General Division of the Course.

1st head — The Effects of heat & mixture on Bodys & Chymical Apparatus

2° — Elementary Bodys —

3 — Vegetable Substances

4 — Animal Substances

Division of the first head.

1st The more general Effects of heat on bodys

2. The more general Effects of mixture on bodys

3 An account of Chymical Apparatus.

1st The more general Effects of heat on bodys

I wish I could give you some well groundd'd Theory to

to explain the nature & operations of heat which are very extensive, but from the imperfect knowledge we have of them, I fear that I am incapable of doing it. Lord Bacon first plann'd out to Chymists the great necessity of attending to facts & experiments, In his treatise on heat, he observes several of the Phenomena attending it & handles the subject in a curious manner, he concludes at least heat is caus'd by motion, many facts favour'd this opinion, such as the heat generat'd by the friction of hard bodys, that a small piece of Iron plac'd upon an Anvil, may by hammering be made red hot, that wheel-axles are sometimes set on fire by rapid motion, that by the Collision of flint & steel where a small piece of steel is shook off which will set fire to Tinder, — Sr. Isaac Newton supports this conjecture by sup-

suppposing that heat is caus'd by the vibrations of the particles of Bodys & communicated by those of a subtile medium to other bodys, this System was generally follow'd by the English Philosophers & Called the Mechanical Philosophy. Another opinion was that fire is a Body sui generis & diffused every where that that is the Vibration of this subtile Elastic fluid, The french Philosophers have mostly adher'd to this System called the Chymical Philosophy, but as both of these are involved in obscurity & do not explain the nature of that, I shall enter no further into such an useless attempt, hower if you shou'd chose afterwards to prosecute this Study you may consult the Works of Lord Verulam, Mr. Boyle & Boerhaaves desportation on fire, I shall therefore proceed to lay before you many of the Effects that it produces on bodys.

the

The first observation that offers itself is that we find it impossible to make that remain in any simple mass of matter setting aside inflamable substances for any length of time, it has an irresistable tendency to flow from a warmer into a Colder body- If heated Iron is laid on a stone the heat flows into the stone, If the Iron is put into Water, the heat flows into it till the Equilibrium is restor'd If the water takes an equal quantity of the fire, In this manner it pierces the densest bodys, being only equal'd by the Magnet, The first effect it produces upon bodys is expasion, that is when any body receives any quantity of heat, it increases its bulk, & to this rule there are few exceptions, there are only three forms under which matter appears to us, the first comprehends solid bodys such as Iron &c. the second inelastic bodys as Water, oil, Spirit of wine &c. the third Elastic fluid bodys as

air

air — I shall now shew you the effects of that
expanding bodys belonging to these three forms,
First, I take a Cylindrical piece of Iron as also
another piece with a hole in it the Cylindrical
piece in its natural state, just passes thro'
the hole, but when heated red hot it will not, a
certain proof of its having increased in breadth,
If the Cylindrical piece is made to go length ways
betwixt two prominences when cold, if heated as
before it will be found lengthned, hence we find
heat to increase it both in length & Breadth, &
if it is throwen hot into cold water it will again
resume its former size ——

To prove the expansion of an unelastic fluid. I put
some spirit of wine into an oblong vessel marked
with degrees on the neck, this I put into a Vessel
of hot water the spirit rises several degrees,
but if put into cold water the spirit contracts

&

& falls to its former height th, an Experiment of
the Expansion of an elastic fluid may be shown
by taking a Bladder with a little air in it
and exposing it to the fire, when its bulk will
be so increased as to burst the Bladder, but
upon exposing it to cold Air it will again resume
its former size — These Phenomena demonstrate —
that every kind of Body expands by heat & con—
tracts by cold, for if I had immers'd the Iron in
a mixture of Salt & snow, it would evidently have
been more Contracted than in its natural state,
some bodys suffer greater Expansion than others —
Rarer & lighter bodys expanding more than heavier
and denser, but this proportion does not al-
-ways follow the degree of Density or Rarity — —
Metals expanding more than Glass, these effects of
heat & Cold prove both useful & inconvenient; The

the

The hooper & wheel-right apply the expansion of Iron with advantage in putting Iron hoops on the Casks & Rings on Carriage Wheels which when heated go on pretty easy, but being cooled with Water they contract & squeeze the sides of the Cask or fellies of the wheel together, sudden heat or Cold applyd to brittle bodys is apt to make them Crack or Breake which proves of considerable inconvenieney in Chymistry & in Chymical processes where glass & cast Iron vessels are used, as either the sudden aplication or diminution of heat is apt to breake them - This is somewhat remided in glass vessels by having them made thin which gives them flexibility of a Spherical form which receives the heat or Cold more equally and of an equal thickness to receive the heat in the same manner, Water suddenly swells in passing from a fluid to a condens'd state

and

and this with such force as to burst very strong
Vessels - Mr Boyle mentions an experiment of
this kind, he took a brass tube of three Inches dia-
meter and took a plug newly fitted to it, which
was put down upon water just into the tube,
and pressed with a weight of 74 pounds, the whole
was exposed to frost when the water freezing rais'd
the weight - The Florentine Accademicians made many
experiments upon this subject especialy one with
a hollow Brass Globe which they fill'd with wa-
ter & compress'd it by a strong screw being turn'd
thro the Globe into the water, upon freezing the
Water the Globe was found too strong to burst
upon which as much was taken off as that it
might give way to the force of the freezing water
when it burst the force found requisite was 27000
pounds, & so immense is this Expansive force that
it has been known to burst a Cannon the water be-
ing

ing closely confin'd in it & exposd to frost, —
from the same Cause proceeds the bursting of Lead-
en pipes for the conveyance of Water, the loosening
of stones after frost, & the decay of Buildings which
is found very great where there is much rain or
frost, & it may be from this effect of frost that
it is of excellent use, fertilizing Soils as it swells
the Earth & loosens its particles by which means
a greater number of them are exposed to the roots of
Vegetables, several opinions has been advanced to
account for the expansion of Water upon freezing
as water converted into Ice is never clear but in-
-terspersed with several cavitys, it has been thought
that Air insinuates itself into the water during
freezing making it more bulky & lighter, but this
opinion has been refuted by placing water under the
receiver of an Air pump & exhausting the air as
much as possible & then frozen, when the same

Cavitys

Cavitys were found as before, & instead of being heavier it floated on the Surface of the Water. Mr. Mr. Marian found that the particles of Water asume a different arangment on freezing from what they had before, & that they formed themselves in specula crosing each other at an Angle of 60 degrees which may be obsew'd in a bason of Water where they shoot on tinies from the Circumference to the centre & that the same thing may be obsew'd in flakes of snow & from their Specula crosing each other, Interstices wou'd happen & make the Ice lighter than Water — from the Crystalization of salt into regular figures it was supposed that there was salts mix'd with the Water which made it take the above form in freezing, but Mr. Margraaf's Experiments show that snow water is the pure-est of any —

Mr.

