John Rowand.

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CHEMICAL LECTURES.

BY

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Volume I.

Chemistry

General History

The Chemists as well as all other artists, have no small pretensions, to the antiquity of their science, but it seems to have been a long time in making any considerable progress. We find well authenticated accounts of Chemical processes and these too of no small consequence at a very early period: for example Tubal Cain was acquainted with with the method of smelting metals from their ores and of forming them into various instruments for the use of mankind. The Egyptians knew the art of dying cloths of various lasting colours: and Moses dissolved the golden calf so as to render it soluble in water. Yet no attempts were made to reduce to a regular science, till after the fall of the Roman Empire; when a very absurd notion crept in among the Arab's and from them was introduced into Europe about the 10 Century, of converting the baser metals into gold. To this ridiculous science they gave the name of Alchimy. Many were the inventions of these crack brain'd Alchymists to impose upon mankind the possibility of their operations. When desired to give ocular demonstration of the success of their processes they very cunningly had a piece of gold fastened to the end of the ladle or instrument used to stir the bodies from which it was to be extracted; or they had gold mixed before hand with the baser metals: & when these & such like tricks were discovered they had a door which opened from a different apartment into the back side of the vessel, and a trusty friend for the purpose to throw in gold from this entrance. Paracelsus was one of the most remarkable among these deluded Chemists, he had long rummaged the Metals for gold in vain. after a terrible waste of money & time, he at last gave it over and applied himself to the study of Medicine in which by chance he made some very useful discoveries. an instance of one was about the time of the siege of Naples when the venereal disorder raged with great violence & seemed to bid utter defiance to medicine, when he by some method found out that sure remedy and certain antidote Mercury by which this disease was restrained from making such terrible havoc among mortals as it had formerly done. This discovery raised him a mighty eclat in the physical world, & was the mean of gaining him the correspondence of some of the first Noblemen in the kingdom and among others the famous Erasmus, Who by a letter told him of a malady which had long trou-bled him very much & which had puzzled the skill of the best Physicians. Paracelous elated with the notice of such a great man returned him an answer describing every thing about the disorder and method of cure, altho' he had never seen him nor heard the particulars of his ailment. Several instances of the same nature made Paracelous begin to deem himself more than Mortal and in order that the world migh not be unacquainted with his dig-nity he employed a great deal of time in in-venting a name which might convey to posterity an idea of his learning, he called himself Aurelius Antonius Theophrastus Paracelsus. Among his other discoveries he imagined he had found out a medicine which he called his Elixir, that would prolong life to 1000 years, but alas he was a melancholy instance of its fallibility for he died at the age of 47.[30] Several others about his time & before it I might mention but they all wandered in the same mystical tract of hypothesis and nonsense. However the many strange phoenomena that appeared in the decomposing of bodies by heat made sensible men at last begin to think it some-thing more than a search after the philo-sophers stone; and the processes of the Alchymist paved the way tho' darkly to many usefull discoveries. At the revival of learning in Europe this science was introduced along with the rest

and afterwards cultivated with great care and assi-
duity. Lord Verulam was the first, who disen-
tangled it, from the superstitious fetters of Al-
-chymy; to him succeeded Mr Boyle, and the great
Sir Isaac Newton; the latter having his attention
turned to it only in consequence of being made
Master of the Mint, did not make such improvements
in it as might have been expected from so penetrating
a genius. It would take a volume to give an ac-
-count of all the Chemists who have improved
this science since that time, and the many usefull
discoveries that have been made by Hoffman,
Stahl, Geoffrey and many others will stand
recorded for ages but particularly Drs Cullen
and Black of Edinburgh who with indefa-
-tigable industry, to a regular elegant & agreeable
study: and to the last mentioned gentleman I owe
the greatest part of the knowledge I may have in this Science.

Chemistry was long considered as an art not as a science as it really is, for we can begin with the first principles and from them deduce all the operations that belong to it.

Authors have varied in their definitions what Chemistry is, & in order that we may the better be able to give one of our own, it will not be amiss to mention their opinions.

Boerhaave was the first who arranged Chemistry into a system, and he also has given us some sketches upon heat, and the component parts of bodies. All the writings before him were mere alchymistical dablings, or a parcel of receipts how to make things without ever explaining the causes, or how these effects were produced on the bodies differently combined. Since Boerhaaves time Chemistry has gradually cleared up and has at length released itself from the unintelligible jargon of the Alchemists. Since the beginning of the last century it has made great and is still making daily improvements.

Before Chemistry was considered as the art carrying on certain operations upon bodies without ever troubling themselves about the causes that produced the effects, or of studying their constituent parts. This was confining it to narrow limits, and considering this noble science simply as an art which kept it long in obscurity: For the principles of bodies which are variously combined in different compositions should first of all be the Chemists study. Stahl a German author defined Chemistry to be the art of resolving bodies into their principles whether considering them as agregates, Mixts, or Compounds; in a word the reduction of bodies to their component parts. As we shall afterwards have occasion to mention these terms of his, it will here be necessary to explain them. Aggregates bodies divided into integral or similar parts: Mixts, or Compounds, bodies or parts of bodies dissimilar or having no resemblance to one another. And further if these Mixts were again divided into other parts these he called Decompounds: and still farther if these Decompounds could be divided into other parts these he called Supradecompounds. But it is seldom we find bodies divisible into so many component parts without meeting with principles or rather parts which can be no farther decomposed.

Dr Black defines Chemistry the effects of heat and mixture upon bodies. This tho a good one may I think be amended by adding. The qualities of bodies distinguished from one another by heat and mixture. Hence it will be natural to divide it as follows

Part. I. of Heat

II. of Mixture

1st. We shall treat of the general effects of Heat.

2dly The most proper method of conveying it to bodies.

The universal effect of Heat is Fire.

The general effects of Heat, are four, and one particular 1. Expansion. 2. Fluidity. 3. Vapour 4. Ignition, and the particular, Inflammation

Along with these I consider the degree of heat necessary to produce the changes with the different vessells appropriated for the purpose. Under the second part I mention the effects of mixture on different substances. These bodies being exemplified we must find out the doctrine of Chemical attraction by this time we shall understand the agents for Chemical processes, and be fit for entering upon the objects of Chemistry, under which we shall find that all bodies are divisible into Organical, and Inorganical, the one endowed with motion and feeling the other not. Organical bodies are divided into, Vegtable and Animal, Inorganical all the Fossile kingdom: these are reduced into Salts, Earths, Inflamable substances, Metals, Vegetable and Animal Substances, Water, and Air, Under these different bodies variously combined we shall consider the effects of heat and Mixture and what appearances they put on in the various stages of the processes. As we go on we shall delineate each particular by itself.

Part VI, of Heat in general

Heat is so subtile that it can never be got by itself to be examined. The original cause of it is difficult to be accounted for: Chemists have held it a substance & Logicians a quality; but the believing and following either would lead us into unaccountable metaphysical distinctions and land us at last in the wilderness of groundless in supporting our own arguments. I shall give you what Lord Verulam and Boerhaave say upon this subject. The first accounted heat to be "produce of friction, and says that the vibrating or "tremulous motion the consequence of friction, ~~producing~~ "heat." The latter accounted it a subtile fluid that "existed in every body and that by certain modifi-"cations, and charges it produced heat. Lord Verulams opinion ~~seems~~ seems really to be favoured by several examples, for instance rub two pieces of wood upon one another for a certain space of time and they will take fire; a blacksmith can by dexterously handling his hammer make a piece of cold iron red hot;

but in this case the heat generated depends on certain circumstances. Thus the iron must be of a certain bigness, for tho, he handles the hammer never so well upon a piece of wire no heat will be produced at least none worth remarking: and Querey may not the heat be collected from the bodies, that surround, from the Atmosphere for example. This theory cannot be ~~[illegible]~~ proved, yet instances may be given to favour it. Thus if we free the iron from every thing that surrounds it and draw out out the air all the hammering in the world shant make it hot. Again if the body is not something large friction will not produce heat, because its surface has not room enough to collect the matter in any quantity from the bodies around. Or Querey may heat not be a principle in the body from which by friction it is produced. I hold it most probable that heat is collected in these the same way as Electrical matter since it is diffused through all bodies also. If we could find a body impenetrable by heat is very probable that by all the friction in the world we should never produce heat, but a substance has never been found that heat could not enter, and diffuse itself thro' it, although it enters with far more difficulty into one body than another. The more solid the body the sooner will heat diffuse itself through it, & vice versa. E.G. I can hold a piece of wood in my hand while the fire consumes the other end, but this I could not do with a piece of iron therefore heat pervades and diffuses itself through iron sooner than wood, and wood again sooner than other bodies that are more rare: but of this there are exceptions. Heat mixes more or less with all bodies. It even diffuses itself through the vacuum in the top of the barometer, altho. that is the rarest place I know in nature. Heat produced upon bodies goes of gradually when the cause that produced it subsides. This holds true in all bodies except inflamable substances. Boerhaaves opinion of a remarkable subtile fluid that exists in bodies is very dark and intricate, he holds that the magnet attracts by means of this fluid.

running betwixt it and the substance to be attracted: but we might with the same propriety say so of a stone falling to the ground. We find by rubbing two pieces of glass upon one another that a fluid is produced upon the surface which pervades with ease the most solid bodies but we are not to believe this till such a fluid is proved to be the cause of attraction although this doctrine has been generally recieved by the German Philosophers.

Of the effects of Heat, accumulated upon bodies.

1st. Expansion. Here I design only to mention its general effects upon simple substances such as Air, Quicksilver, Spirits, Metals &c. The expansion it produces upon different bodies which upon colling return to the same simple state they were in before the heat was applied. From this general rule of bodies expanding by heat there are some few exceptions. The leaves of plants rather contract by heat; when they are full of water the heat evaporates it; but here it contracts by a want of one of its component parts. Lead, Ice, &c. upon these substances heat has the contrary effect. But here I only consider these bodies which are expanded by it. This increase of bodies I shall plainly demonstrate to you by three simple experiments upon three different substances. Viz

1st On an elastic fluid as Air

2. On an incompressible fluid as Water

3 On a solid substance as Iron.

The first I shall demonstrate by means of a bladder which is only about a third filled with Air by means of the ordinary heat of the room: when I hold it over the fire it expands and fills up the bladder as full as it can hold but upon cooling it sinks and wrinkles as before.

The 2 Water, or any incompressible fluid as Spirrit of Wine which being a more rare fluid than water expands sooner, hence not to lose time I shall use it Water holds equally true but only takes a little more time in expan-ding. Here I take a bottle of a conical form whose basis is the bottom of the glass; I fill it up to a mark in the neck of the bottle and by the application of heat you will see it expand so as to run over but it will subside after coolling. The 3^{d}. Iron. Here I take two pieces of iron, the one is larger than the other, and has a notch at every end. between which the smallest piece lies when cool with ease. There is a hole in one of the ends of the largest piece, through which the small easily passes: but upon heating the small piece it will neither then ly betwean the notches nor go into the hole as before. When it cools it is the same as before the heat was applied.

Expansion was originally found out by means of air which heat was found by chance to expand those bodies that expand by heat, are found to do it the more according to the degree of heat applied, and the greater the cold the more they contract: but this doctrine also has some exceptions. for a strong heat applied to fluids will make them fly of in vapour. The degree of expansion is various according to the rareness of solidity of the body: it commonly varies in proportion yet from this general rule we must except wood, which though a more rare body than iron yet it expands a fifth less, as also glass. It is often found that changes of the weather affect the regular going of clocks. If the weather be warm the pendulum will expand, consequently be longer than it was before, hence she will go slower than usual because the pendulum will take a longer time in every oscillation. If the weather on the other hand be cold the pendulum contracts and the clock goes faster. So by this means it will be impossible to have a clock go quite regular except we were to keep the temperature of the room of one uniform warmness, which would be a very troublesome business as it would both require a machine to regulate the degree of heat. and a person always attending The body that expands the least would be the best calculated for a pendulum; Iron, Steel & brass are the substances commonly made use of for this purpose tho very unanswerable as they expand very considerably. Wood as it expands least would answer better than any of the above mentioned but it likewise is liable to inconveniences. An invention lately found out answers best of all by making a pendulum of bars of different metals, which counteract one anothers expanding. For this purpose iron & zinc are found to answer. It may with propriety be queried here, whether all bodies expand by heat: we know only one instance to the contrary, Viz Water in a particular state When it freezes into ice it is quite opposite to the otherwise general law of expansion by heat for ice by heat contracts, and by cold expands. If what Authors have related may be depend^d on the force of water congealed into ice is incredible. By experience we know it to be very great as it will burst the vessel that contains it if it be not pretty strong. Boyle found it to raise 100 weight. and the Florentine Academicians made an experiment with a brass ball about an inch in diameter, which they filled with Water, by a small hole & then plugged it up. This they exposed to the air of a very frosty night when it burst and exploded with great violence. The force that was requisite to break the ball they computed to be about 27740 pound or about 7 or 8 times greater than the force of gun powder. It has been found to burst a cannon, to raise the pavements on the streets by the particles of Water freezing below it and expanding. It frequently bursts the pipes used for the conveyance of Water below ground hence it will always be proper to secure them by, sinking them out of the reach of the frost. The Rustic knows the benefit his ground receives by the frost, as it reduces it into small particles, and as it were pulverises it, and so renders it much more fertile. The Water in the clods freezes, the ice expands & crumbles it down into a powder. It will be proper here to remark that the same degree of heat does not produce the same degree of expansion in different bodies: and there are some substances which expand more than others when both are in a solid state but when they are rendered fluid the one that expanded least in the solid state expands most in a fluid. E. G. Zinc in a solid state expands more than Regulus of Antimony yet when both are reduced to a fluid state the Antimony then expands the most.

