of a primitive form. By this means he has re-duced all the confuſed and irregular forms to certain primitive figures ; and has attributed to nature a plan or primitive deſign, which ſhe va-ries and modifies in a thouſand manners, accord-ing to circumſtances that influence her proceed-ings. This truly great and philoſophical work has rendered this part of mineralogy in the higheſt degree intereſting ; and if we ſhould ad-mit that Mr. De Liſle has perhaps carried theſe reſemblances too far, we cannot but allow that he deſerves a diſtinguiſhed place amongſt thoſe authors who have contributed to the progreſs of ſcience. The Cryſtallographie of this celebrated naturaliſt may be peruſed with advantage.

The abbé Hauy has ſince applied calculation to obſervation. He has undertaken to prove that each cryſtal has a nucleus or primitive form;

form ; and has ſhewn the laws of diminution to which the component laminæ of the cryſtals are ſubject, in their tranſition from the primitive to the ſecondary forms. The developement of theſe fine principles, and their application to cryſtals the beſt known, may be ſeen in his theory of the ſtructure of cryſtals, and in ſeveral of his memoirs printed in the volumes of the Academy of Sciences.

The united labours of theſe celebrated natu-raliſts have carried cryſtallography to a degree of perfection of which it did not appear ſuſcep-tible. But we ſhall, at this moment, attend only to the principles according to which cryſ-tallization is effected.

To diſpoſe a ſubſtance to cryſtallization, it is neceſſary in the firſt place to reduce it to the moſt complete ſtate of diviſion.

This diviſion may be effected by ſolution, or by an operation purely mechanical.

Solution may be effected either by the means of water or of fire. The ſolution of ſalts is in general performed in the firſt liquid, that of metals is effected by means of the ſecond ; and their ſolution is not complete until a degree of heat is applied of ſufficient intenſity to convert them into the ſtate of gas.

When the water which holds any ſalt in ſolu-

D 2   tion

tion is evaporated, the principles of the diffolved body are infenfibly brought nearer to each other, and it is obtained in a regular form. The fame circumftance nearly takes place in the folution by fire. When a metal is impregnated with this fluid, it does not cryftallize but in proportion as this excefs of igneous fluid is withdrawn.

In order that the form of a cryftal may be regular, three circumftances are required ; time, a fufficient fpace, and repofe. Confult Linnæus, Daubenton, &c.

A. Time caufes the fuperabundant fluid to be flowly diffipated, and brings the integral parts nearer to each other by infenfible gradation, and without any fudden fhock. Thefe integrant parts therefore unite according to their conftant laws, and form a regular cryftal. For this reafon it is, that flow evaporation is recommended by all good chemifts. Vide Stahl's Treatife on Salts, chap. 29.

In proportion as the evaporation of the folvent is effected, the principles of the diffolved body approach each other, and their affinity is continually augmented while that of the folvent remains unaltered. Hence it arifes, no doubt, that the laft portions of the folvent are moft difficultly volatilized, and that falts retain

a greater

a greater or lefs quantity, which forms their water of cryftallization. The proportion of water of cryftallization not only varies greatly in the different falts, but it adheres with greater or lefs ftrength. There are fome which fuffer this water to fly off when they are expofed to the air; fuch as foda or the mineral alkali, the ful-phate of foda or Glauber's falt, &c. In this fituation thefe falts lofe their tranfparency, and fall into powder: they are then faid to have efflorefced. There are other falts which obfti-nately retain their water of cryftallization; fuch as the muriate of pot-afh, the nitrate of pot-afh or common nitre, &c.

The phenomena prefented to us by the dif-ferent falts, when forcibly deprived of their water of cryftallization, exhibit other varieties. Some crackle with the heat, and are thrown about in fmall pieces when the water is diffi-pated: this appearance is called decrepitation. Others emit the fame water in the form of fteam, and are liquefied with a diminution of their bulk. Others again fwell up, and become converted into a bliftered or porous fubftance.

We are indebted to Mr. Kirwan for an ac-curate table of the water of cryftallization con-tained in each falt. This table may be feen by confulting his Mineralogy.

The

The simple cooling of the fluid which holds the salt in solution may precipitate a considerable quantity. The caloric and the water dissolve a greater quantity of salt when their action is united; and it may easily be imagined that the subtraction of one of the solvents must occasion the precipitation of that portion which it held in solution. Thus it is that warm water saturated with salt, must suffer a part to precipitate by cooling; and for this reason crystallization always begins at the surface of the liquid, and on the sides of the containing vessel; namely, because these parts are the first which suffer refrigeration.

It is the alternation of heat and cold which causes the atmosphere to dissolve sometimes a greater, and sometimes a less quantity of water; and constitutes mists, the evening dew, &c.

The mutual approach of the constituent parts of a body held in solution may be likewise accelerated by presenting to the water which suspends them, another body which has a stronger affinity to it. It is upon this principle that alcohol precipitates several salts.

B. Space or sufficient room is likewise a condition necessary for obtaining regular crystallization. If nature be restrained in her operations, the product of her labour will exhibit
symptoms

ſymptoms of this ſtate of conſtraint. It may be
aſſerted that nature forms her productions ac-
cording to all the circumſtances which may in-
fluence her operations.

C. A ſtate of repoſe in the fluid is likewiſe
neceſſary to obtain very regular forms. Unin-
terrupted agitation oppoſes all ſymmetrical ar-
rangement ; and in this caſe the cryſtallization
obtained will be confuſed and indeterminate.

I am perſuaded that, in order to obtain bo-
dies under the form of cryſtals, a previous ſolu-
tion is not neceſſary, but that a ſimple mecha-
nical diviſion would be ſufficient. To obtain a
conviction of this truth, it is only neceſſary to
obſerve that ſolution does not change the na-
ture of bodies, but ſimply procures an extreme
ſtate of diviſion; ſo that the diſunited princi-
ples approaching each other very gradually, and
without ſtarts, can adapt themſelves to each
other, by following the invariable laws of their
gravity and affinity. Now a diviſion purely
mechanical produces the ſame effect, and
places the principles in the ſame diſpoſition.
We ought not therefore to be ſurpriſed if moſt
ſalts, ſuch as gypſum, when diſperſed in the
earth, ſhould aſſume regular forms without any
previous ſolution; neither ought we to think
it ſtrange if the imperceptible fragments of

D 4   quartz,

quartz, of ſpar, &c. when carried along and prodigiouſly divided by the action of waters, ſhould be depoſited in the form of regular cryſtals.

A very ſingular property may be obſerved in ſalts; which may be referred to cryſtallization, but is likewiſe in ſome meaſure remote from it, becauſe it does not depend upon the ſame cauſes. This is the property of riſing along the ſides of the veſſels which contain the ſolution. It is known by the name of Saline Vegetation.

I have firſt demonſtrated that this phenomenon depends on the concurrence of air and light; and that the effect may be determined at pleaſure towards any part of the veſſel, by managing and directing the action of theſe two agents.

I have ſhewn the principal forms which this ſingular vegetation affects. The detail of my experiments may be ſeen in the third volume of the Memoirs of the Academy of Touloufe.

Mr. Dorthes has confirmed my reſults; and has moreover obſerved that camphor, ſpirits of wine, water, &c. which riſe by inſenſible evaporation in half-filled veſſels, conſtantly attach themſelves to the moſt enlightened parts the veſſels.

Meſſrs.

Meſſrs. Petit and Rouelle have treated on the vegetation of ſalts ; but a ſeries of experiments on the ſubject was wanting. This is what we have endeavoured to ſupply.

SECTION II.

Concerning the various Means employed
by Chemifts to overcome the Adhefion
which exifts between the Particles of
Bodies.

THE law of affinities, towards which our
attention has been directed, tends conti-
nually to bring the particles of bodies into con-
tact, and to maintain them in their ftate of union.
The efforts of the chemift are almoft all directed
to overcome this attractive power, and the
means he employs are reducible to—1. The di-
vifion of bodies by mechanical operations.
2. The divifion or feparation of the particles
from each other by the affiftance of folvents.
3. The means of prefenting to the feveral
principles of the fame bodies, fubftances which
have a ftronger affinity to them than thofe prin-
ciples have to each other.

I. The different operations performed upon
bodies by the chemift, to determine their nature,
alter their form, their texture, and even in fome
<div align="right">inftances</div>

inftances change their conftitution. All thefe changes are either mechanical or chemical.

The mechanical operations we fhall at prefent defcribe do not change the nature of fubftances, but in general change only their form and bulk. Thefe operations are performed by the hammer, the knife, the peftle, &c. Whence it follows, that the chemical laboratory ought to be provided with all thefe inftruments.

Thefe divifions or triturations are performed in mortars of ftone, of glafs, or of metal. It is the nature of the fubftance under examination which determines the ufe of one or the other of thefe veffels.

The object of thefe preliminary operations is, to prepare and difpofe bodies for new operations which may difunite their principles and change their nature ; thefe laft-mentioned operations, which may be diftinguifhed by the appellation Chemical, are what moft effentially conftitute the analyfis.

II. The folution to which we are at prefent to attend, confifts in the divifion and difappearance of a folid in a liquid, but without any alteration in the nature of the body fo diffolved.

The

The liquid in which the folid difappears, is called the folvent or menftruum.

The agent of folution appears to follow certain conftant laws, which we fhall here point out.

A. The agent of folution does not appear to differ from that of affinity; and in all cafes the folution is more or lefs abundant, the greater the affinity of the integrant parts of the folvent is to thofe of the body to be diffolved.

From this principle it follows, that, to facilitate folution, it is neceffary that bodies fhould be triturated and divided. By this means a greater number of furfaces are prefented, and the affinity of the integrant parts is diminifhed.

It fometimes happens that the affinity between the folvent and the body prefented to it has fo little energy, that it does not become perceptible till after a confiderable interval of time. Thefe flow operations, of which we have fome examples in our laboratories, are common in the works of nature; and it is probably to fimilar caufes that we ought to refer moft of thofe refults whofe caufes or agents efcape our perception or obfervation.

B. Solution is more fpeedy in proportion as the body to be diffolved prefents a greater furface: on this principle is founded the practice

of

of pounding, triturating, and dividing bodies intended to be diffolved. Bergman has even obferved, that bodies which are not attacked in confiderable maffes, become foluble after minute divifion. Letters on Iceland, p. 421*.

C. The folution of a body conftantly produces cold. Advantage has even been taken of this phenomenon to procure artificial cold, much fuperior to the moft rigorous temperature ever obferved in our climates. We fhall again advert to this principle when we come to treat of the laws of heat.

The principal folvents employed in our operations are water, alcohol, and fire. Bodies fubmitted to one or the other of thefe folvents prefent fimilar phenomena ; they are divided, rarefied, and at laft difappear : the moft refractory metal melts, is diffipated in vapour, and paffes to the ftate of gas, if a very ftrong heat be applied to it. This laft ftate forms a complete folution of the metallic fubftance in the caloric.

The effect of caloric is often united with one of the other folvents, to accomplish a more fpeedy and abundant folution.

The three folvents here mentioned do not

* Von Troil's Letters, quoted by Bergman. T.

exercife

exercise an equal action on all bodies indiscrimi-
nately. Skilful chemists have exhibited tables
of the dissolving power of these menstruums.
We may see, in the Mineralogy of Kirwan, with
what care that celebrated chemist has exhibited
the degree of solubility of each salt in water.
The table of Mr. De Morveau may likewise
be consulted on the dissolving power of alcohol.
Journal de Physique, 1785.

Most authors who have treated of solution
have considered it in too mechanical a point
of view. Some have supposed sheaths in the
solvent, and points in the body dissolved. This
absurd and gratuitous supposition has appeared
sufficient to account for the action of acids upon
bodies. Newton and Gassendi have admitted
pores in water, in which salts might insinuate
themselves ; and have by this means explained
why water does not augment in its bulk in pro-
portion to the quantity of salt it takes up.
Gassendi has even supposed pores of different
forms ; and has endeavoured to shew by this
means how water saturated with one salt may
dissolve others of another kind. Dr. Watson,
who has observed the phenomena of solution
with the greatest care, has concluded from his
numerous experiments ; 1. That the water
rises in the vessel at the moment of the immer-
sion

fion of the falt. 2. That it falls during the folution. 3. That it rifes after the folution above the original level. The two laft effects feem to me to arife from the change of tempe-rature which the liquor undergoes. The refri-geration arifing from the folution muft diminifh the volume of the folvent; but it ought to re-turn to its firft ftate as foon as the diffolution is finifhed. The tables of Dr. Watfon refpecting thefe phenomena, and the fpecific gravity of water faturated with different falts, may be confulted in the Journal de Phyfique, vol. xiii. p. 62*.

III. As the peculiar affinities of bodies to each other are various, the conftituent prin-ciples may be eafily difengaged by other fub-ftances; and it is upon this confideration that the action of all the re-agents employed by chemiftry in its analyfis is founded. Some-times the chemift difplaces certain principles, which he can in that ftate examine more accu-rately, becaufe infulated, and difengaged from all their combinations. It frequently happens that the re-agent made ufe of combines with fome principle of the body analyfed; and a compound arifes, whofe characters indicate

* Or in the fifth vol. of his Chemical Effays. T.

to us the nature of the principle which has thus entered into combination, becaufe the combinations of the principal re-agents with various bafes are well known. It likewife frequently happens that the re-agent made ufe of is itfelf decompofed, which circumftance renders the phenomena and the products more complicated; but we are enabled from the nature of thefe products to form a judgment of the component parts of the body analyfed. This laft fact was little attended to by the ancient chemifts; and this is one of the principal defects of the labours of Stahl, who has referred moft of thofe phenomena to the bodies which he fubmitted to analyfis, which in reality arofe only from the decompofition of the re-agents employed in his operations.

SECTION III.

Concerning the Method of Proceeding which the Chemiſt ought to follow in the Study of the various Bodies preſented to us by Nature.

THE progreſs made in any ſcience depends upon the ſolidity of thoſe principles which form its baſis, and upon the method of ſtudying them. It is not, therefore, to be wondered at, that chemiſtry made but little progreſs in thoſe times, when the language of chemiſts was enigmatical, and when the principles of the ſcience were founded only on analogies falſely deduced, or on a few facts ill underſtood. In the times which have followed this epocha, the facts have indeed been more attended to ; but, inſtead of ſuffering them to ſpeak for themſelves, chemiſts have been deſirous of making applications, drawing conſequences, and eſtabliſhing theories. Thus it was that Stahl, when he firſt obſerved that oil of vitriol and charcoal produced ſulphur,

if he had then confined himself to the simple relation of the fact, he would have announced a valuable and eternal truth; but when he concluded that the sulphur was produced by the combination of the inflammable principle of the charcoal with the oil of vitriol, he asserted that which the experiment does not point out: then it was that he proceeded further than the facts warranted; and this first rash step might be a first step towards error. All doctrine, in order to be lasting, ought to consist of the pure and simple expression of facts: but we are almost always governed by our imaginations; we adapt the facts to our manner of seeing them, and thus we are misled by ourselves. The prejudice of self-love afterwards furnishes us with various means to avoid recantation; we exert ourselves to draw our successors into the same paths of error; and it is not till after much time has been lost, after many vain conjectures have been exhibited, and after we have the strongest convictions that it is impossible to bend the nature of things to our caprices and unfounded ideas, that some superior mind disengages itself from the delusion; and returning to experiment, and the nature of things, suffers himself to be led no further than he is authorized by these to proceed.

We

We may affirm, to the honour of ſome of our cotemporaries, that facts are at preſent diſcuſſed by a much ſeverer logic; and it is to this vigorous method of inveſtigation and diſcuſſion that we are indebted for the rapid progreſs of chemiſtry. It is in conſequence of this dialectic march that we have at length arrived to the practice of attending to all the principles which are combined or diſengaged in the operations of nature and art. We keep an account of all the circumſtances which have a more or leſs conſiderable influence on the reſults, and we deduce ſimple and natural conſequences from the whole of the facts; by which means we create a ſcience as ſtrict in its principles as ſublime in its applications.

This then is the moment to draw out a faithful ſketch of the actual ſtate of chemiſtry, and to collect in the numerous writings of modern chemiſts every thing which may ſerve to lay the foundation of this beautiful ſcience.

Not many years ago, it was poſſible to preſent, in a few words, the whole of our knowledge of chemiſtry. It was ſufficient, at that time, to point out the methods of performing pharmaceutical operations; the proceſſes of the arts were almoſt all enveloped in darkneſs, the phenomena of nature were all enigmatical;

and

and it is only ſince this veil has begun to be re-
moved that we have beheld the development of
a collection of facts and reſearches referable to
general principles, and forming a ſcience en-
tirely new.   Then it was that a number of men
of genius reviewed the whole, and attended
to the improvement of chemical knowledge.
Every ſtep in their progreſs brought them
nearer to the truth; and in a few years we have
beheld a perſpicuous doctrine ariſe out of the
ancient chaos.   Every event has appeared con-
formable to the laws they eſtabliſhed; and the
phenomena of art and nature are now explained
with equal facility.

But in order to advance with ſpeed in the
career which has been thus opened, it is neceſ-
ſary to explain certain principles, according to
which we may direct our ſteps.

In the firſt place, I think it proper to avoid
that tedious cuſtom which ſubjects the beginner
in any ſcience to the painful taſk of collecting
all the opinions of various philoſophers before
he decides for himſelf. In reality, facts belong
to all times, and are as unchangeable as nature
herſelf, whoſe language they are.   But the con-
ſequences deduced from them muſt vary ac-
cording to the ſtate of our acquired knowledge.
It is eternally true, for example, that the com-
                                                    buſtion

buftion of fulphur affords the fulphuric acid.
It was believed, for a certain time, that this acid
was contained in the fulphur; but our difcove-
ries on the combuftion of bodies ought to have
led us to the deduction of a very different
theory from that which prefented itfelf to the
earlier chemifts. We ought, therefore, to at-
tach ourfelves principally to facts; or rather
we ought to attach ourfelves to the facts only,
becaufe the explanation which is given of them
at remote times is very feldom fuited to the
prefent ftate of our knowledge.

The numerous facts with which chemiftry
has been fucceffively enriched form the firft em-
barraffment of the ftudent who is defirous of
acquiring the elements of this fcience. In fact,
what are the elements of a fcience? The clear,
fimple, and accurate enunciation of thofe
truths which form its bafis. It is neceffary,
therefore, for the full accomplifhment of this
purpofe, to analyfe all the facts, and to exhibit a
faithful and clear abridgment: but this me-
thod is impracticable on account of the nu-
merous details, and the infinite number of dif-
cuffions, into which it would lead us. The only
proceeding, therefore, which appears to me to
be practicable, is to exhibit the moft decifive
experiments, thofe which are the leaft conteft-

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ed, and to neglect thofe which are doubtful or
inconclufive : for one experiment, well made,
eftablifhes a truth as inconteftably as a thoufand
equally averred.

When a propofition is found to be fupported
by fufpicious or contefted facts, when oppofite
theories are built upon contradictory experi-
ments, we muft have the courage to difcufs
them, to repeat them, and to acquire a certainty
of the truth by our own endeavours.   But
when this method of conviction is out of our
power, we ought to weigh the degree of con-
fidence which the defenders of the oppofite
facts are entitled to ; to examine whether ana-
logous facts do not lead us to adopt certain re-
fults ; after which it becomes us to give our
opinion with that modefty and circumfpection,
fuitable to the greater or lefs degree of proba-
bility annexed to each opinion.

But when any doctrine appears to us to be
eftablifhed on experiments of fufficient validity,
it then remains to be applied to the phenomena
of nature and art.   This, in my opinion, is
the moft certain touchftone to diftinguifh true
principles from thofe which are without foun-
dation.   And when I obferve that all the phe-
nomena of nature unite, and conform them-
felves, as it were, to any theory, I conclude that
this

this theory is the expreſſion and the language of truth. When, for example, I behold that a plant can be ſupported by pure water alone, that metals are calcinable, that acids are formed in the bowels of the earth, have I not a right to conclude that the water is decompoſed? and do not the chemical facts which in our laboratories afford a teſtimony of its decompoſition—do not theſe acquire a new force by the obſervation of the preceding phenomena? I conclude, therefore, that we ought to make a point of uniting theſe two kinds of proofs: and a principle deduced from experiment is not, in my opinion, demonſtrable, until I ſee that it may with facility be applied to the phenomena of art and nature. Hence, if I find myſelf in a ſtate of heſitation between oppoſite ſyſtems, I will decide in favour of that whoſe principles and experiments adapt themſelves naturally, and without force, to the greateſt number of phenomena. I will always diſtruſt a ſingle fact, which is applicable to no concluſion; and I will conſider it as falſe, if it be in oppoſition to the phenomena which nature preſents to us.

It appears to me likewiſe that he who pro-feſſes to ſtudy, or even to teach, chemiſtry, ought not to endeavour to arrive at or exhibit the whole which has been done in each depart-

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ment, or to follow the tedious progress of the
human mind from the origin of a discovery to
the present time. This fastidious erudition is
fatiguing to the learner; and these digressions
ought in no case to be admitted in the enun-
ciation of science, excepting when the histori-
cal details afford interesting facts, or lead us by
uninterrupted degrees to the present state of
our knowledge. It rarely happens, however,
that this kind of researches, this genealogy of
science, affords us such characters; and it ought no
more to be admitted, in general, that an elemen-
tary writer should bring together and discuss
every thing which has been done in a science,
than that he who undertakes to direct a
traveller should previously enter into a long
dissertation on all the roads which have
been successively made, and on those which
still exist, before he should point out the best
and shortest way to arrive at the end of his
journey. It may, perhaps, be said of the his-
tory of science, and more especially that of che-
mistry, that it resembles the histories of nations.
It seldom affords any light respecting the pre-
sent situation of affairs; exhibits many fables
concerning past times; induces a necessity of
entering into discussions upon the circumstances
that pass in review; and supposes a mass of
                                        extra-

extraneous knowledge acquired on the part of
the reader, which is independent of the pur-
poſe aimed at in the ſtudy of the elements of
chemiſtry.

When theſe general principles, reſpecting
the ſtudy of chemiſtry, are once well eſtabliſh-
ed, we may afterwards proceed in the chemical
examination of bodies in two ways : we may
either proceed from the ſimple to the com-
pound, or we may deſcend from the com-
pound to the ſimple. Both theſe methods have
their inconveniences; but the greateſt, no
doubt, which is found in following the firſt me-
thod is, that, by beginning with the ſimpleſt bo-
dies, we preſent ſubſtances to the conſideration
of the learner which nature very ſeldom exhi-
bits in ſuch a ſtate of nakedneſs and ſimplicity;
and we are forced to conceal the ſeries of ope-
rations which have been employed to diveſt
theſe ſubſtances from their combinations, and
reduce them to the elementary ſtate. On the
other hand, if we preſent bodies to the view of
the learner ſuch as they are, it is difficult to
ſucceed in an accurate knowledge of them ; be-
cauſe their mutual action, and in general moſt
of their phenomena, cannot be underſtood with-
out the previous and accurate knowledge of
their

their conftituent principles, fince it is upon thefe alone that they depend.

After having maturely confidered the advantages and inconveniences of each method, we give the preference to the firft.　We fhall therefore begin by giving an account of the feveral bodies in their moft elementary ftate, or reduced to that term beyond which analyfis can effect nothing; and, when we fhall have explained their various properties, we will combine thefe bodies with each other, which will afford a clafs of fimple compounds: and hence we fhall rife by degrees to the knowledge of bodies, and the moft complicated phenomena.　We fhall be careful, in any examination of the feveral bodies to which we fhall direct our refearches, to proceed from known to unknown; and our firft attention fhall be directed to elementary fubftances.　But as it is impoffible, at one and the fame time, to treat of all thofe fubftances which the prefent ftate of our knowledge obliges us to confider as elementary, we fhall confine ourfelves to the exhibition of fuch as are of the greateft importance in the phenomena of the globe we inhabit, fuch as are almoft univerfally fpread over its furface, and fuch as enter as principles into the compofition of the re-agents moft frequently employed in our operations; 6　　　　　　　　　　　　　　fuch,

fuch, in a word, as we continually find in the examination and analyfis of the component parts of the globe. Light, heat, fulphur, and carbone are of this number. Light modifies all our operations, and moft powerfully contributes to the production of all the phenomena which appertain to bodies either living or inanimate. Heat, diftributed after an unequal proportion among all the bodies of this univerfe, eftablifhes their various degrees of confiftence and fixity; and is one of the great means which art and nature employ to divide and volatilize bodies, to weaken their force or adhefion, and by that means prepare them for analyfis. Sulphur exifts in the products of the three kingdoms; it forms the radical of one of the beft known, and moft generally employed, acids; it exhibits interefting combinations with moft fimple fubftances; and, under thefe feveral points of view, it is one of the fubftances the moft neceffary to be known in the firft fteps of chemical fcience. The fame may be faid of carbone; it is the moft abundant fixed product found in vegetables and animals. Analyfis has difcovered it in fome mineral fubftances. Its combination with oxigene is fo common in bodies, and in the operations of art and nature, that there are fcarcely any phenomena which

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do not preſent it to our view, and which conſe-
quently require the knowledge of its proper-
ties. From all theſe reaſons it appears to us,
that for the advancement of chemiſtry it is ne-
ceſſary our firſt proceeding ſhould be founded
on the knowledge of theſe ſubſtances ; and that
we ſhould not direct our attention to other ſim-
ple or elementary ſubſtances, accordingly as
they preſent themſelves.

SECTION IV.

Concerning Simple or Elementary Sub-ftances.

IF we caft an eye over the fyftems which have been fucceffively formed by philofophers relative to the number and nature of the elements, we fhall be aftonifhed at the prodigious variety which prevails in their manner of thinking. In the earlier times, every one feems to have taken his own imagination for his guide ; and we find no reafonable fyftem until the time when Ariftotle and Empedocles acknowledged as elements, Air, Water, Earth, and Fire. Their opinion has been well received for many ages ; and it muft be confeffed that it is calculated to feduce the mind. There are, in fact, enormous maffes, and inexhauftible ftores, that prefent themfelves to our view, of thefe four principles, to which the deftruction or decompofition of bodies appeared to refer all the feveral component parts which formation or creation had taken from them. The authority of all thofe great men who had adopted this fyftem,

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and the analyfis of bodies which prefented only
thefe four principles, afforded fufficient grounds
for admitting this doctrine.

But as foon as chemiftry had advanced fo far
as to difcover the principles of bodies, the pro-
feffors of that fcience prefumed to mark the
number, nature, and character of the elements;
and every fubftance that was unalterable by
the chemical methods of decompofition, was
confidered by them as a fimple or elementary
principle.   By thus taking the limits of ana-
lyfis as the term for indicating the elements,
the number and the nature of thefe muft vary
according to the revolutions and the progrefs
of chemiftry.   This has accordingly happened,
as may be feen by confulting all the authors
who have written on this fubject, from the time
of Paracelfus to the prefent day.   But it muft
be confeffed that it is no fmall degree of rafh-
nefs, to affume the extent of the power of the
artift as a limit for that of the Creator, and to
imagine that the ftate of our acquifitions is a
ftate of perfect knowledge.

The denomination of Elements ought there-
fore to be effaced from a chemical nomencla-
ture, or at leaft it ought not to be ufed but as
an expreffion denoting the laft term of our ana-
lytical refults; and it is always in this fenfe
that we fhall ufe the word.

C H A P.

C H A P. I.

Concerning Fire.

THE principal agent employed by nature to balance the power and natural effect of attraction, is fire. By the natural effect of attraction we fhould poffefs none but folid and compact bodies; but the caloric unequally difperfed in bodies tends inceffantly to deftroy this adhefion of the particles; and it is to this principle that we are indebted for the varieties of confiftence under which bodies prefent themfelves to our obfervation. The various fubftances that compofe this univerfe are therefore fubjected, on the one hand, to a general law which tends to bring them together; and, on the other hand, to a powerful agent which tends to remove them from each other: it is upon the refpective energy of thefe two forces that the confiftence of all bodies depends. When the affinity prevails, they are in the folid ftate; when the caloric is moft powerful, they are in the ftate of gas; and the liquid ftate

appears

appears to be the point of the equilibrium be-
tween these two powers.

It is therefore essentially necessary to treat of
fire, since it acts so leading a part in this uni-
verse; and because it is impossible to treat
any substance whatever without attending to
the influence of this agent.

There are two things to be considered in
fire—heat and light.

These two principles, which have been very
often confounded, appear to be very distinct in
their own nature; because they are scarcely
ever proportional to each other, and because
each can exist without the other.

The most usual acceptation of the word Fire
comprehends heat and light; and its principal
phenomena must have been known for a long
time. The discovery of fire must have been
nearly as ancient as the human species upon
this globe. The shock of two flints, the action
of meteors, or the effect of volcanos, must have
afforded the earliest idea of it; and it is very
astonishing that the inhabitants of the Marian
Islands were not acquainted with its effects be-
fore the invasion of the Spaniards. These
islanders, who became acquainted with this ter-
rible element only in consequence of its ra-
vages, considered it at first as a malevolent
being

being which attached itfelf to all beings, and
devoured them.—See the Abbé Raynal's Hif-
toire Philofophique, &c.

The effects of fire are perhaps the moft afto-
nifhing of any which nature exhibits; and we
ought not to be furprifed that the ancients con-
fidered it as an intermediate being between fpi-
rit and matter, and have built the beautiful
fable of Prometheus upon its origin. We have
had the happinefs, in our time, to acquire well-
founded and extenfive ideas refpecting this
agent, which we fhall proceed to develope in
the two following articles.

A R T I C L E I.

Concerning Caloric and Heat.

When a metal or a liquid is heated, thefe
bodies are dilated in every direction, are re-
duced to vapour, and at laft become invifible
when the moft powerful heat is applied to
them.

Bodies which poffefs the principle of heat,
part with it more or lefs readily. If we atten-
tively obferve a body during its cooling, a flight
movement of undulation will be perceived in
the furrounding air; an effect which may be
compared to the phenomenon exhibited upon

the mixture of two liquors of unequal denfity and weight.

It is difficult to conceive this phenomenon without admitting of a peculiar fluid, which paffes firft from the body which heats to that which is heated, combines with the latter, produces the effects we have fpoken of, and afterwards efcapes to unite with other bodies, according to its affinities, and the law of equilibrium, to which all bodies tend.

This fluid of heat, which we call Caloric, is contained in greater or lefs quantities in bodies, according to the greater or lefs degrees of affinity exifting between it and them.

Various means may be employed to difplace or difengage the caloric. The firft is by the method of affinities : for example, water poured upon the fulphuric acid expels the heat, and takes its place; and while there is a difengagement of heat, the volume of the mixture does not increafe in proportion to the bulk of the two fubftances mixed. This fhews that penetration takes place, which cannot be explained but by admitting that the integrant parts of the water take the place of the caloric, in proportion as it is diffipated.—The fecond method of precipitating caloric, is by friction and compreffion. In this cafe it is expreffed or fqueezed out,

out, in the fame manner as water from a fpunge. In reality, the whole of the heat which may be produced by friction, is not afforded by the body itfelf; becaufe, in proportion as the interior heat is developed, the external air acts upon the body, calcines or inflames it, and itfelf gives out heat during its fixation. Fermentation, and in general every operation which changes the nature of bodies, may difengage caloric, becaufe the new compound may demand and receive a greater or lefs quantity. Hence it is that chemical operations produce fometimes cold, and fometimes heat.

Let us now examine the form under which caloric prefents itfelf.

This fluid is difengaged either in a ftate of liberty, or in a ftate of combination.

In the firft cafe, the caloric always endeavours to obtain an equilibrium ; not that it is diftributed equally among all bodies, but it is difperfed among them according to the degrees of its affinity. Whence it follows, that the circumambient bodies receive and retain a quantity more or lefs confiderable. Metals are eafily penetrated by this fluid, and tranfmit it with equal facility ; wood and animal fubftances receive it to the degree of combuftion; liquids, until they are reduced to vapour. Ice alone

abforbs

abforbs all the heat communicated to it, without giving it out to other bodies until it has acquired the fluid ftate *.

The degree of heat can be appreciated only by its effects: and the inftruments which have been fucceffively invented to calculate it, and are known by the names of thermometers, pyrometers, &c. have been applied to the ftrict determination of the feveral phenomena exhibited in confequence of the abforption of caloric in various bodies.

The dilatation of fluids, or of metals in the fluid ftate, by the feveral degrees of heat, has been long meafured by thermometers formed of glafs; but this very fufible fubftance can only be ufed to afcertain degrees of heat inferior to that which renders the glafs itfelf fluid.