Mr. Reaumeus on the subject of Iron, observes with much ingenuity that cast Iron melted, in passing to a Cold state expands, this effect is more sensible in Iron than any other Metal on account of the Intatey texture of which it is composed, he observes that cold cast Iron thrown into the same metal melted swims on the surface, in this case the immediate expansion of Iron on congealing seems to agree with the water, but they differ in this that Iron never expands by cold afterwards, whereas Ice exposed to a greater degree of Cold becomes more bulky; the whole mass not being closely connected, from a particular arrangment which makes it lighter than before

But to return to the subject of heat in general, while it expands an unelastic fluid as Water, Oil &c. it does it with an irresistable force which is proved by an experiment of the Florentine Academicians upon a

a hollow globe of Gold filled with water & compres-
-ed with a Violent force, but this compression could
not be made without heating & expanding the
water, which made its way thro' the pores of
the Gold or other Cavitys, & appeared on the exter-
nal surface in droops — But the conclusion drawn
from this that water is incompressible is false,
for certain experiments shew that water & Mercury
if placed in a Vessel with stem nicely graduated &
put under an exhausted receiver, will rise a little
by the pressure of the Air being taken off, the least
degree of heat will cause a greater expansion —
It may be observed as remarkable that the heat in-
-creases the bulk, it causes no alteration in the
weight of body as Boerhaave has demonstrated by
Several accurate experiments — W. Musschenbroek says
that a Cube Inch of Iron heated looses one hundredth
part of a grain & that the same quantity of Lead
looses

looses four grains but that when cold they return to their former Weight, but this experiment is liable to fallacy — for weighing the hot metal in the scales ravifys the air around it which may make the metal appear lighter, or the heat might expand the Beam which would make it false — When metals are exposed to a sufficient degree of fire & the free air admitted a Calx is formed & this is found to be heavier than the metal was before, thus 100 ℔ of lead calcined produces 110 of Calx, it was therefore thought that fire was a gravitating body & which during calcination had communicated this weight to the Lead — Musschenbrook is of this opinion, insisting that since fire increases the weight of Bodys whether it is Terestrial or pure Celestial inheres in them & therefore has weight it self. The heated metals are found lighter than when cold, yet

this

this is no argument against the gravity of fire for by heat the bodys are expanded & by their increase of bulk lose more specific gravity than they acquire increase of weight by the heat, Thus Iron when heated is almost the same as When Cold because it expands very little, but Lead in 4 pounds lost 4 grains — while 4 pounds of melted pewter only lost 2 gr. because the lead expands into a greater volume than Pewter & therefore loses more weight, but as long as their bodys remain ~~from~~ masses or are restored to them they expell the fire & return to their former weight which does not hold after Calcination — But if heat was a ponderous body the above reasoning would be insufficient to account for their Phenomena which I shall endeavour to explain on different principles afterwards. ——

As heat or cold increases or decreases the bulk of Bodys

Bodys. we cannot say with propriety that any body has a particular Specific gravity without determining the degree of heat which is now done by the help of Thermometers of which I shall now give you an account.

Thermometers

The invention of Thermometers tho obscure, is given to Drebbel, who published a Treatise on them in the Year 1668, his Thermometers were simple & imperfect being a glass tube with a bulb blown on one end & the other being left open was insert'd into a fluid coloured with red by applying heat to the bulb the air contain'd in the glass was rarify'd & expell'd & on cooling was nearly fill'd with the fluid the part of the tube left unfill'd was graduated so that by the application of heat to the bulb the air was rarify'd & the degree of expansion shewn by the decent of the fluid in the tube

but

but as this Thermometer was liable to be affected by the alterations of the Atmosphere it would not be a proper measure for the different degrees of heat at different times, The Thermometer now in use was first contrived by Santorius a Italian Doct.r he took a Glass Tube blown as before & by expelling the air he filled the Globe of it & part of the tube with coloured Spirits of Wine when it was immersed in Snow or Ice Then by heat he forced the liquour up to the top & sealed it hermetically. During the Space from the degree of Cold to that of heat which raised it to the upper part — may to 100 equal parts & these parted by fives or tens, This kind of Thermometer was thought of by Mr. Boyle much about the same time, & it was held in great repute, but still it had a great Defect which was that none agreed in shewing the same temperature being made at random, to remidy this they

they were made to show the greatest degree of heat in Summer & Cold in Winter by keeping them one Year but this was also found liable to great inconveniency. The method now followed was first pointed out by Sr Isaac Newton & Dr Wallis in 1727. constructed several on this plan for his own use Dr Martin who has published several curious & ingenious discoverys on heat first show'd its advantages, as melted Snow was found to possess the same degree of Cold, & to cool bodys immersed into it to the same point, the Thermometer to be made was first put into it and the place marked where the Spirit of Wine, Oil or Mercury or whatever fluid was used stood at, & from Mr Boyles hint that boiling Water was always of the same heat, the Thermometer was then plung'd into Water in this state & the point also

mark'd

marked where the fluid rose to, thus we have two certain Joints that may be got on any Thermometer that will always be the same, by dividing betwixt these & carrying the divisions both above the boiling Joint & below the freezing, we can acertain the different degrees of heat & cold of various bodys as far as the Thermometers are mad to exhibit, the heat of the human body in healthy persons being almost constantly the same we may have another fixed Joint on the Thermometer, Which is got by putting it into the mouth & the degree to which it rises marked. This method of construcing Thermometers has many advantages as they may be made on the largest or smallest scale & are free from the error of the expansion of the glass but it is a question whether the increment of the fluid in bulk is equal in the equal additions of heat