Some Opinions concerning the cause of the universal exception of Water.

It will be unnecessary to detain you long upon the different hypotheses of authors, concerning the exception from expansion in water congealed into ice; therefore I shall give you some of the particular ones in as concise a manner as I can.

1st. Opinion. That the cause of freezing was owing to "the air separating from the water, and allowing the "particles to come closer to one another hence the "more intense the cold the less air will be contained "in the water, and ice will always be the easier formed "according to the quantity of air in the water.

This very stupid hypotheses will easily be confuted by taking boiled water or water where the air has been tottally drawn out by the pump, and expose it close corked up to a frosty night, with another bottle of water that contains air and we shall find the one that contains most air freeze soonest.

2d. Opinion. Seems something more ingenious & it

even carries a degree of possibility along w it. That ye
water is disposed to have it's particles very closely comp=
-pacted together, but as it begins to lose it's fluidity there
are greater vaccuums left, & it now occupies a greater sp=
-ace than before; & the greater ye cold the greater this ex=
-pansion. this Hypothesis appears to be supported by
experiment. Newman found ye water when freezing was
composed of filaments arranged at angles of 60 degrees
& it is found that 13 inches of water put into a mou=
-ld will produce 14 of ice. thus the cracking of strong
ice may be accounted for by intense frost by its not ha=
-ving room to expand itself between the shores. the re=
-ason why Iron keeps ye figure of ye mould better than
Brass, Silver, Lead or Gold, is because it expands in ye
mould ye very moment it is passing from a fluid to a
solid state, thus it takes the impression much more
lively, This expansion is only momentary, for it
goes off imedeatly upon being cooled —

3d. Opinion. That Ice was formed by ye crystaliz=
-ation of some salt in the water.

But this though a common received Opinion, hardly needs any confutation, for snow water freezes readily which hardly contains any salt at all

But to return, I come next to consider with what force Heat expands Bodies.

This force is said to be infinite, The Florentine Acad=emicians tried to compress that incompressable fluid water. They took a brass ball & filled it wt. water & having skrewed it closely up again, they put it into a strong press where a number of men were set upon it & they endeavoured w. all the force they were masters of to squeeze it together, yet were not able. if by chance a dimple was made in the ball, they always found in it a particle of the water that had come through the ball. But it may be here Queried in the forementioned Academicians brass ball (page 18) Was the water contained in it frozen or not? Certainly no. For without water has room to expand itself into a larger space, it is impossibles that it can freeze

All fluids are not incompressable altho' water, Quicksilver &c are; E.G. Air is capable of compr=-ession for we can squeeze the Air in a bladder into less space. we have now learned that heat in=-creasses bodies & cold contracts them. Then whither or not does heat also increase their weight. This subject has not escaped the notice of Philosophers. some say that it does, others affirm that it does not. The last has been found true by the Ingenious & accurate Dr. Roebuck of Edinr. He took a large mass of Copper, which weighed several pounds: having heated it red hot he put it again into the scales, & found it indeed a little heavier, but he judged this heaviness was occasioned by the heat of the Copper's expainding one side of the scale more than another, as was really the case. Not content with this he tried the experi=-ment again, by putting something to keep off the heat of the Copper, and placing some white paper below incase any of the particles of the metal should scale off, the consequence of the intense heat.

Having managed matters after this manner, he had the mass accurately weighed, heated & put again into the scales, when withe the small particles that fell off from it, it weighed exactly as before, & having let it stand in the scales till it was quite cool he observed no diminution of weight. But there is an experiment which seems to contradict this of Dr. Roebuck's, If we take a pound of Lead, melt and pour it while in its fluid state into the scales, after it cools and becomes solid it will be heavier, the reason of this is evident, that the steams of the hot Lead rise & expand the beam. Lead by its processes into red Lead becomes heavier in proportion of 16 in the 100 here it seems owing to some latent heat got into the composition

Let us next consider of what use the knowledge of Expansion has been to the world. —

It has furnished us with a method to measure the degrees of heat with accuracy by that very ingenious and usefull instrument called a Thermometer, or what is vulgarly called a heat measurer which was said to be invented by Sanctorio an Italian physician but several have laid claim to it, and there have been various disputes, about who was the real author. The way that Sanctorio found out his Thermometer was, he took a glass tube with a ball which enclosed one end end while the other was left open. This tube and ball he found contained air in proportion to the heat of the room. When he held the tube over the fire the air expanded and consequently a quantity of it rushed out at the open end. Finding this to be the case he placed the open end of the tube in a quantity of spirit of wine highly rectified, which rose up till it could get no farther for the air which still remained in the tube. He also found that when he held the ball in his warm hand or if he applied a candle to it, the air expanded and pressed down the spirrit of wine in proportion to the heat applied, the greater the heat the more the air expanded and the farther down the spirrit of wine was forced. This instrument of Sanctorio's marked with the degrees of heat upon it was looked upon for a long time as an excellent machine, and indeed had it altered by heat alone it would have been perfect. But it is liable to one very mischievous in-convenience that of having one end open into the Spirrit of wine, consequently the spirrit exposed to the air was liable to the compression of that air, hence if the air was more close or heavy than usual, it would occasion the spirrit of wine to rise higher in the tube, and if on the other hand more rare the spirrit would fall lower, altho' the heat continued equally the same. Mr Boyle saw and remedied this defect, by hermetically sealing up the open end with wax. The Florentine Accademicians found this out as well as Mr Boyle which has occasioned also disputes who was the first inventor. This thermometer contrary to Sanctorio's rose by the aplication of heat his one fell by the expansion of the air.

Sanctorio's might be said to be both a Thermometer and barometer, with propriety and that to at the same time. Thus if the heat continued the same, but the pressure of the Atmosphere grew heavier, the fluid in spite of the equability of the heat would mount. Hence if it could be kept in one degree of heat, it would answer all the ends of the Barometer. Again if the pressure of the air was kept, the same fluid would fall according to the heat applied and so prove to be a true thermometer, but without these troublesome precautions it is neither a true Thermometer nor Barometer.

Mr Amonton tried another method of makeing Thermometers by placing that fluid Quicksilver above a quantity of air contained below the bulb which was a little inverted upwards. This air in consequence of being heated, expanded, & pressed up, the Quicksilver. This instrument of Ammontons tho a very ingenious contrivance could never be of general use. First its bulk must be incomodous since it must be betwixt 3 and 4 feet long. Secondly, it is only fitted for certain temperatures of the air, ~~ag~~ Spring. & Autumn. Thirdly, it is accompanied with a great inconveniency. It being a matter of impossibility to make a quick experiment, since you must wait the expansion of the air which will often take up a very considerable time; and Fourthly it was open at the top; hence it was also subject to the continual pressure of the atmosphere, as well as dust being apt to fall in, and the fluids evaporating. These defects shew the impropriety of using his Thermometer. And moreover it has been found that Thermometers whose contained fluids are Quicksilver are the better of having their tubes totally deprived of air, before they be sealed up. Again when Spirit of Wine is used as the fluid the greater the quantity of air closed in with it the better.

Before a Quicksilver Thermometer be hermetically sealed, all the air must be drawn out from the tube. The way to know when it is all out is by inverting the tube, and if the Quicksilver runs to the bottom then there is no air, if there is air it will stop the Quicksilver before it gets down. If air be allowed to remain in the tube it will soon make itself evident by changeing the glossy hue of the Quicksilver blackish. Elastic fluids as air have been found to be improper for Thermometers; therefore incompressible ones as water, Spirit of Wine, Lintseed oil, & Quick-silver, which last for several reasons have been found to answer the purpose best.

Query. What are the properties you'd wish Thermometers possessed of.

1 That the expansion should be always as the heat applied.

2 That they would agree one with another, and all be constructed on the same principles, and to point at the same degree when an equal degree of heat is applied.

3 That the fluid should neither boil, nor freeze by the different degrees of heat applied or abstracted

4 That they should all heat and cool very quick.

By considering these properties we shall see what fluid is most proper for a Thermometer.

As to the 1st since it is by expansion we measure heat, so the fluid should expand according to the degree of heat. Here we should wish to know in what manner expansion goes on, whether it expands in an equal ratio as the heat applied or after the manner that a string is extended by a weight. Whether one degree of heat raise it 1 inch and two degrees 2 inches, or whether the second degree raises it only an inch and a half, I see no reason why expansion should not be as the heat applied, and as the heat applied so should the fluid rise in the Thermometer, and that one Degree of heat should raise it one inch and two, two inches. To prove this, here I take two bowls I fill the one with cold the other with warm water and putting a Thermometer in the cold one I allow it to contract as far as it will, when I take it out & mark the place to where the silver fell, then I put it into the bowl with the warm Water, where I allow it to expand and rise as far as it will, & there again I mark it. Having done this I mix the water of the two bowls in one, and if the Quicksilver falls in an exact medium betwixt the two marks, then we may allow the expansion to be as the heat applied: and here you see this rule holds nearly just, but the experiment is not quite faultless for if I pour the warm water into the cold ones it has not only to warm the water but a quantity of heat is lost in warming the bowl, & the reverse happens when I reverse the experiment.

N. B. After mixture the Quicksilver will be a very little above the medium. This experiment does not hold true with Spirit of wine, for upon mixture it falls a considerable space below the medium. This was first taken notice of by Dr. Black and shews that Spirit of Wine is not a proper fluid for Thermometers. Water is still worse, and I believe with regard to this property Lintseed oil answers better than any of them, yet it falls short in others. Quicksilver as it therefore stands this experiment best, is certainly to be preferred to any fluid as yet found out. Salt and water expands more regularly than Spirit of Wine. But to return to the enquiry. Muschenbroek believes that the expansion of bodies are far from equable, but slow at first as if the heat had a difficulty in penetrating the body but which becomes soon very considerable. On the whole I am really of opinion, that the expansion of most substances is very irregular.

As to the 2d the exact agreement of Thermometers one with another. This might be concluded a prove to be an easy matter, yet a posteriori you will find it to be a very difficult one.

First that their size should be equal every one would think to be the first step to make Thermometers agree with one another, yet this same first step is impracti-cable, and again they should be marked with the same degrees in the same places of the Scale. The Florentine Academicians followed a very unsatisfactory method of graduateing their Thermometers. They adjusted their degrees to the warmest day in Summer, & the coldest in Winter, as if every Winter & Summer had been alike. — Mr Boyle remarked this de-fect and at the same time that there were certain changes produced in the appearance of bodies, always at the same degree of heat. In consequence of which he proposed the freezing of essential oil of Aniseeds, as a degree of heat and cold, which kept invariably the same, and might be of use in the right graduation of Thermometers. But he after-wards found that it did not answer the purpose so well as he expected. Dr Halley likewise was sensible of this defect; hence another scheme was

proposed by these learned and ingenious gentlemen.
Mr Boyle found that in a cave fronting the sea cut 130 feet into a cliff with 80 feet of earth above it that the spirit in the Thermometer stood exactly at the same degree both Summer and Winter, without the least variation in the most sultry summer day, or the most chilly winter frosts. And likewise Mariotte de la Hire and others tell us that in the cave under the royal Observatory at Paris the heat continues always the same. yet this degree of heat is far from answering the purpose of graduating all Thermometers alike. for we cannot all have resort to Boyles grotto, or the cave under the royal Observatory, and we are not certain that caves dug under ground, tho' to the same depth in other corners of the World would coincide with those of France: the difference of soils would occasion considerable alterations. I myself have observed that under the Parisian Observatory, the Spirit stands at 53, but if we dip a Thermometer into Spring water (which in my opinion coincides with these caves, as these also undergo no alteration from the different seasons)

we shall find it stand at 52. However we may venture to affirm that there is one fixed point from which Thermometers might be graduated viz the freezing of water, for that degree is really invariably the same, or ice beginning to melt which is the same thing. The heat of boiling water was proposed as the other degree; but this one is more uncertain because we find it varies, as to the pressure of the air. Thus it will boil easier i.e with less degree of heat upon the top of a mountain than at the bottom of a valley, because the air on the mountain top is more rarified, hence the greater the pressure of the atmosphere, the greater degree of heat will it take to make water boil, and vice versa: But this may be remedied by measuring the weight of the air by means of a Barometer. Thus regulate your boiling point of water when the barometer stands at 30. This I account the best method we are as yet acquainted with. Dr Halley again thought that boiling rectified Spirits of wine was a very fixed degree of heat, but this is not so good as the former, at least for regulating Quicksilver Thermometers.