Several means have been fucceffively propofed for calculating the higher degrees of heat. Mr. Leidenfroft has proved that the hotter a metal is, the more flowly will drops of water evaporate from its furface; and he has propofed this principle for the conftruction of pyrometers. A drop of water in an iron fpoon, heated

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* The ingenious author has inadvertently been guilty of an overfight. Not only ice, but all other bodies, abforb heat during liquefaction, as he himfelf fhews hereafter. T.

to the degree of boiling water, evaporates in one
second; a similar drop, poured on melted lead,
is diffipated in fix or feven feconds; and upon
red-hot iron in thirty. Mr. Ziegler, in his Spe-
cimen de Digeftore Papini, has found that 89 fe-
conds were required to evaporate a drop of wa-
ter at 520 degrees of Fahrenheit; and that one
fecond is fufficient at the 300th degree. This
phenomenon, which is more interefting to
chemiftry than pyrometry, to which it will al-
ways afford refults little fufceptible of rigorous
calculation, appears to me to depend upon the
adhefion and decompofition of the water upon
the metal.

The moft accurate pyrometer we are ac-
quainted with, is that which was prefented to
the Royal Society of London by Mr. Wedg-
wood. It is conftructed upon the principle,
that the pureft clay fhrinks in the fire in propor-
tion to the heat applied to it. This pyrome-
ter confifts of two parts; one called the gauge,
which ferves to meafure the degrees of diminu-
tion or fhrinking; the other contains the fimple
pieces of pure clay, which are called thermo-
meter pieces.

The gauge is formed of a plate of baked earth,
upon which are applied two rulers or ftraight
pieces of the fame fubftance. Thefe rulers,

F 3   being

being perfectly straight and even, are placed at
the distance of half an inch from each other at
one of their ends, and three-tenths of an inch
at the other. For greater convenience, the gauge
is divided into two parts, and the two pieces
are placed endways when required to be used.
The length of this rule is divided into 240
equal parts, of which each represents one-tenth
of an inch *. To form the thermometer pieces,
the earth is sifted with the greatest attention, af-
ter which it is mixed with water, and the paste
thrust through an iron tube, which gives it a
cylindrical form, to be cut afterwards into
pieces of a proper size. When the pieces are
dry, they must be presented to the gauge, where
they ought to fit at the place of o on the scale.
If by inadvertence of the workmen any piece
penetrates to one or two degrees further, this
degree is marked on its flat surface, and re-
quires to be deducted when the piece is used
in the admeasurement of heat. The pieces thus
adjusted are baked in a furnace to a red heat,
to give them the consistence necessary for car-
riage. The heat employed in this part of the
process is usually about six degrees, and the

* This is, in fact, the twelve-hundredth of an inch in
the width, according to the dimensions here given. T.

pieces

pieces are diminifhed more or lefs; but this is of no confequence when they come to be fub-mitted to a fuperior degree of heat; and if it fhould happen that an inferior degree of heat is required to be meafured, unbaked pieces are to be ufed, which are preferved in fheaths or cafes to avoid friction.

When this pyrometer is to be ufed, one of the pieces is expofed in the fire-place whofe heat is required to be determined; and when it has acquired the whole intenfity, it is taken out, and fuffered to cool, or for greater fpeed it is plunged in water; after which it is prefented to the gauge, and its degree of contraction eafily determined. Mr. Wedgwood has given us the refult of feveral experiments made with his py-rometer, oppofite to which he has placed the correfpondent degrees of Fahrenheit.

	Pyrometer of Wedgwood.	Thermometer of Fahrenheit.
Red heat vifible by the light	0	1077
Brafs melts at	21	1857
Swedifh copper melts at	27	4587
Pure filver melts at	28	4717
Pure gold melts at	32	5237
The heat of bars of iron raifed to welding { fmall bar	90	12777
{ large bar	95	13427
The greateft heat producible in a fmith's forge	125	17327
Caft iron melts at	130	17977
The greateft heat of a wind furnace of eight inches fquare	160	21877

F 4

Thefe

These various thermometers are not applicable to all cases. We cannot, for example, calculate with strictness the heat which escapes from living bodies, or determine with precision the temperature of any substance. But Messrs. De la Place and Lavoisier (Acad. des Sciences, 1780) have invented an apparatus which appears to leave nothing further to be desired. It is constructed upon the principle that ice absorbs all the heat communicated to it, without communicating it to other bodies until the whole is melted; so that from hence we may calculate the degrees of heat communicated, by the quantity of ice which is melted. It was necessary, in order to afford strict results, to discover the means of causing the ice to absorb all the heat disengaged from the bodies under examination, and to cover it from the action of every other substance which might facilitate its fusion; and, lastly, to collect with great care the water produced by the fusion.

The apparatus constructed by these two celebrated academicians for this purpose, consists of three circular vessels nearly inscribed in each other; so that three capacities are produced. The interior space or capacity is formed by an iron grating, upon supports of the same metal. Here it is that the bodies subjected to experiment

ment are placed. The upper part of this ca-
vity is clofed by means of a cover. The mid-
dle fpace, next to this, is defigned to contain
the ice which furrounds the interior compart-
ment. This ice is fupported and retained by a
grate, upon which a cloth is fpread. In propor-
tion as the ice melts, the water flows through
the grate and the cloth, and is collected in a
veffel placed beneath. Laftly, the external
fpace or compartment of the apparatus contains
ice intended to prevent the effect of the external
heat of the atmofphere.

To ufe this excellent machine, the middle or fe-
cond fpace is filled with pounded ice, as is likewife
the cover of the internal fphere; the fame thing
is done with regard to the external fpace, as
well as to the general covering of the whole
machine: the interior ice is fuffered to drain;
and, when it ceafes to afford water, the covering
of the internal fpace is raifed, to introduce
the body upon which the experiment is in-
tended to be made. Immediately after this in-
troduction, the covering is put on, and the
whole apparatus remains untouched until the in-
cluded body has acquired the temperature of o,
or the freezing temperature of water, which is
the common temperature of the internal capa-
city. The quantity of water afforded by the
melting

melting of the ice is then weighed; and this is an accurate meafure of the heat difengaged from the body, becaufe the fufion of the ice is the effect of this heat only. Experiments of this kind laft fifteen, eighteen, or twenty hours.

It is of great confequence, that in this machine there fhould be no communication between the middle, or fecond, and the external fpace.

It is likewife neceffary that the air of the apartment fhould not be lower than o, becaufe the interior ice would then receive a degree of cold lower than that temperature.

Specific heat is merely the proportional quantity of heat neceffary to raife bodies of equal mafs to the fame number of degrees of temperature; fo that, when the fpecific heat of a folid body is required, its temperature muft be elevated a certain number of degrees, at which inftant it muft be placed in the internal fphere, and there left until its temperature is reduced to o. The water is then collected, and this quantity divided by the product of the mafs of the body; and the number of degrees of its original temperature above o, will be proportional to its fpecific heat.

With regard to fluids, they are inclofed in veffels whofe heat has been previoufly determined.

mined. The operation is then the same as for solids; excepting that the quantity of water afforded muſt be diminiſhed by a deduction of that quantity which has been melted by the heat of the veſſel.

If it be required to determine the heat which is diſengaged during the combination of various ſubſtances, they muſt be all reduced, as well as their containing veſſels, to the temperature of o. The mixture muſt then be placed in the internal ſphere; and the quantity of water collected is the meaſure of the diſengaged heat.

In order to determine the heat of combuſtion and reſpiration, as the renewal of air is indiſpenſable in theſe two operations, it is neceſſary to eſtabliſh a communication between the internal part of the ſphere and the ſurrounding atmoſphere; and in order that the introduction of freſh air may not cauſe any perceptible error, theſe experiments ought to be made at a temperature little differing from o, or at leaſt the air which is introduced muſt previouſly be brought to this temperature.

To determine the ſpecific heat of any gas, it is neceſſary to eſtabliſh a current through the internal part of the ſphere, and to place two thermometers, one at the place of introduction, and the other at the place of eſcape. By compariſon

parifon of the temperatures exhibited by thefe two inftruments, a judgment is formed of the heat abforbed, and the melted ice is meafured.

An excellent memoir of Meffrs. De la Place and Lavoifier may be confulted for the refults of the experiments they have made. The prefent extract contains only a fhort account of their valuable labours.

The various means made ufe of for the admeafurement of heat, are founded on the general principle, that different bodies abforb heat in greater or lefs quantities. If this fact were not generally admitted, it might be eftablifhed on the three following facts. Dr. Franklin having expofed two fmall pieces of cloth, of the fame texture but of different colours, upon the furface of fnow, perceived, a few hours afterwards, that the red cloth was buried in the fnow, while the other which was white had not fuffered any depreffion*. M. de Sauffure obferves, that the peafants of the mountains of Switzerland are careful to fpread a black earth over the furface of grounds covered with fnow, when they are defirous of melting it, to fow their feed. So likewife children burn a black hat in the focus of a fmall lens which would fcarcely heat a white one.

* They were expofed to the rays of the fun. T.

Such

Such nearly are the phenonema of heat when it is difengaged in a ftate of liberty. Let us now contemplate thofe which it prefents when it efcapes from a ftate of combination.

Heat is fometimes difengaged in a ftate of fimple mixture, as in the phenomena of vapours, fublimations, &c. If heat be applied to water, thefe two fluids will unite, and the mixture will be diffipated in the atmofphere; but it would be an abufe of words to call fo weak an union by the name of combination: for, as foon as the heat becomes in a fituation to combine with other bodies, it abandons the water, which returns to a liquid ftate. This body, during evaporation, continually carries with it a portion of heat; and hence, perhaps, refult the advantages of tranfpiration, perfpiration, &c.

But heat very frequently contracts a true chemical union with the bodies which it volatilizes : this combination is even fo perfect, that the heat is not perceptible, but is neutralized by the body with which it is combined. It is then called latent heat, *calor latens.*

The feveral cafes in which heat enters into combination, and paffes to the ftate of latent heat, may be reduced to the two following principles :

The firft principle.—Every body which paffes

from

from the folid to the liquid ftate, abforbs a por-
tion of heat, which is no longer fenfible to the
thermometer, but exifts in a true ftate of com-
bination.

The academicians of Florence filled a veffel
with pounded ice, and plunged a thermometer
in it, which defcended to o. The veffel was
then immerfed in boiling water, and the ther-
mometer did not rife during the whole time of
the liquefaction of the ice. The fufion of ice
therefore abforbs heat.

Mr. Wilcke poured a pound of water, heated
to the 6oth degree of Reaumur, upon a pound
of ice. The melted mixture poffeffed the tem-
perature of o. Sixty degrees of heat had there-
fore entered into combination.

The Chevalier Laudriani has fhewn that the
fufion of metals, of fulphur, of phofphorus, of
alum, of nitre, &c. abforb heat.

Cold is produced in the diffolution of all the
(cryftallized) falts.

Reaumur made a feries of very interefting ex-
periments on this fubject, which confirm thofe
of Boyle. Fahrenheit caufed the thermometer
to defcend to forty degrees, by melting ice by
ftrong nitrous acid. But the moft aftonifhing
experiments are thofe made by Meffrs. Thomas
Bed-

Beddoes*, phyſician, and Walker, apothecary at Oxford, and inſerted in the Philoſophical Tranſactions for the year 1787†. The mixtures which produced the greateſt degrees of cold are, 1. Eleven parts of muriate of ammoniac, or common ſal ammoniac; ten parts of nitrate of pot-aſh, or common nitre; ſixteen parts of ſulphate of ſoda, or Glauber's ſalt; with thirty-two parts by weight of water: the two firſt ſalts ſhould be dry, and in powder. 2. The nitric acid, muriate of ammoniac, and ſulphate of ſoda, lowered the thermometer to eight degrees under o. Mr. Walker has frozen mercury without uſing either ice or ſnow.

It is therefore an incontrovertible principle, that all bodies which paſs from the ſolid to the liquid ſtate, abſorb heat, and retain it in ſo accurate a combination as to afford no ſign of its preſence. The heat is therefore fixed, neutralized, or latent.

The ſecond principle.—All bodies, by paſſing from the ſolid or fluid ſtate to the aëriform ſtate, abſorb heat, which becomes latent;

* It does not appear that Dr. Beddoes either had or pretends to have any other ſhare in the experiments of Mr. Walker, than that of having tranſmitted them to the Royal Society. T.

† Alſo in the ſubſequent volumes.

7   and

and it is by virtue of this heat that such bodies are placed and maintained in that state.

On this principle is founded the process used in China, India, Persia, and Egypt, to cool liquors used for drink.

The water intended for this purpose is put into very porous vessels, and exposed to the sun, or to a current of warm air, to cool the fluid contained within them.

It is by similar means that cool drink is obtained in the long journeys of the caravans. Interesting details on this subject may be seen in the Travels of Chardin, vol. iii. 1723; Tavernier's Voyages, vol. i. edit. 1738; Paul Lucas's Voyages, vol. ii. edit. 1724; and also in the Mundus Subterraneus of P. Kircher, lib. vi. sec. 2. cap. 2.

We may conclude from the experiments of Mr. Richmann, made in 1747, and inserted in the first volume of the Imperial Academy of Petersburgh, 1. That a thermometer taken out of water, and exposed to the air, always descends, even when its temperature is equal or superior to that of the water. 2. That it afterwards rises, until that it has acquired the temperature of the atmosphere. 3. That the time of descending is less than that which it employs to rise again. 4. That when the ther-

6   mometer

mometer, withdrawn from the water, has arisen to the common temperature, its bulb is dry; but that it continues wet during the whole time of its standing beneath this common temperature.

To these consequences we will add others deduced from several curious experiments by the celebrated Cullen. 1. A thermometer suspended in the receiver of the air pump, descends two or three degrees during the time of exhaustion, and afterwards rises to the temperature of the vacuum. 2. A thermometer plunged in alcohol, in the receiver of the air pump, always descends, and the lower in proportion as the bubbles are stronger which issue from the alcohol; if it be withdrawn from this liquor, and suspended wet beneath the receiver, it falls eight or ten degrees while the air is pumping out.

It is well known that if the ball of a thermometer be wrapped in fine linen, and kept moist by sprinkling with ether, and the evaporation be facilitated by agitation in the air, the thermometer will descend to o.

The immortal Franklin has proved, in his own person, that when the body perspires strongly, it is less heated than surrounding bodies, and that perspiration always produces a certain degree of coldness.—See his Letter to Dr. Lind.

The great number of labourers in the burning heats of our climate support themselves only by virtue of a copious perspiration, the fluid for which they replenish by drinking plentifully. The workmen employed in glass-houses, founderies, &c. often live in a medium hotter than their bodies, the natural temperature of which is equalized and moderated by perspiration.

If evaporation be increased by agitation of the air, the refrigeration is the greater. Hence the use of fans, ventilators, &c. which, though intended to give motion to warm air, afford likewise the virtue of cooling by facilitating and favouring evaporation.

Warm and dry air is best suited to form a refreshing current, because it is more calculated to dissolve and absorb humidity ; moist air is less proper, because it is already saturated.— Hence the necessity of frequently renewing the air to preserve the coolness of our apartments.

These principles have a nearer relation to medicine than is generally supposed. We find that almost all fevers end in perspirations, which, beside the advantage of expelling the morbific matter, possess likewise that of carrying off the matter of heat, and restoring the body to its common temperature. The physician who is desirous of moderating the excess of heat in the body

body of a patient, ought to maintain the air in that difpofition which is moft fuitable to his views.

The ufe of volatile alkali is univerfally acknowledged to be of advantage in burns, the tooth-ach, &c. May not thefe effects be attributed to the volatility of this fubftance, which quickly combining with heat, carries it off, and leaves an impreffion of cold ?—Ether is a fovereign remedy for the colic. Does not its virtue depend on the fame principles ?

The heat which has entered into combination with bodies during their tranfition from the folid to the liquid ftate, or from this laft to the aëriform ftate, may be again exhibited by caufing thefe fubftances to return again to the ftates of liquefaction or folidity. In a word, every fubftance which paffes from the liquid to the folid ftate, fuffers its latent heat to efcape, which at this inftant becomes free or thermometrical heat.

The celebrated Fahrenheit, in the year 1724, having left water expofed to a colder temperature than that of ice, the water remained fluid : but it congealed by agitation; and the thermometer, which marked feveral degrees beneath the freezing point, fuddenly rofe to that temperature. Mr. Treiwald mentions a fimilar fact in

the

the Tranfactions; and Mr. De Ratte made the fame obfervation at Montpelier.

Mr. Baumé has fhewn, in his enquiries and experiments relating to feveral fingular phenomena exhibited by water at the inftant of its congelation, that feveral degrees of heat are always developed at that inftant.

Gafeous fubftances are maintained in the aëriform ftate merely by the heat which is combined with them; and when to thefe fubftances, thus diffolved in caloric, another body is prefented, to which they have a very ftrong affinity, they abandon their heat to unite with this laft fubftance; and the caloric, thus expelled or difengaged, appears under the form of free or thermometrical heat. This difengagement of heat, by the concretion or fixation of gafeous fubftances, was obferved by the celebrated Scheele, as may be feen in the valuable experiments which form the bafis of his Treatife on Air and Fire. Since the time of this great man, rigorous calculations have been made of the quantity of latent heat exifting in each of thefe gafes: we are indebted to Meffrs. Black, Crawford, Wilcke, De la Place, Lavoifier, &c. for many excellent refearches on this fubject.

ARTICLE II.

Concerning Light.

It appears that Light is tranfmitted to our eyes by a peculiar fluid which occupies the interval between us and vifible bodies.

Does this fluid arrive directly from the Sun by fucceffive emiffions or eradiations ? or is it a peculiar fluid diftributed through fpace, and put in action by the Sun's rotary motion, or by any other caufe ? I fhall not enter into any difcuffion upon this fubject, but fhall confine myfelf to point out the phenomena.

A. The motion of light is fo rapid, that it paffes through nearly eighty thoufand leagues in a fecond.

B. The elafticity of the rays of light is fuch, that the angle of reflection is equal to the angle of incidence.

C. The fluid of light is ponderous : for if a ray of light be received through a hole in a window-fhutter, and the blade of a knife be prefented to it, the ray is diverted from a light line, and is inflected towards the body. This circumftance fhews that it obeys the law of attrac-

tion,

tion, and fufficiently authorifes us to clafs it among other bodies of this nature.

D. The great Newton fucceeded in decompofing the folar light into feven primitive rays, which prefent themfelves in the following order: red, orange, yellow, green, blue, indigo, violet. Dyes prefent us with only three colours, which are red, blue, and yellow; the combinations and proportions of thefe three principles form all the fhades of colour with which the arts are enriched. Philofophers have maintained that among the folar rays there are three primitive colours.—See Les Recherches de M. Marat.

All natural bodies may be confidered as prifms which decompofe or rather divide the light. Some reflect the rays without producing any change, and thefe are white; others abforb them all, and caufe abfolute blacknefs: the greater or lefs affinity of the feveral rays with various bodies, and perhaps likewife the difpofition of the pores, is no doubt the caufe that, when a pencil falls upon a body, fome rays enter into combination, while others are reflected; and it is this which affords the diverfity of colours, and the prodigious variety of fhades under which bodies appear to our eyes.

We can no longer confine ourfelves to confider light as a merely phyfical fubftance; the
                                                    chemift

chemist perceives its influence in most of his operations, and finds it necessary to attend to its action, which modifies his results : and its effects are no less evident in the various phenomena of nature, than in the experiments performed in our laboratories.

We see that vegetation cannot take place without light. Plants deprived of this fluid become pale; and when in hot-houses the light comes to them from one part only, the vegetables incline towards the aperture, as if to shew the necessity of this beneficial fluid.

Without the influence of light, vegetables would exhibit but one lifeless colour; they are deprived of their beautiful shades by the interception of this luminous fluid. On these principles, celery, endive, and other plants, are bleached.

Vegetables are not only indebted to the light for their colour, but likewise for their smell, taste, combustibility, maturity, and the resinous principle, which equally depend upon this fluid. Hence it is, no doubt, that aromatic substances, resins, and volatile oils, are the inheritance of southern climates, where the light is more pure, constant, and intense.

We see, likewise, that the influence of light is evident in other beings : for, as Mr. Dorthes

G 4 has

has obferved, worms and grubs, which live in the earth or in wood, are of a whitifh colour. The birds and flying infects of the night are likewife diftinguifhable from thofe of the day by the want of brilliancy of colour; and the difference is equally marked between thofe of the north and of the fouth.

A very aftonifhing property of light upon the vegetable kingdom is, that when vegetables are expofed to open day-light, or to the fun's rays, they emit vital air. We fhall again attend to all thefe phenomena when we come to treat of the analyfis of vegetables.

The fine experiments of Scheele and Berthollet have fhewn that the abfence or prefence of light has an aftonifhing effect upon the refult of chemical experiments. Light difengages vital air from feveral fluids, fuch as the nitric acid, the oxigenated marine acid, &c. It reduces the oxides or calces of gold, filver, &c. It changes the nature of oxigenated muriates, according to the obfervations of Mr. Berthollet. Light likewife determines the phenomena of vegetation exhibited by faline folutions, as I have fhewn. From all which circumftances it is evident that we ought to attend to the effect of this agent in almoft all our operations.

"Organi-

" Organization, fenfation, fpontaneous mo-
tion, and life, exift only at the furface of the
earth, and in places expofed to light : we might
affirm that the flame of Prometheus's torch was
the expreffion of a philofophical truth which
did not efcape the ancients. Without light, na-
ture was lifelefs, inanimate, and dead : a bene-
volent God, by producing light, has fpread or-
ganization, fenfation, and thought over the fur-
face of the earth."—Elementary Treatife of
Chemiftry by Mr. Lavoifier.

We ought not to confound the folar light
with the light of our furnaces ; the light of thefe
has, as I am convinced, very evident effects in
certain phenomena ; but thefe effects are flow,
and fcarcely comparable with thofe of the folar
light.

Although heat often accompanies light, the
phenomena we have mentioned cannot be at-
tributed to mere heat. Heat may indeed mo-
dify them where it exifts, but moft affuredly it
cannot produce them.

C H A P.

C H A P. II.

Concerning Sulphur.

WE are obliged to place Sulphur among
the elements, though our predeceſſors
pretended to have determined its conſtituent
principles. This proceeding would appear to
be retrograde, if it were not evident that the
correction of miſtakes is a real advancement in
ſcience.

The ancients uſed the word Sulphur to denote
every combuſtible and inflammable ſubſtance.
Accordingly we find, in all their writings, the
expreſſions ſulphur of metals, ſulphur of ani-
mals, ſulphur of vegetables, &c.

Stahl aſſigneth a determinate value to the de-
nomination of Sulphur; and ſince the time of
this celebrated chemiſt we have confined the
name to denote a body of an orange-yellow
colour, dry, brittle, capable of burning with a
blue flame, and exhaling a penetrating odour
during combuſtion : when rubbed, it becomes
electric ; and by a light preſſure in the hand it
cracks, and becomes reduced to powder.

It appears that ſulphur is formed by the de-
compoſition of vegetables and animals. It has
been

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been found on the walls of neceffary-houfes; and when the ditch of the Porte St. Antoine, at Paris, was cleared, a confiderable quantity was collected, which was mixed with the decayed remains of vegetable and animal fubftances, that had filled the ancient ditches, and there putrefied.

Mr. Deyeux has likewife proved, that fulphur exifts naturally in certain plants, fuch as patientia, cochlearia, &c. His proceffes for extracting it confift in—1. The wafhed root muft be reduced by rafping into a fine pulp; this muft be wafhed in cold water, and paffed through a fieve or cloth of an open texture: the fluid paffes in a turbid ftate, and depofits a precipitate, which when dried proves the exiftence of fulphur. 2. The pulp may be boiled, and the fcum afforded by the ebullition afterwards dried: this fcum contains fulphur. Several fpecies of rumex, confounded under the name of Patience, do not contain fulphur. I have obtained it from the rumex patientia L, which grows on the mountains Cevennes, and is the fame which is ufed at Paris. M. Le Veillard obtained fulphur by fuffering vegetable fubftances to putrefy in well-water. Sulphur is abundantly contained in coal mines; it is found in combination with certain metals; it appears
almoft

almoſt always where vegetable decompoſition takes place; it forms the greater part of thoſe pyritous and bituminous ſchiſti which occupy the focus of volcanos; it is ſublimed in thoſe places where the pyrites are decompoſed; it is thrown out by ſubterraneous fires; and is found in greater or leſs quantities in volcanic diſtricts. Much has been ſaid concerning ſhowers of ſulphur; but it is at preſent well known that this error has chiefly ariſen from the powder of the ſtamina of the pine, which is carried to great diſtances. Henckel ſaw the ſurface of a marſh entirely covered with this powder.

The known proceſſes for extracting ſulphur in the large way, and applying it to the purpoſes of commerce, conſiſt in diſengaging it from the pyrites or ſulphures of copper, or of iron, by methods poſſeſſing various degrees of ſimplicity and economy. On this ſubject, the Pyritology of Henckel, Macquer's Chemical Dictionary, and the Metallurgical Tracts of Mr. Jars, may be conſulted.

In Saxony and Bohemia the ores of ſulphur are diſtilled in earthen tubes diſpoſed in a gallery. The ſulphur which is diſengaged by the heat paſſes into receivers placed without, and in which care is taken to keep a ſufficient quantity of water.

At

At Rammelfberg, at St. Bel, &c. large heaps of pyrites are made, which are decompofed by a gentle heat, at firft applied to the mafs from a ftratum of combuftible matter upon which it is placed. The heat is afterwards kept up by the action of the pyrites amongft each other. The fulphur which exhales cannot efcape laterally, becaufe care is taken to cover the fides with earth. It therefore rifes to the fummit of the truncated pyramid, where it is collected in fmall cavities made for that purpofe. The heat of this part is fufficient to keep the fulphur in a fluid ftate ; and it is taken out from time to time with ladles.

Almoft all the fulphur ufed in France comes from the Solfatara. This volcanic country every where exhibits marks of the agency of fubterraneous fire. The enormous maffes of pyrites which are decompofed in the bowels of the earth produce heat, which fublimes part of the fulphur through apertures which the fire, and the effort of the vapours, have opened in all parts. The earths and ftones which contain fulphur are diftilled ; and it is the refult of this diftillation which is called Crude Sulphur.

The crude fulphur is tranfported into France by the way of Marfeilles, where it receives the neceffary preparations to render it fuitable to various purpofes.

purpoſes.　1. It is reduced into ſticks or rolls, by fuſing it, and pouring it into moulds: or, 2. It is formed into flowers of brimſtone by ſubliming it with a gentle heat, and collecting this ſulphureous vapour in a very cloſe chamber of conſiderable extent. This very pure and finely divided ſulphur is diſtinguiſhed by the name of Flowers of Brimſtone, or Sublimed Sulphur.

Sulphur enters into fuſion by a moderate heat; and if the moment be ſeized in which the ſurface congeals, and the liquid ſulphur contained beneath that ſurface be then poured out, the internal cavity will exhibit long needle-formed cryſtals of an octahedral figure. This proceſs, contrived by the famous Rouelle, has been applied to the cryſtallization of almoſt all the metals. Sulphur is found naturally cryſtallized in Italy, at Conilla near Cadiz, &c. Its uſual form is octahedral; but I have, neverthelefs, ſeen cryſtals of ſulphur in perfect rhomboids.

Stahl thought that he had proved, by analyſis and ſyntheſis, that ſulphur is formed by the combination of his phlogiſton with the ſulphuric acid. The happy ſeries of proofs which he has left behind him for the eſtabliſhment of this opinion, has appeared ſo complete, that, ſince the time of this great man, his doctrine has conſtantly

been

been admitted as founded on absolute proof. This example was even urged as an instance to shew how high a degree of evidence the chemical analysis was capable of affording. But our discoveries respecting gaseous substances have shewn us, that the ancients were necessarily led into error for want of that knowledge. The immense researches of the moderns into the composition of acids, have shewn that these substances are decomposed in a variety of operations; and this revolution in the state of our knowledge must have produced a similar change in our methods of explaining the phenomena. An examination of the principal experiments of Stahl, upon which his doctrine essentially depends, will sufficiently shew the truth of what we have asserted.

If one third part of charcoal, and two thirds of sulphate of pot-ash, or vitriolated tartar, be mixed and fused in a crucible, the product is (liver of sulphur) sulphure of pot-ash. If this sulphure be dissolved in water, and the alkali be engaged by adding a few drops of sulphuric acid, a precipitate is afforded, which consists of true sulphur: " whence," says Stahl, " the sulphur is a combination of phlogiston, or the inflammable principle of the charcoal with the sulphuric acid." The experiment was true, but the

the confequence is abfurd; becaufe it would follow that the fulphuric acid which was added, muft have poffeffed the property of difplacing fulphuric acid united to the alkali *.

If Stahl had more ftrictly analyfed the refult or product of this operation, he would have been convinced that it does not contain a particle of fulphuric acid.

If he had been poffeffed of the power of operating in clofed veffels, and of collecting the gafeous fubftances which are difengaged, he would have obtained a large quantity of carbonic acid, which arifes from the combination of the oxigene of the fulphuric acid with the charcoal.

If he had expofed his liver of fulphur to the air in clofed veffels, he would have feen that the vital air is abforbed, that the fulphure is decompofed, and that the fulphate of pot-afh, or

* Without pretending, on the prefent occafion, to difpute either for or againft phlogifton, I fhall obferve that this argument is one among the many paralogifms urged on both fides in this controverfy. If there be any difficulty in conceiving how dephlogifticated fulphur, or pure vitriolic acid, may difplace phlogifticated vitriolic acid, or fulphur, the fame will apply to the oppofite theory, which afferts that aërated fulphur, or vitriolic acid, difplaces de-aërated vitriolic acid, or pure fulphur. T.

vitriolated

vitriolated tartar is formed; which proves the recompofition of the fulphuric acid.

If charcoal be moiftened with fulphuric acid or oil of vitriol, and then expofed to diftillation, the products are carbonic acid or fixed air, fulphur, and much fulphureous or volatile vitriolic acid.

The experiments of Stahl exhibit the moft perfect demonftration of the decompofition of the fulphuric acid into fulphur and oxigene; and it is not neceffary, in the explanation of them, either to fuppofe the exiftence of an imaginary being, or to fuppofe that fulphur is a compounded body.

C H A P. III.

Concerning Carbone.

PURE charcoal is called Carbone in the new Nomenclature. This fubftance is placed among fimple bodies, becaufe no experiment has hitherto fhewn the poffibility of decompofing it.

Carbone exifts ready formed in vegetables. It may be cleared of all the volatile and oily principles by diftillation; and, by fubfequent wafhing in pure water, it may be deprived of

all

all the falts which are mixed and confounded
with it.

When it is required to procure carbone in a
ftate of great purity, it muft be dried by ftrong
ignition in a clofed veffel : this precaution is
neceffary ; for the laft portions of water adhere
with fuch avidity, that they are decompofed,
and afford hydrogenous gas and carbonic acid.

Carbone exifts likewife in the animal king-
dom : it may be extracted by a procefs fimilar
to that which we have defcribed ; but its quan-
tity is fmall.   It appears in the form of a light
fpungy mafs, difficultly confumed in the air,
and mixed with a great quantity of phofphates,
and even of fodar.

Carbone is likewife found in plumbago, of
which it is one of the principles.

We fhall treat more fully of this fubftance in
the analyfis of vegetables.   But thefe concife
ideas are fufficient to enable us to proceed in our
account of its combinations, which is indeed the
only object of the prefent fhort enumeration of
its properties.

SECTION V.

Concerning Gases, or the Solution of cer-
tain Principles in Caloric, at the Tempe-
rature of the Atmosphere.

CALORIC, in its combination with bo-
dies, volatilizes some of them, and reduces
them to the aëriform state. The permanence
in this state in the temperature of the atmo-
sphere constitutes the gases; so that, to reduce
a substance to the state of gas, consists in dis-
solving it in caloric.

Caloric combines with various bodies, with
greater or less facility; and we are acquainted
with several that, at the temperature of the at-
mosphere, are constantly in the state of gas:
there are others which pass to this state at some
degrees higher, and these are called Volatile or
Evaporable substances. They differ from fixed
substances, because these last are not volati-
lized but by the application and combination of
a strong dose of caloric.

It appears that all bodies do not indiscrimi-
nately require the same quantity of caloric to af-
sume the gaseous state; and we shall see that
this

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this proportion may be deduced from the fixation and concretion of these gaseous substances.

To reduce any substance to the state of gas, the application of caloric may be made in various manners.

The more simple method consists in placing the body in contact with another body which is heated. In this situation, the heat on one hand diminishes the affinity of aggregation or composition, by separating the constituent principles to a greater distance from each other; on the other hand, the heat unites to the principles with which it has the strongest affinity, and volatilizes them. This process is according to the method of simple affinities; for it in fact consists of the exhibition of a third body, which, presented to a compound of several principles, combines with one of them, and carries it off.