heat, as a pound weight may stretch a piece of Cat-
gut one Inch but another pound will not stretch
it an Inch more & still less will be the third
pound, the Question therefore is whether the scale
of of a Thermometer which is one of expansion is also
a scale of the degrees of heat, or are equal degrees of
expansion made by equal degrees of heat, this
Doubt first occurd to me when thinking on some
experiments upon a similiar Subject & has been
overlookd by both Boerhaave & Martin. but on
looking into the Works of Boyle & Benaldini, I
found that the had occurd to them, & the latter has
propos'd an experiment to clear up the matter
but which is attendd with more nicety than he
thought of. Boyle in speaking of this asks whether
a double degree of Cold will produce a double degree
of Condensation? an other Author proposes to solve
it

it by means of mixing cold & boiling Water together
but this was never put in practice, Halley in the
Philosophical Transactions concludes that the degrees
of expansion are not in proportion to those of heat
but his experiments are not to be depended upon,
while Sr Isaac Newton in the same book says that
they are in proportion but this is only supposition
In a later period Dr Brooks Taylor has given an
account of an experiment to acertain the expansi-
-on caused by different degrees of heat & is the
same which occur'd to me before I knew of his Trea-
-tise, It consists in producing three certain tempe-
-ratures of heat which may be had without the
assistance of a Thermometer, If the second is a mean
between the other two, it should be indicated by
the fluid in the Thermometer rising or falling to
the middle point betwixt them this may be
done by taking an equal quantity of hot &
cold Water in different vessels & noting their Tem-
-peratures

Temperatures given by the Thermometer, let them be suddenly mixed togeth & their Temperature taken which should be an Arithmetical mean of the two the experiment has often been perform'd & found to answer pretty exactly - But Dr. Irvine of Glasgow has found that boiling Spirit of wine, and mercury heated to 600° of Farenheit cease to expand regularly & proportionably. The great heat that mercury is capable of enduring without rising in vapour gives it a Considerable advantage over ardent spirits or Oils, tho the oils especially Oleum Lini expand pretty regularly & bear a considerable degree of heat but they are inferior to Mercury as they are apt to adhere to the sides of the tubes and give the degree of heat with less accuracy

In making the above experiment great attention is requisite as it is liable to some fallacy, because in pouring the hot water into the cold a quantity of

of heat is lost by the absorption of the Vessel & on pour-
-ing cold water into the hot so much heat is gain'd
by the heat of the Vessel, This is to be guard against
by two methods either by observing the difference
of pouring hot water into the Cold & the Cold water
into the hot & taking their mean, or by using Ves-
-sels of such thinness as will have little effect on the
Temperature of the water, It is of great consequence
in Thermometers that the bore of the tube be every
where equal as otherwise a quantity of mercury in
one place may be greater or less in another place of
the Tube, The Tubes are proved by filling a part
of them suppose an Inch with mercury which
being moved from one end to the other & frequently
measured by a pair of Compasses, if it still retains
the same length the Tube will be proper for a Thermo-
-meter but if found to Vary, it ought not to be used.
Thermometers are liable to another Defect which is
that they are slow in taking the Temperature of Diff-

different bodys to which they are applyd, the Quantity of Glass or other matter about pocket Thermometers is not favourable to their heating & cooling quickly as it often requires 6, 8 or 10 minutes to bring them to their Temperature which on many occasions we ought to know sooner, therefore those with the Degrees marked by a Diamond on the Stem are the most eligible, the limitation of Thermometers in shewing great degrees of heat & cold is another defect as we are obliged to have them mad with different Liquours for different purposes even mercury boils at 600° of Farenheit, & was frozen at Petersborow, therefore when we want to calculate the higher degrees of heat we must have recourse to Sr. Isaac Newtons ingenious method which he informs us of in the Philosophical Transactions. He took a mass of red hot Iron out of the fire noting the time that he did it, & then exposed it to a stream of Cold Air; from time to time he put upon it pieces of Tin, Lead & other metals & observed at what period of

of time they ceased to be fluid when the Iron was considerably cool'd he applyd his Thermometer & found that it coold in a certain progression, by computing this Facts he found out at what degree the metals placed upon it melted, & the heat of the Iron itself red hot, taking it for granted that it had always cooled in a progression similar to that which he had observd with the Thermometer, another imperfection of Thermometers is, that they dont show us how much heat any body contains or the proportion that the heat of one body bears to that of another which is owing to our ignorance of the first or last degrees of heat, our knowledge of them may be compared to a Chain whereof the two extremities are concealed & only the intermediate links exposed to view. The numbers on the Scales of Thermometers only inform us of the Variations of heat between two certain points which are known but as Scales have been variously marked it has caused Considerable confusion in comparing the experiments made by one Thermometer with those

those performed by another, the greater part of them when first in use were made by those who had occasion for them & the numbers begun at different points as they thought proper, but the most of them may be now pretty well compared as Dr. Martin has given us a Comparative Scale of all those that have been invented, in his Essays — The Scale of Farenheit is most known the lowest point of which is that Shewn by the greatest Cold he could produce by a mixture of snow & Salt. he then marked the point produced by the Cold of melting snow & divided the space into 32 parts protracting his scale regularly upwards he afterwards found that a still greater degree of Cold than that of salt & snow might be produced, he therefore begun his scale at 0 & continued it downwards to express the degrees of greater Cold. In consequence of the invention of thermometers our notions of heat are considerably enlarged, by their aid we know that

there

there is no substance so Cold but what may be made colder by the assistance of salt & snow mixed together & Consequently will lose a quantity of heat it possess'd before. We may therefore account heat a positive & Cold a Negative power as we have no just reason to think that the latter proceeds from a positive Cause. some Philosophers have thought otherwise, & that Cold as an active form froze water from its particles having little Hooks that seized the Globules of Water & condenced them Dr Clark thinks Cold owing to sublime particles in the air of such figures as to produce the common effects of it— The different effects that heat & Cold have on our Senses are considered by some to be an argument for absolute cold, some Degrees of heat giving us pleasant sensations, others uneasy ones, & these are called hot & cold, but it may be replyd that the same water will feel often different to point of heat to both hands of the same person. Some