It is also requisite, for the uniformity of Thermome-
-ters, that the glass expand equally, yet they are found
to vary very sensibly, which may be owing to the
different kinds of glass. Likewise the bore of the
tube should be the same, and the degrees should
be marked at certain intervals, and spaces. Yet
this though one of the main steps to make Ther-
mometers alike has been very little attended to
every one making what numbers he pleased at
the freezing and boiling points.

But after all we neither know where heat begins
nor where it ends. For the degree of heat in fires is
various, and the condensed rays of of the sun in
the focus of a burning glass, surpasses them all,
and the larger the focus the more intense the
heat. Hence our whole knowledge of heat is very
obscure, we are only sensible of a part, and with
propriety may it be likened to a long chain of
which we have only access to a few links in the
midle, while the ends heat and cold are veiled
from our eyes.

I shall here mention three of the noted numbers of authours, where they begin their freezing points

Sir Isaac Newton begins his freezing point at water beginning to freeze, where he marked 0, and at the heat of the human body 12, boiling water 34, and melting tin 71. Lintseed oil was the fluid he used.

Reaumyr marked his freezing point at an artificial congelation of water in warm weather, where he puts down 1000. Spirit of wine was his fluid.

Fahenheit marks his freezing point to where his thermometer subsides being placed in Snow & Water here he marks 32. His boiling point 112, the heat of the human body 96, sultry summer weather 75 and common Sunshine Weather 65. Quicksilver was the fluid he used.

The Method of Making a Thermometer

Put an iron rod into melted glass, let the rod be the bigness that you want the bore of your tube. When you draw it out a quantity of glass will adhere to it, if not sufficent put it in again, and more will adhere to it, Thus with a little polishing are Thermometers made. Place your Thermometer in boiling water, when the Barometer stands at 30 till it

expandi its ~~most,~~ then mark ~~on the~~ scale directly oppo-
site, with a pen dipt in printers ink 212; The heat of boiling
water. Here you obtain one fixed point. And as for
the other, place the Thermometer in water begining to
freeze, or ice beginning to melt; then let it contract as far
as it will and mark 32, Water freezing, and divide the
intermediate space between these two points into equal
numbers. This is the method of Fahrenheits scale, which
is now universaly used except in France.

As to the 3.d that the fluid used in Thermometers
should neither freeze nor boil.

The Necessity of this is evident because all fluids expand
irregularly in either of these states, however the fluid
which is worst to freeze or boil is the most proper. Water on
this account is justly laid aside: Spirit of wine has been
said to freeze in Thermometers during intense colds,
but in this case it was most certainly diluted with water;
for highly rectified spirit of Wine has never been found
to freeze. It is a very ticklish fluid and if keept close shut
up from the air keeps its qualities a long time, and is very
proper when we dont want to measure any degree of heat
beyond its boiling point. It's only fault is as I before men-
tioned, it does not expand regularly as the heat applied.
Oil of Lintseed, has never been found to freeze and it takes
an intense degree of heat to make it boil. But an inconvenience

it has which none of the rest have, Viscidity. Hence on a sudden cold consequently a sudden fall of the oil in the Thermometer, a part of it will adhere to the sides of the tube, which will occasion the surface of the oil to be considerably lower than what it should be for a little. Hence no quick experiment can be made with a Thermometer whose fluid is oil. Quicksilver is liable to neither of these faults beforementioned; It expands very near equally as the degree of heat applied it will not freeze in any degree of cold hitherto found out; and it requires 67½ degrees to make it boil But Query what are we to do if we have to measure any degrees of heat beyond the boiling point of Quicksilver, since we cannot trust to Sir Isaac Newtons arithmetical way of finding it out.

As to the 4th. That they should all heat and cool very quick. For in measuring the degrees of heat in bodies, we should wish to take up as little time in trying the experiments as possible. If the Thermometer is big. it will take a long time to heat, and therfore the smaller your Thermo

meter, the sooner it will point to the degree of heat.
The former Thermometers were all made with speri-
cal bulbs. and these pretty large too. hence before they
could determine the degree of heat it would some-
-times take up an hour, because the bulb being so
large the heat took a long time in diffusing itself
thro' it, as bodies heat and cool according to their
surfaces, and a sphere contains the greatest quantity
of matter under the smallest surface.
Fahrenheits are better adapted for this purpose
for he instead of having the bulb made round
had it of an oval figure, that it should expose a
large surface, consequently it would heat the
sooner, and he also diminished the quantity
of the fluid in the bulb, making at the same
time the tube conforming to the rest, to
prove that Thermometers constructed on
this plan, make experiments quicker than
the old ones, take one of each and you will
find that the least one will point to the
degree of heat as soon again as the large one
will.

Thermometers that are now made use of for quick experiments, have their tubes so small as not to admitt a human hair, the bulbs conforming of an oval figure. These determine the true point of heat in a body in a few seconds

To determine whether a Thermometer is right or not; Try the experement of the two bowls the one filled with warm, the other with cold water, put your Thermometer first into one & then into the other, marking the places exactly where the fluid stands at, and if upon mixing the water of the two bowls into one the fluid stand in the medium. or rather if it stands as far above the midle when the cold water is poured into the warm, as it does below when the warm is poured into the cold. as I mentioned before these variations made a difference, then you may venture to affirm. that your Thermometer is a good one.

Of Heat in a more Extensive View

Now that we know of a measure for determining the degrees of heat, we come to enquire what are the enlarged ideas we have got concerning heat by means of the Thermometer. It has only made us acquainted with different degrees of the same thing. For if we examine the subject with attention we shall find that there is no such thing as cold for the coldest thing as we stile it, is not deprived of heat. E.G. On the top of the Northern hills where snow lies all the year, and where the Thermometer falls below 0, we can make it fall farther by adding an artificial mixture of ~~a quantity~~ of common salt to the snow. Hence what we call cold is only a less degree of heat, and we have no limits to either. These terms are merely relative to our senses, and vary according to our different situations: for a native of the warm countries could not endure the want of heat in our clime, & would stile what we call a temperate day excessively cold, as we would do theirs prodigiously hot. Whatever is above the heat of our bodies we term warm in proportion and when below it cold in proportion. Different persons tho' of the same country differ greatly in their sensations as to heat and cold, hence we find such disagreement about what should be called a temperate day, some saying 52 others 62.

Thermometers have also informed us that all the heat in the world is the same, and that it only differs in quantity not in quality. The Ancients talked respectfully of celestial heat which they concluded to be far superior to any upon earth, and by this solar heat Alchymists imagined that the noble process of making gold could only be performed They also distinguished 5 or 6 kinds of heat upon this globe essentially different from one another. The heat of animals they thought quite another thing than the heat of a fire; boiling water, from the heat of fermenting substances, which last they concluded the lowest species of heat. The heat of a human creature they thought was far superior to that of brutes, that of a man in a fever from one in perfect health, that of one animal from another of a different kind.

But since that curious and useful invention of Thermo-
-meters, these strange hypothetical notions are entirely
discarded. It was a little surprising that the Egyptians
found the heat of the sun produced a chick in an egg
when kept uniformly to the heat of the hen, yet they still
persisted in saying, that the two heats were extremely
different, and they held it as a fact that this could
be done no where but in Egypt. We find that if the
heat of the hen which is about 180 be kept up
a chick will be formed. However it will be necessary
to sprinkle the eggs now and then with a little water
Indeed there is a small degree of difference in the
effects of the suns heat upon certain bodies, not found
to be produced by any other kind. E. G. An attraction
of certain colours used by the dyers from the cloth: hence
they expose their cloth for 12 or 16 days to the direct
rays of the sun, and if no diminution or change be
produced in the colour in that time then they attest
it sufficient. The sun produces, more light is attracted
by dark colours, and reflected by white. In these it
differs from every other degree of heat. —

Thermometers have taught the different degrees of heat existing in the globe. The ancients supposed that there were two places on the globe that nothing could live a moment in. The one so hot as to set fire to inflammable substances, the other so cold as to freeze the blood in the veins. But no such places are but what may be lived in with the help of some simple contrivances. The warmest part in the world when the sun is clouded does not exceed the heat of the human body. Indeed the direct rays of the sun in some places will raise the Thermometer even so high as 175. Hence travellers, it is true are often destroyed, because it is impossible to withstand so many degrees above the natural heat of the human body without something to hinder the effects of the suns rays. For this purpose cover the head and the other places of the body that are most exposed with a white cloth, which by reflection hinders the fatal effects of the suns rays, but any dark colour will absorb the rays and render the heat more intolerable.

The truth of this may be exemplified by rolling up two Thermometers, the one with a white the other with a black cloth, and exposing them to the direct rays of the sun. the one in white shall have its fluid only raised to 96 or the heat of the human body, while the other will be at 212 or the heat of boiling water Spirit of wine rises higher than Quicksilver when both are equally exposed to the rays of the sun, because of its darker colour, but, if you paint the Quicksilver black it will rise far higher. Care must be taken in trying these experiments. that no air blow upon the Thermometers. From the above it is evident that the darker the colour, the more intense and insupportable will the heat be when exposed to the direct rays of the sun, and the whiter the colour vice versa. It may be Queried what is the lowest degree of heat.

This cannot be limited to any stated point, for every year brings us acquainted with more intense degrees of cold. It was formerly thought that water when frozen had lost all heat. but this is a palpable mistake; for it is well known that water after it freezes still grows colder, and that in freezing water there is still a quantity of heat. The Ancients also supposed that there could be no degree of cold below 0 of Fahrenheits scale, without devastation to mankind; but this is also a mere chimera, for there are instances of the human bodies withstanding degrees of cold far below this, and degrees of heat above its own. By this it would appear that the human body has a power of preserving itself in either of the extremes above or below the natural. The Heat of the human body is liable to extremely little variations, for even in the most ardent fevers the heat never surpasses 108 of Fahrenheits scale, in health it is about 96 or 97, and in the most horrid cold fit of the ague, it scarce ever falls below 94. Boerhaave indeed imagined that there was sometimes such a degree of heat produced that the blood was coagulated in the vessels and occasioned immediate death. This is an impossible phaenomenon, for it takes 156 degrees to make the blood lose its fluidity, a degree of heat that the body would be consumed before it arrived at.

In the year 1768 the Thermometer even in this country fell 34 degrees below frost, which is two degrees below 0 in Fahrenheits scale. At Torneo in Lapland near the north polar circle, it fell 38 degrees below 0 as the French Academicians relate. When this intense cold was admitted into their warm rooms they could hardly endure it. Their breasts felt as if they had been rent, and the moisture of the air was converted into whirls of snow. This is a degree as much below freezing water, as that is below the ordinary heat of our skins. We are told that the cold existing naturally in Siberia is 150 degrees below frost, and this cold must undoubtedly be far exceeded at the North pole, where yet a still greater may be produced by an artificial mixture; so that by these accounts we cannot determine where heat begins or where cold alone exists.

Fahrenheit at Amsterdam made some very ingenious experiments in order to find out the lowest degree of heat. He contrived a method of cooling much beyond the ordinary course of nature, by pouring Spirit of Nitre or Aquafortis upon beaten snow or ice, when the temperature of the air was 32. he made the Thermometer fall 74 degrees below the freezing point. This is as much below freezing water, as that is below the heat of our hottest animals, or men in fevers.

Who could have thought, that ice was capable of such an additional quantity of cold: what a terrible degree of cold might be produced by this experiment in Siberia, or still nearer the polar circle where already such intense colds naturally exist.

Mr Brown at Petersborough found one winter the Mercury to sink 40 degrees below 0 in the open air, when Fahrenheits experiment readily occurred to him, and he performed it exactly, and produced so horrid a cold as our limited faculties can never imagine to exist, being 300 degrees below 0 in Fahrenheits scale, where the Mercury became stationary. Having broke the Thermometer he found it solid, and capable of being stretched like lead under the hamer. Some Gentlemen also froze it about 3 years ago, at Hudsons bay in North America, but authors vary at what point Quicksilver does take on its seemingly natural state of solidity, some say at 500, others not till 1000 below 0: but these last are not to be credited, tho' we allow that the difference of the air, quantity of snow, and aquafortis, used for the experiments will make considerable alteractions and variations. — In Mr Browns experiment, when the Quicksilver froze, a spirit of wine Thermometer stood 150 below 0. and was not frozen by the same degree of cold. He also found ~~that~~ some kinds of Quicksilver he could by no means freeze, but this might be owing to a want of exactness in making the experiment, using probably too much of the snow or spirit of Nitre, for the same individual quantity might no be so accurately taken notice of; or some of the silver might contain more of the phlogiston, which undoubtedly would hinder it from freezing. Nay of late it has been asserted, that the natural heat of Siberia, will freeze Quicksilver exposed in a cup: and I make no doubt but Browns experiment, might be done with success, even in this country if proper care were taken in the operation.