The method of double affinity may likewise be used to convert any substance into the gaseous form; and this is what happens when we cause one body to act upon another to produce a combination, in which a disengagement of some gaseous principles takes place. If I pour, for example, the sulphuric acid upon the oxide of manganese, the acid combines with the metal, while its caloric seizes the oxigene, and rises

with

with it. This principle takes place not only in this inftance, but on all other occafions wherein, an operation being performed without the application of heat, there is a production of vapour or gas.

The various ftates under which bodies prefent themfelves to our eyes, depend almoft entirely upon the different degrees of combination of caloric with thofe fame bodies. Fluids do not differ from folids, but becaufe they conftantly poffefs, at the temperature of the atmofphere, the dofe of caloric which is requifite to maintain them in that ftate; they congeal and pafs to the concrete ftate with greater or lefs facility, accordingly as the requifite quantity of caloric is more or lefs confiderable.

All folid bodies are capable of paffing to the gafeous ftate; and the only difference which exifts between them in this refpect is, that a dofe of caloric is required for this purpofe, which is governed—1. By the affinity of aggregation, which connects their principles, retains them, and oppofes itfelf to a new combination. 2. By the weight of the conftituent parts, which renders their volatilization more or lefs difficult. 3. By the agreement and attraction between the caloric and the folid body, which is more or lefs ftrong.

All

All bodies, whether folid or liquid, when they come to be volatilized by heat, appear in two ftates—that of vapour, or that of gas.

In the firft cafe, thefe fubftances lofe, in a fhort time, the caloric which raifed them, and again appear in their original form the moment the caloric finds colder bodies to combine with; but it is rare that bodies thus divided refume their original confiftence. This firft ftate is that of vapour.

In the fecond cafe, the combination of caloric with the volatilized fubftance is fuch, that the ordinary temperature of the atmofphere is infufficient to overcome this union. This ftate conftitutes the gafes.

When the combination of caloric with any fubftance is fuch that a gas is produced, thefe invifible fubftances may be managed at pleafure, by the affiftance of apparatus appropriated within our time to thefe ufes. Thefe apparatus are known by the name of Pneumato-chemic, Hydro-pneumatic apparatus, &c.

The pneumato-chemical apparatus, in general, confifts of a wooden veffel, ufually of a fquare form, and lined with lead or tin : two or three inches beneath the upper edge there is formed a groove, in which a wooden plank flides, having a hole in the middle, and a notch
in

in one of its fides; the hole is made in the center of an excavation made in the fhelf, of the figure of a funnel.

This veffel is filled with water or mercury, according to the nature of the gafes operated upon. There are fome which eafily combine with water, and therefore require to be received over mercury.

The gafes may be extracted in various manners.

When they are difengaged by fire, a recurved tube is adapted to the neck of the retort, one extremity of which is plunged in the water or the mercury of the pneumato-chemical veffel, and opens beneath the aperture in the fhelf, which is in the form of a funnel. The junction of the tube with the neck of the retort is fecured with the ufual lute; a veffel filled with the liquid of the ciftern is inverted upon the fhelf over the aperture. When the gas is difengaged from the materials in the retort, it appears in the form of bubbles, which rife, and gain the fuperior part of the inverted veffel. When all the water is difplaced, and the bottle is full of gas, it is withdrawn, by adapting a glafs plate to its orifice to prevent its diffipation: it may then be poured from one veffel to another, and fub-

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jeded to a variety of experiments to afcertain its nature.

When the gafes are difengaged by means of acids, the mixture which is defigned to afford them is put into a bottle with a recurved tube fitted to its neck; and this tube is plunged in the ciftern in fuch a manner, that the bubbles of gas may pafs, as in the former experiment, through the aperture of the funnel in the fhelf.

The proceffes at prefent ufed to extract the gafes, and to analyfe them, are fimple and commodious: and thefe proceffes have fingularly contributed to our acquifition of the knowledge of thefe aëriform fubftances, whofe difcovery has produced a revolution in chemiftry.

C H A P. I.

Concerning Hydrogenous Gas, or Inflammable Air.

INFLAMMABLE Air is one of the conftituent parts of water; a circumftance which has entitled it to the denomination of Hydrogenous Gas. Its property of burning with vital air has caufed it to be diftinguifhed by the name of Inflammable Air.

Hydro-

Hydrogenous gas has been procured long fince. The famous philofophical candle attefts the antiquity of this difcovery ; and the cele-brated Hales obtained from moft vegetables an air which took fire.

Hydrogenous gas may be extracted from all bodies in which it is a conftituent part ; but the pureft is that afforded by the decompofition of water, and it is this fluid which ufually affords it in our laboratories. For this purpofe the fulphuric acid is poured upon iron, or zinc ; the water, which ferves as a vehicle for the acid, is decompofed on the metal ; its oxigene com-bines with it, while the hydrogenous gas efcapes. This explanation, however contrary to the an-cient notion, is not the lefs a demonftrated truth ; in fact, the metal exifts in the ftate of an oxide in its folution by the fulphuric acid, as may be proved by precipitating it with pure ve-getable alkali : on the other hand, the acid itfelf is not at all decompofed ; fo that the oxi-genous gas cannot have been afforded to the iron but by the water. Water may be decompofed likewife ftill more directly by throwing it upon iron ftrongly heated ; and hydrogenous gas may be obtained by caufing water to pafs through a tube of iron ignited to whitenefs.

The hydrogenous gas may be extracted by the

the simple distillation of vegetables. Vegetable fermentation, and animal putrefaction, likewise produce this gaseous substance.

The properties of this gas are as follow:

A. Hydrogenous gas has a disagreeable, stinking odour. Mr. Kirwan has observed, that when it is extracted over mercury, it has scarcely any smell. It contains half its weight of water, and loses its smell the moment it is deprived of this additional substance.

Kirwan has likewise observed, that the volume of hydrogenous gas is one-eighth larger when received over water than when received over mercury.

These observations appear to prove, that the offensive smell of this gas arises only from the water it holds in solution.

B. Hydrogenous gas is not proper for respiration. The abbé Fontana assures us that he could not take more than three inspirations of this air: the count Morrozo has proved that animals perish in it in a quarter of a minute. On the other hand, several northern chemists have affirmed, in consequence of experiments made on themselves, that hydrogenous gas might be respired without danger; and it is some years since the unfortunate Pilatre du Rozier filled his lungs with it at Paris, and set it on

fire

fire during the expiration, which forms a very curious jet of flame. It was remarked to him, that the abbé Fontana had objected against the accuracy of the Swedish chemists. This intrepid philosopher answered the objection, by mixing one-ninth of atmospherical air with very pure hydrogenous gas. He respired this mixture, as usual; but when he attempted to set it on fire, the consequence was an explosion so dreadful, that he imagined all his teeth were blown out.

This opposition of opinions, and contradiction of experiments, respecting a phenomenon which seems capable of unanswerable decision by one single experiment, induced me to have recourse to trial, to fix my own ideas on the subject.

Birds, successively placed in a vessel of hydrogenous gas, died, without producing the smallest perceptible change in the gas itself.

Frogs placed in forty inches of hydrogenous gas died in the space of three hours and a half: while others lived fifty-five hours in oxigenous gas and atmospheric air; and when I took them out still living, the air was neither vitiated nor diminished. Numerous experiments which I have made upon these animals, have led me to observe that they have the fa-

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culty

culty of ftopping their refpiration, when placed
in any noxious gas, to fuch a degree, that they
infpire only once or twice, and afterwards fuf-
pend every function on the part of the refpira-
tory organ.

I have fince had occafion to obferve that
thefe animals are not reduced into a putrid
mafs by remaining in hydrogenous gas, as was
affirmed fome time ago. The fact which may
have impofed on chemifts who related this cir-
cumftance, is, that frogs are often enveloped in a
mucus or fanies, which appears to cover them;
but they exhibit the fame phenomenon in all the
gafes.

After having tried the hydrogenous gas upon
animals, I determined to refpire it myfelf; and
I found that the fame volume of this air might
be feveral times refpired without danger. But
I obferved that this gas was not changed by
thefe operations; whence I concluded that it is
not refpirable: for, if it were, it would fuffer a
change in the lungs, the object of refpiration
not being confined to the reception and emiffion
of a fluid merely; it is a function much more
noble, more interefting, more intimately con-
nected with the animal œconomy: and we
ought to confider the lungs as an organ which is
nourifhed by the air, digefts that which is pre-
fented

fented to it, retains the beneficial, and rejects the
noxious part. Since therefore inflammable air
can be refpired feveral fucceffive times without
danger to the individual, and without any altera-
tion or change in itfelf, we may conclude in-
deed that inflammable air is not a poifon, but
that it cannot be confidered as an air effentially
proper to refpiration. It is with hydrogenous
gas in the lungs, as with thofe balls of mofs and
refin which certain animals fwallow during the
rigorous feafon of the winter. Thefe balls are
not digefted, fince the animals void them at
the return of fpring : but they delude hunger ;
and the membranes of the ftomach are exer-
cifed upon them without danger, in the fame
manner as the lungs exert themfelves upon the
hydrogenous gas prefented to them.

C. Hydrogenous gas is not combuftible
alone ; it does not burn but by the concurrence
of oxigene. If a veffel filled with this gas be
reverfed, and a lighted taper be prefented to
it, the hydrogenous gas is found to burn at the
furface of the veffel; but the candle is extin-
guifhed the moment it is plunged lower. The
moft inflammable bodies, fuch as phofphorus,
do not burn in an atmofphere of hydrogenous
gas.

D. Hydrogenous gas is lighter than common
air.

air. One cubic foot of atmofpheric air weighs feven hundred and twenty grains ; a cubic foot of hydrogenous gas weighs feventy-two grains. The barometer being at 29′ 9, and the thermometer 60° Fahrenheit, Mr. Kirwan found the weight of this air to that of common air as eighty-four to one thoufand ; confequently it was about twelve times as light.

Its fpecific gravity varies very much, becaufe it is difficult to obtain it conftantly of the fame degree of purity. That which is extracted from vegetables contains the carbonic acid and oil, which increafes its weight.

This levity of hydrogenous gas has caufed certain philofophers to prefume that it ought to arrive at and occupy the fuperior part of our atmofphere ; and upon this fuppofition the moft brilliant conjectures have been made refpecting the influence which a ftratum of this gas, predominating over the reft of the atmofphere, ought to produce in meteorology. They were not aware that this continual lofs of matter is not agreeable to the wife œconomy of nature. They did not obferve that this gas, during its afcent in the air, combines with other bodies, more efpecially the oxigene, and that water and other products are the refult ; the knowledge of which

<div align="right">muft</div>

muft neceffarily lead us to that of moft me-
teors.

The theory of balloons, or aëroftatic machines,
is founded on this levity of the hydrogenous
gas.

It order that a balloon may rife in the atmo-
fphere, it is fufficient that the weight of the bal-
loon itfelf, and the air it inclofes, fhould be lefs
confiderable than that of an equal bulk of at-
mofpheric air ; and it muft rife till its weight
is in equilibrio with an equal volume of the
furrounding air.

The theory of the Mongolfiers is very differ-
ent from this. In this cafe a given volume of
atmofpheric air is rarefied by heat, and kept
feparated from the common mafs by a hollow
veffel of cloth. This rarefied fpace may there-
fore be confidered for a moment as confifting of
a mafs of air of greater levity, which muft ne-
ceffarily make an effort to rife in the atmo-
fphere, and carry its covering along with it.

E. Hydrogenous gas exhibits various cha-
racters, according to its degree of purity, and
the nature of the fubftances which are mixed
with it.

It feldom happens that this gas is pure. That
which is afforded by vegetables contains oil,
and the carbonic acid. The inflammable air
of

of marfhes is mixed with a greater or lefs quantity of carbonic acid; and that which is afforded by the decompofition of pyrites fometimes holds fulphur in folution.

The colour of hydrogene, when fet on fire, varies according to its mixtures. One-third of the air of the lungs, mixed with the inflammable air of pit-coal, affords a flame of a blue colour; inflammable air, mixed with nitrous air, affords a green colour; the vapour of ether affords a white flame. The various mixtures of thefe gafes, and the degree of compreffion to which they are fubjected, when expreffed out of an aperture in order to burn them, have, in the hands of certain operators, afforded very agreeable illuminations, well deferving the attention of learned and curious obfervers.

F. Hydrogenous gas poffeffes the property of diffolving fulphur. In this cafe it contracts a ftinking fmell, and forms hepatic gas.

Mr. Gengembre put fulphur into inverted veffels filled with hydrogenous gas, and diffolved it by means of the burning-glafs. The hydrogenous gas, by this treatment, obtained all the characteriftic properties of hepatic gas.

The formation of this gas is almoft always an effect of the decompofition of water. In fact, the alkaline fulphures, or livers of fulphur, do

not

not emit any difagreeable fmell while they are dry; but the moment they are moiftened, an abominable fmell is perceived, and the ful-phate of pot-afh, or vitriolated tartar, begins to be formed. Thefe phenomena prove that the water is decompofed; that one of its principles unites to the fulphur, and volatilizes it; while the other combines with the alkali, and forms a more fixed product.

Sulphurated hydrogenous gas may be ob-tained by diffolving the fulphures or hepars by acids. Thofe acids in which the oxigene is moft adherent difengage the greateft quantity. The muriatic acid produces twice as much as the fulphuric. That which is produced by this laft, burns with a blue flame; but that which is difengaged by the muriatic acid, burns with a yellowifh white flame.

Scheele has taught us the means of obtaining this gas in great abundance, by decompofing artificial pyrites, formed by three parts of iron and one of fulphur, to which fpirit of vitriol is added.

The natural decompofition of pyrites in the bowels of the earth produces this gas; which efcapes with certain waters, and communicates peculiar virtues to them.

The moſt general properties of theſe gaſes
are :

1. They render the white metals black.

2. They are improper for reſpiration.

3. They impart a green colour to ſyrup of
violets.

4. They burn with a light blue flame, and
depoſit ſulphur by this combuſtion.

5. They mix with the oxigenous gas of the
atmoſpheric air, and form water; at the ſame time
that the ſulphur, before held in ſolution, falls
down. Hence it happens that ſulphur is found
in the channels of hepatic waters, though their
analyſis does not ſhew the exiſtence of an atom
of that ſubſtance held in ſolution.

6. They impregnate water, and are ſpar-
ingly ſoluble in that fluid ; but heat or agita-
tion diſſipates them again.

The air which burns at the ſurface of certain
ſprings, and forms what is known by the name
of burning ſprings, conſiſts of hydrogenous gas
holding phoſphorus in ſolution. It ſmells like
putrid fiſh. The Pere Lampi has diſcovered
one of theſe ſprings in the iſles of St. Colom-
bat. Dauphiny exhibits another ſimilar ſpring
at the diſtance of four leagues from Grenoble.
The ignes fatui which glide along burying-
grounds,

grounds, and which the fuperftitious people
fuppofe to confift of the fpirits of the departed,
are phenomena of this nature, which we fhall
fpeak of when we come to treat of phofphorus.

CHAP. II.

Concerning Oxigenous Gas, or Vital Air.

THIS gafeous fubftance was difcovered
by the celebrated Prieftley, on the 1ft
of Auguft 1774. Since that memorable day,
means have been devifed of obtaining it from
various fubftances; and its properties have
fhewn that it is a production of the moft in-
terefting nature in the knowledge of chemiftry.

No part of the atmofphere exhibits vital air
in its greateft degree of purity. It is always
combined, mixed, or altered by other fub-
ftances.

But this air, which is the moft general agent
in the operations of nature, exifts in combina-
tion with various fubftances; and it is by their

I 2   decom-

decompofition that it may be extracted and procured.

A metal expofed to the air becomes changed; and thefe changes are produced only by the combination of the pure air with the metal itfelf.   Simple diftillation of fome of thefe metals thus changed, or oxides, is fufficient to difengage this vital air; and it is then obtained in a very pure ftate, by receiving it in the hydro-pneumatic apparatus.   One ounce of red precipitate affords about a pint.

All acids have vital air for their bafe : there are fome which yield it eafily.   The diftillation of nitre decompofes the nitric acid; and about twelve hundred cubic inches of oxigenous gas are obtained from a pound of this falt.

The nitric acid, when diftilled from various fubftances, is decompofed, and its conftituent parts may be obtained feparately.

Meffrs. Prieftley, Ingenhoufz, and Sennebier difcovered nearly at the fame time that vegetables expofed to the light of the fun emit vital air.   We fhall elfewhere fpeak of the circumftances of thefe phenomena ; but fhall at prefent confine ourfelves to the obfervation, that the emiffion of vital air is proportioned to the vigour of the plant, and the vivacity of the light ; and that the direct emiffion of the rays

of

of the fun is not neceffary to produce this gafe-
ous dew ; it is fufficient that the plant be well
enlightened, in order that it may tranfpire pure
air : for I have often collected it in abundance
from a kind of mofs which covers the bottom
of a veffel filled with water, and fo well defended
that the fun never fhone directly upon it.

In order to procure the vital air which is dif-
engaged from plants, it is fufficient to inclofe
them beneath a glafs veffel filled with water, and
inverted over a tub filled with the fame fluid.
The moment the plant is acted on by the fun,
fmall bubbles of air are formed on its leaves,
which detaching themfelves, rife to the upper
part of the veffel, and difplace the liquid.

This dew of vital air is a beneficial gift of
nature, to repair inceffantly the confumption of
vital air. The plant abforbs atmofpherical
mephitis, and emits vital air. Man, on the
contrary, is kept alive by vital air, and emits
much mephitis. It appears therefore that the
animal and vegetable kingdoms labour for each
other; and that by this admirable reciprocity
of fervices the atmofphere is continually re-
paired, and an equilibrium maintained between
its conftituent principles.

The influence of folar light is not confined
to the production of vital air by its action upon

I 3 vegetables

vegetables alone ; it has likewife the fingular property of decompofing certain fubftances, and difengaging this gas.

A bottle of oxigenated muriatic acid, expofed to the fun, fuffers all the fuperabundant oxigene which it contained to efcape, and paffes to the ftate of ordinary muriatic acid. The fame acid, expofed to the fun in a bottle wrapped in black paper, does not fuffer any change ; and, when heated in a dark place, is even reducible into gas without decompofition. The nitric acid likewife affords oxigenous gas, when expofed to the fun ; whereas heat alone volatilizes it without decompofition.

The muriate, or marine falt of filver, placed under water, and expofed to the fun, fuffers oxigenous gas to efcape from it. I have obferved that red precipitate likewife affords oxigene in fimilar cafes, and that it becomes black in no very long fpace of time.

We may likewife obtain oxigenous gas by difengaging it from its bafes by means of the fulphuric acid. The procefs to which I give the preference, on account of its fimplicity, is the following :—I take a fmall apothecary's phial, into which I put one or two ounces of manganefe, and pour thereon a fufficient quantity of fulphuric acid to form a liquid pafte. I afterwards

wards fit a cork to the opening of the bottle, with a hole through it, into which is inferted a recurved tube ; one of whofe extremities enters the bottle, while the other is placed under the fhelf of the pneumato-chemical appa-ratus. When the apparatus is thus difpofed, I prefent a fmall coal to the lower part of the bottle, and oxigenous gas is immediately difen-gaged.

The manganefe I ufe was difcovered by me at St. Jean de Gardonnenque. It affords its oxi-gene with fuch facility, that nothing more is ne-ceffary for this purpofe than to incorporate it with the fulphuric acid. This gas is not per-ceptibly mixed with nitrigenous gas (or phlo-gifticated air) ; and the firft bubble is as pure as the laft.

Oxigenous gas exhibits certain properties, ac-cording to its degree of purity. Thefe depend in general upon the fubftances which afford it. That which is obtained from the mercurial oxides almoft always holds a fmall quantity of mercury in folution : I have been a witnefs to its having produced a fpeedy falivation on two perfons who ufed it for diforders of the lungs. In confequence of thefe obfervations, I filled bottles with this gas, expofed them to an intenfe cold, and the fides became obfcured with a

I 4　　　　　　　　ftratum

ſtratum of mercurial oxide, in a ſtate of extreme
diviſion. I have ſeveral times heated the bath,
over which I cauſed this gas to paſs; and I ob-
tained, at two different times, a yellow precipi-
tate in the bottle in which I had received the
gas.

The oxigenous gas extracted from plants is
not equally pure with that afforded by the me-
tallic oxides : but from whatever ſubſtances it
is obtained, its general properties are the fol-
lowing :

A. It is more ponderous than the air of the
atmoſphere; the cubic foot of atmoſpherical
air weighing ſeven hundred and twenty grains,
while the cubic foot of pure air weighs ſeven hun-
dred and ſixty-five. According to Mr. Kirwan,
its weight is to that of common air as eleven
hundred and three to one thouſand. One hun-
dred a nd ſixteen inches of this air weighed.
39,09 grains; one hundred and ſixteen inches
of common air weighed 35,38 grains at the
temperature of ten degrees of Reaumur, and
twenty-eight inches of preſſure. One hundred
parts of common air weighed forty-ſix, and
one hundred parts of vital air fifty.

B. Oxigenous gas is the only fluid proper
for combuſtion. This acknowledged truth
<div align="right">cauſed</div>

caufed the celebrated Scheele to give it the name of Air of Fire.

To proceed with greater order in the exa-mination of one of the moſt important proper-ties of oxigenous gas, ſince it belongs excluſively to this fluid, we ſhall lay down the four follow-ing principles, as inconteſtable reſults of all the known facts.

The firſt principle.—Combuſtion never takes place without vital air.

The ſecond principle.—In every combuſtion there is an abſorption of vital air.

The third principle.—There is an augmenta-tion of weight in the products of combuſtion equal to the weight of the vital air abſorbed.

The fourth principle.—In all combuſtion there is a diſengagement of heat and light.

I. The firſt of theſe propoſitions is a ſtrict truth. Hydrogenous gas does not burn alone, without the aſſiſtance of oxigene; and all com-buſtion ceaſes the moment that oxigenous gas is wanting.

II. The ſecond principle contains a truth no leſs general. If certain bodies, ſuch as phoſ-phorus, ſulphur, &c. be burned in very pure oxigenous gas, this is abſorbed to the laſt par-ticle; and when the combuſtion is effected in a mixture

mixture of several gases, the oxigene alone is absorbed, and the others remain unchanged.

In the flower combustions, such as the rancidity of oils, and the oxidation of metals, there is equally an absorption of oxigene, as may be shewn by confining these bodies in a determinate mass of air.

III. The third principle, though not less true than the preceding, requires more explanation ; and for this purpose we shall distinguish those combustions whose result, residue, and product are fixed, from those which afford volatile and fugacious substances.   In the first case the oxigenous gas quietly combines with the body ; and by weighing the same body the moment the combustion has completely taken place, it is easily ascertained whether the increase in weight be proportioned to the oxigene absorbed.   This happens in all the cases wherein the metals are oxided, or oils rendered rancid ; and in the production of certain acids, such as the phosphoric, the sulphuric, &c.   In the second case, it is more difficult to weigh all the results of the combustion, and consequently to ascertain whether the augmentation in weight be proportioned to the quantity of the air absorbed.   Nevertheless, if the combustion be made in inverted vessels,

and

and the whole of the products be collected, it is found that their augmentation in weight is strictly equal to that of the air abforbed.

IV. The fourth principle is that whofe applications are the moft interefting to be known.

In moft combuftions, the oxigenous gas becomes fixed and concrete. It therefore abandons the caloric which maintained it in the aëriform ftate ; and this caloric being fet at liberty, produces heat, and endeavours to combine itfelf with the fubftances neareft at hand.

The difengagement of heat is therefore a conftant effect in all the cafes wherein vital air is fixed in bodies; and it follows, from this principle—1. That heat is moft eminently refident in the oxigenous gas which maintains combuftion. 2. That the more oxigene is abforbed in a given time, the ftronger will be the heat. 3. That the only method of producing a violent heat confifts in burning bodies in the pureft air. 4. That fire and heat muft be more intenfe in proportion as the air is more condenfed. 5. That currents of air are neceffary to maintain and expedite combuftion. It is upon this principle that the theory of the effects of the cylinder lamps is founded : the current of air, which is renewed through the tube, fupplies frefh air every inftant ; and by continually applying

plying a new quantity of oxigenous gas to the flame, a heat is produced sufficient to ignite and destroy the smoke.

It is likewise on the same principle that we explain the great difference that exists between heat produced by a slow combustion, and that which is afforded by rapid combustion. In the latter case the same quantity of heat and light is produced in a second, which might have been produced in the other case in a much longer time.

The phenomena of combustion, by means of oxigenous gas, depend likewise upon the same laws. Professor Lichtenberger, of Gottingen, soldered the blade of a knife to a watch spring by means of oxigenous gas; Messrs. Lavoisier and Erhmann have subjected almost all the known bodies to the action of fire maintained by oxigenous gas alone; and they produced effects which the burning-glass could not have operated.

Mr. Ingenhousz has shewn us, that if an iron wire be bent into a spiral form, and any combustible substance whatever be fixed to one of its ends, and set on fire, the wire will itself be fused by plunging it into oxigenous gas.

Mr. Forster, of Gottingen, found that the light of glow-worms is so beautiful and bright in

in oxigenous gas, that one single insect was suf-
ficient to afford light to read the Annonces Sa-
vantes of Gottingen, printed in a very small
character. Nothing more is wanting therefore
than to apply this air to combustion with facility
and œconomy; and Mr. Meusnier has suc-
ceeded in this, by constructing a simple and com-
modious apparatus. On this subject the treatise
of Mr. Erhmann upon fusion may be consulted.

The description of the gazometer may like-
wise be seen in the Elementary Treatise of Che-
mistry, by Mr. Lavoisier.

We shall distinguish three states in the very
act of combustion—ignition, inflammation, and
detonation.

Ignition takes place when the combustible
body is not in the aëriform state, nor sus-
ceptible of assuming that state by the simple
heat of combustion. This happens when well-
made charcoal is burned.

When the combustible body is presented to
oxigenous gas, in the form of vapour or gas, the
result is flame; and the flame is more consider-
able, in proportion as the combustible body is
more volatile. The flame of a candle is not
kept up but by the volatilization of the wax,
which is continually effected by the heat of the
combustion.

Deto-

Detonation is a speedy and rapid inflamma-
tion, which occasions a noise by the instanta-
neous formation of a vacuum. Most detona-
tions are produced by the mixture of hydroge-
nous and oxigenous gas, as I have shewn in my
Memoir upon Detonations, in the year 1781.
It has been since proved, that the product of the
rapid combustion of these two gases is water.
Very strong detonations may be produced by
burning a mixture of one part of oxigenous
gas with two of hydrogene. The effect may be
rendered still more terrible, by causing the mix-
ture to pass through soap-water, and setting fire
to the bubbles which are heaped on the surface
of the fluid.

Chemistry presents several cases in which the
detonation arises from the sudden formation of
some gaseous substances, such as that which is
produced by the inflammation of gunpowder;
for in this case there is a sudden production of
carbonic acid, of nitrogene gas, &c. The pro-
duction or instantaneous creation of any gas
whatever, must occasion a shock or agitation in
the atmosphere, which necessarily affords an ex-
plosion; the effect of these explosions increases,
and becomes stronger, from the opposition of any
obstacles against the escape of the gas.

C. Oxigenous gas is the only gas proper for

respira-

refpiration. It is this moft eminent property which has entitled it to the name of Vital Air; and we fhall give the preference to this denomination in the prefent article.

It has long fince been known that animals cannot live without the affiftance of air. But the phenomena of refpiration have been very imperfectly known until lately.

Of all the authors who have written concerning refpiration, the ancients are thofe who have had the moft accurate ideas of it. They admitted in the air a principle proper to nourifh and fupport life, which they denoted by the name of *pabulum vitæ*; and Hippocrates exprefsly fays, *fpiritus etiam alimentum eft*. This idea, which was connected with no hypothefis, has been fucceffively replaced by fyftems void of all foundation. Sometimes the air has been confidered as a ftimulus in the lungs, which kept up the circulation by its continual action. Vide Haller.—Sometimes the lungs have been confidered as bellows defigned to cool the body, heated by a thoufand imaginary caufes: and when it was proved that the volume of air was diminifhed in the lungs, it was thought to be an explanation of every difficulty, to fay that the air was deprived of its fpring.

At this day, however, we are enabled to throw
fome

some light on one of the most important func-
tions of the human body. In order to proceed
with more perspicuity, we shall reduce our no-
tions to several principles.

1. No animal can live without the assistance
of air. This fact is universally admitted; but
it has not been known until lately that the fa-
culty which the air possesses of answering the
purpose of respiration, arises only from one of
the principles of atmospheric air, known by the
name of vital air.

2. All animals do not require the same pu-
rity in the air. Birds, as well as men, and the
greatest part of quadrupeds, require a very pure
air; but those which live in the earth, or which
hide themselves in a state of stupefaction dur-
ing the winter, can subsist by means of a less
pure air.

3. The manner of respiring the air is diffe-
rent in the several subjects. In general, nature
has given to animals an organ, which by its
involuntary dilatation and contraction receives
and expels the fluid in which the animal moves
and exists. This organ is more or less perfect,
more or less concealed and defended from ex-
ternal injury, according to its importance, and
influence upon the life of the creature, as Mr.
Broussonnet has observed.

Amphi-

Amphibious animals respire by means of lungs : but they can suspend their motion even whilst they are in the air; as I have observed with regard to frogs, which stop their respiration at pleasure.

The manner of respiration in fishes is very different; these animals come from time to time to inhale the air at the surface of the water, where they fill their vesicle, and digest it afterwards at their ease. I have for a long time observed the phenomena of fishes in the act of respiration; and am well assured that they are sensible of the action of all the gases, like other animals. Mr. De Fourcroy has observed that the air contained in the vesicle of the carp is nitrogene gas (phlogisticated air).

Insects with tracheæ exhibit organs still more remote from ours in their construction. In these animals, respiration is effected by the tracheæ distributed along the body. They accompany all the vessels, and terminate by losing themselves in insensible pores at the surface of the skin.

These insects appear to me to exhibit several very evident points of analogy with vegetables.

1. Their respiratory organs are formed in the same manner, being disposed through the whole body of the vegetable and the animal.—

2. Infects do not require a great degree of purity in the air; and plants are nourished with atmospherical mephitis.—3. Both the one and the other transpire vital air. The abbé Fontana discovered several infects in stagnant waters, which, when exposed to the fun, afforded vital air: and the green matter which is formed in stagnant waters, and is by Dr. Priestley placed among the confervæ, in conformity with the opinion of his friend Mr. Bewley—which Mr. Senebier has supposed to be the *conferva cespitosa filis rectis undique divergentibus Halleri*, and which has appeared to Dr. Ingenhousz to be nothing else but a mass of animalcula—affords a prodigious quantity of this air when exposed to the fun.—4. Infects likewise afford, by chemical analysis, principles similar to those of plants, such as refins, volatile oils, &c.

Father Vaniere appears to have known, and very elegantly expressed, the property of vegetables to support themselves by means of vital air:

. . . . Arbor enim (res non ignota), ferarum
Inftar et halituum, pifcifque latentis in imo
Gurgite, vitales et reddit et accipit auras.

PROEDIUM RUSTICUM, l. vi.

Animals with lungs respire only by virtue of the vital air which surrounds them. Any gas deprived

deprived of this mixture becomes immediately improper for refpiration; and this function is exercifed with fo much the greater liberty, as vital air exifts in a greater proportion in the air refpired.

Count Morozzo placed fucceffively feveral full-grown fparrows under a glafs bell, inverted over water. It was at firft filled with atmofpherical air, and afterwards with vital air. He obferved—

1. In atmofpherical air,

	Hours.	Min.
The firft fparrow lived	3	0
The fecond -	0	3
The third -	0	1

The water rofe in the veffel eight lines during the life of the firft; four during the life of the fecond; and the third produced no abforption.

2. In vital air,

	Hours.	Min.
The firft fparrow lived	5	23
The fecond -	2	10
The third -	1	30
The fourth -	1	10
The fifth -	0	30
The fixth -	0	47
The feventh -	0	27
The eighth -	0	30
The ninth -	0	22
The tenth -	0	21

From

From thefe experiments it may be concluded,
1. That an animal lives longer in vital air than
in atmofpherical air. 2. That an animal can
live in air in which another has died. 3. That,
independent of the nature of the air, refpect
muft be had to the conftitution of the animals, as
the fixth lived forty-feven minutes, and the fifth
only thirty.   4. That there is either an abforp-
tion of air, or the production of a new kind of
air, which is abforbed by the water as it rifes.

It remains, at prefent, to examine what are
the changes produced by refpiration. 1. In
the air. 2. In the blood.

The gas emitted by expiration is a mixture
of nitrogene gas, carbonic acid, and vital air.
If the air which iffues from the lungs be made
to pafs through lime-water, it renders it turbid;
if it be received through tincture of turnfole, it
reddens it; and if a pure alkali be fubftituted
inftead of the tincture of turnfole, it becomes
effervefcent.