Hence cold & hot does not depend on any thing stea-
-dy on the bodys themselves but upon the state of
the Organs to which they are applyd in common lan-
-guage most extremes have different terms given to
them & which seems to be the orgin of this dispute
for we have no reason but to suspose that if heat
were taken away we should have absolute cold &
if cold were taken away we should have heat, therefore
as we have greater appearance of a cause of heat than
of Cold I shall use the term Heat & by Cold only
mean a diminution of it —

In some countrys a very Just degree of Cold has been
experienced, Farenheit by a mixture of strong
aquafortis & snow produced a degree of Cold 32° below
frost but some of the French Academicians who
Ventured within the artic Circle found that the
Thermometer fell to 33° below 0 they lived in
Rooms that excluded the external air & when a little
was admitd it froze their breath to snow & their
lungs on inspiration seemd to be torn asunder, the
spirit

Spirit of Wine that was frozen was not much strong-
-er than Brand & the Thermometer fell to 65° below
frost which is as much Under it as the animal —
heat is above it, In Siberia the more to the but
far from the sea, the mercury has been known to
fall 120° below 0, a degree of Cold which destroys
the parts of an animal as effectually as the heat
of red hot Iron — Professor Brown in Petersburgh in
1760 found the coldness of the air to be 40° below 0 of
Farenheits scale & on mixing strong Nitrous acid —
with the snow that the mercury fell to 352° below
0, when it became stationary & on the Glass being broke
the metal was congeald & took several strokes of
a hammer to break it, he also congeald some Mer-
cury in a ballow tube & found its hollow on the top
in the same manner as lead after being metted &
cooled, the Thermometer is said to have fallen lower
than 352° below 0 but we may observe that some de-
-ception might have taken place and that the degree
of Cold was not so intense, for the ball of the Ther-
-mometer was often track'd which would make the Mer-
-cury

Mercury but it is difficult to immerse Bodys in
in this fluid & with a considerable heat it is
apt to evaporate & make its use expensive, &
as Sand Answers the purpose as well in Prosp.
furnaces we have no occasion to use it ——

From the above reason we may explain why deeps
of water don't freeze in the Coldes winter, when
the cold air rushes over the surface of the water
a part is cooled & will sink while warmer water
supplys its place from below, so that the
whole heat of the water must be carried off before
the water can freeze to the bottom which a Winters
Cold may not be able to do — & hence the remark-
able temperature of the air on the ocean & in Is-
lands in winter in comparison of continents
in the same Latitude, but the equal distribution
of heat does not seem to agree with the same
Phenomena that occurs, when we acend into the
higher parts of the atmosphere ~~this~~ seem to
increase in coldness as is found in the Pyrenees alps

and

-in several of which the Ice & snow are high-
-er than the fluids & seem still to increase, hail
showers are also another proof of the coldness
that must sometimes prevail in the upper parts
of the atmosphere, this distribution of heat has
been explained in different ways, but these
appearances may be solv'd by considering that
as the sun is the general source of heat on
this globe, & that his rays act but little on
transparent bodys in comparison of what they do on
opaque ones consequently they will have but little
effect on such a medium as air when tho sensible
near the Earths surface where densest it must be
exceedingly thrifling on the high regions of the
atmosphere — This is exceedingly evident on ap-
plying a Burning Glass upon Water in a Glass
which will hardly be affected, but if a piece of
Wood is presented to the focus it is immediately
burnt to a black coal — we may observe too that
in Sunshine & other opaque bodys are sooner &

mor

be heated than those less so — Air is a fluid very
different from Water especially in its great com-
pressibility whereby it becomes much denser on
the Earth's surface than higher up where there is
less pressure upon it. This weight seems to have
a great effect in retaining heat in bodys, for
those in Vacuo lose their heat much sooner —
than expos'd to air, as may be seen in water
which boils easier in Vacuo than in the open air
& also sooner on the top of a Mountain at least —
with less heat than at its foot — Franklin has
given us some curious experiments on this sub-
-ject — when the equilibrium of the Atmosphere is
undisturbed it remains dense below & rarer in
proportion to its height but on the production of
great heat on the earths surface by the reflec-
-tion of the suns rays or other means a quantity
of air becomes rarify'd & buoy'd up in the heavier
air, its place is Immediately supply'd by the cir

cumam

circumambient air & when the heat has been considerable the rushing in of air on all sides will be so great as to produce a whirlwind ——

The different density of air at different heights is employ'd by miners to produce a Circulation of air in these mines — When their level has gone some length it is necessary a Current of fresh air be admitted, for this purpose they sink a shaft or perpendicular vent down to where they are working as Summer or Winter has very little effect on air at any depth below ground, that in the mines is pretty nearly equal but in Winter the external air at the level mouth being colder than that within it, it will be forced up the shaft & a current of air carried on, but in Summer the air on the mouth of the level will be rarify'd & heated more than that in the mine, consequently the course of the Current will be chang and the air will be driven out of the Level mouth

On

Spring and Autum the air within & without being often of an equal temperature a Stagnation of air will ensue & recourse must be had to fires to promote a Circulation of air ——

The Ventilation of Chimneys also depends very much on the same cause, as the air in the vent being raren below runs up and fresh air rushes in from below & supplys a continual circulation— From such experiments & facts it is plain that unless fresh air is admitt'd to supply the place of rarify'd air it will stagnate from the pressure of the Atmosphere & be retain'd in the place where the rarifaction begun— & this may be deduced as a proof of the advantage of planting round the higher parts of Countrys which preserve the air from too quick circulation and the heat is retained in it as in a green house to the great benefit of vegitation & moisture is not drained so quickly off which is of service in improved Countrys in Dry Years, I shall now proceed to the next general effect of heat which is Fluidity