From what I have advanced already on this subject, we find that different parts of this globe vary prodigiously in their degrees of heat, and some parts even change remarkably with the seasons. About the Equator, the difference betwixt the winter and summer heat is only about 10 degrees, but in this country it frequently exceeds 80, nay we have often a change of 40, or 50 degrees of the night from the day, so changeable a clime do we live in. In Siberia again the summer & winter heats differ 160 degrees. Certainly such immense differences of heat in different climes of which I have only given you an example ought particularly to be observed in the cultivation of the vegetable kingdom.

Of Planetary Heat

The planets, bodies that roll round the sun receive heat in proportion to their distances from that grand luminary. Yet there are other things besides their vicinity to the sun that may influence and determine its heating virtue; viz the atmosphere which variously reflects and combines the rays of the sun, as it does upon our earth. If it were not for these conditional

circumstances, we are ~~not~~ ~~sensible~~ certain if the heat of the sun would be to us very sensible. &c.
We find that all low lying places are warmest because they are inclosed with the greatest highth of atmosphere; and on the contrary the higher you ascend to the tops of hills you will find it the colder, yea so cold as that snow lyes perpetually on their tops all the year round; If there was no other circumstance to produce heat than vicinity to the Sun, certainly the nearer you approach it the more warm should it be.
As to planetary heat Sir Isaac Newton was the first that gave us an idea of reasoning to find out the heats existing in them. Thus reckoning the force of the Suns heat to be caeteris paribus as the density of its rays, or reciprocally as the squares of its Distances from the central fire. By this computation the planet Mercury as it is 7 times nearer the sun than our earth ~~must have no atmosphere at all~~ hence if the inhabitants there be like ours, ~~also~~ they must ~~would~~

have no atmosphere at all, also they would be scorched to death; their water too must be different from that which we have, or it will be continually going of in vapour. Again the Planets Jupiter and Saturn, as they are of such an immense distance from the sun, if they are constructed as our earth is, they would be chilled to death and their waters eternally froze up yet for ought we know they may have their surfaces so constructed, as to render the solar heat as comfortable to them as ours is to us. It is evident that there are modifications on this earth both for reflecting and refracting the rays of the sun, so as this abode of ours may be rendered an agreeable and proper habitation. Thus the direct rays of the sun reflected upon a piece of wood iron or any dark coloured substance, by means of the focus of a burning glass, they shall be consumed in a moment, and the iron lose its solidity, yet this reflection produces

no alteration upon transparent bodies such as water
Altho' some may imagine that the heating of this earth depends upon the sun. yet we can prove that there is a very great source of heat in it independent of any known cause. Nay all terrestrial bodies posess this property. E.G. Caves or pitts deep under its surface are found to be of equal warmth, summer and winter. History and experience teach us that the earth was once several degrees warmer than it is at present, for vast tracts of land which were once habitable are now buried in perpetual snow, so that the frigid zones are still increasing in cold, while the torrid are still becoming colder, and consequently more habitable. This heat seems to have been produced by some original cause, and the earth not yet cooled down to the surrounding medium, altho' it is still loseing of its heat. According to this doctrine we should rather dread that that this world is to be destroyed by cold instead of heat if we had not divine revelation to the contrary.

Let us next inquire whether we can determine the heat of bodies by Thermometers.

It was the opininion of the Ancients that heat was diffused in equal spaces thro' equal quantities of matter. i. e that equal quantities of matter took equal quantities of heat, to make them both alike hot, but since we can now judge the truth by Thermometers we find that this is a mere hypo-thesis. E. G. Water requires a greater quantity of heat to make it boil than spirit of wine does. Dr. Black was the first that ascertained this to which he gave the name of equilibrium. In order to prove that Quicksilver rises sooner at its equi-librium than water. he took a pint of it: heated the Quicksilver 30 degrees hotter than the water, then he pour this last upon the ~~water~~ Quicksilver the Quicksilver will lose 20 degrees while the water will only be heated 10. The Equilibrium is different in different bodies. some are disposed to take a greater quantity of heat than another, to bring both to an equilibrium, the hot one losing and the cold one gaining till they are both arrived at it. The thermometer shows us, when and whether bodies are equally heated, but not the quantity of heat they take to make them so. To Illustrate the whole I shall give you a gross example — Suppose you enter a large company of jolly companions, who had been severally a bozing thro' the day, and who were all become pretty hearty you could not distinguish by appearances, how much each person had drank, some 3. 4. 5 6 bottles of wine, so in the heating of bodies different degrees of the Thermometer points their equilibrium. We shall next Query by what law bodies heated ~~are~~ disposed to lose that heat.

We have found that some substances are longer in heating than others, consequently they will be longer in cooling, and vice versa. Bodies that heat soon cool soon. The quantities of heat lost in a body exposed to a cold stream of air, is at first faster and afterwards slower as Mushenbroeks experiments have proved, and

Sir Isaac Newton has learnedly given us a definition of the quantities of heat lost in a body cooling down to the surrounding air. His hypothesis which is a very ingenious one. vide Martin on heat Page 53. In trying experiments of this kind we must always take care to let a stream of fresh air play upon the cooling body else it will gather a warm atmosphere around it, and so hinder its cooling regularly. This may be clearly illustrated by a very common example. Blow a pair of bellows upon your hand, and it will feel cold. which is owing to nothing else but dispelling the warm atmosphere around the human body which also surrounds other warm bodies, for tho' you blow on the bulb of a Thermometer no such effect will take place. Some bodies part with heat sooner than others Spherical bodies for example are longer in cooling than oval ones, suppose they contain equal quantities of matter, because the round ones contain their matter in less space and have not such a large surface exposed to the air as the others. Muschenbroeck supposes that the denser the body the worse to cool & heat, and vice versa. From experiments we find this opinion to be entirely wrong. for rather the very reverse takes place almost always. Thus Quicksilver heats sooner than water, yet it is far more dense, and there is no body the rarest that I know, heats so soon as Quicksilver except air. Rare bodies in common, heat and cool with most difficulty. except water. Spirit of wine and a few more examples of the above. A piece of wood heats slower than iron. Feathers and wool heat slower than either, yet these are almost the rarest bodies in Nature. These appear and feel warm when aplied to the surface of the body. The reason of this is evident, because they hinder the warm air of our bodies from passing to the external atmosphere, and likewise the cold air external air's passing to our bodies. Upon the same principles. It has been discovered that when a body is heating. for example water, there are a number of whirling eel like particles, rising in a continual eel like stream from the bottom of the vessel to the top. These are heated globules expanding hence you will always find the hottest part of the water at the top before boiling, these giving room to other cold particles, which fall down and arise successively. Also, and for the same reasons we find lakes and pools and other deep Waters not frozen thro' the severest winter frost. Thus the particles on the top as soon as they accquire the cold of the surrounding atmosphere fall down and give way to the warmer particles below, and so on successively till the whole be cooled down to the freezing point, which takes a prodigious time, and the deeper the longer. But after it is all cooled down we shall find one nights frost freeze it over. In the cooling of a piece of iron too, the hot vapour rises and gives way to the cold. From these principles we also account for that current of air which continually blows to the icy countries, and from these countries when you arrive at a certain distance from them. The Chemists from the knowledge of these examples have invented a machine which produces a prodigious degree of heat. By placing rare and spongy bodies such as charcoal and clay mixed together round the inside of a furnace which confines the whole of the heat within the machine where a most terrible heat is raised, so great as to melt iron in a moment, while you can touch the outside with your fingers.

To conclude this first general effect of heat we shall mention the conclusions drawn from it 1st. If the power of expansion be greater than the specific gravity of the body, this body if mixed with another body that does not expand so much, and a certain degree of heat be applied, will swim upon its top. But if a stronger degree of heat be applied, it falls to the bottom and the other rises, and again if the heat be lessened it will rise and the other fall, and so on successively without mixing. Zinc and Bismuth exemplify this conclusion.

2d.

II. Fluidity.

Or that property which considers bodies when they are changed from a solid to a fluid state by means of heat. —

It would appear that this disposition of bodies depends entirely upon heat. and that if there was no heat in the world every thing would be in a solid state. However authors have objected against this doctrine, and exemplify air, Alcohol Quicksilver and Ether as four bodies that never become solid. As for Quicksilver, we have already heard of its being found in a solid state, and the French Academicians relate that at Tornea, the Spirit of wine in their Thermometers was frozen, but here we must suppose that their spirits were not sufficiently rectified. yet we make no doubt, but they would also become solid if heat was far enough diminished. Some authors have guessed at what degree they would lose their fluidity as for examples air, say they would become solid at 450 degrees below 0 of Fahrenheits scale, but these hypothesis are not worth mentioning.

Fluidity by Chemists has been accounted for thus; that it causes the particles of bodies to become spherical: others account account on the other hand for fluids becoming solid; by certain frigorific particles in nature that disposes bodies to become solids: but of this afterwards. Fluidity is universal to all bodies at different degrees of heat. Yet there are three substances, clay chalk, and flint. that have never been found to melt alone, by the strongest fires we have been able to raise. yet I make no doubt, but if we could make a strong enough fire but these as well as all others would liquify. We have reason to believe this from their very redily melting when mixed with other bodies. Now it is said that a piece of flint was once melted in the focus of a large burning glass.

Fluidity (differs in one thing remarkably from Expansion). Every thing in the world undergoes alternately expansion and contraction according to the different temperatures of the seasons, and the expansion is the greater in proportion to the heat. But when a body by means of heat once becomes fluid, it can never be made more fluid. and that all bodies become fluid at certain fixed degrees of heat. and at no other. Thus Spermaceti boils at about 116. Tin at 432. Lead at 452, but if a heat be applied either above or below these. no change will take place but a proportional expansion or contraction. This degree of heat when bodies are disposed to lose their ~~fluidity~~ * is called the melting point; and on the contrary when fluids become solid by means of a diminution of heat, such as water becoming ice, it is called the freezing point. These changes are attended with different appearances. and at different degrees of heat in different bodies, and these are variously distinguished with names by the Chemists.

* Solidity

1st When a body is melted and upon cooling returns to the same nature as it was before this is called Fusion. as for example Lead ice &c.

2dly. When bodies melted. change into different forms, when become cool, from what they were before this is called Vitrification. An example of Sand, &c, becoming glass

3dly. When a body changes into two different forms. Thus Lead ore when melted. has a quantity of dross separated from it. which floats on the surface while the pure lead falls to the bottom.

4thly. When the dross is sucked up by vessels prepared for the purpose, and leaves the Metal which was formerly mixed with the dross, pure by itself in the bottom of the vessel. This is called Cupellation.

But a body subject to Fusion may be melted as oft as you please, and if upon cooling it returns to the same state it was in before it still gets the name of fusion. Vitrification, can only be performed once on the same body, altho' afterwards you melt it it will be only fusion. because it will return to the same state as before. The same happens in Scorification.

These four constitute the general effects of heat as to their appearance when melted;

Besides these we ought to be well acquainted how the heat is to be applied; what is to be done during the process. and likewise the machines used to retain the melted substances.

Chemical Machines for these processes

You can easily see, that it will be necessary that the machines used to retain these substances when melting should not themselves melt by any degree of heat used for these processes. Hence the materials should be of the most refractory kind. In making of these machines two things are to be considered 1st If it be for the speculative Chemist only, your machines must be small and of fine materials. 2dly. If in the great way of working for sale, they must be large and the materials coarse. The Machines ought not to be liable to any alterations ~~from~~ by heat. and if possible they ought to be possessed of the five following properties.

1st That they should bear every degree of heat we can apply

2dly that they should endure sudden exposures of heat and cold.

3 That they should neither act, nor be acted upon

4. That if possible, they should be endowed with transparency.

5 That they should be strong enough to endure handling without breaking during the operations.

No one substance yet found in nature is possessed of all these properties, therefore the Chemists have had recourse to three joined together, viz. glass. metal. and earth.

As to the first glass. It neither acts nor is acted upon by bodies. and is transparent, but it cracks by the sudden application of heat & cold, is easily broke, and melts soon after it is red hot. Yet for all these inconveniences it is the bases of several useful machines. but scarce any where fluidity is the process, because no metallic substances can be fixed in it.

As to the 2d. Metals. All of them have a great degree of strength, are not apt to break, but they all melt at a moderate degree of heat, in proportion to those we have occasion for. Gold and Silver indeed are not so fusible as the rest, but these are too costly for common experiments: Copper and Brass are next to be preferred. but these again are apt to be corroded very much by substances. They indeed endeavour to remedy this by coating the inside with tin. but this is as improper: as tin it-self is so easily melted.