When the carbonic acid has been abforbed
by the foregoing procefs, the remainder of this
air confifts of nitrogene gas and vital air. The
vital air is fhewn to be prefent by means of ni-
trous air.   The air in which I had caufed five
fparrows to perifh, afforded feventeen hundredth
parts of vital air. After having thus deprived
the

the expired air of all its vital air, and all its carbonic acid, the remainder is nitrogene gas.

It has been obſerved that frugivorous animals vitiate the air leſs than carnivorous animals.

A portion of the air is abſorbed in reſpiration. Borelli formerly took notice of this; and Dr. Jurin had calculated that a man inſpired forty cubic inches of air in his uſual inhalations, and that in the greateſt he could receive two hundred and twenty inches; but that a portion was always abſorbed. The celebrated Dr. Hales endeavoured to determine this abſorption more ſtrictly, and he eſtimated it at a ſixty-eighth of the total of the reſpired air; but he did not conſider it as more than a hundred and thirty-ſixth, on account of errors which he ſuppoſed to have taken place. Now a man reſpires twenty times in a minute, and inhales forty cubic inches of air at each inſpiration: this makes forty-eight thouſand per hour; which, divided by one hundred and thirty-ſix, gives about three hundred and fifty-three inches of air abſorbed and deſtroyed in the hour. The proceſs of Hales is not exact; becauſe he paſſed the air expired through water, which muſt have retained a ſenſible proportion.

From more accurate experiments, Mr. De la Metherie

K 3

Metherie has proved, that three hundred and sixty cubic inches of vital air are abforbed in an hour.

My experiments have not shewn near so great a loss.

This fact affords a proof of the facility with which air is vitiated by respiration when it is not renewed, and shews why the air of theatres is in general so unwholesome.

II. The first effect which the air appears to produce upon the blood is, that of giving it a vermilion-colour. If the blackish venous blood be exposed in a pure atmosphere, it becomes of a vermilion-colour at its surface: this fact is daily observed when blood is suffered to remain exposed in a porringer to the air. Air which has remained in contact with blood, extinguishes candles, and precipitates lime-water. Air injected into a determinate portion of a vein between two ligatures, renders the blood of a higher colour, according to the fine experiments of Dr. Hewson.

The blood which returns from the lungs is of a higher colour, according to the observations of Messrs. Cigna, Hewson, &c. Hence arises the great intensity of the colour of arterial blood, compared with venous blood.

Mr. Thouvenel has proved, that by with-

drawing

drawing the air which is in contact with the blood, it may be again made to lose its colour.

Mr. Beccaria exposed blood in a vacuum, where it remained black, but assumed the most beautiful vermilion-colour as soon as it was again exposed to the air. Mr. Cigna covered blood with oil, and it preserved its black colour.

Dr. Priestley caused the blood of a sheep to pass successively into vital air, common air, mephitic air, &c. and he found that the blackest parts assumed a red colour in respirable air, and that the intensity of this colour was in proportion to the quantity of vital air present. The same philosopher filled a bladder with blood, and exposed it to pure air. That portion of blood which touched the surface of the bladder, became red, while the internal part remained black; an absorption of air therefore took place through the bladder, in the same manner as when the contact is immediate.

All these facts incontestably prove, that the vermilion-colour assumed by the blood in the lungs, is owing to the pure air which combines with it.

The vermilion-colour of blood is therefore the first effect of the contact, absorption, and combination of pure air with the blood.

The

The fecond effect of refpiration is to eftablifh a real focus of heat in the lungs; which is a circumftance very oppofite to the precarious and ridiculous notion of thofe who have confidered the lungs as a kind of bellows defigned to cool the human body.

Two celebrated phyficians, Hales and Boerhaave, have obferved that the blood acquired heat in paffing through the lungs; and modern phyfiologifts have eftimated this augmentation of heat at eleven hundredths.

The heat in each clafs of individual animals is proportioned to the magnitude of their lungs, according to Meffrs. De Buffon and Brouffonet.

Animals with cold blood have only one auricle and one ventricle, as Ariftotle obferved.

Perfons who have refpired vital air, agree in affirming that they perceived a gentle heat vivifying the lungs, and infenfibly extending from the breaft into all the other parts of the body.

Ancient and modern facts unite therefore to prove, that a focus of heat really exifts in the lungs, and that it is maintained and kept up by the air of refpiration. We are able, at prefent, to explain all thefe phenomena. In fact there is an abforption of vital air in refpiration: Refpiration then may be confidered as an opera-

tion

tion by means of which vital air paffes conti-
nually from the gafeous to the concrete ftate:
it muft therefore at each inftant abandon the
heat which held it in folution, and in the ftate
of gas. This heat produced at every infpira-
tion muft be proportioned to the volume of
the lungs, to the activity of this organ, to the
purity of the air, the rapidity of the infpirations,
&c. Hence it follows that, during the winter,
the heat produced muft be more confiderable,
becaufe the air is more condenfed, and exhi-
bits more vital air under the fame volume. By
the fame reafon, refpiration ought to produce
more heat in the inhabitants of northern cli-
mates; and this is one of the caufes prepared
by nature to temperate, and continually balance,
the extreme cold of thefe climates. It follows
likewife that the lungs of afthmatic perfons are
lefs capable of digefting the air; and I am af-
fured that they emit the air without vitiating it:
from which caufe their complexion is cold, and
their lungs continually languifhing; vital air
is therefore wonderfully comfortable to them.
It may be eafily conceived from thefe princi-
ples why the heat of animals is proportioned to
the volume of their lungs; and why thofe which
have only one auricle, and one ventricle, have
cold blood, &c.

The

The phenomena of refpiration are therefore the fame as thofe of combuftion.

Vital air, by combining with the blood, forms the carbonic acid, which may be confidered as antiputrefcent as long as it remains in the circulation; and that it is afterwards emitted through the pores of the fkin, according to the experiments of the count De Milly, and the obfervations of Mr. Fouquet.

Vital air has been ufed with fuccefs in certain diforders of the human body. The obfervations of Mr. Caillens are well known. He caufed perfons affected with phthifical diforders to refpire it with the greateft fuccefs. I have myfelf been a witnefs to the moft wonderful effects of this air in a fimilar cafe. Mr. De B—— was in the laft ftage of a confirmed phthifis. Extreme weaknefs, profufe fweats, a flux of the belly, and in fhort every fymptom, announced the approach of death. One of my friends, Mr. De P——, put him upon a courfe of vital air. The patient refpired it with delight, and afked for it with all the eagernefs of an infant at the breaft. During the time that he refpired it he felt a comfortable heat, which diftributed itfelf through all his limbs. His ftrength increafed with the greateft rapidity; and in fix weeks he was able to take long walks.
This

This state of health lasted for six months : but after this interval he relapsed ; and being no longer able to have recourse to the use of vital air, because Mr. De P—— had departed for Paris, he died.—I am very far from being of opinion that the respiration of vital air ought to be considered as a specific, in cases of this nature. I am even in doubt whether this powerful air is perfectly adapted to such circumstances ; but it inspires cheerfulness, renders the patient happy, and in desperate cases it is most certainly a precious remedy, which can spread flowers on the borders of the tomb, and prepare us in the gentlest manner for the last dreadful effort of nature.

The absolute necessity of vital air in respiration, enables us to lay down positive principles for purifying the corrupted air of any given place. This may be done in three ways. The first consists in correcting the vitiated air by means of substances which are capable of seizing the noxious principles. The second consists in displacing the corrupted air, and substituting fresh air in the room of it ; as is done by means of ventilators, the agitation of doors, &c. And the third consists in pouring into the mephitised atmosphere a new quantity of vital air.

The

The proceſſes employed in purifying cor-
rupted air, are not all certain in their effects.
The fires which are lighted for this purpoſe have
no other advantage than to eſtabliſh aſcending
currents, and to burn unhealthy exhalations;
and perfumes do nothing more than diſguiſe the
bad ſmell, without changing the nature of the
air, as the experiments of Mr. Achard ſhew.

C H A P.   III.

Concerning Nitrogene Gas, Azote, or Atmoſpherical
Mephitis.

IT has been long ſince aſcertained, that air
which has ſerved the purpoſes of combuſ-
tion and reſpiration, is no longer proper for
thoſe uſes : the air thus corrupted has been
diſtinguiſhed by the names of Phlogiſticated Air,
Mephitiſed Air, Atmoſpherical Mephitis, &c.
I call it Nitrogene Gas, for the reaſons ex-
plained in the preliminary diſcourſe.

But this reſidue of combuſtion or reſpiration
is always mixed with a ſmall quantity of vital
air

air and carbonic acid, which muſt be removed in order to have the nitrogene gas in a ſtate of purity. There are ſeveral methods which may be uſed to obtain nitrogene gas, in a very pure ſtate.

1. Scheele has taught us, that by expoſing ſulphure of alkali, or liver of ſulphur, in a veſ-ſel filled with atmoſpherical air, the vital air is abſorbed; and, when the abſorption is complete, the nitrogene gas remains pure.

By expoſing, in atmoſpheric air over mercury, a mixture of iron and ſulphur, kneaded toge-ther with water, Mr. Kirwan obtained nitro-gene gas ſo pure, that it ſuffered no diminution by nitrous gas. He deprived it of all humidity, by ſucceſſively introducing dried blotting-paper into the veſſel which contained it. Care muſt be taken to withdraw this air in time from the paſte which affords it; otherwiſe it will be mixed with hydrogene or inflammable gas, which is afterwards diſengaged. 2. When by any means, ſuch as the oxidation of metals, the rancidity of oils, the combuſtion of phoſphorus, &c. the vital air of the atmoſphere is abſorbed, the reſidue is nitrogene gas. All theſe proceſſes afford me-thods of greater or leſs accuracy to determine the proportions of vital air and nitrogene gas in the compoſition of the atmoſphere.

3. This

3. This mephitis may likewife be procured by treating muſcular fleſh, or the well-waſhed fibrous part of blood, with nitric acid in the hydro-pneumatic apparatus. But it muſt be carefully obferved that thefe animal matters ought to be freſh; for, if they have begun to be changed by the putrid fermentation, they afford carbonic acid mixed with hydrogene gas.

A. This gas is improper for refpiration and combuftion.

B. Plants live in this air, and freely vegetate in it.

C. This gas mixes with the other airs, without combining with them.

D. It is lighter than the atmofpheric air, the barometer ftanding at 30.46, and Fahrenheit's thermometer at 60 : the weight of nitrogene gas is to that of common air as nine hundred and eighty-five to one thoufand.

E. Mixed with vital air, in the proportion of 72 to 28, it conftitutes our atmofphere. The other principles which analyfis exhibits in the atmofphere, are only accidental, and by no means neceffary.

SECTION VI.

Concerning the Mixture of Nitrogene and Oxigene Gas ; or of Atmofpheric Air.

THE gafeous fubftances we have treated of feldom exift alone and infulated ; nature prefents them every where to our obfervation in a ftate of mixture or of combination. In the firft cafe thefe gafes preferve the aëriform ftate ; in the fecond they for the moft part form fixed and folid bodies. .Nature, in its feveral decompofitions, reduces almoft all the principles of bodies into gas. Thefe new fubftances unite together, combine, and from thence refult compounds of confiderable fimplicity in their principles, but which become complicated by fubfequent mixtures and combinations. We may follow the operations of nature, ftep by ftep, without departing from the plan we have adopted.

The mixture of about feventy-two parts of nitrogene gas, and twenty-eight of oxigene, form this fluid mafs in which we live. Thefe two

<div align="right">principles</div>

principles are fo well mixed, and each of them
is fo neceffary to the fupport of the various
functions of individuals which live or vegetate
upon the globe, that they have not yet been
found feparate and alone.

The proportion of thefe two gafes is fub-
ject to variation in the mixture which forms
the atmofphere : but this difference depends
only upon local caufes ; and the moft ufual
propor tion is that which we have here men-
tioned.

The characteriftic properties of vital air are
modified by thofe of nitrogene gas, and thefe
modifications even feem to be neceffary : for if
we were to refpire vital air in its ftate of purity,
it would quickly confume our life; and this
virgin air is no more fuitable to our exiftence
than diftilled water.	Nature does not ap-
pear to have defigned us for the ufe of thefe
principles in their greateft degree of perfec-
tion.

The atmofpheric air is elevated feveral
leagues above our heads, and fills the deepeft
fubterraneous cavities. It is invifible, infipid,
inodorous, ponderous, elaftic, &c.	It was the
only gafeous fubftance known before the pre-
fent epocha of chemiftry ; and the infinite gra-
dations of all the invifible fluids which prefented
them-

themselves so frequently to the observation of philosophers, were always attributed to modifications of the air. Almost the whole of what has been written upon the air relates only to its physical properties. We shall confine ourselves to point out the chief of these.

A. Air is a fluid of extreme rarefaction, obedient to the smallest motion : the slightest percussion deranges it ; and its equilibrium, which is continually destroyed, is continually endeavouring to restore itself.

Though very fluid, it passes with difficulty through orifices by means of which grosser liquids can easily penetrate. This has caused philosophers to suppose that its parts were of a branched form*.

B. The atmospheric air is invisible. It refracts the rays of light without reflecting them : for it is without sufficient proofs that some philosophers have imagined that large masses of this fluid are of a blue colour.

It appears that the air is inodorous itself; though it is the vehicle of odorant particles.

* This is a deception. It is true that the cohesive attraction renders it difficult to displace any dense fluid from a capillary tube by the intrusion of air ; but every experiment of the air-pump, the condensor, and the barometer, shews with what facility the air passes through the smallest orifices. T.

It may be considered as insipid; and when its contact affects us variously, we ought to attribute it to its physical qualities.

C. It was not until the middle of the last century that its weight was ascertained by accurate experiments. The impossibility of supporting water in a tube open at the bottom, to a greater height than thirty-two feet, caused Torricellius to suspect that an external cause supported the liquid at that height, and that it was not the horror of a vacuum which precipitated the water in the barrels of pumps. This celebrated philosopher filled a tube closed at one of its extremities with mercury: he reversed this into a vessel filled with the same metal; and observed that the mercury, after several oscillations, constantly subsided to the height of twenty-eight inches. He immediately saw that the difference of elevations corresponded with the relative weights of these two fluids, which are in the proportion of fourteen to one. The immortal Paschal proved, some time afterwards, that liquids were supported at this elevation by a column of atmospherical air; and he ascertained that their height varies according to the length of the column which presses upon them.

D. The elasticity of the air is one of the pro-
perties

perties upon which natural philosophers have made the greatest number of experiments ; and it has even been applied to considerable advantage in the arts.

SECTION VII.

Concerning the Combination of Oxigenous Gas and Hydrogene, which forms Water.

WATER has been long confidered as an elementary principle ; and when accurate experiments had compelled chemifts to clafs it among compound fubftances, a refiftance and oppofition were made to it, which were not manifefted when the air, the earth, and the other matters reputed to be elementary, were fubjected to fimilar revolutions. It feems to me, however, that this analyfis is equally ftrict with that of the air. Water is decompofed by feveral proceffes ; it is formed by the combination of oxigene and hydrogene : and we find that all the phenomena of nature and art confpire to prove the fame truth. What more can be required to afford an abfolute certainty refpecting any phyfical fact ?

Water is contained in bodies in a greater or lefs quantity, and may be confidered in twoftates:

it is either in the ſtate of ſimple mixture, or in a ſtate of combination. It the firſt caſe, it renders bodies humid, is perceptible to the eye, and may be diſengaged with the greateſt facility. In the ſecond, it exhibits no character which ſhews that it is in a ſtate of mixture. It exiſts in this form in cryſtals, ſalts, plants, animals, &c. It is this water which the celebrated Bernard has called Generative Water ; and of which he has made a fifth element, to diſtinguiſh it from exhalative water.

Water, exiſting in a ſtate of combination in bodies, concurs in imparting to them hardneſs and tranſparency. Salts, and moſt ſtóny cryſtals, loſe their tranſparency when they are deprived of their water of cryſtallization.

Some bodies are indebted to water for their fixity. The acids, for example, acquire fixity only by combining with water.

Under theſe various points of view, water may be conſidered as the general cement of nature. The ſtones and ſalts which are deprived of it, become pulverulent ; and water facilitates the coagulation, re-union, and conſiſtence of the particles of ſtones, ſalts, &c. as we ſhall ſee in the operations performed with plaſters, lutes, mortar, &c.

Water, when diſengaged from its combina-

L 3   tions,

tions, and in a state of absolute liberty, is one of the most considerable agents in the operations of this globe. It bears a part in the formation and decomposition of all the bodies of the mineral kingdom : it is necessary to vegetation, and to the free exercise of most of the functions of animal bodies ; and it hastens and facilitates the destruction of these bodies, as soon as they are deprived of the principle of life.

For a certain time water was thought to be a fluid earth. The distillation, trituration, and putrefaction of water, which always left an earthy residue, afforded credit to an opinion that it was converted into earth. On this subject, the works of Wallerius and Margraff may be consulted : but Mr. Lavoisier has shewn that this earth arises from the wear of the vessels ; and the celebrated Scheele has proved the identity of the nature of this earth with that of the glass vessels in which the operations were made. So that the opinions of the philosophical world are at present decided in this respect.

In order to obtain accurate ideas of a substance so necessary to be known, we will consider water under its three different states of solidity, fluidity, and gas.

1   A R T I-

ARTICLE I.

Concerning Water in the State of Ice.

Ice is the natural ſtate of water, whenever it is deprived of a portion of that caloric with which it is combined when it appears in the form of a liquid or gas.

The converſion into ice is attended with ſeveral phenomena which ſeldom vary.

A. The firſt of all, and at the ſame time the moſt extraordinary, is a ſenſible production of heat at the moment in which the water paſſes to the ſolid ſtate. The experiments of Meſſrs. Fahrenheit, Treiwald, Baumé, De Ratte, leave no doubt on this ſubject; ſo that the water is colder at the inſtant of congelation than the ice itſelf.

A ſlight agitation of the fluid facilitates its converſion into ice, nearly in the ſame manner as the ſlighteſt motion very frequently determines the cryſtallization of certain ſalts. This ariſes, perhaps, from the circumſtance, that by this means the caloric, which is interpoſed between the particles, and may oppoſe itſelf to the production of the phenomenon, may be

L 4   expreſſed

expreffed or difengaged. In proof of this opinion, it is feen that the thermometer rifes at the very fame inftant, according to Fahrenheit.

B. Frozen water occupies a larger fpace than fluid water: we are indebted to the Academy del Cimento for the proofs of this truth. In their experiments, bomb fhells, and the ftrongeft veffels, being filled with water, were burft into pieces by the congelation of this fluid. The trunks of trees are fplit and divided with a loud noife, as foon as the fap freezes; and fo likewife ftones are broken in pieces the moment the water with which they are impregnated paffes to the ftate of ice.

C. Ice appears to be nothing more than a confufed cryftallization. Mr. De Mairan obferved that the needle-formed cryftals of ice unite in an angle of either fixty or one hundred and twenty degrees.

Mr. Pelletier obferved, in a piece of fiftulous ice, cryftals in the form of flattened triangular prifms, terminated by two dehedral fummits.

Mr. Sage obferves, that if a piece of ice, which contains water in its internal parts, be broken, the water runs out, and the internal cavity is found to be lined with beautiful tetrahedral prifms, terminated in four-fided prifms. Thefe prifms are often articulated and croffed.

Vide

Vide M. Sage, Annales de Chimie, tom. i. p. 77.

Mr. Macquart has obferved, that when it fnows at Mofcow, and the atmofphere is not too dry, the air is obferved to be loaded with beautiful cryftallizations regularly flattened, and as thin as a leaf of paper. They confift of an union of fibres which fhoot from the fame center to form fix principal rays, and thefe rays divide themfelves into fmall blades extremely brilliant : he obferved feveral of thefe flattened radii which were ten lines in diameter.

D. When water pafles from the folid to the liquid ftate, it produces cold by the abforption of a portion of heat, as is confirmed by the fine experiments of Wilcke. This production of cold, by the fufion of ice, is likewife proved by the practice of the confectioners, who fufe certain falts with ice, in order to produce a degree of cold below o.

Ice is found in many places in great maffes, known by the name of Glacieres : certain mountains are conftantly covered with them, and the fouthern ocean abounds with them. The ice formed by falt water affords frefh water when melted ; and in feveral northern provinces water is faid to be concentrated by froft, to collect the falt it holds in folution. I have likewife obferved, that

that feveral metallic falts are precipitated by ex-
pofing their folutions to a temperature fufficient
to freeze them. The ice which was formed
did not poffefs the characters of the falt which
had been diffolved.

Hail and fnow are nothing but modifications
of ice. We may confider hail as produced by
the fudden difengagement of the elaftic fluid,
which concurs in rendering water liquid: it is
almoft always accompanied with thunder. The
experiments of Mr. Quinquet have confirmed
this theory.—I will here relate a fact to which
I myfelf was witnefs, at Montpelier, and of
which philofophers may advantageoufly avail
themfelves. On the 29th of October, 1786,
four inches of water fell at Montpelier; a vio-
lent explofion of thunder, which was heard about
four in the evening, and which appeared to be
very near, caufed a moft dreadful fhower of
hail. At this inftant a druggift, who was em-
ployed in his cellar in preventing the mifchief
occafioned by the filtration of water through the
wall, was highly aftonifhed to behold that the
water which came through the wall was inftantly
changed into ice. He called in feveral neigh-
bours to partake of his furprife. I vifited the
place a quarter of an hour afterwards, and found
ten pounds of ice at the foot of the wall: I was
                                        well

well affured that it could not have paffed through the wall, which did not exhibit any crack, but appeared to be in very good condition. Did the fame caufe, which determined the formation of hail in the atmofphere, act equally in this cellar?—I relate the fact only, and forbear to make any conjecture upon it.

ARTICLE II.

Concerning Water in the Liquid State.

The natural ftate of water appears to be that of ice: but its moft ufual ftate is that of fluidity; and under this form it poffeffes certain general properties, which we fhall proceed to defcribe.

The experiments of the Academy del Cimento have caufed the philofophical world to deny the leaft elafticity to water, becaufe it efcaped through the pores of balls of metal ftrongly compreffed, rather than yield to preffure. But Meffrs. Zimmerman, and the abbé Mongez, have endeavoured to prove its elafticity from the very experiments upon which the contrary opinion has been built *.

The

* The experiments of Canton, to prove the compreffibility of water, are well known, and may be feen in the Philofo-
phical

The liquid state renders the force of aggregation in water less powerful, and it enters into combination more readily in this form. Water which flows on the surface of our globe is never pure. Rain-water is seldom exempt from some mixture, as appears from the fine series of experiments of the celebrated Margraff. I have ascertained, at Montpelier, that the rainwater in storms is more impure than that of a gentle shower—that the water which falls first is less pure than that which falls after several hours or several days rain—that the water which falls when the wind blows from the sea to the southward, contains sea-salt; whereas that which is produced by a northerly wind, does not contain a particle.

Hippocrates has made several very important observations respecting the various qualities of water, relative to the nature of the soil, the temperature of the climate, &c.

As it is of importance to the chemist to have very pure water for several delicate operations,

phical Transactions. He inclosed water in spherical glass vessels, from which a narrow neck proceeded, like that of a thermometer: the water was found to occupy a larger space when the pressure of the atmosphere was removed by the airpump, and a less space when a greater pressure was added by the condensor. T.

it

it is neceffary to point out the means which may
be ufed to carry any water whatever to this de-
gree of purity.

Water is purified by diftillation. This ope-
ration is performed in veffels called Alembics.
The alembic is compofed of two pieces; a
boiler or cucurbit, and a covering called the
capital or head.

The water is put into the cucurbit, from which
it is raifed in vapours by means of fire, and
thefe vapours are condenfed by cooling the
head with cold water. The condenfed vapours
flow into a veffel defigned to receive them. This
is called Diftilled Water; and is pure, becaufe
it has left behind it in the cucurbit the falts
and other fixed principles which altered its
purity.

Diftillation is more fpeedy and quick, in pro-
portion as the preffure of the air is lefs upon the
furface of the ftagnant fluid. Mr. Lavoifier dif-
tilled mercury *in vacuo*; and the abbé Rochon
has made a happy application of thefe prin-
ciples to diftillation. It is to this fame prin-
ciple that we muft refer the obfervations of al-
moft all naturalifts and philofophers, who have
remarked, that the ebullition in the liquid be-
comes more eafy, in proportion as we afcend a
mountain from any other elevation; and it is

in

in consequence of these principles, that Mr. Achard constructed an instrument to determine the heights of mountains, by the degrees of temperature of the ebullition of boiling water.

The abbé Mongez, and Mr. Lamanow, observed that ether evaporates with prodigious facility upon the peak of Teneriffe; and Mr. De Saussure has confirmed these experiments on the mountains of Switzerland.

A true distillation is carried on every where at the surface of our globe. The heat of the sun raises water in the form of vapours; these remain a certain time in the atmosphere, and afterwards fall in the form of dew, by simple refrigeration. This rise and fall of humidity, which succeed each other, wash and purge the atmosphere of all those particles, which by their corruption or development might render it infectious; and it is perhaps this combination of various miasmata with water which renders the evening dew so unwholesome.

It is to a similar natural distillation that we ought to refer the alternate transition of water from the liquid state to that of vapour, which forms clouds, and by this means conveys the water from the sea to the summits of mountains, from which it is precipitated in torrents, to return again to the common receptacle.

We

We find traces of the distillation of water in the most remote ages. The first navigators in the islands of the Archipelago filled their pots with salt-water, and received the vapour in spunges placed over them. The process of distilling the water of the sea has been successively brought to perfection; and Mr. Poissonnier has exhibited a very well constructed apparatus to procure fresh water at all times in abundance.

Pure water requires to be agitated, and combined with the air of the atmosphere, to render it wholesome. Hence, no doubt, it is, that water immediately produced by melting snow, is unfit to drink.

The characters of potable water are the following:

1. A lively, fresh, and agreeable taste.

2. The property of boiling readily, and also that of boiling pease, and other pulse.

3. The virtue of dissolving soap without curdling.

ARTICLE III.

Concerning Water in the State of Gas.

Many substances are naturally in the state of an aëriform fluid, at the degree of the temperature

ture of our atmofphere : fuch, for example, are the carbonic acid ; and the oxigenous, the hydrogenous, and the nitrogenous gafes.

Other fubftances evaporate at a degree of heat very near that in which we live. Ether and alcohol are in this fituation. The firft of thefe liquors paffes to the ftate of gas at the temperature of 35 degrees ; the fecond, at that of 80 (of Reaumur).

Some fluids require a ftronger heat for this purpofe ; fuch as water, the fulphuric and nitric acids, oil, &c.

To convert water into an aëriform fluid, Meffrs. De la Place and Lavoifier filled a glafs veffel with mercury, and reverfed it over a difh filled with the fame metal. Two ounces of water were transferred beneath this veffel ; and the mercury was heated to the temperature of between ninety-five and a hundred of Reaumur, by plunging it in a boiler filled with the mother water of nitre. The included water became rarefied, and occupied the whole capacity.

Water, by paffing through earthen veffels ignited in the fire, becomes converted into gas, according to Prieftley and Kirwan. The æolipile, the fteam-engine, the digefter of Papin, and the procefs of the glafs-blowers, who blow large globes by injecting a mouthful of water

through

through their iron tube, prove the converſion of water into gas.

It follows from theſe principles, that the volatilization of water being nothing more than a direct combination of caloric with this liquid, the portions of water which are the moſt immediately expoſed to heat, muſt be the firſt volatilized: and this is daily obſerved; for it is continually ſeen that ebullition begins at the part moſt heated. But when the heat is applied equally at all parts, the ebullition is general.

Several phenomena have led us to believe that water may be converted into air. The proceſs of the glaſs-blowers to blow large ſpheres; the hydraulic organ of father Kircher; the phenomena of the æolipile; the experiments of Meſſrs. Prieſtley and Kirwan; the manner of aſſiſting combuſtion, by ſprinkling a ſmall quantity of water upon the coals—all theſe .circumſtances appeared to announce the converſion of water into air. But it was far from being ſuppoſed that moſt of theſe phenomena were produced by the decompoſition of this fluid; and the genius of Mr. Lavoiſier was neceſſary to carry this point of doctrine to the degree of certainty and preciſion, which in my opinion it now appears to poſſeſs.

Meſſrs. Macquer and De la Metherie had already obſerved, that the combuſtion of inflam-

VOL. I.   M   mable

mable air produced much water. Mr. Cavendiſh confirmed theſe experiments in England, by the rapid combuſtion of inflammable air and vital air. But Meſſrs. Lavoiſier, De la Place, Monge, and Meuſnier, have proved that the whole maſs of the water might be converted into hydrogene and oxigene; and that the combuſtion of theſe two gaſes produced a volume of water proportioned to the weight of the two principles employed in this experiment.

1. If a ſmall glaſs veſſel be inverted over mercury, and a known quantity of diſtilled water and filings of iron be put into the upper part of this veſſel, inflammable air will be gradually diſengaged, the iron will ruſt, and the water which moiſtens it will diminiſh, and at length diſappear; the weight of the inflammable air which is produced, and the augmentation in weight of the iron, will be equivalent to the weight of the water made uſe of. It appears therefore to be proved, that the water is reduced into two principles, the one of which is inflammable air, and the other is the principle which has entered into combination with the metal. Now we know that the oxidation or calcination of metals is owing to vital air; and conſequently the two ſubſtances produced, namely the vital air and inflammable air, ariſe from the decompoſition of water.

2. When

2. When water is converted into the state of vapour, in its paſſage through an ignited iron tube, the iron becomes oxided, and hydrogene is obtained in the ſtate of gas. The augmentation of weight in the metal, and the weight of the hydrogene obtained, form preciſely a ſum equal to that of the water employed.

The experiment made at Paris, in the preſence of a numerous commiſſion of the Academy, appears to me to leave no further doubt concerning the decompoſition of water.

A gun-barrel was taken, into which a quantity of thick iron wire, flattened by hammering, was introduced. The iron and the gun-barrel were weighed : the gun-barrel was then covered with a lute proper to defend it from the contact of the air ; it was afterwards placed in a furnace, and inclined in ſuch a manner as that water might run through it. At its moſt elevated extremity was fixed a funnel deſigned to contain water, and to let it paſs drop by drop by means of a cock : this funnel was cloſed, to avoid all evaporation of the water. At the other extremity of the gun-barrel was placed a tubulated receiver, intended to receive the water which might paſs without decompoſition; and to the tubulure of the receiver the pneumato-chemical apparatus was adapted. For

greater

greater precaution, a vacuum was made in the
whole apparatus before the operation began.
Laftly, as foon as the gun-barrel was red-hot,
the water was introduced drop by drop. Much
hydrogenous gas was obtained : and at the end
of the experiment the gun-barrel was found to
have acquired weight; and the flat pieces of
iron included within were converted into a
ftratum of black oxide of iron, or Ethiops
martial, cryftallized like the iron ore of the
ifland of Elba. It was afcertained that the iron
was in the fame ftate as that which is burned in
oxigenous gas; and the increafed weight of the
iron, added to that of the hydrogene, was accu-
rately equal to that of the water employed.

The hydrogenous gas obtained was burned
with a quantity of vital air equal to that which
had been retained by the iron, and the fix
ounces of water were recompofed.

3. Meffrs. Lavoifier and De la Place, by
burning in a proper apparatus a mixture of four-
teen parts of hydrogenous gas, and eighty-fix of
oxigene, obtained a proportionate quantity of
water. Mr. Monge obtained the fame refult at
Mezieres, at the fame time.

The moft conclufive and the moft authentic ex-
periment which was made upon the compofition
or fynthefis of water, is that which was begun
on

on the 23d of May, and ended on the 7th of June, 1788, at the Royal College, by Mr. Le fevre de Gineau.

The volume of oxigenous gas confumed, when reduced to the preffure of twenty-eight inches of mercury, at the temperature of ten degrees of the thermometer of Reaumur, was 35085 (French) cubic inches, and its weight 250 gros 10,5 grains.

The volume of hydrogenous gas was 74967,4 cubic inches, and the weight 66 gros 4,3 grains.

The nitrogenous gas and the carbonic acid which were mixed with thefe gafes, and which had been extracted out of the receiver at nine feveral times, weighed 39,23 grains.

The oxigenous gas contained $\frac{1}{38}$ of its weight of carbonic acid; fo that the weight of the gafes burned was 280 gros 63,8 grains, which makes 2 pounds 3 ounces 0 gros 63,8 grains.

The veffels were opened in the prefence of the gentlemen of the Academy of Sciences, and feveral other learned men, and were found to contain 2 pounds 3 ounces 0 gros 33 grains of water : this weight anfwers to that of the gafes made ufe of, wanting 31 grains ; this deficiency may arife from the caloric which held the gafes in folution being diffipated when they became

M 3   fixed,

fixed, which muſt neceſſarily have occaſioned a loſs.

The water was ſubacid to the taſte, and afforded 27½ grains of nitric acid, which acid is produced by the combination of the nitrogene and oxigene gaſes.