Fluidity

The next general effect of heat is fluidity wh.ch both experience & observation prove to be as Univer-sal as the former— we not only find that solid bodys by heat alone may be made fluid, but that those to whom fluidity seems essential— owe this Quality to the heat they contain, & when that is sufficiently diminished they become cold— There are indeed some bodys that conduce to fluidity, for by adding Spirit of Wine or salts to water it is found to retain its fluidity in a much stronger degree than before— But mixtures of Bodys generally melt sooner than either of them seperate as may be inslan'd in metals but this is only an increase of disposition to fluidity which depends on heat at least— There are some few instances where we have not ocular Demonstration of the fluidity of bodys depending upon heat but there is the greatest reason to believe that only a proper degree of Cold is requisite to Make them solid & that those bodys are only

rely more fusible than others the least degree
of heat being sufficient to keep them in a flu-
-id state, of this kind is mercury which no na-
-tural cold can congeal & was therefore thought
incapable of freezing till Professor Browns
experiments provd the contrary, that fluidity
is a general effect of heat has been much dis-
puted & particularly by Musschenbrook who
adopting the common prejudices with respect
to water supposes that fluidity is essential to it
from the smoothness & globular figure of its-
particles & that its cōgelation depends on their
being fixed by the admission of frigorific par-
-ticles- Priestley with this opinion he has been
misled in his experiments and reasoning on this
subject, As he is an Author of reputation, I shall
now consider the principal of these and point wher-
-in he seems to be wrong. 1st He says that water
if preserved on perfect tranquility tho' exposed to
an air greatly below the freezing point will re-
-tain

tain its fluidity but if disturbed it will im-
mediately freeze This is true & rather seems against
his Theory than for it as such a sudden genera-
tion of frigorific particles seems difficult to account
for. I shall give an explanation of this afterwards
2nd He observes that frost will continue till the
Thermometer has risen to 36° or 41° but several cir-
cumstances should be known in this case before
a conclusion is drawn, the state of the air sometime
exposition if the Thermometer on a Wall or on--
Wood projecting from a house or towards the North
as any variations in these will affect the Thermo-
meter differently, besides in many places the
Ground after long continued frosts will become
much colder than the freezing point sometimes
9 or 10 Degrees, & When a thaw comes on suddenly
it will affect the air & Consequently the Thermo-
-meter will be raised before the ground is affect
-ed

rejected, but I shall mention some circumstances
with regard to this afterwards ———

3rdly That frost has happend when the Thermo-
meter was above the freezing point & showers of
rain & snow when below it. These instances are
owing to the same cause as the last mentioned,
for it cannot be said that Water will freeze
when cold is above the freezing point & vice versa

4.ly He has obserd frequently in the months of March,
April & even in June, that on mornings succeed-
-ing a very warm day the has been a hoar frost
& Ice upon ditches, hence he supposes that ab-
sence of heat alone without the assistance of some re-
-frigerating particles could not have produced
such a degree of Cold - but in such times it often
happens that early in the night the Wind turns
to the North or East & may bring them a sufficient
quantity of Cold as well as at any other time
of the Year to produce such slight kinds of freezing

wch

which generally affect the dew that has fallen on
the leaves of vegetables —— 5.ly It freezes more
in some Countrys than in others of the same degree
of Latitude, this usually defends on their distance
from the Ocean, 6.thly the Ice produced on standing
water is not in proportion to the absolute Cold —
I have observ'd that air has not so much power
to carry away heat from still water as from —
that which is in agitation. 7.ly A Quantity of
salt & snow being mixed in a vessel & the whole
put on the fire if a glass of water is put into
this it will freeze faster than if it had not —
been set on the fire — here he has allow'd himself
to be imposed upon, the manner in which salt
& snow act upon each other, I shall explain here-
after. 8.thly Aquafortis mix'd with Water makes
it hotter but it makes Ice colder. Musschenbroek
thinks there must be some thing heterogeneous in
the

the Ice to produce this cold, but I shall explain this on a different Hypothesis

9.thly A wet cloth hanging out in the open air will sometimes freeze when there is no appearance of Ice on Water & when the Thermometer is above 32°, I shall shew that this depends entirely upon the evaporation that is going on from the Cloth which when the Thermometer stands at 33° or 34° may reduce the Cold on the Surface of the Cloth to the freezing point. —— 10.th Ice-Water will not molify the more tender plants nor make Tea or Coffee till boiled for a long time this I apprehend is a deception — 11.th That all other bodys except Water are condensed by Cold it is expand'd, but this is not true for Iron & Regulus of antimony also take a different arrangment of particles & expand after fusion, & if we suppose that frigorific particles enter the water we must suppose them likewise entering Iron & Regulus of Antimony when red hot —

from

from the little weight of these argument & from what
I shall offer you afterwards it will seem that flu-
-idity is not an essential quality of water, nor
extraneous particles necessary to its congelation &
only one of the general effects of heat, the only kinds
of matter which have a reluctancy to become fluid
are some earths & stones but this number is
few & now render'd still fewer since the invention
of burning Glasses which have greatly enlarged our
notions of the effects of heat, such bodys as resist
fusion are very White & those that are of this colour
reflect the rays of light & hence not so easily affect.
as black ones which absorb them, besides these
bodys that do not melt by themselves will when
mixed with others from which we may reasonably con-
-clude that they would melt if we would apply—
sufficient heat to them. This new Hypothesis is to
say that fluidity depends on the Globular figure of
particles as upon this supposition the particles of all
fluid bodys should have the same figure & these change
when

supposed produced produced by the fire itself as he got
the alkaly from the solution in fossile acids & concludes
that the same prevails in other Vegetable matters.
However notwithstanding this alkaly we cannot help
considering it as an acid as it has many of their proper-
-ties, In its natural state it has little attraction for
Water requiring twenty four times its own weight
to dissolve it. It does not effervesce with an alkaly
when mixed in cold water. But when the water is
heated the Tartar dissolves & unites readily & effervesc.
with the alkaly, its other Qualities I shall defer till
I come to the compound salts. These are the Prin-
cipal Species of Vegetable acids, there are indeed some
few which differ in appearance from them but only
in being compounded of the qualitys of both some
approaching more to the Acetous, others more to
that of the Tartar; thus the Juice of Sorrel Crysta-
lized in its external appearance seems to be of the Tar-
ta

Tartareous kind but it approaches the acetous-
acid in being very Soluble in water- again Lemon
Juice tho at first sight it appears to be of the acetous kind
yet still retains its acid tho exposed to Heat for a long
time & tho considerably diminished in bulk, in this
particular it resembles the Tartarous & is quite op-
-posite to the Acetous