As to the 3d Earth. We have found that that the other two are improper for fusion. we shall next see, what effect clay and sand have. The first is the basis of all machines used for melting substan-ces in. It will not melt. is strong, easily fashion-ed; but it cracks. and is apt to fall in pieces by heat. This defect is remedied by adding of sand 4 parts to one of clay, which will endure the most in-tense degree of heat. Yet this scheme will by no means answer in the process of vitrification, for it would run into glass: but this again may be remedied by burning the clay before hand and reducing it into powder. or as they do in the glass. Bray down the old machines to make new ones. It was necessary to premise these materials. before we mention the particular machines for each process.

1st Crucibles, are the machines commonly employed for fusion. These are inverted conical vessels, easily lifted from the fire, and their contents as easily poured out into a mould. There are two kinds of them, the Hessian, and the Austrean. The first are made of one part clay, and four parts sand This kind can hardly be used twice. for they are sure to crack. and if the heat be very intense they are apt to run into glass. The Austrean a-gain are made of Clay and black lead mixed together. This kind may be heated as often & as intensely as we please, and are fitted for every kind of fusion. During the process of fusion there are two things to be observed, first. That no air be allowed to blow from the grate upon the bottom of the vessel, else the process will be disturbed. besides endanger-ing the cracking of it. To remedy this Chemists have employed what they call Seiges: things to set crucibles upon. 2dly That no fewel fall into the crucible upon the body. To prevent this, we may invert a crucible above the one where the process is going on, and fill up the interstice with clay and sand. This inventi-on may also supply the place of seeges, by inverting one below. These are all the vessels employed for fusions.

2d. Crucibles are also employed for vitrification, but they must be otherwise made than either of the two former. They may be made of one half brick dust and clay, or as they do in the glass, powder down the old vessels to make new ones.

3d. Tests are employed for scorification. These machines are never required to be large, are of an oval figure, sometimes circular, broad in proportion to their depth, made of clay burnt, and unburnt equal parts. They must be broad & shallow, so that a broad surface may be exposed to the air of a pair bellows, which are employed to blow of the sco-riae as it rises on the top, and to leave the other pure and principle part unchanged in the bottom.

4 Cupels are the vessels employed for cupellation. These are made of bone dust, drenched with water

They must be made large in proportion to the quantity of matter they contain. Their use -- Suppose a bit of lead had some silver in it which we want to get separated. Expose it to heat in the Cupell where the lead melts, and sinks into the vessel while the silver remains clear and unchanged in the bottom. In managing this process we must allow a stream of air to pass into the Cupell, while great care must be taken not to allow any inflammable matter to fall in upon the materials. For this purpose Muffles have been invented, and which sufficiently supply all defects. Thes semicylindrical machines have commonly slits in their sides to allow a current of air to pass in upon the mouths the Cupels are open at one end to put in the machines & materials. But I have found, that a Muffle open at one end, without any slits in its sides, answers all the ends of allowing air to pass in and out to the Cupel. E.G. The cold stream comes in at the open end, and when heated it expands and rises up to the concave top of the muffle, and is forced out retrogradely as to its entry. Hence a cold stream is continually coming in below, while the hot one is going out above. Muffles are likewise used in the art of Enamelling. as the dials of watches. clocks &c and in painting upon glass. This last art is supposed by many to be lost. but is as well understood at present as ever it was. The only inconveniency that attends it. is to get glass that is easier fusible than that upon which you are going to paint.

Having mentioned this much concerning the machines. let us now return to our subject of fusion.

Query. How is it that a substance when heated is disposed to become fluid. and by cold, solid.

Some authors imagine that nothing more is necessary to make a substance become fluid. than raise a degree of heat above its melting point. According to this opinion there should be no stoppage when it comes to its melting point, but that it should all at once become fluid. and at its freezing point, it should at once become solid

But undoubted experiments prove that a body melting cannot be made warmer till the whole become fluid, nor colder till the whole become solid. This observation we owe to Dr Black which occasioned him to in-vent a very pretty Theory, the truth of which I am not going to call in question. as there are several experiments that favour it and cannot be objected to.

Theory of Latent Heat.

Dr Black affirms that the change of a body from a solid to a fluid state, does not depend solely on the heat applied, but that a quantity of heat has before been an ingredient in it without, tending to make the substance any warmer. This he calls latent heat, so that the change produced is partly owing, to the insensible heat in the body. Hence we can easily see how when a substance is mel-ting, it cannot be made hotter till it all be melted. The fluidity of bodies is owing probably to this la-tent heat wch it absorbs. from the sensible, and while this

insensible heat remains a constituent part in the body, that body will continue fluid, but whenever it goes out to the surrounding bodies, it becomes solid. In fine he holds that all bodies
" when aproaching their melting point are disposed to take
" up a quantity of the sensible heat, and which escapes
" the exactest notice of the best Thermometers, and lies latent
" in the body as long as it continues in a fluid State.

The conversion of sensible heat into latent is different in different bodies. E.G. If a quantity of lead be heated above its melting point, consequently not melted, the best and speediest way to make it melt, is to throw in a quantity of cold lead, which by its absorbing a quantity of latent heat, from the other piece occasions its melting. It is owing to this absorption of heat that the weather is so cold during a thaw, and that we can preserve ice in ice houses so long, even in the warmest weather. But it perhaps may be objected that the heat that entered into the body did not become latent, but was entirely destroyed, and this objection is urged chiefly by those who hold that heat depends upon vibration. But this is not the case. for the heat which became latent in the body when melting, becomes again sensible during its freezing.

Expert. 1st. I take two vessels every way equal and putting a lib. of ice in the one whose temperature is 32 and a pound of water in the other whose temperature is the same. I bring them into a warm room. where we have no reason to misbelieve. but the heat of the room will enter into both ice & water; yet there are no signs of its entering the ice. for till it is wholly melted the Thermometer stands at 32 while the water in the other vessel will be equally heated with the room. Here according to Dr Black a quantity of sensible heat is converted into latent. This must either be the case or we must conclude that the ice did not recieve it as the water did, but it is evident that it did recieve heat for there was a stream of cold air ascending from the vessel.

Expt. 2d. Take a quantity of ice melting which expands the Thermometer to 32, put it into a quan tity of water, and place it into a room of the temperature of 48. Here for all the height of the warmth of the room above that of the ice, when brought in we shall have it stand several hours, and the ice shall only point to 32: this it will do untill it all melts into water.

Expt 3d. Take equal quantities of ice and water at 32, pour them into different iron vessels red hot, the water will boil, but the ice will only be melted and the vessel at the same time cooled.

All bodies melting have a power of absorbing a quantity of sensible heat, which they retain latent and which does not add to their own warmness, but it takes a quantity sensibly from the body whose heat causes the melting.

The quantity of latent heat may be determined by the following experiment. Take a lb of ice and a lb of boiling water, mix them together and the Thermometer shall stand at 50, instead of standing at a medium between 32 and 212; the quantity of heat lost here lyes latent in the ice.

The converse of the foregoing proposition, I shall next shew that this heat said to be latent, has really entered into every fluid, and that it goes out when it becomes solid.

Exp^t 101. Take two cups equal in bigness and put into them equal quantities of water: - Place in each of them a Thermometer, expose them to a cold air, such for example as when the ~~Barometer~~ Therm stands at 24. or 8 Degrees below the freezing point. The Thermometers shall subside till they come to 32; where they'l stand till the water becomes ice let the temperature of the air be never so cold, but whenever they are thoroughly frozen, they shall sink to the temperature of the atmosphere around. From the halt at the freezing point it is plain that there was something coming out of the water which kept the Thermometer so much above the temperature of the surrounding air; If you add to one of the cups a third part of common Salt &

expose them as above, the one that has no salt in it will
will stop as usual at 32, while the other will fall below
it without freezing. By this it would appear that salt
gives it a power of containing its latent heat, below the
point that it does when no salt is in it. Fahrenheit
made some experiments. I believe to try if water would
freeze without air. He took a number of brass balls,
filled them with water, and hermetically sealed them.
(N. B. The air was taken from the water before it was
put in.) There he exposed them to a frosty night, consi-
derably below the freezing point, and he found them
next morning not frozen, but upon breaking them
the water was immediately congealed into ice. It is
well known that if water be kept calm without the
least motion, will not freeze so soon as if it was
kept in a small degree of motion, tho' they be exposed
to the same degree of cold. When there is no tremor
upon the water it will sometimes fall 8 or 10 degrees
below the freezing point without being turned into
ice, but give the water the smallest motion it

immediately freezes. The Thermometer tho' before stand-
ing at 24 when all was calm, will upon the shaking
rise to 32. The cause of all this is by the latent
heats being converted into sensible instantaneously,
but how the tremor causes it I cannot account for.
The water here used must be pure from a spring,
for if the air be taken out by the air pump or
boiling, it will freeze sooner. Yet tho' this hold
true that boiled water will begin freezing sooner
than unboiled yet the unboiled will be over freezing
as soon as the ~~u~~nboiled. The reason seems to be,
the boiled water attracts as much air as produces
a tremulous motion on its surface, which seems
to be so necessary for waters freezing soon. Also
if bodies become softer tho' not fluid, there is a
quantity of latent heat enters their composition ne-
cessary to make that softness. This conversion of
sensible heat is not confined to the melting and
freezing of bodies, but is also extended to the So-
lution of Salts. E.G. If I saturate ~~[illegible]~~ boiling

water with Glaubers salts, and cork fast the phial to hinder the airs getting in, let it stand to cool without shaking in a short space it will be equal with the temperature of the room, and colder. Take it up cooled so. and shake it a greater part of the salt becomes instantly solid and the whole turns sensibly warmer; owing to the latent heat which the salt absorbed (during its solution becoming instantly sensible.

Thus a quantity of heat is absorbed (during the fusion of bodies, becomes an ingredient in them and escaping the notice of the Thermometer and our senses. That this heat (during the freezing of bodies becomes sensible and gradually emerges from them.

I shall here take notice of Mr Muschenbrock's opinion concerning freezing water. He accounts the absence of heat the sole cause of freezing of water and then he holds that the frigorific particles enter into it and it congeals into ice. In proof of this doctrine he asserts. 1st. That all other bodies except water are contracted in bulk when they become solid, and that this increase of water when ice is owing to the frigorific particles entered into it. This is a mere hypothesis for why dont these particles increase its weight as well as its bulk. which they do not.

2d.. That water in certain circumstances can be cooled down below the freezing point. because it sometimes does not recieve these particles.

3d.. That it is frost sometimes on the fields when the Thermometer stands at 30, but this experiment has not been accurately examined.

4th. That there is frequently frost on the grass before any place else. This he attributes to the grass its recieving more of the frigorific particles than other bodies. But the true reason of this phoenomenon is that the grass exposes a greater surface in proportion to the quantity of matter.

5th. That East and North winds produce frost very readily, even after a very warm day, owing he thinks to their being fraught with frigorific particles But the reason is these winds blow over an immense tract of foreign seas & cold countries

6th. That if we dip a piece of cloth in water & hang it out to the air, it will be stiff frozen before there be any ice upon water. This holds true with other rare bodies. but it does not happen except in a dry air, when a part of the water is evaporated.

7th. That cold is different in different ~~climates~~ countries of the same latitude, which he also attributes to those particles abounding more in one place than another. But this difference seems only to arise from the different soils. neighborhood of lakes, seas, mountains &c.

9th. That cold produced by snow & aquafortis is owing the snow's containing frigorific particles. But according to Dr Blacks theory it is the absorption of sensible heat into latent during the dissolving of the snow.

10th. That snow and salt produce a greater degree of cold over a fire than otherwise, owing to the fires driving out the particles from the snow into the water. This experiment succeeds better when at a distance from a fire: the intention of this seems only to make it the more surprising.

These arguments together with the doctrine of Frigorific particles, are perfectly childish and absurd.

Having mentioned Dr Blacks theory I think it will not be improper here to endeavour to shew for what reason a body absorbs heat. We mean to shew only why it is impossible to heat a body when melting, or cool it when freezing, or why a quantity of heat enters a body when melting, and comes out again when freezing or becoming Solid.

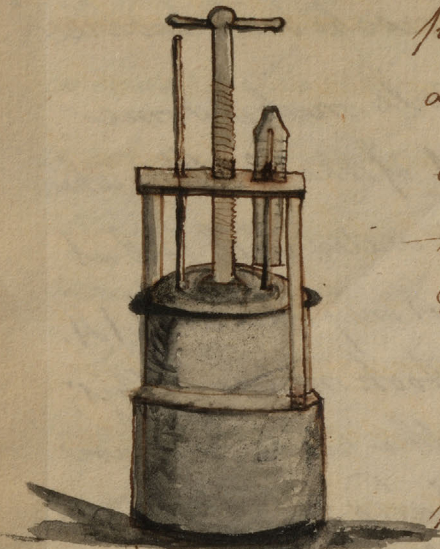
It appeared from what you heard formerly that the same quantity of heat had different effects upon different bodies, producing a greater expansion and more sensible heat than others. This appeared evident to me from a number of experiments which I tryed. That the same quantity of heat has different effects upon bodies according as they are in a solid or a fluid state, and it appears that almost all bodies when in a fluid state require a greater quantity of heat to raise them to the same degree of sensible warmth than an equal quantity would when in a solid state. From which circumstance it would ap-pear that the reason why a body when changing from a solid to a fluid state, does not turn sensibly warmer by the most intense degrees of heat till it all be melted. is because it requires a greater quantity of heat to raise it to the same degree in a fluid state than it does in a solid. And exactly the reverse takes place, when a body is from a fluid assuming a solid form.