From the experiment of the decompoſition of water, 100 parts of this fluid contained

$$\text{Oxigene} \quad 84,2636 = 84\tfrac{1}{4}.$$
$$\text{Hydrogene} \quad 15,7364 = 15\tfrac{3}{4}.$$

According to the experiment of its compoſition, 100 parts of water contained

$$\text{Oxigene} \quad 84,8 = 84\tfrac{4}{5}.$$
$$\text{Hydrogene} \quad 15,2 = 15\tfrac{1}{5}.$$

Independent of theſe experiments of analyſis and ſyntheſis, the phenomena exhibited by water, in its ſeveral ſtates, confirm our ideas with regard to the conſtituent parts which we acknowledge it to poſſeſs. The oxidation of metals in the interior parts of the earth, at a diſtance from the atmoſpherical air, the effloreſcence of pyrites, and the formation of ochres, are phenomena which cannot be explained without the aſſiſtance of this theory.

Water, being compoſed of two known principles, muſt act like all other compound bodies which we know; that is, according to the affinities of its conſtituent parts. It muſt therefore

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in

in some instances yield its hydrogene, and in others its oxigene.

If it be placed in contact with bodies which have the strongest affinity with oxigene, such as the metals, oils, charcoal, &c. the oxigenous principle will unite with these substances ; and the hydrogene, being set at liberty, will be dissipated. This happens when hydrogene gas is disengaged, by causing the acids to act upon certain metals ; or when red-hot iron is plunged in water, as Messrs. Haffenfratz, Stoulfz, and D'Hellancourt have observed.

In vegetables, on the contrary, it seems that the hydrogene is the principle which fixes itself; while the oxigene is easily disengaged, and makes its escape.

SECTION VIII.

Concerning the Combinations of Nitrogene
Gas. 1. With Hydrogene Gas. 2. With
the Earthy Principles forming the Alkalis.

IT appears to be proved, that the combina-
tion of nitrogene gas with hydrogene forms
one of the substances comprised in the class
of alkalis. It is very probable that the others
are composed of this same gas and an earthy
basis. It is from these considerations that we
have thought proper to place those substances
here : and we have adopted that decision with
so much the more foundation, because the know-
ledge of alkalis is indispensably necessary to
enable us to proceed with order in a course of
chemistry ; and because these re-agents are most
frequently employed, and their combinations
and uses present themselves at every step in the
phenomena of nature and art.

It is an established convention to call every
substance an Alkali, which is characterised by
the following properties :

                                    A. An

A. An acrid, burning, urinous taſte.

B. The property of converting ſyrup of violets green; but not the tincture of turnſole, as certain authors announce.

C. The virtue of forming glaſs, when fuſed with quartzoſe ſubſtances.

D. The faculty of rendering oils miſcible with water; of efferveſcing with certain acids; and of forming neutral ſalts with all of them.

I muſt obſerve that none of theſe characters is rigorous and excluſive; and that conſequently no one of them is ſufficient to afford a certainty of the exiſtence of an alkali: but the re-union of ſeveral form, by their concurrence, a maſs of proofs or indications, which lead us to ſufficient evidence.

The alkalis are divided into fixed alkalis, and volatile alkalis. This diſtinction is eſtabliſhed upon the ſmell of theſe ſubſtances: the former are not volatilized, even in the focus of the burning mirror, and emit no characteriſtic ſmell; whereas the latter are eaſily reduced into vapour, and emit a very penetrating odour.

2   C H A P.

C H A P. I.

Concerning Fixed Alkalis.

NO more than two kinds of fixed alkalis
have hitherto been difcovered : the one
which is called Vegetable Alkali, or Pot-Afh ;
the other Mineral Alkali, or Soda.

A R T I C L E I.

Concerning the Vegetable Alkali, or Pot-Afh.

This alkali may be extracted from various
fubftances ; and it is more or lefs pure, accord-
ingly as it is afforded by one fubftance or ano-
ther. Several varieties are made in commerce,
to which different names have been affixed, and
which are indifpenfably neceffary to be known.
The chemift may indeed confound all thefe dif-
tinctions, in his writings, under one fingle deno-
mination : but the diftinctions eftablifhed by the
artifts are founded upon a feries of experiments,
which have proved that the virtues of thefe feveral
alkalis are very different ; and this conftant va-
riety

riety in their effects appears to me to justify the various denominations assigned to them.

1. The alkali extracted from the lixivium of wood-ashes, is known by the name of *Salin*. The *salin* calcined, and by this means disengaged from all the blackening principles, forms pot-ash.

The ashes are more or less rich in alkali, according to the nature of the wood which affords them ; in general, hard woods contain the most. The ashes of beech afford from 11 to 13lb. per quintal, according to the experiments which I have made in the large way, at St. Saveur; those of box afforded from 12 to 14lb. The tables drawn up by the several administrators of the gunpowder and saltpetre manufactories may be consulted, respecting the quantity of alkali afforded by the combustion of several plants : they used 4000lb. of each in their various experiments.

To extract this alkali, nothing more is necessary than to wash the ashes, and to concentrate the dissolution in boilers of cast iron. It is on account of the alkali that wood-ashes are employed in the lixiviums used by laundresses or bleachers. The use of alkali, in this case, is to combine with the fat substances, and to render them soluble in water.

Almost

Almoſt all the pot-aſh ſold in commerce for the uſe of our glaſs-houſes, our ſoap-makers, our bleaching-grounds, &c. is fabricated in the north, where the abundance of wood admits of its being applied to this ſingle purpoſe. We might eſtabliſh works of this kind to ſufficient advantage in the foreſts of our kingdom. But there is more to be done than is generally ſuppoſed, before the inhabitants of the mountains can be turned towards this ſpecies of induſtry. I have experienced this difficulty in the attempts and very conſiderable ſacrifices which I have made, to ſecure this reſource in the neighbour-hood of Laigoual and Leſperou. The accurate calculations which I have made, have neverthe-leſs proved that the pot-aſh would coſt only from 15 to 17 livres the quintal, whereas we purchaſe that from the north at 30 or 40 livres.

2. The lees of wine is almoſt totally con-verted into alkali by combuſtion. This alkali is called *Cendres Gravelées :* it has almoſt al-ways a greeniſh colour. This alkali is con-ſidered as very pure.

3. The combuſtion of tartar of wine likewiſe affords an alkali of conſiderable purity. It is uſually burned wrapped up in paper, in ſmall packets, which are dipped in water, and after-wards

wards expofed upon burning coals. In order to purify it, the refidue of the combuftion is diffolved in water, the folution concentrated by fire, the foreign falts feparated in proportion as they precipitate; and a very pure alkali is at laft obtained, which is known by the name of Salt of Tartar.

To procure falt of tartar more fpeedily, as well as more economically, I burn a mixture of equal parts of nitrate of pot-afh, or common nitre and tartar. The refidue, after lixiviation, affords a beautiful falt of tartar.

Salt of tartar is the alkali moft commonly employed in medical ufes; it is given in the dofe of feveral grains.

4. If faltpetre be fufed upon charcoal, the acid is decompofed and diffipated, while the alkali remains alone and difengaged : this is called Extemporaneous Alkali.

When the vegetable alkali has been brought to the greateft ftate of purity, it attracts the humidity of the air, and is refolved into a liquor. In this ftate it is known by the very improper name of Oil of Tartar per Deliquium.

ARTICLE II.

Concerning the Mineral Alkali, or Soda.

The Mineral Alkali has been so called, because it forms the basis of marine salt.

It is obtained from marine plants by combustion : for this purpose heaps of the saline plants are formed; and at the side of these heaps a round cavity is dug, which is enlarged towards the bottom, and is three or four feet in depth : this is the fire-place in which the vegetables are burned. The combustion is kept up without interruption for several days ; and when all the plants are consumed, a mass of alkaline salt is found remaining, which is cut into pieces, to facilitate its carriage and sale. This is known by the name of Rock Soda, or Soda.

All marine plants do not afford soda of the same quality. The barilla of Spain affords the beautiful soda of Alicant. I am assured that we might cultivate it upon our coasts in the Mediterranean, with the greatest success. This culture is highly interesting to the arts and commerce; and government ought to encourage this new species of industry. But an individual, however inclined or devoted to the public good,

<div align="right">might</div>

might make vain efforts to appropriate this commerce to our advantage, if he were not powerfully affifted by government; becaufe the Spanifh miniftry has prohibited the exportation of the feed of barilla, under the ftrongeft penalties. In Languedoc, and in Provence, we cultivate on the banks of our ponds a plant known by the name of Salicor, which affords foda of a good quality; but the plants which grow without cultivation produce an inferior fort. I have made an accurate analyfis of each fpecies, the refults of which may be feen at the article *Verrerie* of the *Encyclopedie Methodique*.

The mineral alkali is cleared of all heterogeneous falts by diffolving it in water, and feparating the feveral falts in proportion as they fall down. The laft portion of the fluid being concentrated affords the foda, which cryftallizes in rhomboidal octahedrons.

The mineral alkali is fometimes found in a native ftate: in Egypt it is known by the name of Natron. The two lakes of Natron defcribed by Sicard and Mr. Volney, are fituated in the defert of Chaiat, or St. Macaire, to the weft of Delta. Their bed is a natural cavity of three or four leagues in length, and a quarter of a league in breadth; the bottom is folid and ftony. It is dry during nine months in the year;

year; but in winter a water of a violet-red co-
lour oozes out of the earth, which fills the lake
to five or six feet in depth : the return of the
heat of summer evaporates this, and leaves a
bed of salt behind it of two feet in thickness,
which is dug out with bars of iron. The quan-
tity obtained annually amounts to 36,000 quin-
tals.

Mr. Prouſt found natron upon the ſchiſti
which form the foundation of the town of An-
gers; the ſame chemiſt likewiſe found it upon
a ſtone from the ſalpetriere of Paris.

The mineral alkali differs from the vege-
table, becauſe—1. It is leſs cauſtic. 2. It is ſo
far from attracting humidity, that it effloreſces in
the air. 3. It cryſtallizes in rhomboidal octa-
hedrons. 4. It forms different products with
the ſame baſes. 5. It is more proper for vitri-
fication.

Do the alkalis exiſt ready formed in vegetables,
or are they the product of the ſeveral opera-
tions made uſe of in extracting them?—This
queſtion has divided the opinions of chemiſts.
Du Hamel and Groſſe proved, in 1732, the ex-
iſtence of alkali in cream of tartar, by treating it
with the nitric, ſulphuric, and other acids. Mar-
graff has given additional proofs of this, in a
Memoir which forms the twenty-fifth of his col-
lection.

lection. Rouelle read a Memoir to the Academy on the 14th of June, 1769, upon the same subject : he even affirms that he was acquainted with this truth before the work of Margraff appeared.—See the Journal de Physique, vol. i.

Rouelle, and the marquis De Bullion, proved that tartar exists in must.

It must not be concluded from the existence of an alkali in vegetables, that this salt is there found in a disengaged state. On the contrary, it is found combined with acids, oils, &c.

The alkalis, such as we have described them, even after they have been disengaged from every mixture, by solution, filtration, and evaporation, are not nevertheless in that state of purity and disengagement, which is necessary to be obtained in many cases : they are nearly in the state of neutral salts, by their combination with the carbonic acid. When it is required to disengage this acid, the alkali must be dissolved in water, and quick lime then slacked in the solution. This substance seizes the carbonic acid of the alkali, and gives out its caloric in exchange. We shall speak of the circumstances of this operation when we shall have occasion to treat of lime. The alkali being deprived of the carbonic acid, no longer effervesces with other

acids;

acids; it is more cauftic, and more violent in its action; unites more eafily to oils; and is then called Cauftic Alkali, Pure Pot-afh, or Pure Soda.

When this alkali is evaporated, and brought into the dry form, it is known by the name of Lapis Caufticus. The corrofive virtue of this fubftance depends principally upon the avidity with which it feizes humidity, and falls into deliquium.

The cauftic alkali, as it is ufually prepared, always contains a fmall quantity of carbonic acid, filiceous earth, iron, lime, &c. Mr. Berthollet has propofed the following means of purifying it :—He concentrates the cauftic lixivium until it has acquired a flight degree of confiftence; at which period he mixes it with alcohol, and draws off a portion by diftillation. As foon as the retort is become cold, he finds it to contain cryftals, mixed with a blackifh earth, in a fmall quantity of liquor of a dark colour, which is feparated from the folution of alkali in the alcohol, which fwims above like an oil. Thefe cryftals confift of the alkali faturated with the carbonic acid, and are infoluble in fpirit of wine; the depofition confifts of filiceous earth, lime, iron, &c.

The cauftic alkali in a ftate of great purity,
diffolved

diffolved in the alcohol, fwims above the aqueous folution which contains the effervef-cent alkali. If the fpirituous folution of alkali be concentrated on the fand-bath, tranfparent cryftals are formed, which confift of the pure alkali itfelf : thefe cryftals appear to be formed by quadrangular pyramids inferted one in ano-ther; they are very deliquefcent, are foluble in water and in alcohol, and produce cold by their folution.—See the Journal de Phyfique, 1786, page 401.

The alkalis we have juft fpoken of, combine eafily with fulphur.

This combination may be effected—1. By the fufion of equal parts of alkali and fulphur. 2. By digefting the pure and liquid alkali upon fulphur.—In thefe cafes the alkali becomes of a reddifh-yellow colour.

The folutions of fulphur in alkali are known by the name of Livers of Sulphur, Sulphures of Al-kali, &c. They emit an offenfive fmell, refembling that of rotten eggs. This is occafioned by the efcape of the ftinking gas, called Hepatic Gas.

The fulphur may be precipitated by acids; and the refult of this precipitation is what the ancient chemifts diftinguifhed by the name of Milk of Sulphur, and Magiftery of Sulphur.

N 2 Thefe

These sulphures or hepars diffolve metals. Gold itself may be so divided by this means as to pass through filters. Stahl has supposed that Moses made use of this method to enable the Israelites to drink the golden calf.

Though the analysis of the two alkalis has not been made with strictness, several experiments lead us to believe that nitrogene is one of their principles. Mr. Thouvenel, having exposed washed chalk to the exhalations of animal substances in putrefaction, obtained nitrate of pot-ash, or common nitre. I have repeated this experiment in a closed chamber of six feet square. Twenty-five pounds of chalk well washed in warm water, and exposed to the exhalation of bullock's blood in putrefaction during eleven months, afforded nine ounces of nitrate of lime, in a dried state; and three ounces one gros of crystals of nitrate of pot-ash, or common nitre.

The repeated distillation of soaps decomposes them, and affords ammoniac. Now the analysis of this last, by Mr. Berthollet, proves the existence of nitrogenous gas as one of its constituent parts. There is therefore room to apprehend that nitrogene gas is one of the principles of alkalis.

The experiments of Mr. Thouvenel, as well

as

as my own, lead me to believe that this gas, when combined with lime, forms pot-afh, or the vegetable alkali; while its union with magnefia forms foda. This laft opinion is fupported by the experiments—1. Of Dehne, who obtained magnefia from foda (fee Crell's Chemical Annals, 1781, páge 53). 2. Of Mr. Deyeux, who obtained fimilar refults even before Mr. Dehne. 3. Of Mr. Lorgna, who obtained much magnefia by diffolving, evaporating, and calcining foda repeatedly (Journal de Phyfique, 1787). Mr. Ofburg confirmed thefe various experiments in 1785.

C H A P. II.

Concerning Ammoniac, or the Volatile Alkali.

OUR refearches have not hitherto exhibited more than one fpecies of volatile alkali. Its formation appears to be owing to putrefaction; and though the diftillation of fome fchifti affords it, yet this circumftance may be attributed to their origin, which is pretty generally afcribed to vegetable and animal

N 3   decom-

decompofition. We find frequently enough, in thefe fubftances, the print of fifhes, which is in favour of this opinion. Some plants likewife afford volatile alkali; for which reafon they have been called Animal Plants. But the volatile alkali is more efpecially afforded by animal fubftances: the diftillation of all their parts affords it in confiderable abundance. Horns are employed in preference, becaufe they are refolved almoft entirely into oil and volatile alkali. The putrefaction of all animal fubftances produces volatile alkali; and in this cafe, as well as in diftillation, it is formed by the combination of its two conftituent parts: for the analyfis very often fails in exhibiting any alkali ready formed, in fuch parts as diftillation or putrefaction would abundantly afford it from.

Almoft all the volatile alkali made ufe of in commerce or medicine, is afforded by the decompofition of fal ammoniac. It is even on account of this circumftance that the chemifts who have drawn up the New Nomenclature have diftinguifhed the volatile alkali by the name of Ammoniac.

To obtain ammoniac in a ftate of confiderable purity, equal parts of fifted quick-lime and muriate of ammoniac, or common fal ammoniac in powder, are mixed. This mixture is then introduced

troduced into a retort, to which a receiver and
the apparatus of Woulfe have been adapted. A
quantity of pure water is to be put into the bot-
tles, correfpondent to the weight of the falt em-
ployed; and the junctures of the veffels are
made good with the ufual lutes. The ammo-
niac is difengaged in the ftate of gas, at the firft
impreffion of the fire. It combines with the
water with heat; and when the water of the firft
bottle is faturated, the gas paffes to that of the
fecond, and faturates it in its turn.

Volatile alkali is known by its very ftrong
but not difagreeable fmell. It is eafily reducible
into the ftate of gas, and preferves this form at
the temperature of the atmofphere. This gas
may be obtained by decompofing the muriate
of ammoniac by quick-lime, and receiving the
product over mercury.

Alkaline gas kills animals, and corrodes the
fkin. The irritation is fuch, that I have feen
pimples arife all over the bodies of fome birds
expofed to its atmofphere.

This gas is improper for combuftion; but
if a taper be gently immerfed in it, the flame is
enlarged before it goes out, and the gas fuffers a
decompofition. Alkaline gas is lighter than at-
mofpheric air; and has even been mentioned, on
account of its lightnefs, as a proper fubftance to

fill

fill balloons. The count De Milly propofed to place a brazier, or veffel containing fire, under the balloon, to keep the gas in its greateft ftate of expanfibility.

The experiments of Dr. Prieftley, who changed alkaline gas into hydrogene gas by means of the electric fpark; thofe of the chevalier Laudriani, who, by paffing the fame gas through ignited glafs tubes, obtained a large quantity of hydrogenous gas—occafioned a fufpicion of the exiftence of hydrogene among the principles of alkaline gas. But the experiments of Mr. Berthollet have removed all doubts on this fubject; and all obfervations appear to unite in authorifing us to confider this alkali as a compound of the nitrogenous and hydrogenous gafes.

1. If the oxigenated muriatic acid be mixed with very pure ammoniac, an effervefcence takes place, with a difengagement of nitrogenous gas, a production of water, and a converfion of the oxigenated acid into the ordinary muriatic acid. In this beautiful experiment, the water which is produced is formed by the combination of the hydrogene of the alkali and the oxigene of the acid; and the nitrogene gas being fet at liberty, is diffipated.

2. When the nitrate of ammoniac is expofed

to

to diftillation, nitrogene gas is obtained, and a greater quantity of water is found in the receiver than the falt itfelf contained. After the operation, the ammoniac is found no longer to exift. The water of the receiver is flightly charged with a fmall quantity of nitric acid, which had paffed over. In this cafe, the hydrogene of the alkali, and the oxigene of the acid, form the water in the receiver, while the nitrogenous gas efcapes.

If the oxides of copper or gold be heated with ammoniacal gas, the product is water and nitrogenous gas, and the metals are reduced.

I have obferved that the oxides of arfenic, being digefted with ammoniac, are reduced, and often form octahedral cryftals of arfenic. In this cafe there is a difengagement of nitrogene gas, and a formation of water.

It very often happens when metals, fuch as copper or tin, are diffolved by means of the nitric acid, that an abforption of air takes place, inftead of a difengagement of nitrous gas, as might be expected : I have feen feveral perfons very much embarraffed in fuch cafes, and I have often been fo myfelf. This phenomenon takes place more efpecially when a very concentrated acid is made ufe of, and the copper is in fine filings: in this cafe ammoniac is produced. I have
ſhewn

shewn this fact to my auditors long before I was acquainted with the theory of its formation. That which led me to suspect its existence, was the blue colour which the solution takes in this case. This ammoniac is produced by the combination of the hydrogene of the water with the nitrogene gas of the nitric acid; while the oxigene of the same acid, and that of the water, oxided the metal, and prepared it for solution. It is to a similar cause that we must refer the experiment of Mr. John Michael Haussman of Colmar, who by passing nitrous gas through a certain quantity of precipitate of iron, in the mercurial apparatus, observed that this gas was speedily absorbed, and the colour of the iron changed; at the same time that vapour of ammoniac was found in the vessels. It is by a similar theory we may account for the formation of alkaline gas, by the mixture of hepatic gas and nitrous gas over mercury, as Mr. Kirwan observes.

Mr. Austin formed ammoniac; but he observed that the combination of nitrogenous gas with the base of hydrogene does not take place, unless this last is in a state of great condensation.

The formation of ammoniac by distillation and putrefaction, appears to me likewise to indicate

dicate its conftituent parts. In fact, there is in both thefe operations a difengagement of hy-drogene and nitrogene gas, and their combina-tion produces ammoniac.

Mr. Berthollet has proved, by the way of de-compofition, that one thoufand parts of ammo-niac, by weight, are compofed of about eight hundred and feven of nitrogene gas, and one hundred and ninety-three of hydrogene gas. —See the collection of the Royal Academy, 1784, page 316.

According to Dr. Auftin, the nitrogene gas is in proportion to the hydrogene, as one hundred and twenty-one to thirty-two.

SECTION IX.

Concerning the Combination of Oxigene with certain Bases forming Acids.

IT appears to be out of doubt, that the bodies which we are agreed to call Acids, are combinations of vital air with a certain elementary substance. The analysis of almost all the acids, whose component parts are known, establishes this truth in a positive manner; and it is on account of this property that the denomination of Oxigenous Gas been given to vital air.

Every substance which possesses the following properties is called an Acid:

A. The word *sour*, which is usually employed to denote the impression or lively and sharp sensation produced on the tongue by certain bodies, may be regarded as synonimous to the word *acid*. The only difference which may be established between them is, that the one denotes a weak sensation, whereas the other comprehends all the degrees of force from the least perceptible taste to the greatest degree of caufticity. We say, for example, that verjuice, gooseberries, or lemons, are *sour*; but we use
the

the word *acid* to exprefs the impreffion which
the nitric, fulphuric, or muriatic acids make
upon the tongue.

The caufticity of acids appears to arife from
their ftrong tendency to combination; and it is
from this property that the immortal Newton
has defined them to be bodies which attract and
are attracted.

It is likewife from this property that certain
chemifts have fuppofed acids to be pointed
bodies.

On account likewife of this decided tendency
to combination which acids poffefs, it feldom
happens that we find them in a difengaged
ftate.

B. A fecond property of acids is that of
changing certain blue vegetable colours into
red, fuch as the colour of turnfole, fyrup of vio-
lets, &c. Thefe two re-agents are commonly
ufed to afcertain the prefence of acids.

The tincture of turnfole is prepared by lightly
infufing in water that fubftance which is known
in common under the name of Turnfole or Lit-
mus. If the water be too highly charged with
the colouring matter, the infufion has a violet
tinge, and muft in that cafe be diluted with water
until it becomes blue. The tincture of turn-
fole, when expofed to the fun, becomes red,

even

even in clofed veffels; and fome time afterwards
the colouring part is difengaged, and falls down
in the form of a mucilaginous difcoloured fub-
ftance. Alcohol may be ufed inftead of water
in the preparation of this tincture.

It is generally fuppofed that the turnfole fa-
bricated in Holland is nothing more than the co-
louring matter extracted from the rags or cloths
of turnfole of Grand-Galargues, and precipi-
tated upon a marly earth. Thefe rags are pre-
pared by impregnating them with the juice of
nightfhade (morelle), and expofing them to
the vapour of urine, which develops their blue
colour. The rags are fent into Holland, which
has given rife to the opinion that they are ufed
in the fabrication of turnfole; but fubfequent
enquiries have taught me that thefe cloths are
fent to the dealers in cheefe, who extract a
colour by infufion, and wafh their cheefes with
it, to give them a red colour. I am convinced,
by the analyfis of turnfole, that the colouring
matter is of the fame nature as that of archil
(orfeille); and that this principle is fixed on
a calcareous earth, and a fmall quantity of pot-
afh. In confequence of this analyfis, I have en-
deavoured to caufe the liken parellus of Au-
vergne to ferment with urine, lime, and alkali;
and I obtained a pafte fimilar to that of turnfole.

The

The addition of alkali appears to me to be neceffary to prevent the development of the red colour, which, when combined with the blue, forms the violet of the archil.

When any concentrated acid is to be tried with fyrup of violets, there are two particulars to be attended to. 1. The fyrup of violets is often green, becaufe the petal of the violet contains a yellow part at its bafe, which, when combined with the blue, forms this green colour: it is therefore effential to employ only the blue of the petal in order to have a beautiful blue infufion. 2. Care muft be taken to dilute the fyrup with a certain quantity of water; becaufe otherwife concentrated acids, fuch as the fulphuric, would burn it, and form a coal.

The fimple infufion of violets may be ufed inftead of the fyrup.

The colouring matter of indigo is not fenfible to the impreffion of acids. The fulphuric acid diffolves it, without altering the colour.

C. A third character of acids is, that they effervefce with alkalis; but this property is not general. 1. Becaufe the carbonic acid, and almoft all weak acids, cannot be diftinguifhed by this property. 2. Becaufe the pureft alkalis combine with acids, without motion or effervefcence.

Is

Is there not one single acid in nature, of which the others may be only modifications?

Paracelsus admitted an universal principle of acidity, which communicated taste and solubility to all its compounds.

Becher believed that this principle was composed of water and vitrifiable earth. Stahl endeavoured to prove that the sulphuric acid was the universal acid; and his opinion was adopted by most chemists for a long time.

Long after the time of Stahl, Meyer maintained that the acid element was contained in fire. This system, which is founded on certain known facts, has had its supporters.

The chevalier Landriani imagined he had succeeded in reducing all the acids to the carbonic acid; because, by treating them all with different substances, he obtained this last as the constant result of his analysis. He was led into an error, for want of having sufficiently attended to the decomposition of the acids he made use of, and the combination of their oxigene with the carbone of the bodies which entered into his experiments, and produced the carbonic acid.

Lastly, the strict analysis and synthesis of most of the known acids, have proved to Mr. Lavoisier that oxigene is the base of all of them; and that their differences and varieties arise

I   only

only from the fubftance with which this com-
mon principle is combined.

Oxigene united with metals forms oxides;
and among thefe laft there are fome which pof-
fefs acid characters, and are claffed amongft
acid fubftances.

Oxigene combined with inflammable fub-
ftances, fuch as fulphur, carbone, and oils, forms
other acids.

The action of acids upon bodies in general
cannot be underftood but by founding our ex-
planations upon the data which we have eftab-
lifhed refpecting the nature of their conftituent
parts.

The adhefion of oxigene to the bafe is more
or lefs ftrong in the feveral acids, and confe-
quently their decompofition is more or lefs eafy;
as, for example, in metallic folutions, which do
not take place excepting when the metal is in
the ftate of an oxide. The acid which will yield
its oxigene with the greateft facility to oxide the
metal, will have the moft powerful action upon
it. Hence it happens, that the nitric and the
nitro-muriatic acids are thofe which diffolve
metals the moft readily; and hence likewife it
happens that the muriatic acid diffolves the
oxides more eafily than the metals, while the
nitric acid acts contrariwife: hence alfo it

arifes that this laft acts fo powerfully upon oils, &c.

It is impoffible to conceive and explain the various phenomena prefented to us by acids in their operations, if we have no idea of their conftituent principles. Stahl would not have believed in the formation of fulphur, if he had underftood the decompofition of the fulphuric acid upon charcoal ; and if we except the com- binations of acids with alkalis, and with cer- tain earths, thefe fubftances are either totally or partially decompofed in all the operations made with them upon metals, vegetables, and ani- mals, as we fhall find by obferving the feveral phenomena exhibited in thefe cafes refpect- ively.

We fhall at prefent treat only of fome of the acids, and fhall direct our attention to the others in proportion as we fhall have occafion to treat of the various fubftances which afford them : we fhall attend in preference to thofe which are the beft known, and which have the greateft influ- ence in the operations of nature, as well as in thofe of our laboratories.

C H A P.

niac, or common fal ammoniac in fine powder. This mixture is put into a retort, and diftilled ; the ammoniac and the carbonic acid being dif-engaged from their bafes, and reduced into va-pours, combine together, and are depofited on the fides of the receiver, where they form a ftratum more or lefs thick.

The cryftallization of this carbonate ap-peared to me to be that of a four-fided prifm, terminated by a dihedral fummit.

The carbonate has lefs fmell than the ammo-niac ; it is very foluble in water. Cold water diffolves its own weight of this falt, at the tem-perature of fixty degrees of Fahrenheit.

One hundred grains of this falt contain forty-five parts acid, forty-three alkali, and twelve water, according to Bergmann.

Moft acids decompofe it, and difplace the carbonic acid.

CHAP.

CHAP. II.

Concerning the Sulphuric Acid.

SULPHUR, like every other combuftible
fubftance, cannot be burnt but by virtue
of the oxigenous gas which combines with
it.

The moft ufual phenomena which accom-
pany this combuftion, are, a blue flame, a whit-
ifh and fuffocating vapour, and a ftrong, pene-
trating, and difagreeable fmell.

The refults of this combination vary accord-
ing to the proportion in which thefe two prin-
ciples enter into this fame combination.

The fulphureous or the fulphuric acid may
be at pleafure obtained from fublimed fulphur,
or from crude fulphur, accordingly as a greater
or lefs quantity of oxigene is combined with the
fulphur, by means of combuftion.

When the current of air which maintains the
combuftion is rapid, the fulphur is carried, and
depofited without any apparent alteration, into
the internal part of the leaden chambers in
which

C H A P. I.

Concerning the Carbonic Acid.

THIS acid is almoſt always obſerved in the ſtate of gas. We find that the ancients were in ſome meaſure acquainted with it. Van Helmont called it Gas Silveſtre, the gas of muſt, or of the vintage. Becher himſelf had a conſiderably accurate notion of it, as appears by the following paſſage : " Diſtinguitur autem inter fer-
" mentationem apertam et clauſam; in apertâ
" potus fermentatus ſanior eſt, ſed fortior in
" clauſâ : cauſa eſt, quod evaporantia rarefacta
" corpuſcula, imprimis magna adhuc ſilveſ-
" trium ſpirituum copia, de quibus antea egi-
" mus, retineatur, et in ipſum potum ſe preci-
" pitet, unde valde eum fortem reddit."

Hoffmann attributed the virtue of moſt mineral waters to an elaſtic ſpirit contained in them.

Mr. Venel, a celebrated profeſſor in the ſchools at Montpellier, proved in 1750 that the waters of Seltzer owed their virtue to a ſuperabundant portion of air.

In 1755, Dr. Black of Edinburgh advanced that lime-ftone contains much air of a different nature from common air. He affirmed that the difengagement of this air converted it into lime, and that by the reftoration of this air calcareous ftone was regenerated. In the year 1746, Dr. M'Bride fupported this doctrine with new facts. Mr. Jacquin, profeffor of Vienna, refumed the fame purfuit, multiplied experiments on the manner of extracting this air, and added other proofs in confirmation that the abfence of the air rendered alkalis cauftic, and formed lime. Dr. Prieftley exhibited all the perfpicuity and precifion on this fubject which might be expected from his abilities, and his fkill in making experiments of this kind. This fubftance was then known by the name of Fixed Air. In 1772, Bergmann proved that it is an acid, which he called by the name of Aerial Acid. Since the time of this celebrated chemift, it has been diftinguifhed by the names of Mephitic acid, Cretaceous acid, &c. : and as foon as it was proved to confift of a combination of oxigene and carbone, or pure charcoal, the name of Carbonic acid was appropriated to it.

The carbonic acid is found in three different ftates.   1. In that of gas.   2. In a ftate of mixture.   3. In a ftate of combination.

It

It is found in the ftate of gas at the Grotto del Cano, near Naples; at the well of Perols, near Montpellier; in that of Negrae in Vivarais; upon the furface of the Lake Averno in Italy, and on thofe of feveral fprings; in various fubterraneous places, fuch as tombs, cellars, neceffaries, &c. It is difengaged in this form by the decompofition of vegetables heaped together, by the fermentation of wine or beer, by the putrefaction of animal matters, &c.

It exifts in the ftate of fimple mixture in mineral waters, fince in thefe it poffeffes all its acid properties.

It exifts in a ftate of combination in limeftone, common magnefia, alkalis, &c.

Various proceffes are employed to collect it, according to the ftate in which it is found.