Sedative Salt

Of the origin of this Salt we are not Certain & we only
find it in borax which is brought from the East-Indies
& when seperated from it we get it in shoy stals w.ch
at first appear like small flakes of snow or ra-
-ther spermaceti, when Heat is applyd to this
Salt put into a Glass vessel with a strait neck
some of the salt sublimes & fixes on the top in
a fine light substance from which we might be
induced to think it volatile but this is not the
case as what remains in the retort cannot be
made volatile by any degree of Heat, but while

warm

warm continues ductile like melted Glass & the sub-
limed matter returns's just on the same appearance
when mixed with water it dissolves & being left
to Chrystalize resumes its first form, the reason of
the sublimation is that as the Chrystals contain
a small portion of water, when it rises the steam
carries up with it a small portion of the salt &
when the water is dispersed no more sublimes it has
but little attraction for water unless warm, when
it Dissolves in large Quantitys it requires near twen-
-ty times its weight of water to Dissolve it, & may
be seperated by Chrystalization - In its taste it is
bitterish, it changes Vegetable blues to a purple
but has much less effect than either the Fosile
Acid or Alkalys - It effervesces with alkalys & shows
some attraction for inflamable substances it dissolves
in spirit of wine & in burning tinges its flame of
a green Colour - I might have here mentioned some other
Acids, as those got from ants Urine, Amber &c. but

as

as they are connected with the objects of Chymistry not yet treated of I shall delay an acct. of them till afterwards

Compound Salts

Compound salts are produced from the combination of the three alkalys & six acids, we might be led to conclude that the various mixtures of them would produce a great number of Compounds but we shall find that alkalys have no attraction for alkalys nor acids for acids, they may be mixed together without much altering their quality, the only combination then that we can form is alkalys with acids which are found to unite only in a certain proportion & with effervescence, the acid suffering no change but only dispersed thro' the alkaly united with its particles & may be yet seperated from it again & neither alkalys nor acids can mix with more than one kind at a time, if a Quantity of the solution of alkaline salt in water be put in a glass vessel

and

& a few drops of the nitrous acid added to it a Violent effervescence ensues till the acid I suppose unites itself to a portion of the alkaline salt the remaind.r being in Statu quo & ready to Effervesce on the addition of more acid, & thus continues with the addition of the acid till the whole particles of the acid have join'd themselves to those of the acid when the Effervescence ceases & the Alkaly or acid is said to be saturated & have then no attraction for more of each other, In performing this operation agetation is requisite to bring the particles of both within the spheres of their mutual attraction, otherways we may err in adding too much of either one or other, & consequently the ceasing of the effervescence is not a Criterion of saturation — We must therefore examine some of its properties, if either acrid or sour it is not compleat, & if too much of the acid or Alkaly it will tinge a Vegetable blue to a red or green, which it will not if a perfect saturation.

The

The best way is to have some bibulous paper stained with march violet juice for the best of the Alka-lys, & litmus for that of the acids, & by dipping a piece of it in the mixture now & then we may satisfy ourselves of the true point of saturation — In some Cases this nicety is not requisite as when we combine a Volatile Alkaly with an Acid, where the volatile alkaly should predominate as either in Evaporation or Chrystalization, the alkaly that is superfluous is carried off & dispersated; Tho all the Comb'd salts we are to treat of are compounds of an alkaly & an acid, yet we are not to consider them as taken in purely & join'd together as most of them are form'd by nature without assistance. Neutrals or Compound salts have less attraction for water than the simple ones — Most of them Chrys-talize & have less acrimony in acting upon Animal Vegetables or mineral substances, so that the both

acids

Acids & Alkaly in their seperate State corrode & disolve these Substances, Yet when United they form a mild Compound & used as a medicine, their action by union being repulsed & this generally in proportion to the closeness of their Combination — If the Alkaly or acid before Mixture be Volatile this property is also generally repuls'd & the Compound becomes capable of Bearing a strong red Heat — Hence these Salts are call'd Salts made Salts Neutrals &c. from the supposition of the one destroying the effect of the other. From this view of the nine simple Salts Viz. the three Alkalys & Six Acids there will result eighteen Compounds which are few in comparison of the number you'll meet with in Chymical authors, But many of these are synonimous from their not being acquainted sufficently with the Principles of their Art —— I shall therefore reduce the Variety of Compound Salts into a Table where their compounding ingredients may be seen by inspection placing the several Acids in the first line above & the three

alkalys

Alkalys in the first Column to the right & where these join the Salts formed by their union will be found, Below, I shall insert the synonimous names that have been given to these compounds to prevent the ambiguities that might ensue from misunderstanding Authors who treat them as different substances.

Table of Compound Salts

	Vitriolic Acid ⊖›	Nitrous Acid ⊖›	Muriatic Acid ⊖›	Acetous Acid ⊕	Tartarous Acid	Sedative Salt
Fossile Alkaly ⊕v	Sal Glauberi	Nitrum Cubicum	Sal Communis		Sal Rupellens	Borax
Vegetable Alkaly ⊕v	Tartarus Vitriolatus	Nitrum	Sal Digestivus	Tartarus Regenerat:	Tartarus Tartarisat.	
Volatile Alkaly ⊖^	Ammonica Vitriolicus	Ammonia Nitrosus	Sal Ammonia	Ammonica Vegetabilis		