III Vapour.

By this effect of heat a body is converted from a fluid that is incompressible to one that is compressible and Elastic like air. commonly called Vapour or Steam. The degree of heat at which this takes place has been called the Vaporific or boiling point of the body. which varies prodigiously in different Substances. Under this head I shall make my principal observations on water as what may be said upon it may be applied to other substances; the boiling point of water which is 212. The Elastic fluid which flies of from water thus heated is of a very great strengh, an instance of which may be seen in that machine called Eolopile. The Vapour of water is not possessed of its greatest elasticity at its boiling point, for it produces a much greater effect a few degrees above it. The knowledge of this elasticity has been the cause of several useful inventions, such as the blowing of large glass vessels, which have cost several their lives in attempting to do with their lungs. The manner they do is as follows. After blowing a small quantity into the mass which is to form the glass they put two or three drops of water down the pipe which when it comes to the warm glass expands and is converted into vapour, which heaves up the glass to any bulk which is determined by keeping the pipe close to the operators cheek and so holding in the vapour. When he has gott it to the bigness he wants it, he allows the vapour to escape, and so the operation is ended. The prodigious and surprising force of steam is evident in large founderies where cannon are cast, if any water happens accidentally to be in the mould it drives up the metal with irresistible force.

Since some bodies require a great, and some a small degree of heat to convert them into Vapour, the Chemists therefore have divided them into Volatile and Fixt; by the last is meant those that require an intense degree, and the first those that are easily converted into Vapour. Boiling is attended with a strong intestine motion which is raised by the heats converting into vapour that part of the fluid which lyes next to it & this rising to the surface occasions the commotion.

This effect of heat generally takes place in the same substance at the same degree, yet it is liable to alterations from the presure of the external atmosphere being sometimes greater or less; the greater the pressure, the worse to boil, and vice versa. The pressure of the air will make some inches of variation in the height of the ☿. Thus when the Barometer stands at 28 water will boil at 208 but when it stands at 31 it only boils at 214. Mr Boyle was the first that took notice of this; observing that when water boiled in the reciever of an air pump, he could hold his hand in it. Again if the pressure upon the surface of the fluid be increased, you hinder it from boiling, till it rises a number of degrees above its boiling point in the ordinary state of the atmosphere. This was first discovered by Papin, who contrived a strong cylindrical copper vessel of which the drawing will give you a faint resemblance. This vessel is half an inch thick with a cover or lid of the same which is kept screwed down by means of a cross barr firmly notched on the sides of the vessel. Remark before the lid is put down



put in some wet paper between it and the vessel, that no ~~air~~ vapour may escape thro'. In the lid there are two holes, into one of which put a Thermometer for determining the degree of heat and into the other a long glass tube which must be placed in a quantity of quicksilver fixed in the bottom to the inside of the Diogester, in order to see with what force the vapour will raise the Quicksilver, or how far up the tube will ascend by the pressure of the vapour within the machine. Here all the vapour is kept close and as there is still more and more of it detached from the water consequently, the elastic force will become the greater: By this small machine we can heat water to 380 degrees. From this we see if it were not for the atmospherical pressure many fluids would appear in form of Vapour.

The Boiling of water has been thought to depend upon its being heated to a certain degree past wh it could not be made warmer, and after its arrival at this degree the heat passed up thro' it and occasioned the commotion: this is purely hypothetical. It has likewise been imagined that it depended upon the continual separation of air from it. That water contains air is true but that this air is the occasion of the commotion called boiling is false, for water from which all the air has been extracted will boil violently. If the pressure of the atmosphere continue the same the heat of boiling water cannot be raised, and if this heat be kept at it, it will entirely go of in vapour. Altho' the water be so prodigiously heated in Papins Digester, yet allow the vapour to come out and put a Thermometer into it, it will only raise it to 212 because the heat becomes latent in the vapour. Here there is more than 300 degrees become insensible. The steam from a tea kettle burns the hand owing to nothing else but the latent heat becoming sensible by being condensed upon it. Also if you take two pieces of iron equal every way; & hold the one in the vapour while you hold the other in the boiling water you shall find the one in the vapour hottest. Thus it appears that a quantity of heat is absorbed, and becomes latent during the conversion of a fluid into vapour, and that this heat again becomes sensible when the vapour is reduced to its original fluid. Of all fluids water seems to require the greatest quantity of latent heat, before it can be converted into vapour; hence the Refrigatory is much more heated in distilling water, than Spirrits &c.

The moment vapour is produced it occupies a greater space than it did before, but not in proportion to the heat applied. Mr Watt found it fill 180 more than water. This effect is not confined to fluid bodies but even extends to solids.

The Effects of heat generally happen upon bodies in the order I mentioned, 1st Expansion. 2d: Fluidity 3d: Vapour. However there are a few variations as Arsenic, Camphor, and Sal Ammoniac. These are converted into vapour before they are melted; in the open air Camphor cannot be melted, it only can be melted by the presure on its surface, because its (as well as the other two's) vaporific point is below the melting.

The different degrees of Volatility in bodies gave rise to different operations. Thus when I have a compound of wc I want only to preserve the fixed part. I expose it to heat and so dispell the volatile part. This process is called evaporation. If we again want the volatile part we are obliged to expose them in close vessels. and to con-duct the vapour to a cold place for condensation. This process is called Distillation if the substance be fluid and Sublimation if it be solid. The part sublimed is called Sublimate or Fluors.

Cementation is performed in purifying gold as when we convert a body into vapour that it may act more powerfully upon another.

Each of these processes require different vessels, which it will be necessary to mention.

Machines for Vapour

1st. Evaporation which is the most important is the first that belongs to this effect of heat. The vessels for this purpose are best which expose a large surface in proportion to their capacity. When we want to separate the volatile parts of a vegetable, we use glass or earthen vessels, & here the operation must be regulated very carefully; Hence the vessels are sometimes set among sand and sometimes among Water. If we employ glass vessels the heat must be applied slowly or else they will be very apt to break. By the sudden application of heat to the outside of these vessels, that part wc comes in imediate contact with the fire expands, while the inside will remain as before, consequently it must crack.

However there are two ways to remedy this inconveniency, either by the interception of a third body between the glass and fire as a Balneum Mariae vel arenae which gradually brings on the heat; or if you apply heat ~~externally~~, at the same time pour boiling ~~water~~ water into the vessel, then the heat being applied equally to both sides at once it will expand equally. The same holds true when we pour warm water into a glass, while no heat is applied to the outside, the glass will crack because it expands on the inside and not on the out. When we want to ~~want~~ evaporate bodies in glass vessels, we must never apply so great a heat as to melt the glass. If we want to obtain a salt from a fluid, in the form of crystals, which we do when the water contains More than it can keep dissolved, then we employ globular vessels cut thro' by one of the lesser circles.

2d. In Distillation again when we want to obtain the volatile parts of a body without any regard to the more fixed, we are obliged to have recourse to the following apparatus. Distilling is divided into three kinds, viz Descensus, Ascensus and per Latus.

1st. When the vapour descends, and is condensed by the bottom of the vessel. This kind is only made use of for one operation, that of separating tar from fir. Thus a quantity of fir is put into an oven heated moderately so as to raise the tar in form of vapour, which descending passes thro' a hole in the bottom of the oven into a cool place & is there condensed.

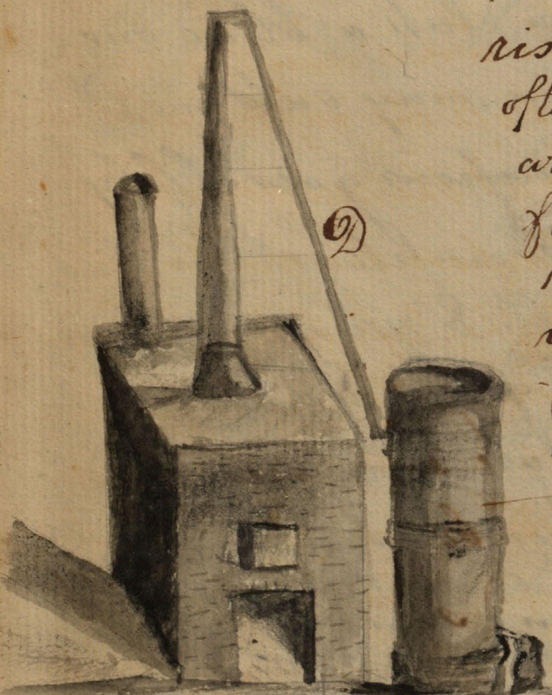
In all kinds of distillation the vapour properly speaking must ~~be carried to an~~ first ascend before it be carried to a convenient place for condensation, tho' indeed in the two following it must be carried to a considerable height.

2d. When the Vapour ascends. Alembics or what are commonly called Stills are employed. These are usually of the mettalic kind when when water or spirits are the substances to be distilled.

They consist of a large copper vessel of a cylindrical shape lined on the inside. Into this we put the substance to be operated upon and place it properly on a fire. When the vapour ascends and is collected by the second part of the vessel called the head, which is closely fitted to the mouth of the body. From this head the vapour is condensed by a long tube sometims straight and sometimes spiral hence it is called the worm. This passes thro' a vessel of cold water called the refrigatory, by means of which the vapour is condensed, and falls drop by drop into a reciever provided for it..

In this process it is necessary that we so form the vessel, that none of the fluid come over it before it is converted into vapour, hence it must be raised to a certain height, before the worm be bended away to the reciever; Likewise we must have room enough in the top of the Alembic, for the vapour when it rises, and the worm too, is to be in proportion, else the elasticity of the vapour not getting room will blow the vessel to pieces. Again the worm must be cooled in the Refrigatory, so that all the vapour may be condensed before it arrives at the reciever, else it will fly off. For this purpose the greater surface the worm exposes in the Refrigatory, according to the quantity of vapour it contains the better. A contrivance has been proposed to have two worms, whose capacities are only equal to one hence it will cool as quick again. This worm should be tin as copper is apt to produce verdigrease. It is also necessary that the water in the Refrigatory be kept as cold as possible by pumping now and then a stream of cold water into it, which falls down to the bottom because it is heavier & presses out the warm.

2nd. If there be no great difference betwixt the volatilities of the two bodies, it will then become necessary to to carry the vapour to a considerable height before it is carried off into the reciever: a machine for this purpose has also been contrived but it is attended with an evident inconvenience the length the vapour has to rise is great hence it will often be condensed before it arrives at the top & then fall back into the Alembic to be again converted into vapour, & so fall down successively which renders the operation exceedingly tedious. NB The descending tube D is joined to the worm & passes thro the refrigeratory into the reciever as in the last.



In some cases where this operation is to be performed on corrosive substances, we make use of glass vessels called Cucurbits w^t consist of a body & head; the vapours arise

condense in the head & are conducted thence by a glass tube. The only difficulty in using this machine is to get the head closely fitted to the body. If instead of this head you clap a blind one on it you may sublime wt it. 3^d: When the vapour goes off by the side - The vessels employed for this purpose are called retorts & recievers. These are generally made of glass, & as pretty strong degrees of heat are sometimes used in order to prevent their breaking we coat them over with clay and sand. The retorts commonly made use of are of two kinds; one of a globular form, the other more of a conical figure. An inconvenience that attends this way of distilling is the smallness of the recievers, hence if the matter be very elastic they are extremely apt to break. Of this afterwards. The retort & reciever must be well luted with linseed oil & fine clay or with quicklime besmeared with the yokes of eggs.

But there is a necessity of taking off this luting every time we put in fresh matter: a contrivance

to remedy this we have in the accumulated retort, by adding the tube B to the above we have it. into this tube we put a stopper which we can pull out & pour in fresh materials.

Yet as the machine is made of glass it will be apt to break by the sudden cooling of the new quantity we put in. I mentioned page 98 the inconveniency of having small recievers wt cannot contain a large quantity of matter especially if it be elastic without bursting. To remedy this again it has

been contrived to have two or more recievers joined to-
-gether by a tube coming from the bottom of the one
& entering the mouth of the other. This is
called Tubulating, the first is called the reciever
the rest adopters. This invention we owe to
Mr Woolfe of London, & hence it commonly goes
by the name of his ap-
-paratus. NB in the

destilling per latus the
the process goes on slow-
-ly because no great de-
-gree of heat dare be ap-
-plied. But in the
ascensum where a very considerable degree of heat
is raised it goes on pretty fast. It is neces-
-sary when we put a fluid into a retort to be
destilled, that we may convey it to the bottom
without allowing a single drop to fall on the neck
of it for if it be so that any of it lodges there it
will be carried over as it is into the reciever with
the first vapour yt rises. The funnel answers all the

ends of removing this inconvenience But we must take particular care in taking out the wet funnel, for there will always remain in it a few drops w^c if we were to draw it out straight would fall into the neck of the reciever. This can be hindered by raising the retort a little, hence the drops will fall back into the funnell, then draw it along the upper side close to the neck of it & there will be no hazard of letting the smallest drop fall.