I. When the carbonic acid exifts in the ftate of gas, it may be collected—1. By filling a bottle with water, and emptying it into the atmofphere of this gas : the acid takes the place of the water, and the bottle is afterwards corked to retain it. 2. By expofing lime-water, cauftic alkalis, or even pure water, in its atmofphere : the gafeous acid mixes or combines with thefe fubftances ; and may be afterwards extracted by re-agents, which we fhall proceed to defcribe.

II. When the carbonic acid exifts in a ftate

of

of combination, it may be extracted—1. By distillation with a strong heat. 2. By the reaction of other acids, such as the sulphuric acid, which has the advantage of not being volatile, and consequently is not altered by its mixture with the carbonic acid which is disengaged.

III. When the carbonic acid exists in the state of simple mixture, as in water, brisk wines, &c. it may be obtained—1. By agitation of the liquid which contains it; as Mr. Venel practised, by making use of a bottle to which he adapted a moistened bladder.

2. By distillation of the same fluid.—These two first methods are not accurate.

3. The process indicated by Mr. Gioanetti, consists in precipitating the carbonic acid by means of lime-water, weighing the precipitate, and deducting thirteen thirty-second parts for the proportion of carbonic acid; it having been deduced from analysis, by this celebrated physician, that thirty-two parts of carbonate of lime contain seventeen lime, two water, and thirteen acid.

This substance is an acid, as is proved—1. Because tincture of turnsole, agitated in a bottle filled with this gas, becomes red. 2. Ammoniac, or volatile alkali, poured into a vessel filled with this gas, is neutralized. 3. Water im-

impregnated with this gas is ftrongly fub-acid. 4. It neutralizes alkalis, and caufes them to cryftallize.

It remains at prefent to examine the properties of this acid gas.

A. It is unfit for refpiration. Hiftory informs us that two flaves whom Tiberius caufed to defcend into the Grotto del Cano, were immediately ftifled ; and two criminals that Peter de Toledo caufed to be fhut in there, fuffered the fame fate. The abbé Nollet, who had the courage to refpire the vapour, perceived a fuffocating fenfation, and a flight degree of acidity, which produced coughing and fneezing. Pilatre de Rofier, who prefents himfelf to our notice on all occafions wherein danger was to be faced, caufed himfelf to be faftened by cords fixed under his arms, and defcended into the gafeous atmofphere of a back of beer in fermentation. He had fcarcely entered into the mephitis before flight prickings obliged him to fhut his eyes ; a violent fuffocation prevented him from refpiring ; he felt a giddinefs, accompanied with thofe noifes which characterize the apoplexy : and when he was drawn up, his fight remained dim for feveral minutes ; the blood had filled the jugulars ; his countenance had become purple ; and he neither heard nor fpoke but

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with great difficulty : all these symptoms how-
ever disappeared by degrees.

It is this gas which produces the many un-
happy accidents at the opening of cellars, in
places where wine, cyder, or beer are suffered
to ferment. Birds plunged into the carbonic
acid gas, suddenly perish. The famous Lake
of Averno, where Virgil placed the entrance
of hell, exhales so large a quantity of carbonic
acid, that birds cannot fly over it with impunity.
When the waters of Boulidou of Perols are
dry, such birds as attempt to quench their
thirst in the clefts, are enveloped in the mephi-
tic vapour, and die.

Frogs, plunged in an atmosphere of carbonic
acid, live from forty to sixty minutes, by suf-
pending their respiration.

Insects are rendered torpid after a certain
time of remaining in this air ; but they resume
their liveliness the moment they are exposed to
the free air.

Bergmann pretended that this acid suffocates
by extinguishing irritability : he founds his opi-
nion upon the circumstance of his having taken
out the heart of an animal which had died in
the carbonic acid, before it was cold, and it
exhibited no sign of irritability. The cheva-
lier Landriani has proceeded still further : for

he

he affirms that this gas extinguishes irritability, even when applied to the skin; and has asserted that, by tying a bladder full of this gas to the neck of a fowl, in such a manner that the head only of the animal was in the open air, and the whole body enveloped in the bladder, the fowl immediately perished. The abbé Fontana has repeated and varied this experiment on several animals, none of which died.

The count Morrozzo published experiments made in the presence of Dr. Cigna; the results of which appear to invalidate the consequences of the celebrated Bergmann: but it is to be observed, that the chemist of Turin caused his animals to die only in air vitiated by the death of another animal; and that in this circumstance the nitrogene gas predominates.—See the Journal de Physique, tom. xxv. p. 112.

B. The carbonic acid is improper for vegetation. Dr. Priestley having kept the roots of several plants in water impregnated with the carbonic acid, observed that they all perished; and in those instances where plants are observed to vegetate in water or in air which contains this gas, the quantity of gas is very small.

Mr. Senebier has even observed, that plants which are suffered to grow in water slightly acidulated

dulated with this gas, emit a much larger quantity of oxigenous gas; becaufe, in this cafe, the acid is decompofed, the carbonaceous principle combines and is fixed in the vegetable, while the oxigene is thrown off.

I have obferved that thofe fungi which are formed in fubterraneous places, are almoft totally refolved into carbonic acid: but if thefe vegetables be gradually expofed to the action of light, the proportion of acid diminifhes; while that of the coaly principle augments, and the vegetable becomes coloured. I have purfued thefe experiments with the greateft care in a coal mine.

C. The carbonic acid is eafily diffolved in water. Water impregnated with this acid poffeffes very valuable medicinal qualities; and feveral apparatus have been fucceffively invented to facilitate this mixture. The apparatus of Nooth, improved by Parker and Magellan, is one of the moft ingenious. On this fubject the Encyclopedie Methodique may be confulted, article Acide Mephitique.

The natural acidulous mineral waters do not differ from thefe, excepting in confequence of their holding other principles in folution; and they may be perfectly imitated when their analyfis is well known. It is abfurd to think that

art

art is incapable of imitating nature in the com-
pofition of mineral waters. It muft be admitted
that the proceffes of nature are abfolutely un-
known to us, in all the operations which relate
to life; and we cannot flatter ourfelves with the
hope of imitating her in thefe circumftances.
But when the queftion relates to an operation
purely mechanical, or confifting of the folution
of certain known principles in water, we can
and ought to perform it even ftill better, as we
have the power of varying the dofes, and pro-
portioning the efficacy of any artificial mineral
water to the purpofes to which it is intended
to be applied.

D. The carbonic acid gas is heavier than
common air. The proportion between thefe
two airs in weight, according to Mr. Kirwan, is
45,69 to 68,74. The proportion, according to
the experiments of Mr. Lavoifier, is 48,81 to
69,50.

This confiderable weight caufes it to occupy
the loweft fituations; and even gives it the pro-
perty of being poured out from one veffel to
another, fo as to difplace the atmofpheric air.
This truly curious phenomenon was obferved
by Mr. De Sauvages, as may be feen in his Dif-
fertation upon Air, which was crowned in Mar-
feilles in 1750.

4   It

It appears to be proved, by fufficient experiments, that the carbonic acid is a combination of carbone, or pure charcoal, and oxigene.
1. The oxides of mercury, when diftilled, are reducible without addition, and afford only oxigenous gas; but if a fmall quantity of charcoal be mixed with the oxide, the product which comes over confifts of carbonic gas only, and the weight of the charcoal is diminifhed.

2. If well-made charcoal be ignited, and plunged into a veffel filled with oxigenous gas, and the veffel be inftantly clofed, the charcoal burns rapidly, and at laft goes out: the product in this experiment is carbonic acid, which may be feparated by the known proceffes; the remainder is a fmall quantity of oxigenous gas, which may be converted into carbonic acid by the fame treatment.

In thefe experiments I fee nothing but charcoal and oxigenous gas; and the confequence deduced is fimple and natural.

The proportion of charcoal is to that of oxigene as 12,0288 to 56,687.

When the carbonic acid, in fome cafes, is obtained by burning hydrogenous gas, it arifes from carbone held in folution in this gas. The carbone may even be diffolved in hydrogenous gas, by expofing it to the focus of the burning
mirror

mirror in the mercurial apparatus, under a glafs vefſel filled with this gas.

The hydrogenous gas which is extracted from a mixture of fulphuric acid and iron, holds more or lefs of charcoal in folution; becaufe iron itſelf contains this fubſtance in a greater or lefs quantity, as is afcertained by the fine expe-riments of Meffrs. Berthollet, Monge, and Vander Monde.

The alkalis, fuch as we ufually meet with them, contain carbonic acid; and it is this acid which modifies them, and diminifhes their energy, at the fame time that it communicates to them the property of effervefcing. We may therefore confider alkalis as carbonates with excefs of alkali; and it is eafy to faturate this fuperabundant alkali, and to form true cryſtal-lizable neutral falts.

ARTICLE I.

Carbonate of Pot-aſh.

The carbonate of pot-aſh was formerly dif-tinguifhed by the name of Cretaceous Tartar. The method of caufing oil of tartar to cryſtal-lize, has long been known. Bonhius and Mon-tet have fucceffively fhewn thefe proceffes : but

the

the simplest consists in exposing an alkaline so-
lution in an atmosphere of the acid gas which
is disengaged in the vinous fermentation; the
alkali becomes saturated, and forms tetrahedral
prismatic crystals terminated by very short four-
sided pyramids.

I have several times obtained those crystals
in the form of quadrangular prisms, with their
extremities cut off slantwise.

This neutral salt no longer possesses the urin-
ous taste of the alkali, but exhibits the pene-
trating taste of neutral salts, and may be em-
ployed in medicine with the greatest success. I
have been a witness to its being taken in the
dose of one dram (gros) without the least incon-
venience.

This salt possesses an advantage beyond the
salt of tartar, in being less caustic, and always
of the same virtue.

It contains, according to the analysis of Berg-
mann, twenty parts acid, forty-eight alkali, and
thirty-two water, in the quintal.

It does not attract the humidity of the air. I
have preserved some of it for several years in a
capsule, without any appearance of alteration.

The carbonate of pot-ash is decomposed by
silex in a sufficient heat, which occasions a con-
siderable boiling or ebullition. The residue is
glass,

glafs, in which the alkali is in the cauftic ftate.
Lime decompofes the carbonate, by uniting to
the acid; and acids produce the fame effect, by
combining with the alkaline bafes.

ARTICLE II.

Carbonate of Soda.

The denominations of Aërated Mineral Al-
kali, Cretaceous Soda, &c. have been fuccef-
fively given to this kind of carbonate.

The mineral alkali, in its natural ftate, con-
tains a greater quantity of carbonic acid than
the vegetable; and nothing more is neceffary
than to diffolve it, and duly evaporate the wa-
ter, in order to obtain it in cryftals.

Thefe cryftals are ufually rhomboidal octa-
hedrons; and fometimes have the form of rhom-
boidal laminæ, applied obliquely one upon the
other, fo that they refemble tiles.

This carbonate efflorefces in the air.

One hundred parts contain fixteen parts acid,
twenty alkali, and fixty-four water.

The affinity of its bafis with filex is ftronger
than that of the carbonate of pot-afh; in confe-
quence of which, the vitrification it produces
is more quick and eafy.

Lime,

Lime and the acids decompose it, with the same phenomena which we have observed at the article Carbonate of Pot-ash.

ARTICLE III.

Carbonate of Ammoniac.

This salt has been generally known by the name of Concrete Volatile Alkali. It has likewise been distinguished by that of Cretaceous Volatile Alkali, &c.

It may be obtained by distillation from many animal substances. Tobacco affords, likewise, a large proportion; but almost the whole of that which is employed in the arts, and in medicine, is formed by the direct combination of the carbonic acid and ammoniac, or volatile alkali. This combination may be effected—1. By passing the carbonic acid through ammoniac, or the pure volatile alkali in solution. 2. By exposing ammoniac in an atmosphere of carbonic acid gas. 3. By decomposing the muriate of ammoniac by the neutral salts which contain this acid, such as the carbonate of lime or common chalk. For this purpose, white chalk is taken, and very accurately dried; and then mixed with equal parts of muriate of ammoniac,

which the oil of vitriol is made. If the current of air be rendered more moderate, the combination is somewhat more accurate; the sulphur is partly changed, and is deposited in a pellicle upon the surface of the water. This pellicle is flexible like a skin, and may be handled and turned over in the same manner. If the current be still less rapid, and the air be suffered to have a sufficient time to form an accurate combination with the sulphur, the result is sulphureous acid; which acid preserves its gaseous form at the temperature of the atmosphere, and may become liquid like water by the application of cold, according to the fine experiments of Mr. Monge. If the combustion be still slower, and the air be suffered to digest upon the sulphur a longer time, and with greater accuracy, the result is sulphuric acid : this last combination may be facilitated by the mixture of saltpetre, because this substance furnishes oxigene very abundantly.

Numerous experiments which I have made in my manufactory, to economize the saltpetre employed in the fabrication of oil of vitriol, have several times exhibited the results here mentioned.

All the processes which are capable of being adapted for extracting the sulphuric acid, are

<div align="center">P 2</div> <div align="right">reducible</div>

reducible to—1. The extraction of it from sub-
stances which contain it. 2. Its direct forma-
tion by the combination of sulphur and oxi-
gene.

In the first case, the sulphures, or vitriolic
salts of iron, copper, or zinc, and even those
whose bases are clay and lime, according to
Newman and Margraff, may be exposed to dif-
tillation. But these expensive processes are not
very easy to be carried into execution; and ac-
cordingly they have been abandoned, to make
room for others of greater simplicity.

In the second case, the oxigene may be pre-
sented to the sulphur in two forms; either in the
state of gas, or in the concrete state.

1. The combustion of sulphur by oxigenous
gas, is performed in large chambers lined with
lead. The combustion is facilitated by mixing
about one-eighth of a nitrate of pot-ash with
the sulphur. The acid vapours which fill the
chamber are precipitated against its sides, and
the condensation is facilitated by a stratum of
water disposed on the bottom of the chamber.
In some manufactories in Holland, this com-
bustion is performed in large glass balloons with
large mouths, and the vapours are precipitated
upon water placed at the bottom.

In both cases, when the water is sufficiently
impreg-

impregnated with acid, it is concentrated in leaden boilers, and rectified in glafs retorts, to render it white, and to concentrate it fufficiently for the purpofes of trade. The acid, when of a due ftrength, indicates fixty-fix degrees, according to the acrometer of Mr. Baumé; and when it has not been carried to this degree, it is unfit for moft of the ufes for which it is intended. It cannot, for example, be employed in diffolving indigo; for the fmall quantity of nitric acid which it contains, unites with the blue of the indigo, and forms a green colour. I have afcertained this phenomenon by very accurate experiments; and I have been a witnefs to the failing of colours, and the lofs of ftuffs, in confequence of the imperfection of the acid.

2. When the oxigene in the concrete ftate is prefented to the fulphur, it is then in combination with other bodies, which it abandons to unite with this laft. This happens when the nitric acid is diftilled from fulphur. Forty-eight ounces of this acid, at thirty-fix degrees, diftilled from two ounces of fulphur, afforded near four ounces of good fulphuric acid. This fact was known to Matte Lafaveur: but I pointed out all the phenomena and circumftances of the operation in 1781.

Sulphur may likewife be converted into ful-

P 3   phuric

phuric acid by means of the oxigenated muriatic acid.——Encyclopédie Méthodique, tom. i. p. 370.

The sulphuric acid which is found disengaged in some places in Italy, appears likewise to arise from the combustion of sulphur. Baldassari has observed it in this state in a hollow grotto, in the midst of a mass of incrustations deposited by the baths of Saint Philip, in Tuscany. He asserts that a sulphureous vapour continually arises in this grotto. He likewise found sulphureous and vitriolic effervescences at Saint Albino, near mount Pulciano ; and at the lakes of Travale, where he observed the branches of a tree covered with concretions of sulphur and the oil of vitriol.——Journal de Physique, t. vii. p. 395.

O. Vandelli relates that, in the environs of Sienna and Viterbo, sulphuric acid is sometimes found dissolved in water. Mr. (the commander) De Dolomieu affirms that he found it pure and crystallized in a grotto of mount Etna, from which sulphur was formerly obtained.

According to a first experiment of Mr. Berthollet, sixty-nine parts of sulphur with thirty-one parts of oxigene formed one hundred parts of sulphuric acid; and, according to a second experiment, seventy-two of sulphur and twenty-eight

ty-eight of oxigene formed one hundred parts
of dry acid.

The various degrees of concentration of the
fulphuric acid have caufed it to be diftinguifhed
by different names, under which it is known in
commerce. Hence the denominations of Spirit
of Vitriol, Oil of Vitriol, and Glacial Oil of
Vitriol, to exprefs its degrees of concentra-
tion.

The fulphuric acid is capable of paffing to
the concrete ftate by the impreffion of intenfe
cold. This congelation is a phenomenon long
fince known. Kunckel and Bohn have fpoken
of it; and Boerhaave fays exprefsly, " Oleum vi-
trioli, fummâ arte puriffimum, fummo frigore
hiberno in glebas folidefcit perfpicuas; fed, fta-
tim ac acuties frigoris retunditur, liquefcit et
diffluit."—We are indebted to the Duke
D'Ayen for fome very valuable experiments
upon the congelation of this acid; and Mr.
De Morveau repeated them with equal fuccefs in
1782, and proved that this congelation may
be effected at a degree of cold confiderably
lefs than what had been mentioned*.

I have already feveral times obtained beau-

* See alfo the experiments of Mr. Kier, and the late
experiments of Mr. Cavendifh, on the congelation of acids,
in the Philofophical Tranfactions.

tiful

tiful cryſtals of ſulphuric acid in flattened hexahedral priſms, terminated by an hexahedral pyramid; and my experiments have enabled me to conclude—1. That the very concentrated acid cryſtallizes more difficultly than that whoſe denſity lies between ſixty-three and ſixty-five. 2. That the proper degree of cold is from 1 to 3 degrees below o of Reaumur. The detail of my experiments may be ſeen in the volume of the Academy of Sciences of Paris for the year 1784.

The characters of the ſulphuric acid are the following :

1. It is unctuous and fat to the touch, which has occaſioned it to obtain the very improper name of Oil of Vitriol.

2. It weighs one ounce and ſeven gros in a bottle containing one ounce of diſtilled water.

3. It produces heat, when mixed with water, to ſuch a degree as to exceed that of boiling water. If one end of a tube of glaſs be cloſed, and water poured into it, and the cloſed end of this tube be plunged into water, the water in the tube may be made to boil by pouring ſulphuric acid into the external water which ſurrounds the tube.

4. It ſeizes with great avidity all inflammable ſub-

substances; and it is blackened and decomposed by this combination.

Stahl supposed the sulphuric acid to be the universal acid. He founded this opinion more especially upon the circumstance, that cloths soaked in a solution of alkali, and exposed to the air, attracted an acid which combined with the alkali; and formed a neutral salt, by him supposed to be of the nature of sulphate of pot-ash, or vitriolated tartar. Subsequent and more accurate experiments have shewn that this aërial acid was the carbonic; and the present state of our knowledge is such as permits us still less than ever to believe in the existence of an universal acid.

ARTICLE I.

Sulphate of Pot-ash.

The sulphate of pot-ash is described indifferently under the names of Arcanum Duplicatum, Sal de Duobus, Vitriolated Tartar, Vitriol of Pot-ash, &c.

This salt crystallizes in hexahedral prisms, terminating in hexahedral pyramids, with triangular faces.

It has a lively and penetrating taste, and melts difficultly in the mouth.

It

It decrepitates on hot coals, becomes red-hot before it fuſes, and is volatilized without decompoſition.

It is ſoluble in ſixteen parts of cold water, at the temperature of 60 degrees of Fahrenheit; and boiling water diſſolves one-fifth of its weight.

100 grains contain 30.21 acid, 64.61 alkali, and 5.18 water.

Moſt of the ſulphate of pot-aſh uſed in medicine is formed by the direct combination of the ſulphuric acid and pot-aſh, or the vegetable alkali; but that which is met with in commerce is produced in the diſtillation of aqua-fortis, by the ſulphuric acid: this has the form of beautiful cryſtals, and is ſold in the Comtat Venaiſin at forty or fifty livres the quintal. The analyſis of tobacco has likewiſe afforded me this ſulphate.

Mr. Baumé proved to the Academy, in 1760, that the nitric acid, aſſiſted by heat, is capable of decompoſing the ſulphate of pot-aſh. Mr. Cornette afterwards ſhewed that the muriatic acid poſſeſſes the ſame virtue; and I ſhewed, in 1780, that this acid may be diſplaced by the nitric acid, without the aſſiſtance of heat; though the ſulphuric acid reſumes its place when the ſolution is concentrated by heat.

ARTICLE II.

Sulphate of Soda.

This combination of the sulphuric acid and soda is still known under the names of Glauber's Salt, Sal Admirabile, Vitriol of Soda, &c. This salt crystallizes in rectangular octahedrons, of a prismatic or cuneiform figure, of which the two pyramids are truncated near their basis.

It has a very bitter taste, and easily dissolves in the mouth.

It swells up upon heated coals, and boils, in consequence of the dissipation of its water of crystallization. After this water has been dispersed, there remains only a white powder, difficult of fusion, which is volatilized without decomposition by a strong heat.

By exposure to the air, it effervesces, loses its transparency, and is reduced to a fine powder.

Three parts of water, at 60 degrees of Fahrenheit's thermometer, dissolved one part of this salt; but boiling water dissolves its own weight.

100 grains of sulphate of soda contain 14 acid, 22 alkali, and 64 water.

It

It is formed by the direct combination of the two principles which contain it; but the tamarix gallica, which grows on the fea coafts, contains fo large a quantity, that it may be extracted to advantage. Nothing more is neceffary for this purpofe, than to burn the plant, and lixiviate the afhes. That falt which is fold in the fouth of France, in fine cryftals, is prepared in this manner. It is very pure, and the price does not exceed thirty or thirty-five livres the quintal. This fulphate is likewife formed in our laboratories when we decompofe the muriate of foda, or common falt, by the fulphuric acid.

Pot-afh diffolved by heat in a folution of fulphate of foda, precipitates the foda, and takes its place. See my Chemical Memoirs.

A R T I C L E III.

Sulphate of Ammoniac.

The fulphate of ammoniac, commonly known by the name of Glauber's Secret Ammoniacal Salt, is very bitter.

It cryftallizes in long flattened prifms with fix fides, terminated by fix-fided pyramids.

It

It cannot be obtained in well-formed cryftals but by infenfible evaporation.

It flightly attracts the humidity of the air.

It liquefies by a gentle heat, and rifes over a moderate fire.

Two parts of cold water diffolve one of this falt; and boiling water diffolves its own weight, according to Fourcroy. The fixed alkalis, barytes, and lime, difengage the ammoniac from it.

The nitric and muriatic acids difengage the fulphuric acid.

The different fubftances of which we have treated are of confiderable ufe in the arts and medicine.

The fulphureous acid is employed in whitening filk, and giving it a degree of luftre. Stahl had even combined it with alkali, and formed the falt fo well known under the name of Stahl's Sulphureous Salt. This combination paffes quickly to the ftate of fulphate, if it be left expofed to the air; as it fpeedily abforbs the oxigene which is wanting for that purpofe.

The principal ufe of the fulphuric acid is in dying, in which art it ferves to diffolve indigo, and carry it in a ftate of extreme divifion upon the ftuffs to be dyed; it is likewife ufed by the manufacturers of Indiens, or filk and
                                                    ftuff

stuff mixtures, to carry off the preparation of these goods, wherein lime is used. The chemist makes great use of this acid in his analyses; and to separate other acids from their combination, such as the carbonic, the nitric, and the muriatic acids.

The sulphate of pot-ash is known in medicine as an alterative, and is used in cases of lacteous coagulations. It is given in the dose of a few grains, and is even purgative in a greater dose.

The sulphate of soda is an effectual purgative in the dose of from four to eight gros, or drams. For this purpose it is dissolved in a pint of water.

C H A P. III.

Concerning the Nitric Acid.

THE nitric acid, called Aqua Fortis in commerce, is lighter than the sulphuric. It usually has a yellow colour, a strong and disagreeable smell, and emits red vapours. It gives a yellow colour to the skin, to silk, and

to

to almoft all animal fubftances with which it
may come in contact. It diffolves and fpeed-
ily corrodes iron, copper, zinc, &c. with the
efcape of a cloud of red vapours during the
whole time its action lafts. It entirely deftroys
the colour of violets, which it reddens. It
unites to water with facility; and the mixture
affumes a green colour, which difappears when
ftill further diluted.

This acid has been nowhere found in a dif-
engaged ftate. It always exifts in a ftate of
combination; and it is from thefe combinations
that the art of chemiftry extracts it, to apply it
to our ufes. The nitrate of pot-afh, or com-
mon nitre, is the combination which is beft
known, and is likewife that from which we
ufually extract the nitric acid.

The procefs ufed in commerce to make
aqua fortis, confifts in mixing one part of falt-
petre with two or three parts of red bolar
earth. This mixture is put into coated retorts,
difpofed in a gallery or long furnace, to each
of which is adapted a receiver. The firft va-
pour which arifes in the diftillation is nothing
but water, which is fuffered to efcape at the
place of juncture, before the luting: and when the
red vapours begin to appear, the phlegm which
is condenfed in the receiver is poured out; and
the

the receiver, being replaced, is carefully luted
to the neck of the retort. The vapours which
are condensed, form at first a greenish liquor:
this colour disappears insensibly, and is re-
placed by another which is more or less yel-
low. Some chemists, more especially Mr.
Baumé, were of opinion that the earth acted
upon the saltpetre by virtue of the sulphuric
acid it contains. But not to mention that this
principle does not exist in all the earths made
use of, as Messrs. Macquer, De Morveau, and
Scheele have proved, we know that pulverized
flints equally produce the decomposition of
saltpetre. I am therefore of opinion that the
effect of these earths upon the salt ought to be
referred to the very evident affinity of the al-
kali to the silex, which is a principal compo-
nent part; and more especially to the slight de-
gree of adhesion which exists between the con-
stituent principles of nitrate of pot-ash.

We decompose saltpetre in our laboratories
by means of the sulphuric acid. Very pure ni-
trate of pot-ash is taken, and introduced into a
tubulated retort, placed in a sand bath, with a
receiver adapted. All the places of junction
are carefully luted; and as much sulphuric acid
as amounts to half the weight of the salt is pour-
ed through the tubulure; and the distillation is

<div align="right">pro-</div>

proceeded upon. Care is taken to fit a tube into the tubulure of the receiver; the other end of which is plunged into water, to condenfe the vapours, and to remove all fear of an explofion.

Inftead of employing the fulphuric acid, we may fubftitute the fulphate of iron, and mix it with faltpetre in equal parts. In this cafe the refidue of the diftillation, when well wafhed, forms the mild earth of vitriol made ufe of to polifh glafs.

Stahl and Kunckel have fpoken of a very penetrating aqua fortis, of a blue colour, obtained by the diftillation of nitre with arfenic.

Whatever precaution is taken in the purification of the faltpetre, and however great the attention may be which is beftowed upon its diftillation, the nitric acid is always impregnated with fome foreign acid, either the fulphuric or muriatic, from which it requires to be purified. It is cleared of the firft by rediftilling it upon very pure faltpetre, which retains the fmall quantity of fulphuric acid that may exift in the mixture. It is deprived of the fecond by pouring into it a few drops of a folution of nitrate of filver. The muriatic acid combines with the filver, and is precipitated with it in the form of an infoluble falt. The fluid is then fuffered to

remain at reft, and is afterwards decanted from the precipitate or depofition. This acid, fo purified, is known under the name of Aqua Fortis for Parting, Precipitated Nitrous Acid, Pure Nitric Acid, &c.

Stahl had confidered the nitric acid as a modification of the fulphuric, produced by its combination with an inflammable principle. This opinion has been fupported by feveral new facts, in a differtation of Mr. Pietfh, crowned by the Academy of Berlin in 1749.

The experiments of the celebrated Hales led him ftill nearer to this conclufion, as his manipulations were fucceffively employed upon the two conftituent principles of the nitric acid. This celebrated philofopher had obtained ninety cubic inches of air from half a cubic inch of nitre; and he proceeded no further in his conclufions, than to affert that this air is the principal caufe of the explofions of nitre.

The fame philofopher relates that the pyrites of Walton, treated with equal quantities of fpirit of nitre and water, produce an air which has the property of abforbing the frefh air, which may be made to enter the veffel. This great man, therefore, extracted fucceffively the two principles of the nitric acid; and thefe capital expe-

experiments put Dr. Prieſtley in the road to the diſcoveries he has ſince made.

It was not however until the year 1776 that the analyſis of the nitric acid was well known. Mr. Lavoiſier, by diſtilling this acid from mercury, and receiving the ſeveral products in the pneumato-chemical apparatus, has proved that the nitric acid, whoſe ſpecific gravity is to that of diſtilled water as 131607 to 100000, contains—

	oz.	gros.	grains.
Nitrous gas	1	7	$51\frac{1}{4}$
Oxigenous gas	1	7	$7\frac{1}{2}$
Water	13	—	—

By combining theſe three principles together the decompoſed acid was regenerated.

The action of the nitric acid on moſt inflammable matters, conſiſts in nothing more than a continual decompoſition of this acid.

If the nitric acid be poured upon iron, copper, or zinc, theſe metals are inſtantly attacked with a ſtrong efferveſcence; and a conſiderable diſengagement of vapours takes place, which become of a red colour by their combination with the atmoſpheric air, but which may be retained and collected in the ſtate of gas in the hydropneumatic apparatus. In all theſe caſes the metals are ſtrongly oxided.

Q 2   The

The nitric acid, when mixed with oils, ren-
ders them thick and black, converts them into
charcoal, or inflames them, accordingly as the
acid is more or lefs concentrated, or in a great-
er or lefs quantity.

If very concentrated nitric acid be put into
an apothecary's phial, and be poured upon
charcoal in an impalpable powder, and very
dry, it fets it on fire inftantly, at the fame time
that carbonic acid and nitrogene gas are dif-
engaged.

The various acids which are obtained by the
digeftion of the nitric acid on certain fubftan-
ces, fuch as the oxalic acid, or acid of fugar,
the arfenical acid, &c. owe their exiftence
merely to the decompofition of the nitric acid,
the oxigene of which is fixed in combination
with the bodies upon which the acid is diftil-
led.   The facility with which this acid is de-
compofed, renders it one of the moft active;
becaufe the action of acids upon moft bodies
is a confequence of their own proper decom-
pofition.

The characters of nitrous gas, which is ex-
tracted by the decompofition of the acid, are—
1. It is invifible, or perfectly tranfparent. 2. Its
fpecific gravity is rather lefs than that of at-
mofpherical air.   3. It is unfit for refpiration,
though

though the abbé Fontana pretends that he re-
spired it without danger. 4. It does not main-
tain combustion. 5. It is not acid, according
to the experiments of the Duke de Chaulnes.
6. It combines with oxigene, and reproduces
the nitric acid.

But what is the nature of this nitrous gas?
It was at firft pretended that it confifts of the
nitric acid faturated with phlogifton. This
fyftem ought to have been abandoned as foon
as it was proved that the nitric acid depo-
fited its oxigene upon the bodies on which it
acted; and that the nitrous gas was lefs in
weight than the acid made ufe of. A capital
experiment of Mr. Cavendifh has thrown the
greateft light on the fubject. This chemift
having introduced into a tube of glafs feven
parts of oxigenous gas obtained without nitrous
acid, and three parts of nitrogene gas; or, by
eftimating thefe quantities in weight, ten parts
of nitrogene to twenty-fix of oxigene—and hav-
ing caufed the electric fpark to pafs through
this mixture, perceived that its volume or bulk
was greatly diminifhed, and fucceeded in con-
verting it into nitric acid. It may be prefumed,
from his experiment, that the acid is a combi-
nation of feven parts of oxigene, and three of
nitrogene. Thefe proportions conftitute the

ordi-

ordinary nitric acid; but when a portion of its oxigene is taken away, it paffes to the ftate of nitrous gas; fo that nitrous gas is a combination of nitrogene gas, with a fmall quantity of oxigene.

Nitrous gas may be decompofed by expofing it to a folution of the fulphure of pot-afh, or hepar of fulphur : the oxigene gas unites to the fulphur, and forms fulphuric acid; while the nitrogene gas remains behind in a ftate of purity.

Nitrous gas may likewife be decompofed by means of pyrophorus, which burns in this air, and abforbs the oxigenous gas.

The electric fpark has likewife the property of decompofing nitrous gas. Mr. Van Marum has obferved that three cubic inches of the nitrous gas are reduced by electricity to one cubic inch and three quarters; and that this refidue no longer poffeffed any property of nitrous gas. Laftly, according to the experiments of Mr. Lavoifier, one hundred grains of nitrous gas contain thirty-two parts nitrogene, and fixty-eight parts oxigene : according to the fame chemift, one hundred grains of nitric acid contain feventy-nine and a half oxigene and twenty and a half nitrogene; and this is the reafon why nitrous gas fhould be employed in a lefs portion
than

than nitrogene gas, to combine with the oxigene gas, and form the nitric acid.