Table

Table of Saline Synonima

1 Fossile Alkaly 2 Nitrum	6 Spir.t Aluminis 7 Acid Calcanthe 8 Acid universale 9 Acid primogenium 10 Acidum citrum 11 Acidum Veg. fossile	1 Sal Glauberi 2 Sal cathartic 3 Sal mirabilis } Glauberi	1 Sal Digestivus 2 Sal Febifugus 3 Sal Marin. Tegun: 4 Sal marin coagul } Sylvii
1 Vegetable Alkaly 2 Sal absynthii 3 Sal Tartari 4 Nitrum fixum 5 Cinis Clavilati aqua solutum 6 Oleum Tartari per Deliquium 7 Sal vitum tartari	1 Acidum Nitrosum 2 Spiritus Nitre 3 Sp. nitri Glauberi 4 Aqua fortis	1 Tartarus Vitriolatus 2 Sal polychrestis 3 Nitrum Votriolatum 4 Sal Enixum 5 Sal Eduobus	1 Tartar Regeneratus 2 Sal Diureticus 3 Terra foliata Tartari
1 Alkale Volatile 2 Sal Amon: Volatile 3 Sal cornu cervi 4 Sal Urinæ aqa solutum 5 Sp.t Salis Ammon: 6 Sp.t cornu cervi 7 Sp.t Urina	1 Acetum 2 Acetum distillatum 3 Sp.ts aceti	1 Ammon: Vitriolicus 2 Ammon: secretus Glauberi	1 Amon. Vegetab. 2 Sp.ts Mindereri
1 Acidum Vitriolic 2 Oleum Vitriolicum 3 Spiritus Vitriolic 4 Acidum sulphuris 5 Spiritus Sulp. & Camph.	1 Acidum muriatic 2 Sp.ts salis 3 Sp.ts salis Glauberi	1 Nitrum cubicum 2 Nit.m Quadrangul	1 Sal Ruspellons 2 Sal polychrest Rupellens 3 Sal. sylvetti
	1 Tartarus 2 Chrystali tartari 3 Cremo tartari	1 Nitrum 2 Sal petre	1 Tartar Tartarisat 2 Tartar Solubilis
	1 Sal Sedativus 2 Sal Nascoticus Hombergii	1 Amm. Nitrous 2 Nit Acre Volatile 3 Nit Flammans	
		1 Sal communis 2 Sal gemma 3 Sal marinus 4 Sal fontium	

In arranging these acids I have had regard to their elective attraction placing the Vitriolic acid first then the Nitrous, the marine acetous, acid of tartar & last of all the sedative salt. If these acids & Alkalys are combined the Compound salts formed by their Union may be again seperated by Heat especially where the one is much more Volatile than the other But in general we must have recourse to Elective attraction, Here when we want to seperate one of the Ingredients an acid or Alkaly is applyd that has a stronger attraction for the one with which the required one is united, than it has with the other If it were required to seperate the marine acid from its alkaline Basis I should add some of the Vitriolic or nitrous acid which having a greater attraction for the fixed alkaly than the Marine acid it is set free, & thus any of the acids placed before the sedative salt would seperate it from any of its combinations, & those before the acetous would disunite it the two first Alkalys which in the Table are not seperated by a line having an equal attrac

attraction for the acids will not decompose any compound of each other from an acid but they will seperate the Volatile alkaly from any of its combinations with acids. Thus Sal ammoniac dissolv'd in water & mix'd with any of the fix'd alkalys will have the Volatile alkaly set free — There is a seeming objection to the Order of this Table which is that the sedative salt is sometimes employ'd to dislodge the nitrous & Muriatic acids & unites with the fix'd alkaly, but this is only done by heat which would partly seperate those more Volatile acids alone, & When these are dispersed the sedative salt unites with the alkaly & renders the seperation more compleat. I shall now proceed to consider the common properties of the compound salts —

Glauber's Salts

They are so named from the invention & is compound'd of the Vitriolic Acid & the Fossile Alkaly they have a pungent bitterish saline tase & so strong is the adhesion of

of their Ingredients that Heat cannot seperate them & it requires a great Degree of it to make them fluid, neither can the addition of any of the simple salts produce a disunion as their attraction for each other is the greatest of any. It was long look'd upon as an impossible or at least thought a very difficult process to seperate them Dr Stahl confounded the Chymists by advancing that he knew a method of Performing this in the hollow of the hand which set others about trying different ways, by Stahls method it was necessary to convert the acid into sulphur by adding to it the principle of Inflamability in Charcoal Dust &c. for which it has a particular attraction & greater than for the fixd Alkaly, thus the seperation may be perform'd by double elective attraction as by the addition of the principle of Inflamability in the Charcoal a sulphur is form'd by it & the Vitriolic acid,

(, and

nd they form a Hepas sulphuris with the alkaly of the
Glaubersatts by the addition of the acetous acid, it unites
with the alkaly of the Hepas sulphuris & leaves the
sulphurous Vitriolic acid which may be purify'd by
Inflamation, but this proces is easier in speculati-
-on than practice for the acetous acid & the alkaly are
so near an equal fixity as not to be seperated by
fire at best to leave the alkaly impure, the acid may
be freed by the addition of one of the others but this
only increases the difficulty so that this method is
never put in practice to obtain either the alkaly
or acid for use - Glaubers salts dissolve easily in
water & require 3 or 4 times their own weight of boiling
water which when set by to cool throw down chrys-
tals of 6 sides when the operation is well perform'd, they
contain a great deal of water & on exposure to a dry air lose
it & turn mealy on the outside which by some ignorant
people is thought a sign of impurity whereas it is y^e contrary.

As

Substances, the Air indeed contains a small quantity of it as we see often some collected round the mouths of Bottles containing Volatile Salts, & some acids when exposd to the Air seem to Attract it from thence & become Neutral, it is got from putrifying animal Substances, from Bones, Horns &c, & from being first got from the Horns of Harts was call'd Cornu cervi, but contains it in considerable Quantity as also Urine which has from thence its detergent quality. Near Volcanos it is got in the form of a Compound salt call'd Sal Ammoniac & the Alkaly obtaind from this seems the purest of any tho now chiefly got from the Horns & Bones of Animals— Its general names are salt of Urine salt of Hartshorn & Volatile amonica, when combin'd with water Chymists Call it spirit, hence the names spirit of urine spirit of hartshorn & Spirits of Sall Ammoniac.

ACIDS

There are a greater number of acids than alkalys, I shall therefore reduce them to the order in which they

seem to be in greatest purity & least combin'd with water the Fossile Acids shall be first consider'd and they are these in number ——

1st Vitriolic Acid
2 Nitrous Acid
3 Muriatic Acid

General properties of Acids ——

In treating of the general properties of acids I shall consider them in their strongest & most highly concentrated State on purpose to be more concise, The first is the most fixed not being volatile till heated up to 600 degrees of Farenheits Thermometer at which mercury boils, while the other two becomes Volatile with a much less degree of heat, so great is the attraction of acids for Water that we never can obtain them in a solid form & they unite with a kind of Violence or impetuosity and generate a considerable Heat when the Acids are dilated with Water they may be partly seperated again by distillation tho the whole cannot be carried off, This is

is what is called concentration rarefication a
deflegmation & ought to be considered as solid
salts in a fluid from disolvd in water, with Ice
or snow they produce a degree of cold greater than
either had before which has been thought Ex-
-traordinary but from what has been said on
the Lequefaction of Ice this may be very easi-
ly explained, it has been said that the
Vitriolic acid with Ice does not produce cold
but rather Heat, this however must be a
deception or caused by the addition of too much
acid as if a larger quantity is applyd than
suffices to Lequefy the Ice, Heat will be pro-
duced, the acids have the common property of
changing the colour of Vegetable Blue as
Syrop of Violets or infusion of roses &c to a red
or scarlet colour by the addition of an alkaly
this red is destroyed & the green takes place —
which may be alternately destroyed & recovered
by the application of first the one & then the
other.