3^d Apparatus for Sublimation

Upon this very little need be said because the same vessels that are used for Distillation will answer for Sublimation. Retorts & recie-vers can be used to Sublime with without any alteration. In some cases a cucurbit with a blind head is used having a small hole thro' its top that there may be a com-munication with the air and that any/

elastic matter during the process that is not disposed to condense when sublimed may get out & so save the vessel from bursting. The Florence flask or even common vials will do to to sublime with. These last are a little incon

venient on account of their thick bottom wh makes them liable to break, hence the first is more commodious; care must be taken to hinder the substance sublimed from blocking up the neck of the flask by now & then introducing an iron rod. As to the elastic matter we must allow it to escape for the safety of our vessels. But if we want to

retain it we must have recourse to Alodials, machines contrived for this purpose, where the elastic matter is allowed to rise to one to another till it all condenses. These however are seldom made use of, & in no process that I know except one concerning gun powder. 4 The last operation I mentioned was the purifying of gold by Cementation.

The materials used for being converted into vapour for the purpose of purifying of gold are either a mixture of copperas & Salt petre or Copperas & common Salt. The method is this. Beat the gold to be purified into thin plates, put first into the vessel (wc is commonly a crucible) a layer of the fore mentioned cement, then a plate of gold next a layer of cement & so on till the vessel be full then apply a strong heat.

By this effect of Vapour we are able to separate a great many substances from each other. E.G. If we have a mixture of water, clay, & quicksilver by destillation the water being the most volatile comes over first then the quicksilver leaving the clay behind. It has not been determined whether all substances can be converted into vapour, some bodies as those of the earthy kind cannot be evaporated with the most violent heat we are able to produce, & Mr Boyle exposed gold and silver in a crucible to the heat of a glass house for a month without any alteration being made on them. But it has been found that these metals when exposed to the condensed rays of the sun in the focus of a large burning glass have emitted vapour which on cooling condensed again into a solid state

The conversion of bodies into vapour is by no means confined to the boiling point it is produced at less degrees but not so copiously. This kind is called Spontaneous evaporation; such is the vapour that arises from water in the common heat of the air. This is not so elastic as that produced by boiling, several experiments have been made to find out the lowest degree of heat that will convert water into vapour. Even in the form of ice it gives it out, but the dryer the air the more it gives out, and vice versa. There must certainly be something more than cold in the air, that condenses the spontaneous vapour and sends it down in the form of hail and rain. and snow, forming lakes, pools and rivers for the benefit of this our earth.

Some conjecture it is upon the Electrical fluid that it depends, but it is hard to determine upon what this disposition of the air really depends. Several hypotheses have been raised also to account for the cause of spontaneous evaporation, but none of them except one are worth our notice. Le Roy a Frenchman says. "That "Spontaneous evaporation depends upon the airs dissolving "water, the same way as water dissolves Sugar or Salt, which "when dissolved is raised into vapour, and as water "dissolves more Salt when agitated than when at rest "so water is easier converted into vapour when agitated with the wind, and that hot air dissolves more "water and causes a greater spont.s evaporation. But this doctrine is entirely confuted by waters being evaporated when there is no air, as in the empty reciever of an air pump.

IV. Ignition.

This last general effect of heat may be dispatched in a few words. Ignition is that effect which heat has in rendering bodies luminous. i.e. causing them emit rays of light. It appears from experiment the greater the heat, the brighter the light; hence by it we can guess at the degree of heat in the ignifyed body. Accordingly Chemists have distinguished red heat into three; 1 A low degree which they call, a worm red of a dull liver like colour; 2. a Red heat, being a mixture of red and yellow. 3.^d A White heat. These different appearances are all we have to depend upon in several operations of Chemistry. There is a great connection betwixt heat and light, altho Boerhaave and his followers seem to think the contrary. That there is light without heat say they 'tis evident from several natural causes. E.G. The Moon has light without heat. This they say is, owing to the rays from it diverging: the suns are paralel. But in a strict geometrical sense there can be no difference observed as to their being paralel. I for my part am not of Boerhaaves opinion, tho he seems to be very much elated with this supposed discovery, for the rays of the Moon are only reflected from those of the sun, and the reason why we dont percieve heat from the rays of the Moon is because of their rareness, for by experiment they are found to be 300 000 times rarer than those of the sun. The principle argument that Boerhaave and his followers advances on this subject is from experiment, for having condensed the rays of the Moon 300,000 times in the focus of a burning glass, yet the heat was never found sensible upon the Thermometer. But a capital objection to this experiment is that the fluid in the Thermometer which they used was air a very improper fluid, as it is transparent, hence heat does not act so sensibly upon it. Even the same experiment with the rays of the sun would have very little sensible effect. Had the fluid been black I am convinced the rays of the moon would have a considerable effect. The favourers of this doctrine mention a number of bodies becoming light without heat E. G Wood rotting appears luminous in a dark place, the Phosphorine kind and the light of the sea in a storm, which last is indeed sometimes surprising, and the more so formerly when the cause was unknown; It is produced by the agitation of the billows with the wind owing to a species of putrefaction. Any body may produce the same sort of light artificially, by taking a quantity of salt water, letting fish stand in it for a day, then shake it and it will appear luminous in a dark place; The same appearance is also occasioned by a number of small animals swimming on its surface. Electricity has likewise been said by the Boerhaavians to be without heat, but experience tells us that if we drive it along an iron rod it will make it red hot.

But to return, bodies are disposed to become luminous at nearly the same degree of heat. To know at what degree Ignition does begin, depends greatly upon the acuteness of the senses of the observer; manner of making the experiment &c. One very good way is, to let the person stay in a dark room for a while then let a shining piece of iron be brought in, and immediately when he loses sight of the light let him toss it into a certain quantity of water, & calculate how much the iron has heated the water; or as Sir Isaac Newton did to calculate how much heat it lost in any given time, then proceed to enumerate the whole by Arithmetical progression.

We come now to enquire whether Ignition be common to all bodies; so far as Experiment determines it seems to be the case but many bodies are converted into vapour before they come near their Igniting point which we commonly reckon about 783, hence those that go off in vapour before they arrive at it, cannot be Ignited. All solid bodies seem to be ignited at or near this ~~point~~ degree of heat. But we may query whether will volatile bodies if heated to that degree of heat become luminous; Water for instance which can only be heated to about 212 in the open air yet if we confine the vapour it is possible to heat it up to the igniting point. Concerning this we shall relate an experiment by a* member of this university a few years ago. He filled a piece of a pistol barrel with water, then he drove a plugg of iron into the open extremity so far as to allow the end of the barrel to be hammered over it. Having ordered matters securely he put it into a smiths forge where he heated it gradually till the barrel became red hot, when to his great surprise the barrel bursted with such violence that it drove

* Dr Wilson Professor of Astronomy

down a piece of the house where the experiment was made. But a better method and without danger can be taken to heat Water to the igniting point by means of the Eolopile. This machine filled with water is made use of to blow up fire. At first sight this would seem something curious how water could have that effect, for we should rather imagine it would drown it out. But when the water in the Eolopile boils it carries out the vapour at its narrow extremity with a great deal of force together with a great deal of air which blows up the fire. With this machine I say we can heat water to the Igniting point thus. The vapour which goes across (suppose it to be a strong red fire) is heated up to this point yet it never appeared in any of my experiments to become luminous: yet this vapour that steams across the fire is so intensely hot as to make a bar of iron luminous in a very short time yet it has no light itself. Hence I am of opinion that transparent bodies will not become luminous at the Igniting point, but at some greater degree of heat, and that even when arrived at their own igniting point they dont emit so much light as those bodies that are opaque, and that after transparent bodies are ignited they will ~~ever after~~ be opaque. E.G. Flint glass which is the most transparent solid body that I know when it is ignited becomes ~~ever after~~ opaque. All Opaque solid bodies become luminous at nearly the same degree of heat.

Of all the general effects of heat Ignition is applicable to the fewest purposes in Chemistry

I should here as I have formerly done mention the Machines, and uses to which it is applied, but there are no machines to be described for it, and all the use that I know of it is in the Ouling of metals. i e, restoring Ductility to those that have lost it by hammering &c. Ignition makes them become, malleable again. The reverse of this ignite a body and plunge it into cold water, by causing a different arrangement of its particles it becomes steel, but if you allow it to cool slow its particles will arrange as formerly. Ignition is also employed to give certain ~~shades to metals~~ colours to metals.

Here I give you a scale of heat in order to assist your memories, with the different points at which bodies are disposed to lose their fluidity Solidity &c, which I have mentioned already. The degrees of heat are marked at which, Solidity, fluidity, vapour, and Ignition take place.

V. Inflammation

We come now to consider the last effect of heat Inflammation. "Whereby a particular class of bodies "when heated to a certain degree, take fire and

"become luminous. continuing after the heating cause
"is removed to emit heat and light from a source
"within themselves, till they are changed into a
"substance entirely different from what they were
"before, i.e. from being an inflamable substance
"they are converted into an Uninflammable one.

Inflammable bodies are different from all others, they alone are active with regard to fire, while all others are passive. All other bodies allow heat to go in and out for any number of times returning to the same state as before: but Inflammables when set on fire emit heat and light till they are entirely changed, and there is no reproducing the same from what remains, nor can the process of Inflammation be twice produced on the same body. The parts that are left behind are soot and ashes, the first rises with the flame in form of a thick dense vapour, the second remaining behind in the form of a spongy grey earthy matter. Now since these parts either separate or mixt, cannot be made to produce an inflammable substance, it is evident that something escapes during the inflammation which the Chemists have in vain endeavoured to confine. Boerhaave calls it the pabulum ignis, and concludes it to be much of the same nature as Alcohol since it burns without leaving any thing behind. This theory is found to be false. Experiments have been made to prove the existence of the principle which is in all inflammable bodies, by endeavouring to restore it again to the ashes or smoke This can be done by adding a fresh inflamable body. E.G. The smoke that arises from brimstone when burning, being condensed is oil of vitriol, to which if we add an inflammable substance we shall reproduce brimstone with all its properties. To this principle, the metals owe their most valuable properties. They too when reduced to a calx, become metals again by the addition of an inflamable body. This is called the reduction of metals from their calxes. It may not be improper here to mention that the calces of metals suffer various changes as to colour by long exposure to heat. E.G. The calx of lead plumbum Ustum which is of a ~~grey~~ ash colour, when exposed to a stronger heat becomes of a yellow, and this heat continued converts into a red colour Minium, which last does not differ from the first but in being longer calcined, for add an inflamable substance and we shall reproduce the original metal. This principle is the cause of the lustre, ductility, strength &c which metals are endowed with.

There are but few of the fossils capable of Inflammation. The chief are Rock Oil, Amber, brimstone, & pit coal and it seems very probable that these have got their inflammable principle from the vegetable kingdom, as well as all animals which get it either directly from hence by eating vegetables or indirectly by eating the flesh of other animals that live upon the produce of that kingdom. Nay there are pieces of pit coal that cannot be distinguished from wood. I showed a wright some years ago a bit that I had asking him which it was: he told me it was a piece of beech; nor is the depth that fossils are found under ground any objection to this doctrine, for we find that the valleys are still filling up by the rains gradually washing down the earth from the mountains. This is evident from our observing places from vales which were not seen before some years ago; and it is farther proved by our finding flies, shells, straw, insects &c, in the bosom of the earth many fathoms below ground, and by the same analysis as above we can reproduce vegetables from these fossils

Sulphur alone being an exception to this Doctrine for from it we can produce no Vegetable, but there are perhaps certain changes which the Sulphur undergoes in the earth that may hinder us from tracing its origin.

We are next led to Query from whence does the vegetable kingdom itself get this principle since it appears that the Animal and Mineral are served from it.

Vegetables are derived and nourished by Water, Earth and Air, of these three we find by experiment that earth can be most easily wanted. If air be excluded from a Vegetable it will grow but then it is of a dead white colour, insipid without smell and Wants the principle of inflammability: Nor in this case can one vegetable be distinguished from another. But if a crevice be made in the vessel where the plant is thus shut up and a ray of light admitted, it will stretch and bend itself to the crevice, and will gradually be restored to its natural colour, taste, smell and will at last also become inflammable. By this it would appear that vegetables have a power of attracting this principle from the rays of light, and that to it all plants owe their valuable properties whether Culinary or Medicinal.