These ideas upon the composition of the nitrous acid, appear to be confirmed by the repeated proofs we now have of the necessity of causing substances, which afford much nitrogene gas, to be presented to the oxigene gas, in order to obtain nitric acid.

The several states of the nitric acid may be clearly explained according to this theory:—
1. The fuming nitrous acid is that in which the oxigene does not exist in a sufficient proportion; and we may render the whitest and the most saturated nitric acid fuming and ruddy, by depriving it of a part of its oxigene by means of metals, oils, inflammable substances, &c. or even by disengaging the oxigene by the simple exposition of the acid to the light of the sun, according to the valuable experiments of Mr. Berthollet.

The property which nitrous gas possesses, of absorbing oxigene to form the nitric acid, has caused it to be employed to determine the proportion of oxigene in the composition which forms our atmosphere. The abbé Fontana has constructed, on these principles, an ingenious eudiometer, the description and manner of using

which

which may be seen in the first volume of Dr.
Ingenhoufz's Experiments upon Vegetables.

Mr. Berthollet has very juftly obferved, that
this eudiometer is inaccurate, or productive of
deception—1. Becaufe it is difficult to obtain
nitrous gas conftantly formed of the fame pro-
portions of nitrogene gas and oxigene; for
they vary, not only according to the nature of
the fubftances upon which the nitric acid is de-
compofed, but likewife accordingly as the fo-
lution of any given fubftance by the acid is
made with greater or lefs rapidity. If the acid
be decompofed upon a volatile oil, nothing but
nitrogene gas can be obtained; if the acid act
upon iron, and it be much concentrated, nitro-
gene gas only will be obtained, as I have ob-
ferved, &c. 2. The nitric acid which is formed
by the union of nitrous gas and oxigene, dif-
folves a greater or lefs quantity of nitrous gas
according to the temperature, the quality of the
air which is tried, the fize of the eudiometer, &c.
fo that the diminution varies in proportion to
the greater or lefs quantity of nitrous gas
obtained by the nitric acid which is formed:
confequently the diminution ought to be greater
in winter than in fummer, &c.

According to the experiments of Mr. Lavoi-
fier,

fier, four parts of oxigenous gas are fufficient to faturate feven parts and one third of nitrous gas; whereas it is found that nearly fixteen parts of atmofpheric air are required to produce the fame effect: whence this celebrared chemift has concluded, that the air of the atmofphere does not in general contain more than one-fourth of oxigenous or refpirable gas. Repeated experiments at Montpellier, upon the fame principle, have convinced me that twelve or thirteen parts of atmofpheric air are conftantly fufficient to faturate feven parts and one-third of nitrous gas.

These experiments fhew, to a certain degree of accuracy, the proportion in which vital air exifts in the air which we refpire; but they do not give us any information refpecting the noxious gafes which, when mixed with the atmofpheric air, alter it, and render it unwholefome. This obfervation very much curtails the ufe of this inftrument.

The combination of the oxigenous and nitrous gafes always leaves an aëriform refidue, which Mr. Lavoifier eftimated at about one thirty-fourth of the whole volume: it arifes from the mixture of the foreign gafeous fubftances, which more or lefs affect the purity of the gafes made ufe of.

ARTI-

ARTICLE I.

Nitrate of Pot-ash.

The nitric acid, combined with pot-ash, forms the salt so well known under the names of Nitre, Saltpetre, Nitre of Potash, &c.

This neutral salt is rarely the product of any direct combination of its two constituent parts. It is found ready formed in certain places; and in this manner it is that the whole of the nitre employed in the arts is obtained.

In the Indies, it effloresces on the surface of uncultivated grounds. The inhabitants lixiviate these earths with water, which they afterwards boil and crystallize in earthen pots. Mr. Dombey has observed a great quantity of saltpetre near Lima, upon earths which serve for pasture, and which produce only gramineous plants. Mr. Talbot Dillon, in his travels into Spain, relates that one-third of all the grounds, and in the southern parts of that kingdom even the dust of the roads, contain saltpetre.

Saltpetre is extracted in France from the ruins and plaster of old houses.

This salt exists ready formed in vegetables, such as parietaria and buglos, &c. And one of
my

my pupils, Mr. Virenque, has proved that it is produced in all extracts which are capable of fermenting.

The fermentation of saltpetre may be favoured, by causing certain circumstances to concur which are of advantage to its formation.

In the north of Europe, the saltpetre-beds are formed with lime, ashes, earth of uncultivated grounds, and straw, which are stratified, and watered with urine, dunghill-water, and mother waters. These beds are defended by a covering of heath or broom. In the year 1775, the King caused a prize to be proposed by the Royal Academy of Sciences at Paris, to discover a method of increasing the product of saltpetre in France, and to relieve the people from the obligation of permitting the saltpetre-makers to examine their cellars, in order to discover and carry away saltpetre earths. Several Memoirs were offered on the subject, which the Academy united into a single volume; and these have added to our knowledge, by instructing us more especially concerning the nature of the matters which favour the formation of nitre. It was known, for example, long since, that nitre is formed in preference near habitations, or in earths, impregnated with animal products : it was likewise known that, in general, the alkaline basis was afforded by the con-

currence

currence of a vegetable fermentation. Mr.
Thouvenel, whose Memoir was crowned, has
proved that the gas which is difengaged by pu-
trefaction, is neceffary for the formation of nitre;
that blood, and next to it, urine, were the ani-
mal parts which were the moft favourable to
its formation; that the moft minutely divided
and the lighteft earths were the moft proper for
nitrification; that the current of air muft be
properly managed, to fix upon thefe earths the
nitric acid which is formed, &c.

It feems to me that Becher poffeffed a con-
fiderably accurate knowledge of the formation
of nitre, as appears from the following paffages:

" Hæc enim (vermes, mufcæ, ferpentes)
" putrefacta in terram abeunt prorfus nitrofam;
" ex qua etiam communi modo nitrum copio-
" fum parari poteft, fola elixatione cum aqua
" communi."—Phyf. Subt. lib. i. S. V. t. i.
p. 286.

" Sed et ipfum nitrum necdum finis ultimus
" putrefactionis eft; nam cum ejufdem partes
" igneæ feparantur, reliquæ in terram abeunt
" prorfum puram & infipidam, fed fingulari
" magnetifmo præditam novum fpiritum aëreum
" attrahendi, rurfufque nitrum fiendi."—Phyf.
Subt. S. V. t. i, p. 292.

From all the difcoveries and obfervations
which

which have been hitherto made, it follows that, in order to eſtabliſh artificial nitre beds, it is neceſſary that animal putrefaction and vegetable fermentation ſhould concur. The nitrogene gas, in its diſengagement from the animal ſubſtances, combines with the oxigene, and forms the acid, which again unites with the alkali, whoſe formation is favoured by the vegetable decompoſition.

When the manufacturer is in poſſeſſion of ſaltpetre-grounds, whether by the ſimple operations of nature or by the aſſiſtance of art, the ſaltpetre is extracted by the lixiviation of theſe earths; which lixivium is afterwards concentrated, and made to cryſtallize. In proportion as the evaporation goes forward, the marine ſalt, which almoſt always accompanies the formation of nitre, is precipitated. This is taken out with ladles, and ſet to drain in baſkets placed over the boilers.

As a great part of the nitre has an earthy baſis, and requires to be furniſhed with an alkaline baſis to cauſe it to cryſtallize, this purpoſe is accompliſhed either by mixing aſhes with the ſaltpetre earths, or by adding an alkali ready formed to the lixivium itſelf.

Nitre obtained by this firſt operation is never pure, but contains ſea-ſalt, and an extractive and

and colouring principle, from which it muſt be cleared. For this purpoſe it is diſſolved in freſh water, which is evaporated; and to which bullocks blood may be added, to clarify the ſolution. The nitre obtained by the ſecond manipulation is known by the name of Nitre of the Second Boiling. If recourſe be had to a third operation to purify it, it is then called Nitre of the Third Boiling.

The purified nitrate of pot-aſh is employed in delicate operations, ſuch as the manufacture of gunpowder, the preparation of aqua fortis for parting, and the ſolution of mercury, &c. The ſaltpetre of the firſt boiling is uſed in thoſe works where aqua fortis is made for the dyers. It affords a nitro-muriatic acid, which is capable of diſſolving tin by itſelf.

The nitrate of pot-aſh cryſtallizes in priſmatic octahedrons, which almoſt always repreſent ſix-ſided flattened priſms, terminated by dihedral ſummits.

It has a penetrating taſte, followed by a ſenſation of coldneſs.

It is fuſible upon ignited coals; and in this caſe its acid is decompoſed. The oxigene unites with the carbone, and forms the carbonic acid; the nitrogene gas and the water are diſſipated; and it is this mixture of principles which

has

has been known under the name of Clyffus of Nitre.

The diftillation of the nitrate of pot-afh affords twelve thoufand cubic inches of oxigenous gas for each pound of the falt.

Seven parts of water diffolve one of nitre, at fixty degrees of Fahrenheit; and boiling water diffolves its own weight of this falt.

One hundred grains of the cryftals of nitre contain thirty acid, fixty-three alkali, and feven water.

When a mixture of equal parts of nitre and fulphur are thrown into a red-hot crucible, a faline fubftance is obtained, which was formerly called Sal Polychreft of Glafer, and which has fince been confidered as Sulphate of Pot-afh. If nitre be fufed, and a few pinches of fulphur be thrown upon this falt in fufion, and the whole be afterwards poured out or caft into plates, it forms a falt known by the name of Cryftal Mineral.

A mixture of feventy-five parts of nitre, nine and a half of fulphur, and fifteen and a half of charcoal, forms gunpowder. This mixture is triturated from ten to fifteen hours, care being taken to moiften it from to time. This trituration is ufually performed by pounding mills, whofe peftles and mortars are of wood. In order

2   to

to give the powder the form proper to granulate it, it is passed through sieves of skin, whose perforations are of various sizes. The grained powder is then sifted, to separate the dust, and it is afterwards carried to the drying-house. Gunpowder for artillery, or cannon-powder, receives no other preparation; but it is necessary to glaze the powder which is intended for fowling. This last preparation is effected by putting it into a kind of cask which turns on an axis, and by whose movement the angles of the grains are broken, and their surfaces polished. We are indebted to Mr. Baumé and the chevalier Darcy for a series of experiments, in which they have proved—

1. That good gunpowder cannot be made without sulphur.

2. That charcoal is likewise indispensably necessary.

3. That the quality of gunpowder depends, cæteris paribus, upon the accuracy with which the mixture is made.

4. That the effect of powder is greater when simply dried than when it is granulated.

The effect of gunpowder depends upon the rapid decomposition which is made in an instant of a considerable mass of nitre, and the sudden formation of those gases which are the immediate

diate product. Bernoulli, in the laſt century, aſ-
certained the development of air by the de-
flagration of gunpowder: he placed four grains
of powder in a recurved tube of glaſs, plunged
the tube in water, and ſet fire to the gunpowder
by means of the burning-glaſs; after the com-
buſtion the interior air occupied a larger ſpace,
ſo that the ſpace abandoned by the water was
ſuch as would have contained two hundred
grains of gunpowder.—Hiſt. de l'Académie des
Sciences de Paris, 1696, t. ii. Mémoire de M.
Varignon ſur le Feu et la Flamme.

The fulminating powder, which is made by
the mixture and trituration of three parts of
nitre, two of ſalt of tartar, and one of ſulphur,
produces effects ſtill more terrible. In order
to obtain the full effect, it is expoſed in a ladle
to a gentle heat; the mixture melts, a ſulphu-
reous blue flame appears, and the exploſion takes
place. Care muſt be taken to give neither too
ſtrong nor too ſlight a degree of heat. In either
caſe, the combuſtion of the principles takes
place ſeparately, and without exploſion.

ARTICLE II.

Nitrate of Soda.

This ſalt has received the name of Cubic

Nitre

Nitre on account of its form; but this denomination is not exact, because it affects a figure constantly rhomboidal.

It has a cool, bitter taste.

It slightly attracts the humidity of the air.

Cold water, at sixty degrees of Fahrenheit's thermometer, dissolves one-third of its weight; and hot water scarcely dissolves more.

It fuses upon burning coals with a yellow colour; whereas common nitre affords a white flame, according to Margraff—24 Differt. fur le Sel Commun, t. ii. p. 343.

100 grains of this salt contain 28.80 acid, 50.09 alkali, and 21.11 water.

It is almost always the product of art.

ARTICLE III.

Nitrate of Ammoniac.

The vapours of ammoniac, or volatile alkali, being brought into contact with those of the nitrous acid, combine with them, and form a white and thick cloud, which slowly subsides.

But when the acid is directly united to the alkali, the result is a salt, which has a cool, bitter, and urinous taste.

Mr. De Lisle pretends that it crystallizes in
beautiful

beautiful needles, fimilar to thofe of fulphate of pot-afh.

These cryftals cannot be obtained but by a very flow evaporation.

When this falt is expofed to the fire, it liquefies, emits aqueous vapours, dries, and detonates.

Mr. Berthollet has analyfed all the refults of this operation, and has drawn from them a new proof of the truth of the principles which he has eftablifhed with regard to ammoniac.

C H A P. IV.

Concerning the Muriatic Acid.

THIS acid is generally known by the name of Marine Acid, and it is ftill diftinguifhed among artifans by the name of Spirit of Salt.

It is lighter than the two preceding acids; it has a ftrong penetrating fmell, refembling that of faffron, but infinitely more pungent; it emits white vapours when it is concentrated; it precipitates filver from its folution in the

form

form of an infoluble falt, &c. This acid has
no where been found difengaged ; and, to obtain
it in this ftate, it is neceffary to difengage it
from its combinations. Common falt is ufually
employed for this purpofe.

The fpirit of falt of commerce is obtained by
a procefs little differing from that which is ufed
in the extraction of aqua fortis. But as this
acid adheres more ftrongly to its bafis, the pro-
duct is very weak, and only part of the marine
falt is decompofed.

Flints pulverized, and mixed with this falt,
do not feparate the acid. Ten pounds of flints
in powder, treated by a violent fire with two
pounds of the falt, did not afford me any other
product than a mafs of the colour of litharge.
The fumes were not perceptibly acid. If clay,
which has once ferved to decompofe marine falt,
be mixed with a new quantity of the fame falt,
it will not decompofe an atom of it, even though
the mixture be moiftened and formed into a
pafte. Thefe experiments have been feveral
times repeated in my manufactory, and have
conftantly exhibited the fame refults.

The fulphate of iron, or martial vitriol, which
fo eafily difengages the nitric acid, decompofes
marine falt; but very imperfectly.

The impure foda known in France by the
name

name of Blanquette, and in which my analyſis
has exhibited twenty-one pounds of common
ſalt out of twenty-five, ſcarcely affords any mu-
riatic acid when it is diſtilled with the ſulphuric
acid; but it affords abundance of ſulphureous
acid. Mr. Berard, director of my manufac-
tory, attributed theſe reſults to the coal con-
tained in this ſoda, which decompoſed the ſul-
phuric acid. He therefore calcined the blan-
quette to deſtroy the charcoal; and then he found
he could treat it in the ſame manner as common
ſalt, and with the ſame ſucceſs.

The ſulphuric acid is uſually employed to
decompoſe marine ſalt. My method of pro-
ceeding conſiſts in drying the marine ſalt,
pounding it, and putting it into a tubulated re-
tort placed upon a ſand bath. A receiver is
adapted to the retort, and afterwards two bottles,
after the manner of Woulfe, in which I diſtri-
bute a weight of diſtilled water equal to that
of the marine ſalt made uſe of. The joinings
of the veſſels are then luted, but with the
greateſt caution; and when the apparatus is
thus fitted up, a quantity of ſulphuric acid is
poured through the tubulure equal to half the
weight of the ſalt. A conſiderable ebullition is
immediately excited; and when this efferveſ-

R 3   cence

cence is flackened, the retort is gradually heated, and the mixture made to boil.

The acid is difengaged in the ftate of gas; and mixes rapidly with the water, in which it produces a confiderable degree of heat.

The water of the firft bottle is ufually fatu-rated with the acid gas, and forms a very con-centrated and fuming acid ; and though the fe-cond is weaker, it may be carried to any de-fired degree of concentration, by impregnating it with a new quantity of the gas.

The ancient chemifts were divided refpecting the nature of the muriatic acid. Becher fup-pofed it to be the fulphuric acid modified by his mercurial earth.

This acid is fufceptible of combining with an additional dofe of oxigene ; and, what is very extraordinary, it becomes more volatile in con-fequence of this additional quantity; whereas the other acids appear to acquire a greater de-gree of fixity in the fame circumftances. It may even be faid, that its acid virtues become weaker in this cafe, fince its affinities with alka-lis diminifh ; and it is fo far from reddening blue vegetable colours, that it deftroys them.

Another phenomenon not lefs interefting, which is prefented to us by this new combina-
tion,

tion, is, that though the muriatic acid feizes the oxigene with avidity, yet it contracts fo weak a union with it, that it yields it to almoft all bodies, and the mere action of light alone is fufficient to difengage it.

It is to Scheele that we are indebted for the difcovery of the oxigenated muriatic acid. He formed it in the year 1774, by employing the muriatic acid as a folvent for manganefe. He perceived that a gas was difengaged, which poffeffed the diftinctive fmell of aqua regia; and he was of opinion that in this cafe the muriatic acid abandoned its phlogifton to the manganefe; in confequence of which notion he called it the Dephlogifticated Marine Acid. He took notice of the principal and truly aftonifhing properties of this new fubftance; and all chemifts fince his time have thought their attention well employed in examining a fubftance which exhibits fuch fingular properties.

To extract this acid, I place a large glafs alembic of one fingle piece upon a fand bath. To the alembic I adapt a fmall receiver; and to the receiver three or four fmall bottles nearly filled with diftilled water, and arranged according to the method of Woulfe. I difpofe the receiver and the bottles in a ciftern, the places of junction being luted with fat lute, and

<center>R 4</center>

<div align="right">fecured</div>

secured with rags foaked in the lute of lime and white of egg. Laftly, I furround the bottles with pounded ice. When the apparatus is thus difpofed, I introduce into the alembic half a pound of manganefe of Cevennes, and pour upon it, at feveral repetitions, three pounds of fuming muriatic acid. The quantity of acid which I pour at once is three ounces; and at each time of pouring a confiderable effervefcence is excited. I do not pour a new quantity until nothing more comes over into the receivers. This method of proceeding is indifpenfably neceffary, when the operator is defirous of making his procefs with a definite quantity of the materials. For if too large a quantity of acid be poured at once, it is impoffible to reftrain the vapours; and the effervefcence will throw a portion of the manganefe into the receiver. The vapours which are developed by the affufion of muriatic acid are of a greenifh yellow colour; and they communicate this colour to the water when they combine with it. When this vapour is concentrated by means of the ice, and the water is faturated with it, it forms a fcum at the furface, which is precipitated through the liquid, and refembles a congealed oil. It is neceffary to affift the action of the muriatic acid by means of a moderate heat applied to the fand bath.

bath. The secure luting of the veffels is alfo an effential circumftance; for the vapour which might efcape is fuffocating, and would not permit the chemift to infpect his operation clofely. It is eafy to difcover the place where it efcapes through the lutes, by running a feather dipped in volatile alkali over them : the combination of thefe vapours inftantly forms a white cloud, which renders the place vifible where the vapour efcapes. An excellent Memoir of Mr. Berthollet, publifhed in the Annales Chimiques, may be confulted upon the oxigenated muriatic acid.

The fame oxigenated muriatic acid may be obtained by diftilling, in a fimilar apparatus, ten pounds of marine falt, three or four pounds of manganefe, and ten pounds of fulphuric acid.

Mr. Reboul has obferved that the concrete ftate of this acid is a cryftallization of the acid, which takes place at three degrees of temperature below the freezing point of Reaumur. The forms which have been obferved are thofe of a quadrangular prifm, truncated very obliquely, and terminated by a lozenge. He has likewife obferved hollow hexahedral pyramids on the furface of the liquor.

To make ufe of the oxigenated acid in the
arts,

arts, and in order to concentrate a greater quantity in a given volume of water, the vapour is made to pass through a solution of alkali. A white precipitate is at first formed in the liquor; but a short time afterwards the deposition diminishes, and bubbles are disengaged, which are nothing but the carbonic acid. In this case two salts are formed, the oxigenated muriate, and the ordinary muriate. The mere impression of light is sufficient to decompose the former, and convert it into common salt. This lixivium contains, indeed, the oxigenated acid in a stronger proportion. The execrable smell of the acid is much weakened. It may be employed for various uses with the same success, and with great facility; but the effect is very far from corresponding with the quantity of oxigenated acid which enters into this combination, because the virtue of a great part is destroyed by its union with the alkaline basis.

The oxigenated muriatic acid has an excessively strong smell. It acts directly on the larynx, which it stimulates, excites coughing, and produces violent head-aches.

Its taste is sharp and bitter. It speedily destroys the colour of tincture of turnsole. But it appears that the property which most oxigenated substances possess, of reddening blue colours, arises

arifes only from the combination of oxigene with the colouring principles; and that, when this combination is very ftrong and rapid, the colour is deftroyed.

The oxigenated muriatic acid with which a folution of cauftic alkali is faturated, affords, by evaporation in veffels fecluded from the light, common muriate and oxigenated muriate. This laft detonates upon charcoal; is more foluble in hot than in cold water; cryftallizes, fometimes in hexahedral laminæ, and oftener in rhomboidal plates. Thefe cryftals have an argentine brilliancy, like mica. Its tafte is faint; and its cryftals, when they are diffolved in the mouth, produce a fenfation of coolnefs refembling that of nitre.

Mr. Berthollet has afcertained, by delicate experiments, that the oxigenated muriatic acid which exifts in the oxigenated muriate of potafh, contains more oxigene than an equal weight of oxigenated muriatic acid diffolved in water; and this has led him to confider the oxigenated acid combined in the muriate as being fuperoxigenated. He confiders the common muriatic gas with relation to the oxigenated muriatic gas, the fame as the nitrous gas or fulphureous gas with refpect to the nitric and fulphuric acids. He pretends that the production of the fimple muriate

riate and the oxigenated muriate in the fame operation, may be compared to the action of the nitric acid, which in many cafes produces nitrate and nitrous gas. Hence he has confidered the muriatic acid as a pure radical, which, combined with a greater or lefs quantity of oxigene, forms either fimple muriatic acid gas, or the oxigenated muriatic acid gas.

The oxigenated muriates of foda do not differ from thofe of pot-afh, but in being more deliquefcent and foluble in alcohol, like all the falts of this nature.

The oxigenated muriate of pot-afh gives out its oxigene in the light, and by diftillation as foon as the veffel is heated to rednefs. One hundred grains of this falt afford feventy-five cubic inches of oxigenous gas reduced to the temperature of twelve degrees of Reaumur. This air is purer than the others, and may be employed for delicate experiments. The oxigenated muriate of pot-afh, when cryftallized, does not trouble the folutions of nitrate of lead, of filver, or of mercury.

Mr. Berthollet has fabricated gunpowder, by fubftituting the oxigenated muriate inftead of faltpetre. The effects it produced were quadruple. The experiment in the large way, which was made at Effone, is but too well known.

known, by the death of Mr. Le Tors and Ma-
demoiſelle Chevraud. This powder exploded
the moment the mixture was triturated.

The oxigenated muriatic acid whitens thread
and cotton. For this purpoſe the cotton is
boiled in a weak alkaline lixivium ; after which
the ſtuff is wrung out, and ſteeped in the oxigen-
ated acid. Care is taken to move the cloth oc-
caſionally in the fluid, and to wring it out. It
is then waſhed in a large quantity of water, to
deprive it of the ſmell with which it is impreg-
nated.

I have applied this known property to the
whitening of paper and old prints : by this
means they obtained a whiteneſs which they ne-
ver before poſſeſſed. Common ink diſappears
by the action of this acid ; but printers ink is
not attacked by it.

Linen and cotton cloths, and paper, may be
bleached by the vapour of the oxigenated ma-
rine acid. I have made ſome experiments in the
large way, which have convinced me of the poſ-
ſibility of applying this method to the arts. The
Memoir in which I have given an account of my
experiments, will be printed in the volume of
the Academy of Paris for the year 1787.

The oxigenated muriatic acid thickens oils;
and oxides metals to ſuch a degree, that this
<div align="right">proceſs</div>

procefs may be advantageoufly ufed to form ver-
diter.

The oxigenated muriatic acid diffolves metals
without effervefcence; becaufe its oxigene is
fufficient to oxide them without the neceffity of
the decompofition of water, and confequently
without the difengagement of gas.

This acid precipitates mercury from its folu-
tions, and converts it into the ftate of corrofive
fublimate.

It converts fulphur into fulphuric acid, and
inftantly deprives the very black fulphuric acid
of its colour.

When mixed with nitrous gas, it paffes to the
ftate of muriatic acid, and converts part of the
gas into nitric acid.

When expofed to light, it affords oxigenous
gas, and the muriatic acid is regenerated.

The muriatic acid acts very efficacioufly upon
metallic oxides, merely in confequence of its be-
coming oxigenated; and in this cafe it forms
with them falts, which are likewife more or lefs
oxigenated.

ARTI-

ARTICLE I.

Muriate of Pot-ash.

This salt is still distinguished by the name of Febrifuge Salt of Sylvius.

It has a disagreeable strong bitter taste.

It crystallizes in cubes, or in tetrahedral prisms.

It decrepitates upon coals; and when urged by a violent heat it fuses, and is volatilized without decomposition.

It requires three times its weight of water, at the temperature of sixty degrees of Fahrenheit, for its solution.

It is subject to scarcely any alteration in the air.

One hundred grains of this salt contain 29.68 acid, 63.47 alkali, and 6.85 water. It is frequently met with, but in small quantities, in the water of the sea, in plaster, in the ashes of tobacco, &c. The existence of this salt in the ashes of tobacco might with justice have surprised me, as I had reason to expect the muriate of soda which is employed in the operation called watering. Was the soda metamorphosed into pot-ash by the

the vegetable fermentation ? This may be determined by direct experiments.

ARTICLE II.

Muriate of Soda.

The received names of Marine Salt, Common Salt, and Culinary Salt, denote the combination of muriatic acid with foda.

This falt has a penetrating but not bitter tafte. It decrepitates on coals, fufes, and is volatilized by the heat of a glafs-maker's furnace, without d ecompofition.

It is foluble in 2.5 times its weight of water, at fixty degrees of Fahrenheit's thermometer.

One hundred grains of this falt contain 33.3 acid, 50 of alkali, and 16.7 of water.

It cryftallizes in cubes. Mr. Gmelin has informed us that the falt of the falt lakes in the environs of Sellian on the banks of the Cafpian fea, forms cubical and rhomboidal cryftals.

Mr. De Lifle obferves, that a folution of marine falt, left to infenfible evaporation during five years by Mr. Rouelle, had formed regular octahedral cryftals refembling thofe of alum.

Marine falt may be obtained in octahedrons, by pouring frefh urine into a very pure folution

2   of

of fresh salt. Mr. Berniard is convinced that this addition changed only the form of the salt, without altering its nature.

Common salt is found native in many places. Catalonia, Calabria, Switzerland, Hungary, and Tyrol possess mines, which are more or less abundant. The richest salt mines are those of Wieliczka in Poland. Mr. Berniard has given us a description of them in the Journal de Physique; and Mr. Macquart, in his Essays on Mineralogy, has added interesting details concerning the working of these mines.

Our salt springs in Lorraine and Franche-comté, and some indications afforded by Bleton, have appeared sufficient motives to Mr. Thouvenel to presume that salt mines exist in our kingdom. This chemist expresses himself in the following manner:

" At the distance of two leagues from Saverne, between the village of Huctenhausen and that of Garbourg, in a lofty mountain called Pensenperch, there are two great reservoirs of salt water; the one to the east, at the head of a large deep and narrow valley, which is called the great Limerthaal; the other to the west, upon the opposite slope, towards Garbourg. They communicate together by five small streams, which are detached from the upper re-

fervoir, and unite in the lower one. From thefe two falt refervoirs flow two large ftreams; the upper runs into Franche-comté, and the lower into Lorraine, where they fupply the well-known falt works."

The waters therefore flow to the diftance of feventy leagues from the refervoir.

Salt mines appear to owe their origin to the drying up of vaft lakes. The fhells and madre-pores found in the immenfe mines of Poland are proofs of marine depofitions. There are like-wife fome feas in which the falt is fo abundant, that it is depofited at the bottom of the water; as appears from the analyfis of the water of the lake Afphaltites, made by Meffrs. Macquer and Sage.

This native falt is often coloured; and as in this ftate it poffeffes confiderable brilliancy, it is called Sal-gem. It almoft always contains an oxide of iron, which colours it.

As thefe falt mines are neither fufficiently abundant to fupply the wants of the inhabitants of the globe, nor diftributed with that unifor-mity as to permit all nations to have ready re-courfe to them, it has been found neceffary to extract the falt from the water of the fea. The fea does not contain an equal quantity in all cli-mates: Ingenhoufz has fhewn us that the nor-

<div align="right">thern</div>

thern seas contain lefs than the fouthern. Marine falt is fo abundant in Egypt, that, according to Haffelquift, a frefh-water fpring is a treafure which is fecretly tranfmitted from father to fon.

The method of extracting the water of the fea varies according to the climates.

1. In the northern provinces, the falt fands of the fea coafts are wafhed with the leaft poffible quantity of water, and the falt is obtained by evaporation.—See the defcription of this procefs by Mr. Guettard.

2. In very cold countries, falt water is concentrated by freezing, and the refidue is evaporated by fire.—See Wallerius.

3. At the falt fprings of Lorraine and Franche-comté, the water is pumped up, and fuffered to fall upon heaps of thorns, which divide it, and caufe a part to evaporate. The farther concentration is effected in boilers.

4. In the fouthern provinces, at Peccais, at Peyrat, at Cette, and elfewhere, the extraction is begun by feparating a certain quantity of water from the general mafs of the fea, which is fuffered to remain in fquare fpaces, called Partenemens. For this purpofe it is neceffary to have fluices which may be opened and fhut at pleafure, and to form furrounding walls which pre-

S 2   vent

vent all communication with the fea, except by means of thefe gates. It is in the partenemens that the water goes through the firft ftage of evaporation; and when it begins to depofit its falt, it is raifed by bucket wheels to other fquare compartments, called Tables, where the evaporation finifhes.

The falt is heaped together, to form the *cammelles* ; in which ftate it is left for three years, in order that the deliquefcent falts may flow out of it ; and, after this interval of time, it is carried to market.

Exertions and enquiries have long fince been made to difcover a cheap method of decompofing marine falt, to obtain the mineral alkali at a low price, which is of fuch extenfive ufe in the manufactures of foap, glafs, bleaching, &c. The proceffes hitherto difcovered are the following :

1. The nitric acid difengages the muriatic acid, and forms the nitrate of foda, which may be eafily decompofed by detonation.

2. Pot-afh difplaces the foda, even in the cold, as I found by experiment.

3. The fulphuric acid forms fulphate of foda by decompofing the marine falt ; the new falt, when heated with charcoal, is deftroyed; but a fulphure of foda, or liver of fulphur, is formed,

which

which is difficult to be entirely separated; and this procefs does not appear to me to be economical. The fulphate may likewife be decompofed by the acetite of barytes, and the foda afterwards obtained by calcination of the acetite of foda.

4. Margraff tried in vain to accomplifh this purpofe, by means of lime, ferpentine, iron, clay, &c. He adds that if common falt be thrown upon lead heated to rednefs, the falt is decompofed, and muriate of lead is formed.

5. Scheele has pointed out the oxides of lead for the decompofition of common falt. If common falt be mixed with litharge, and made into a pafte, the litharge gradually lofes it colour, and becomes converted into a white matter, from which the foda may be extracted by wafhing. It is by procefses of this kind that Turner extracts it in England; but this decompofition never appeared to me to be complete, unlefs the litharge was employed in a proportion quadruple to that of the falt. I have obferved that almoft all bodies are capable of alkalizing marine falt, but that the abfolute decompofition is very difficult.

6. Barytes decompofes it likewife, according to the experiments of Bergmann.

7. The vegetable acids, combined with lead,

S 3

may

may likewife be ufed to decompofe common falt. When thefe falts are mixed, a decompofition takes place: the muriate of lead falls down; and the vegetable acid, united to the foda, remains in folution. The vegetable acid may be diffipated by evaporation and calcination; and the alkali remains difengaged.

Marine falt is more efpecially employed at our tables, and in culinary purpofes. It removes and corrects the infipidity of our food, and at the fame time facilitates digeftion. It is ufed in a large proportion to preferve flefh from putrefaction; but in a fmall dofe it haftens that procefs, according to the experiments of Pringle, Macbride, Gardane, &c.