Acids unite with alkalys with a considerable effervescence, as also with limestone marble & other absorbent Earths they produce the same Phenomenon with metallic bodies with which they unite &c. Acids in their most concentrated State are highly corosive & taken Inwardly in this State are certain portion considering animal substances as much as a burning coal would, but when sufficently dilated they are cooling agreable & wholesome, they are used for preventing fermentation, & also in Bleaching, to the taste they are sour & disagreably rough.

Vitriolic Acid

Vitriolic Acid is so calld from Vitriol or Copperas which yelds it by distillation over a strong fire when pure it is colourless and transparent & very heavy its specific gravity to water as 17 or 18 to 10 on this account it has the sluggish appearance of oil & hence calld oil of Vitriol tho destitute of the properties of oily fluids. The salt it contains is more fixed

fixed than water & emits no smell, it has
a strong attraction for water & a Violent heat is
produced by their commixture & if exposed in a
vessel to damp air it imbibes a great quantity
of the moisture, when mixed with boiling Wa-
-ter a great effervescence & additional heat ensues
& the Water is dissipated quickly— some Bleachers
imagine that it cannot be intimately united
with water unless the latter is boiling-but when
this is done the acid & hot water are scattered a-
-bout spoiling the Linnen that is next it— when
diluted with water the mixture becomes milky &
by standing a calcareous Earthy substance is de-
-posited united with the acid which gets the
name of a selenite salt. the more the mixture is
boild, the more aptt is to let fall this powder
to leave the acid pure & free from it. it must be
redestilled in close vessels what arises first is
almost pure water increasing its acidity as the

operation increases till at last what arises is equally with with what remains in the Retort Then the concentration can be carried no further by repeated Distillations This acid may be made a little strong-er & sometimes deposite Chrystal but this I imagine is owing to some impurity in the acid. The Vitriolic Acid has a very great attraction for the principle of Inflamability & bodys that contain it in considerable quantity if not ~~fattened~~ with-too much other matter - Thus when put into a glass with common Florence oil they unite with Heat & Effervescence, the mixture acquiring a thick consistence & forming a substance like Tar. But if added to the oil of Turpentine which contains the principle of Inflamability in a more loose & unfet-tered state it produces a more Violent Heat Ebulition emitting a quantity of fumes tho the oil requires a considerable degree of Heat to make it boil. The Result of this mixture is a very thick substance of

of a black colour & fatid smell - This accounts for the dark dusky appearance that the Vitriolic acid acquires on being kept in a negligent manner, as the last dust of animal or vegetable matter is sufficient to produce the Effect - it may however be ~~but~~ ~~separated~~ seperated by applying a small degree of heat these matters rising & the Vitriolic acid left pure, but if the quantity of the Inflamable substance is more considerable in any body, it unites with it & undergoes greater changes from its connection with this acid as we see in the case of Brimstone, as when we take a body which has the acid in a dry state as Allum where it is combin'd with Earth & add to this the Principle of Inflamability as in Sharesal (Dust &c. or with oils, in both these cases the acid arises in a Volatile form & like oil but considerably chang. in consistency & colour & comeules in the neck of the retort in a matter much resembling Sulphur

that

that the nature of sulphur is from the combination of the Vitriolic acid with the principle of Inflamability, appears from many Instances, for if we set sulphur on fire what arises when condenced is found to be Vitriolic acid & no ashes or soot remains. & the Principle of inflamability left freely off. the combination of the latter with the volatile acid has a surprising effect in changing it from a corrosive & acrimonious to a mild & harmless state & which may be taken without danger in considerable quantity- its attraction for water is now destroyed & also for other bodys with which in its seperate state it was disposed to act upon we shall find this often to happen in Chymistry

That the activity of Bodys in their simple State is much greater than what it would be when united with others- Sulphur however unites with alkaly very readily as may be shewn by putting some alkaly into a vessel & some sulphur in powder as it is necessary that one or both of them be flu-

-id

fluid in order to have them Unite we may either effect
this powering boiling Water on them or put them
dry together & expose them to a gentle Heat when
they will unite with an Ebullition & emit an ex-
-tremely nauseous, Smell the Compound formed is call-
-ed Hepar Sulphureous from it colour resembling the
liver of some Animal. The Sulphur itself has no
attraction for Water yet with the Alkaly it acquires
one so great as to attract moisture from the air &
become humid on being exposed to it, When mix-
-ed with water it acquires a Yellow or redish colour
Sulphur may also be combin'd with vg. Vol. Alk.
but does not emit such a disagreable Smell as when
united with the fixed alkaly, The process shall be
mentioned when the inflamable bodies are treated
of— to seperate the Vitriolic Acid from the Sulphr.
There are several methods used, There is one menti-
-oned in the dispensatory which is by inflamation
but very little is to be got in this way as greatest
part of it rises in a Suffocating vapour which can-
-not

cannot be condensed the reason of this is that the sulphur is but imperfectly decomposed and retains the acid which rises along with its parts, some have a particular method of decomposing the sulphur by inflamation by means of which they get a great quantity of the acid but the process is kept a secret from interested views

Origin of the Vitriolic acid

Some Chymists have supposed that this acid is diffused thro the air & every thing else, & that on exposing fix'd alkalys to the influence of the Atmosphere they become neutrals, but the experiments made to prove this are related in such a manner as shew they are not to be depend'd upon, besides many Experiments made by Boyle & Margraaf give us reason to conclude that there is not the smallest quantity of it to be got from the air nor from rain or snow, whence it is probable that if it would have been got if any such acid had been in the atmosphere, its principal source is from