ARTICLE III.

Muriate of Ammoniac.

Of all the combinations of ammoniac this is the moft interefting, and the moft generally ufed. It is known by the name of Sal Ammoniac.

This falt may be directly formed by decompofing the muriate of lime by the means of ammoniac, as Mr. Baumé has practifed at Paris. But almoft all the fal ammoniac which circulates in
commerce

commerce is brought to us from Egypt, where
it is extracted by diftillation from foot, by the
combuftion of the excrements of fuch animals as
feed on faline plants.

The details of the procefs which is ufed have
not been very long known. One of the firft
writers who gave a defcription of this operation
is father Sicard. He informed us, in 1716,
that diftilling veffels were charged with the foot
of the excrements of oxen, to which fea falt and
camels urine were added.

Mr. Lemaire, conful at Cairo, in a letter
written to the Academy of Sciences in 1720,
affirms that neither urine nor fea falt are ad-
ded.

Mr. Haffelquift has communicated to the
Academy of Stockholm a confiderably exten-
five defcription of the procefs : by which we
learn, that the dung of all animals which feed on
faline plants is indifcriminately ufed, and that
the foot is diftilled, to obtain fal ammoniac.

This dung is dried by applying it againft the
walls ; and it is burned inftead of wood, in fuch
countries as do not poffefs that fuel. The fub-
limation is performed in large round bottles of
one foot and a half diameter, terminating in a
neck of two inches in height; and they are filled
to within four inches of the neck. The fire is

kept

kept up during three times twenty-four hours; the falt is fublimed to the upper part of thefe veffels, where it forms a mafs of the fame figure as the veffels themfelves. Twenty pounds of foot afford fix pounds of fal ammoniac, according to Rudenfkield.

I was always of opinion that fal ammoniac might be extracted by treating the dung of the numerous animals which feed on faline plants in the plains of La Camargue and La Crau, in the fame manner; and after having procured, with the greateft difficulty, two pounds of the foot, I extracted from it four ounces of fal ammoniac. I muft obferve, to fave much trouble to thofe who may wifh to follow this branch of commerce, that the dung produced during the fummer, the fpring, or the autumn, does not afford this falt. I did not know to what circumftance to attribute the verfatility of my refults, until I found that thefe animals do not eat faline vegetables, excepting at the time when frefh plants cannot be had; and that they are reduced to the neceffity of having recourfe to faline plants only during the three winter months. This obfervation appears me to be a proof, that marine falt is decompofed in the firft paffages; and that the foda is modified to the ftate of ammoniac.

Sal ammoniac is continually fublimed through

the

the apertures of volcanic mountains. Mr. Ferber found it; and Mr. Sage admitted its existence among volcanic products. It is found in the grottos of Puzzolo, according to Meſſrs. Swab, Scheffer, &c.

It is found in the country of the Calmucs. Model analyſed it.

It is alſo produced in the human body, and exhales by perſpiration in malignant fevers. Mr. Model has proved this fact in his own perſon: for at the time of a violent ſweat which terminated a malignant fever, he waſhed his hands in a ſolution of pot-aſh, and obſerved that a prodigious quantity of alkaline gas was diſengaged.

Sal ammoniac cryſtallizes by evaporation in quadrangular priſms, terminated by ſhort quadrangular pyramids. It is often obtained in rhombic cryſtals by ſublimation. The concave face of the loaves of ſal ammoniac in commerce is ſometimes covered with theſe cryſtals.

This ſalt has a penetrating, acrid, urinous taſte. It poſſeſſes a degree of ductility which renders it flexible, and cauſes it to yield to a blow of the hammer. It does not change in the air; which circumſtance renders it probable that our ſal ammoniac is different from that mentioned by Pliny and Agricola, as that attracted humidity. Three parts and a half of water diſ-
ſolve

solve one part of sal ammoniac, at sixty degrees of Fahrenheit's thermometer: a considerable degree of cold is produced by its solution.

One hundred parts of sal ammoniac contain fifty-two parts acid, forty ammoniac, and eight water.

This salt is not at all decomposed by clay; nor by magnesia except with difficulty, and in part only; but it is completely decomposed by lime and fixed alkalis. The sulphuric and nitric acids disengage its acid.

This salt is used in dying, to bring out certain colours. It is mixed with aqua fortis, to increase its solvent power.

It is used in soldering; in which operation it possesses the double advantage of clearing the metallic surface, and preventing its oxidation.

CHAP.

C H A P. V.

Concerning the Nitro-muriatic Acid.

THE acid which we call Nitro-muriatic, is a combination of the nitric and muriatic acids.

Our predecessors distinguished it by the name of Aqua Regia, on account of its property of dissolving gold.

There are several known processes for making this mixed acid.

If two ounces of common salt be distilled with four of nitric acid, the acid which comes over into the receiver will be good nitro-muriatic acid.

This is the process of Mr. Baumé.

The nitrate of pot-ash may be decomposed by distilling two parts of muriatic acid from one of this salt : good aqua regia is the product of this operation ; and the residue is a muriate of pot-ash, according to Mr. Cornette.

Boerhaave affirms that he obtained a good aqua regia, by distilling a mixture of two parts of nitre, three of sulphate of iron or martial vitriol, and five of common salt.

The

The simple diftillation of nitre of the firft boiling affords aqua regia; which is employed by the dyers in the folution of tin, for the compofition of the fcarlet dye. This aqua fortis is a true aqua regia: and it is by virtue of the mixture of acids that it diffolves tin; for if it confifted of the nitric acid in a ftate of too great purity, it would corrode and oxide the metal without diffolving it. The dyers then fay that the aqua fortis precipitates the tin; and they correct the acid by diffolving fal ammoniac or common falt in it.

Four ounces of fal ammoniac in powder, diffolved gradually, and in the cold, in one pound of nitric acid, form an excellent aqua regia. An oxigenated muriatic acid gas is difengaged for a long time; which it is imprudent to attempt to coerce, and which ought to be fuffered to efcape by convenient apertures.

Aqua regia is likewife formed by mixing together two parts of pure nitric acid and one of muriatic acid.

The very evident fmell of oxigenated muriatic acid, which is difengaged in every procefs which can be adopted to form the acid at prefent in queftion; and the property which it poffeffes, equally with the oxigenated muriatic acid, of diffolving gold, have led certain chemifts to

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infer

infer that, in the mixture of thefe two acids, the muriatic acid feized the oxigene of the nitric, and affumed the character of oxigenated muriatic acid : fo that the nitric acid was confidered as anfwering no other purpofe than that of oxigenating the muriatic. But this fyftem is inconfiftent ; and though the virtues of the muriatic acid are modified by this mixture, and it is oxided by the decompofition of a portion of the nitric acid, neverthelefs the two acids ftill exift in the aqua regia : and I am convinced that the beft made aqua regia, faturated with pot-afh, will afford the ordinary muriate, the oxigenated muriate, and the nitrate. It appears to me that the powerful action of aqua regia depends fimply on the union of the two acids ; one of which is exceedingly well calculated to oxide the metals, and the other diffolves the oxides or calces with the greateft avidity.

CHAP.

C H A P.   VI.

Concerning the Acid of Borax.

THE acid of borax, more generally known
by the name of Homberg's Sedative Salt,
is almost always afforded by the decomposition
of the borate of soda, or borax. But it has been
found perfectly formed in certain places; and we
have reason to hope that we shall speedily ac-
quire more accurate information respecting its
nature.

Mr. Hoefer, director of the Pharmacies of
Tuscany, was the first who detected this acid
salt in the waters of the lake Cherchiajo, near
Monte-rotondo, in the inferior province of Sien-
na : these waters are very hot, and they afforded
him three ounces of the pure acid in one hundred
and twenty pounds of the water. This same chemist
having evaporated twelve thousand two hundred
and eighty grains of the water of the lake of
Castelnuovo, obtained one hundred and twenty
grains. He presumes, moreover, that it might
be found in the water of several other lakes, such
as those of Lasso, Monte-cerbeloni, &c.

                                            Mr.

Mr. Sage has deposited in the hands of the Royal Academy of Sciences some acid of borax, brought from the mines of Tuscany by Mr. Besson, who collected it himself.

Mr. Westrumb found sedative salt in the stone called Cubic Quartz of Luneburg. He obtained it by decomposing this stone by the acids of sulphur, nitre, &c. The result of his analysis is the following :

Sedative salt	—	$\frac{6}{10}$
Calcareous earth	—	$\frac{1}{10}$
Magnesia	—	$\frac{1}{10}$
Clay and silex	—	$\frac{2}{100}$
Iron —		$\frac{1}{200}$ to $\frac{2}{200}$

This stone, according to the observations of Lassius, has the form of small cubical crystals, sometimes transparent, in other specimens milky, and affords sparks with the steel.

The acid of borax is generally found combined with soda. It is from this combination that it is disengaged, and obtained either by sublimation or crystallization.

When it is proposed to obtain it by sublimation, three pounds of calcined sulphate of iron, and two ounces of borate of soda, are dissolved in three pounds of water. The solution is then filtered, and evaporated to a pellicle; after which

which the fublimation is performed in a cucurbit of glafs with its head. The acid of borax attaches itfelf to the internal furface of the head, from which it may be fwept by a feather.

Homberg obtained it by decompofing of borax with the fulphuric acid. This procefs fucceeded with me wonderfully well. For this purpofe I make ufe of a glafs cucurbit with its head, which I place on a fand bath. I then pour upon the borax half its weight of fulphuric acid, and proceed to fublimation. The fublimed acid is of the moft beautiful whitenefs.

'Stahl, and Lemery the younger, obtained the fame acid by making ufe of the nitric and muriatic acids.

To extract the acid of borax by cryftallization, the borax is diffolved in hot water, and an excefs of fulphuric acid is poured in. A falt is depofited during the cooling on the fide of the veffel, in the form of thin round plates, applied one upon the other. This falt, when dry, is very white, very light, and of a filvery appearance. It is the acid of borax.

We are indebted to Geoffroy for this procefs. Baron has added two facts: the firft, that the vegetable acids are equally capable of decompofing borax ; and the fecond, that borax may

be

be regenerated by combining the acid of borax with foda.

This acid may be purified by folution, filtration, and evaporation ; but it muſt be obſerved, that a conſiderable part is volatilized with the water which flies off in the evaporation.

The acid of borax has a faline cool taſte. It colours the tinčture of turnfole, fyrup of violets, &c. red.

One pound of boiling water diſſolved no more than one hundred and eighty-three grains, according to Mr. De Morveau.

Alcohol diſſolves it more eaſily ; and the flame which this folution affords is of a beautiful green. This acid, when expoſed to the fire, is reduced to a vitriform and tranſparent fubſtance, inſtead of riſing; which proves, as Rouelle has obſerved, that it is only fublimed by favour of the water, with which it forms a very volatile compound.

As moſt of the known acids decompoſe this acid, and exhibit it in the fame form, it has been thought a juſtifiable concluſion that it exiſts ready formed in the borax. Mr. Baumé has even affirmed that he compoſed this acid by leaving a mixture of grey clay, greaſe, and cows dung expoſed to the air in a cellar. But Mr. Wiegleb, after an unfucceſsful labour of three

years and a half, thinks himself authorised to give a formal negative to the French chemist.

Mr. Cadet has endeavoured to prove——
1. That the acid of borax always retains a portion of the acid employed in the operation.
2. That this same acid has still the mineral alkali for its basis.——Mr. De Morveau has, with his usual sagacity, discussed all the proofs brought forward by Mr. Cadet; he has shewn that none of them are conclusive, and that the acid of borax is entitled to retain its place among the chemical elements.

ARTICLE I.

Borate of Pot-ash.

The acid of borax combined with pot-ash forms this salt. It may be obtained either by the direct combination of these two separate principles, or by decomposing borax by the addition of pot-ash.

This salt, which is yet little known, afforded Mr. Baumé small crystals.

The acids decompose it by seizing its alkaline base.

ARTI-

ARTICLE II.

Borate of Soda.

This combination forms Borax, properly fo called.

It is brought to us from the Indies; and its origin is ftill unknown *.

" The article Borax may be confulted in Bomare's Dictionary of Natural Hiftory.

It does not appear that borax was known to the ancients. The chryfocolla, of which Diofcorides fpeaks, was nothing but an artificial folder compofed, by the goldfmiths themfelves, with the urine of children and ruft of copper, which were beaten together in a mortar of the fame metal.

The word Borax is found for the firft time in the works of Geber. Every thing which has been written fince that time concerning borax,

* The origin of borax is very well afcertained in two Papers, in the feventy-feventh volume of the Philofophical Transactions, Numbers xxviii. and xxix. It is dug up in a cryftallized ftate from the bottom of certain falt lakes in a mountainous, barren, volcanic diftrict, about twenty-five days journey to the eaftward of Laffa, the capital of the kingdom of Thibet.
T.

is

is applicable to the fubftance which is at prefent known to us by that name.

Borax is found in commerce in three different ftates.—The firft is brute borax, tincall, or chry-focolla. It comes to us from Perfia, and is en-veloped and foiled by a greafy covering. The pieces of brute borax have almoft all of them the form of a fix-fided prifm, flightly flattened, and terminated by a dihedral pyramid. The fracture of thefe cryftals is brilliant, with a green-ifh caft. This kind of borax is very impure. It is pretended that borax is extracted from the Lake of Necbal, in the kingdom of Grand Thi-bet. This lake is filled with water during the winter, which exhales in the fummer; and when the waters are low workmen enter, who detach the cryftals from the muddy bottom, and put them into bafkets.

The Weft Indies contain borax. It is to Mr. Antony Carera, a phyfician eftablifhed at Potofi, that we are indebted for this difcovery. The mines of Riquintipa, and thofe in the neigh-bourhood of Efcapa, afford this falt in abun-dance. The natives ufe it in the fufion of cop-per ores.

The fecond kind of borax known in com-merce comes from China. It is purer than the preced-

preceding, and has the form of small plates cryftallized upon one of their furfaces, on which the rudiments of prifms may be perceived. This borax is mixed with a white powder, which appears to be of an argillaceous nature.

Thefe feveral kinds of borax have been purified at Venice for a long time, and afterwards in Holland; but Meffrs. Laguiller refine it at prefent in Paris: and this purified borax forms the third kind which is met with in commerce.

In order to purify borax, nothing more is neceffary than to clear it of the unctuous fubftance which foils it, and impedes its folution.

Crude borax added to a folution of mineral alkali, is more completely diffolved, and may be obtained of confiderable beauty by a firft cryftallization; but it retains the alkali made ufe of: and borax, purified in this manner, poffeffes a greater proportion of alkali than in its crude ftate.

The oily part of borax may be deftroyed by calcination. By this treatment it becomes more foluble, and may in fact be purified in this way. But the method is attended with a confiderable lofs, and is not fo advantageous as might be imagined.

The moft fimple method of purifying borax, confifts in boiling it ftrongly, and for a long

time,

time. This solution being filtrated, affords by evaporation cryftals rather foul, which may be purified by a fecond operation fimilar to the foregoing. I have tried all thefe procefies in the large way; and the latter appeared to me to be the moft fimple.

Purified borax is white, tranfparent, and has a fomewhat greafy appearance in its fracture.

It cryftallizes in hexahedral prifms, terminated by trihedral and fometimes hexahedral pyramids.

It has a ftyptic tafte.

It converts fyrup of violets to a green.

When borax is expofed to the fire, it fwells up, the water of cryftallization is diffipated in the form of vapour; and the falt then becomes converted into a porous, light, white, and opake mafs, commonly called Calcined Borax. If the fire be more ftrongly urged, it affumes a pafty appearance, and is at length fufed into a tranfparent glafs of a greenifh yellow colour, foluble in water; and which lofes its tranfparency by expofure to the air, in confequence of a white efflorefcence that forms upon its furface.

This falt requires eighteen times its weight of water, at the temperature of fixty degrees of Fahrenheit's thermometer, to diffolve it. Boiling water diffolves one-fixth of its weight.

Barytes

Barytes and magnefia decompofe borax. Lime-water precipitates the folution of this falt ; and if quick-lime be boiled with borax, a falt of fparing folubility is formed, which is the borate of lime.

Borax is ufed as an excellent flux in docimaf-tic operations. It enters into the compofition of reducing fluxes, and is of the greateft ufe in analyfes by the blow-pipe. It may be applied with advantage in glafs manufactories ; for when the fufion turns out bad, a fmall quan-tity of borax re-eftablifhes it. It is more efpe-cially ufed in foldering. It affifts the fufion of the folder, caufes it to flow, and keeps the fur-face of the metals in a foft or clean ftate, which facilitates the operation. It is fcarcely of any ufe in medicine. Sedative falt alone is ufed by fome phyficians ; and its name fufficiently indi-cates its application.

Borax has the inconvenience of fwelling up, and requires the greateft attention on the part of the artift who ufes it in delicate works, more efpecially when defigns are formed with gold of different colours. It has been long a defidera-tum to fubftitute fome compofition in the room of borax, which might poffefs its advantages without its defects.

Mr. Georgi has publifhed the following pro-

cefs :—" Natron, mixed with marine falt and
Glauber's falt, is to be diffolved in lime-water;
and the cryftals which feparate by the cooling of
the fluid may be fet apart. The lixivium of
natron is then to be evaporated; and this falt
afterwards diffolved in milk. The evaporation
affords fcarcely one-eighth of the natron em-
ployed, and the refidue may be applied to the
fame ufes as borax."

Meffrs. Struve and Exchaquet have proved
that the phofphate of pot-afh, fufed with a cer-
tain quantity of fulphate of lime, forms an ex-
cellent glafs for foldering metals.—See the Jour-
nal de Phyfique, t. xxix. p. 78, 79.

ARTICLE III.

Borate of Ammoniac.

This falt is ftill little known. We are indebted
to Mr. De Fourcroy for the following indica-
tions :—He diffolved the acid of borax in am-
moniac, and obtained by evaporation a bed or
plate of cryftals connected together, whofe fur-
face exhibited polyhedral pyramids. This falt
has a penetrating and urinous tafte; it renders
the fyrup of violets green; gradually lofes its
cryftalline form, and becomes of a brown co-
lour,

lour, by the contact of air. It appears to be of confiderable folubility in water. Lime difengages the volatile alkali.

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Concerning Mineral Waters*.

THE name of Mineral Water is given to any water whatever which is fufficiently loaded with foreign principles to produce an effect upon the human body, different from that which is produced by the waters commonly ufed for drink.

Men, doubtlefs, were not long in attending to the differences of waters. Our anceftors appear even to have been more ftrictly attentive than ourfelves to procure wholefome drink. It was almoft always the nature of the water which

* As mineral waters bear relation to every part of chemiftry, their analyfes may be indifferently placed at the end of any one of the parts. But as the nature of the principles they contain fuppofe an acquaintance with the products of the three kingdoms, it is more natural to referve the article of the mineral waters for the conclufion of a courfe of chemiftry. I have thought proper to change this order for no other reafon, than becaufe I forefaw that the third volume of this work would be of too large a fize even without it. T.

deter-

determined their preference in the fituation of
towns, the choice of habitations, and confequent-
ly the union of citizens. The fmell, the tafte, and
more efpecially the effects of waters upon the
animal economy, have been thought fufficient,
during a long time, to determine their nature.
We may fee, in the writings of Hippocrates,
how much obfervation and genius are capable
of performing in fubjects of this nature. This great
man, of whom it would afford but a very imper-
fect idea to confider him merely as the Father
of Medicine, was fo well acquainted with the
influence of water upon the human body, that he
affirms that the mere quality of their ufual drink
is capable of modifying and producing a difference
between men; and he recommends to young phy-
ficians to attend more particularly to the na-
ture of the waters their patients ought to ufe.
We fee that the Romans, who were frequently
under the neceffity of fettling in parched cli-
mates, fpared no exertions to procure whole-
fome water to their colonies. The famous
aqueduct which carried the water of Uzes to
Nifmes, is an unequivocal proof of this; and
we ftill poffefs feveral mineral fprings at which
they formed colonies, for the advantage of the
baths.

It was not till near the feventeenth century
that

that the application of chemical methods to the examination of waters was firſt made. We are indebted to the preſent revolution of chemiſtry for the degree of perfection to which this analyſis has been carried.

The analyſis of waters appears to me to be neceſſary, in order—

1. That we may not make uſe of any water for drink but ſuch as is wholeſome.

2. That we may become acquainted with thoſe which poſſeſs medicinal virtues, and apply them to the uſes to which they are ſuited.

3. To appropriate to the different works or manufactories that kind of water which is the beſt calculated for their reſpective purpoſes.

4. To correct impure waters, or ſuch as are either impregnated with any noxious principle, or charged with any ſalt.

5. To imitate the known mineral waters, in all places and at all times.

The analyſis of mineral waters is one of the moſt difficult problems of chemiſtry. In order to make a perfect analyſis, it is neceſſary to be aware of all the diſtinctive characters of the ſubſtances which may be held in ſolution in any water. The operator muſt be acquainted with the means of ſeparating from an almoſt inſenſible reſidue

3

refidue the different fubftances which compofe
it. He muft be able to appreciate the nature
and quantity of the products which are car-
ried off by evaporation; and likewife to afcer-
tain whether certain compounds are not formed
by the operations of his analyfis, while others
may be decompofed.

The fubftances contained in waters are held
either in fufpenfion or in folution.

1. Thofe fubftances which are capable of
being fufpended in waters are, clay, filex in a
ftate of divifion, calcareous earth, magnefia,
&c.

Thofe which are foluble are, pure air, the car-
bonic acid, pure or compound alkalis, lime,
magnefia, the fulphates, the muriates, the ex-
tractive matter of plants, hepatic gas, &c. The
moft ancient, the moft general, and the moft
fimple divifion of mineral waters, is that which
diftinguifhes them into cold waters and hot or
thermal waters, accordingly as their temperature
is the fame, or exceeds that of common water.

A divifion founded on the feveral qualities of
thefe waters, will arrange them in four claffes.

I. Acidulous or Gafeous Waters.—Thefe are
known by their penetrating tafte; the facility with
which they boil; the difengagement of bubbles

by

by fimple agitation, or even by mere ftanding; the property of reddening the tincture of turn-fole; the precipitating lime-water, &c.

They are either cold or hot. The firft are thofe of Seltz, of Chateldon, of Vals, of Perols, &c. The fecond are thofe of Vichi, of Mont-d'or, of Chatelguyon, &c.

II. Saline waters, properly fo called.—Thefe are characterifed by their faline tafte, which is modified according to the nature of the falts they contain. The falts moft generally found in wa-ters are, the muriate of magnefia, the fulphates of foda, of lime, &c. Our waters of Balaruc, of Yeufet, &c. are of this nature.

III. Sulphureous Waters.—Thefe waters have long been confidered as holding fulphur in folu-tion. Meffrs. Venel and Monnet oppofed this affertion. Bergmann has proved that moft of thefe waters are merely impregnated with hepa-tic gas. It appears, however, that there are fome which hold true liver of fulphur in folu-tion, fuch as thofe of Bareges and of Cotteret; whereas the waters of Aix la Chapelle, Mont-morency, &c. are of the nature of thofe men-tioned by Bergmann. We may, with Mr. De Fourcroy, call the firft by the name of Hepatic Waters, and the latter by the name of Hepa-tized Waters.

This

This class is known by the smell of rotten eggs which they emit.

IV. Martial Waters.—These have the property of exhibiting a blue colour by the solution of prussiate of lime : they have besides a very evident astringent taste. The iron is held in solution either by the carbonic or the sulphuric acid. In the first case the acid is either in excess, and the water has a penetrating subacid taste, as the waters of Bussang, Spa, Pyrmont, Pougue, &c.: or the acid is not in excess, and consequently the waters are not acidulous ; such are the waters of Forges, Condé, Aumale, &c. Sometimes the iron is combined with the sulphuric acid, and the water holds in solution a true sulphate of iron. Mr. Opoix admits this salt in the waters of Provins ; and those of Rougne near Alais are almost saturated with it. Mineral waters of this quality are frequently found in the vicinity of strata of pyrites. There are several near Amalou, and in the diocese of Uzes.

There are some waters which may be placed indiscriminately in several of the classes. Thus, for example, there are saline waters which may be confounded with gaseous waters, because air is constantly disengaged from them. The waters of Balaruc are of this kind.

We

We do not comprehend among mineral waters
thofe which fuffer gas to efcape through them, with-
out communicating any characteristic property;
fuch as the burning fpring of Dauphiny, &c.

When the nature of any water is afcertained,
its analyfis may be proceeded upon by the union
of chemical and phyfical means. I call thofe
methods phyfical, which are ufed to afcertain
certain properties of water without decompofing
them. Thefe methods are, for the moft part,
fuch as may be carried into effect at the fpring
itfelf. The appearance, the fmell, and the tafte
afford indications by no means to be neglected.

The limpidity of any water indicates its purity,
or at leaft the accurate folution of the foreign
principles it may contain; an imperfect tranf-
parency denotes that foreign fubftances are fuf-
pended. Good water has no fmell: the fmell
of rotten eggs denotes liver of fulphur, or hepa-
tic gas; a fubtle and penetrating fmell is pro-
per to acidulous waters; and a fetid fmell cha-
racterizes ftagnant waters.

The bitternefs of waters in general depends
on neutral falts. Lime, and the fulphates, give
them an auftere tafte.

It is likewife of importance to afcertain the
fpecific gravity of the water, which may be
done either by means of the areometer, or by
the

the comparifon of its weight with that of an equal volume of diftilled water.

The degree of heat muft likewife be taken by means of a good mercurial thermometer. Thermometers made with fpirits of wine ought to be rejected ; becaufe the dilatation, after the thirty-fecond degree of Reaumur, is extreme, and no longer correfponds with the temperature of the water. It is interefting to calculate the time which the water requires to become cool, in comparifon with diftilled water raifed to the fame degree of temperature. Notice muft likewife be taken whether any fubftance exhales, or is precipitated by the cooling.

The obferver ought likewife to enquire whether rains, dry feafons, or other variations of the atmofphere, have any influence on the temperature or quantity of water of the fpring. If thefe caufes act upon the fpring, its virtue cannot but vary exceedingly. This is the caufe why certain mineral waters are more highly charged with their principles in one year than in another ; and hence alfo it arifes that certain waters produce wonderful effects in fome years, though in other feafons their effects are trifling. The celebrated De Haen, who analyfed for feveral fucceffive years all the waters in the neighbourhood of Vienna, never found them to contain the fame

I   principles

principles in the same proportion. It would therefore be an interesting circumstance, if, at the time of taking up or bottling of these waters, a skilful physician were to analyse them, and publish the result.

After these preliminary examinations have been made at the spring, further experiments must be made according to the methods of chemistry. These experiments ought to be performed at the spring itself: but if this cannot be done, new bottles may be filled with the water; and, after closing them very accurately, they may be carried to the laboratory of the chemist, who must proceed to examine them by reagents, and by the method of analysis.

I. The substances contained in water are decomposed by means of re-agents; and the new combinations or precipitates which are formed, immediately point out the nature of the principles contained in the waters. The most efficacious and the only necessary re-agents are the following:

1. Tincture of turnsole becomes red by its mixture with acidulous waters.

2. Prussiate of lime, and that of ferruginous pot-ash not saturated, precipitate the iron contained in a mineral water of a blue colour.

3. The very concentrated sulphuric acid de-

composes

compoſes moſt neutral ſalts; and forms with their baſes ſalts very well known, and eaſily diſtinguiſhed.

4. The oxalic acid, or acid of ſugar, diſengages lime from all its combinations, and forms with it an inſoluble ſalt.

The oxalate of ammoniac produces a more ſpeedy effect; for, by adding a few cryſtals of this ſalt to water charged with any calcareous ſalt, an inſoluble precipitate is inſtantly formed.

5. Ammoniac or volatile alkali affords a beautiful blue colour with the ſolutions of copper. When this alkali is very pure, it does not precipitate the calcareous ſalt, but decompoſes the magneſian only. In order to have it in a highly cauſtic ſtate, a ſyphon may be plunged in the mineral water, and ammoniacal gas or alkaline air paſſed through it. The water ought to be kept from the contact of the atmoſphere, which otherwiſe might occaſion a precipitation by virtue of its carbonic acid.

6. Lime water precipitates magneſia; and it likewiſe precipitates the iron from a ſolution of ſulphate of iron.

7. The muriate of barytes detects the ſmalleſt particle of ſulphuric ſalts, by the regeneration of ponderous ſpar, which is inſoluble, and falls down.

8. Alco-

8. Alcohol is a good re-agent, on account of its affinity with water.

The nitrates of silver and of mercury may likewise be employed to decompose sulphuric or muriatic salts.

II. These re-agents, indeed, point out the nature of the substances contained in any water; but they do not exhibit their accurate proportions. For this purpose we are obliged to have recourse to other means.

There are two things to be considered in the analysis of any water—1. The volatile principles. 2. The fixed principles.

1. The volatile principles are carbonic acid gas and hepatic gas. The proportion of carbonic acid may be ascertained by various processes. The first, which has been used by Mr. Venel, consists in half filling a bottle with the gaseous water intended to be analysed. A bladder is then to be tied upon the neck of the bottle, and the water agitated. The air which is disengaged inflates the bladder; and by that indication an estimate may be made of its quantity. This process is not acurate; because agitation is not sufficient to disengage the whole of the carbonic acid. Neither is the evaporation of the water in the pneumato-chemical apparatus much more exact; because the water which rises with the

air

air combines again with it, and the gaseous pro-
duct consists only of a part of the gas contained
in the water. The precipitation by lime-water
appears to me to be the most accurate process.
Lime-water is poured into a determinate quan-
tity of the water, until it ceases to cause any pre-
cipitate. This precipitate being very accurately
weighed, $\frac{1}{32}$ parts of the whole must be de-
ducted for the proportion in which water and
earth enter into it; and the remainder is the
acid contained in this carbonate of lime.

Hepatic gas may be precipitated by the very
concentrated nitric acid, according to the expe-
riments of Bergmann.

The oxigenated muriatic acid has been pro-
posed by Scheele; and Mr. De Fourcroy has
pointed out the sulphureous acid, the oxides of
lead, and other re-agents, to precipitate the
small quantity of sulphur held in solution in he-
patic gas.

2. Evaporation is commonly used to ascer-
tain the nature of the fixed principles contained
in any mineral water. Vessels of earth or porce-
lain are the only kind suitable to this purpose.

The evaporation must be moderate; for
strong ebullition volatilizes some substances,
and decomposes others. In proportion as the
evaporation proceeds, precipitates are afforded,
        6   which

which Mr. Boulduc propofes to take out as they are formed. The celebrated Bergmann advifes evaporation to drynefs, and to analyfe the refidue in the following manner:

1. This refidue muft be put into a fmall phial, and ftrongly agitated with alcohol; after which the fluid muft be filtrated.

2. Upon the refidue pour eight times its weight of cold diftilled water; agitate this, and filter the fluid, after ftanding feveral hours.

3. Laftly, the refidue muft be boiled for a quarter of an hour in five or fix hundred parts of diftilled water, which fluid muft be feparated by filtration.

4. The refidue, which is neither foluble in water nor in alcohol, muft then be moiftened, and expofed for feveral days to the fun: by this treatment, the iron which it may contain, rufts. It muft then be digefted in diftilled vinegar, which diffolves lime and magnefia; and this folution, evaporated to drynefs, affords either an earthy falt in filaments which are not deliquefcent, or a deliquefcent falt; which laft has magnefia for its bafe. The infoluble refidue contains iron and clay, which are to be diffolved in the muriatic acid. The iron is firft to be precipitated by the pruffiate of lime; and afterwards the clay by another alkali.

The

The salts which the alcohol has diffolved, are the muriates of magnefia and of lime. They are eafily known by decompofing them by the fulphuric acid.

With refpect to the falts diffolved in the cold water, they muft be flowly cryftallized; and their form, and other obvious qualities, will fhew what they are.

The folution by boiling water contains nothing but fulphate of lime.

When the analyfis of any water has been well made, the fynthefis becomes eafy; and the compofition or perfect imitation of mineral waters is no longer a problem infoluble to chemifts. What, in fact, is a mineral water? It is rain water, which, filtering through the mountains, becomes impregnated with the various foluble principles it meets with. Why, therefore, when once we know the nature of thefe principles, can it not be poffible to diffolve them in common water, and to do that which nature itfelf does? Nature is inimitable only in its vital operations; we may imitate its effects perfectly in all other proceffes: we may even do better; for we can at pleafure vary the temperature and the proportions of the conftituent parts. The machine of Nooth, improved by Parker, may be made ufe of to compofe any gafeous

<div align="right">mineral</div>

mineral water, whether acidulous or hepatic; and nothing is more eafy than to imitate fuch waters as contain only fixed principles.

THE END OF THE FIRST VOLUME.