It has also been Queried what the nature and properties of this inflammable principle is.

The Chemists all agree that this very subtile principle is the same in all inflammable bodies, yet they differ extremely as to its nature & properties. Authors have given us different names for it according to the notion they had of it, but these names give us no insight into the principle itself; such as the Oily Sulphureous, Phlogystic &c. Dr Black with the greatest propriety calls it the principle of Inflammability. It is evident that this principle is not itself inflammable, for if that were the case we would be obliged to suppose some other principle on which its inflammation depended. In the same way we must suppose that the principle on which gravitation depends to be itself a body which does not gravitate. It is only during the separation of this principle, that inflammation takes place. Some there are who deny the existence of such a principle altogether because say they we have never seen any thing such, by itself, and we find by the burning of an inflammabl substance we have lost nothing but rather gained, since we have both more bulk and weight. As to the first no Chemist could indeed ever show it alone, but they can separate it from an inflammable body, and render that body uninflammable, while they join it to a body that was uninflammable before and so render it inflammable. And as to the second which is their main one, that inflammable bodies become heavier after Inflammation. E.G. If we burn 16 oz of brimstone we may collect from it 18 or 20 of vitriolic acid. If we calcine 100 lib of lead we shall have from 150 to 120 lib of calces. Here say they substances from being deprived of this principle part become heavier Here we should be led to conclude that this principle is no matter at all, but the truth of the matter seems to be, that this principle of Inflammability has a power when joined with bodies of making them lighter, wc is contrary to all other substances we know. Many have endeavoured to give reasons for this curious property. Some think that the ashes of an inflamable become heavier because of a quantity of air which has mingled with them. But not to fill your heads with improbable theories I shall mention what appears to me to be the real cause of it. Natural Philosophy teaches us, that every attraction has its opposite repulsion, for the Magnet which is attracted by one pole, is repelled by another. In like manner the Earth has an attraction for a stone thrown up into the air, so it has a repulsion for the △ and an attraction for the oil of vitriol. calces of Metals or the ashes of inflammable substances. these when joined suppose the calces, the attraction will be lessened, and if separate the calces will

be attracted with full force to the earth; hence its hea-
-viness. This increase of the weight of the calces of metals is the same, whatever method be taken to de-
-prive them of Δ, whether by calcination or solution in acids. The existence of such a principle is evident in flint when we strike it against a piece of steel, or in steel filings when we throw them into the fire these crackle and burn because they contain Δ. This principle also enables bodies to continue longer fluid i.e. they remain fluid in degrees of cold, which they would not do were they deprived of it, and at the same time it gives them the property of being sooner converted into vapour. E.G. Spirit of Wine which is composed of water and this principle, re-tains its fluidity in a far greater degree of cold than water does, and it is sooner converted into vapour. Thus oil of Vitriol which in its ordi-nary state is a very fixt substance, requiring a heat of 535 degrees to convert it into vapour but if we add a small quantity of the Δ it will be converted into vapour with the common heat of

the air; and in proportion as we separate this principle from bodies, we render them less and less capable of fusion, and this is the case with all bodies from which it can be separted & or joined.

Altho' this principle is necessary to make bodies inflammable yet there are other circumstances requi-red to make them undergo inflammation. Two things especially are absolutely necessary to carry it on and begin it. Viz a sufficient degree of heat, to be brought in contact with it in order to set it a burning, and a continual supply of fresh air during the inflammation, and we is necessary to continue its burning. as the first was to set it on fire. The degree of heat requi-site to begin inflammation is very different in different bodies; some being set on fire with the common heat of the air as the Phosphorine kind, while others require the most intense heat of our furnace. Again as no inflammable body will burn without air, hence the Chemists by depriving them of air in close vessels, make them undergo the several processes by heat which inflam-mable ones do. The air which supports the inflam-mation undergoes certain changes, it becomes dense assuming less bulk than it formerly did, and cannot now be breathed by animals without the most fatal effects, nor on the other hand will that air which has often been breathed by animals serve to support the inflammation of an inflammable body. Some have supposed that this is owing to the want of the Nitre in the air, Some others say that it is owing to the air's absorbing a quantity of fumes from the burning body; which causes it to lose its elasticity. But the true reason is, it is owing to the Union of △ with the air from the burnt body.

Having made these general observations (as I did in the other effects of heat) it will be proper to shew to what uses in Chemistry this effect of heat Inflammation is applied. but before I proceed to this it will not be amiss to mention the different methods of producing heat, then describe the method of raising it to the most violent degree

1st The Method of producing Heat

Chemical authors have generally divided them into seven; not that all these can be applied to use-full purposes in Chemistry, but only that by all these methods heat can be produced; Viz. By Friction or percussion, Electricity, Mixture, putrefaction, the rays of the sun, the heat of animals and by combustible bodies.

1st. Friction or percussion, by this method we cannot raise a great degree of heat, neither can we make it very permanent. Solid substances are the only ones which produce this kind. E.G. The percussion of steel against flint in kindling tinder. Fluids however violently agitated pro-duce no heat, so far from doing it they hinder it, if we wet two solid bodies with water they will not produce heat. One instance and only one of fluids becoming warmer we have in the churning of milk, this will from the common heat of the air become as warm as the human body, but it will be observed, that this depends ~~on the~~ separation of the more fluid parts from the oil of the animal hence it gives out a quantity of latent heat wc becomes sensible.

V. Electricity This one I would willingly strike out of the list for it produces no expansion; The Chemists reason for taking it is because it ~~produces no exp.~~ sets fire to inflammable substances, Glass, wax, silk &c, being rubbed a fluid is collected on their surfaces, which when applied to a dry substance emits sparks of fire. This Electrive ~~substance~~ matter has also been said to have melted money in peoples pockets without injuring the person or his cloths. I cannot credit this story of actual fusions taking place, I should rather conclude it a kind of calcination, for they do not assert its being in one general mass. When a great quantity of this matter is collected upon a body it produces heat, and lightening is occasioned by this Electric matter in the air.

This kind of heat is so very troublesome to raise that it is never applied to any useful purposes in Chemistry.

3. Mixture. The heat raised by this means is sometimes very considerable; it is produced by mixing a fluid and a solid together. E.G. Oil of vitriol and bone ashes. This heat is produced by the mixing a fluid and a solid. and when by shaking the whole becomes solid. The reverse of this happens when after ~~mixing~~ shaking a fluid and a solid both become fluid, then a very great degree of cold is produced. By mixing Snow & aquafortis or Sal ammoniac in water. By this last method we can always diminish the heat of the water 20 degrees, hence we can bring Spring water (52) to the freezing point at any season in the year. hence by putting a small quantity of water in thin

glass and placing it in this mixture we shall have ice whenever we please. This cooling property in Sal ammoniac is made use of in warm countries to cool their drink, and by evaporating the Water the Sal ammoniac may be got back again and may be used any number of times for the same purpose.

4th Putrefaction. Nothing uninflammable will produce this kind of heat because none but inflammables will putrify. Animals and vegetables are the only substances that produce this sort of heat. The change that bodies suffer by putrefaction seems to be somewhat similar, to that which inflammable bodies suffer by inflammation. Only in the first the principle is not so fast separated. The degree of heat produced depends upon the quantity & moisture of the bodies accumulated. Horse dung or that of other animals, and bark, are those that are commonly used by Chemists for raising putrefactive heat. Animal dung ~~when heated~~ when heated together in great quantities, produces a heat nearly equal to boiling water: this heat gradually diminishes by long exposure, hence gardeners allow dung to ly on their hot beds 8 or 10 days before they sow the seed, because the heat at first is so great that it would scorch them and render them useless. This sort of heat has also been used for the manufactory of white lead, where a very moderate degree is required; likewise for the hatching of eggs for wc last purpose it should be kept about 108.

5 The rays of the Sun. By this method we can produce a very intense degree of heat, but it can be applied to very small use in Chemistry, as it is produced only at certain times and situations and even then but a very short time. Only when the sun is a little above the horizon, the rays then condensed in the focus of a burning glass, will melt substances in a moment that had withstood the most violent heat we were able to produce in our furnaces. There are two ways of producing heat by burning glasses 1st by Reflection, i e, when the focus of the burning glass darts back the rays upon the body. 2d When the rays are allowed to pass thro' a hole

in the lens upon the body. In warm countries the heat of the sun is used for evaporating the water of the sea & making salt. The rays of the sun have a remarkable effect upon coloured bodies. If a piece of cloth is ill dyed the suns rays will destroy the colour; hence dyers expose their cloth a fortnight to the rays of the sun & if it suffers no change during that time in the colour they pronounce it well done and sufficient. The rays of the sun have very little effect on transparent bodies. but all black coloured bodies absorb it, hence the benefit in warm countries of wearing white cloathing.

6. The heat of Animals. The bodies of all animals consist of fluids and solids: thro' the solids the fluids are dispersed & circulate for the nourishment of the whole, sensibility produced by the brain and nerves is necessary to carry on this motion, yet this may be altered by several causes and none more ready to do it than heat. The alterations of the consistence of the fluids depends chiefly upon heat, tho' there are other circum-

stances that assist. If animal heat were dimini-
-shed by a great degree of cold the blood would freeze
and the animal die. Again if the heat were incre-
-ased ~~the~~ 156. the blood would coagulate and the
death of the animal ~~as~~ certainly be the consequence
But wise providence has placed animal heat
in a medium betwixt these two extremes, and has
given animals a power of preserving themselves
in a cold far below, or a heat far above their own
The Blood of animals is the most important since
from it the whole animal ~~nourishment~~ is derived and
nourished, hence it is of greater consequence
than any of the other fluids for they only are
secreted from it by various Mechanisms.

Naturalists have divided animals into the
hot and cold. The hot animals have their tem-
-perature from 96 to 108. Man seems to be a-
-mong the coldest of this class, scarcely ever
surpassing 96 or 97. in fevers perhaps a degree
more, but our fluids stand not the least hazzard

of coagulating by heat in Diseases tho' Boer-
-haave was of opinion that Death was occasi-
-oned by heat in some fevers coagulating our blood
but this notion is perfectly absurd as the blood
will not coagulate till 156 degrees of heat be
applied, and the human frame would be entirely
consumed before it arrived any thing near it.
To this hot class belong dogs cows horses, sheep
hogs &c with all the ordinary quadrupeds
together with the feathered tribe

To the class of cold animals belong all
the fish kind, except the cetaceous, and
all the insect tribe except the bees. The
animals of this class have also a power of
preserving themselves in a cold far below their
own. This appears evident from the follow-
ing example I saw tried by Mr Hunter.
He filled two vials with water into one of
which he put a small fish, and then placed
both the vessels in a mixture of snow and salt

in a room of the temperature of 24. The vial without the fish froze in a very short time, the other taking a considerable space. At first a ring of ice ~~of ice~~ was formed, which gradually approaching at length arrived at the fish. The animal finding itself entangled made several violent motions to free itself by which it died, and not till then did the water in the vial became ~~begun to freeze~~ ice. Again several of the insect kind endure the most severe winter frost with little or no shelter. Reamur observes that young caterpillars live in a cold 4 degrees above 0, and there are many that can withstand a degree far below this yet none of this class are able to endure a heat above their natural. But different animals have different sensations as to heat and cold, and even the same species differ remarkably as to this. E. G. I have seen a man who could hold his hand in water so hot as to be intolerable to most others. Animals that sleep during the winter are as it were restored to life by the aproaching warmth of the Spring, which renders the blood fluid and raises the vegebable kingdom. Hence I have artificially laid animals into this benumbed state by cold and have gradually restored them to life again by heat, but if one warm them too quick they die; hence the necessity of warming slowly a frost-bit limb else it mortifies. Travellers tell us that near Newfound land, there is a frost fish wc when taken out of the water appears to be dead, yet tho' kept for a ~~fortnight~~ out of its element, will upon being thrown into water be restored again to life.

7th Combustible bodies (v. d fuel) This is the most proper method of producing heat, because by this kind with proper manegement we can render the heat regular & constant. All Inflammable bodies are not used by Chemists for fuel; some of them are too expensive others not convenient for the purpose. This class is divided into the fluid and solid Inflammables the first do not raise a great degree of heat, yet pretty equal: the most generally used are Spirit of Wine and oils. The second are various and may be made to raise a great degree of heat, such as peat or turf, wood, & pit coal. The fluid inflammables are burnt upon wicks on which the fluid rises by capillary attraction. Spirit of Wine in some respects answers this purpose best because the wick on which it burns is not clogged by any feculent matter, it burning without leaving any matter behind & without any soot. Oils again are defective upon account of a feculent matter wc fills up the interstices between the threads, and hence hinders the regular capillary attraction. An invention to remedy this is to take a wick of brass or copper instead of threads. This method however is found to be faulty. Oil likewise separates a smoke w^c rises & condenses on the bottom of the vessel, & which on account of its - being rare body, hinders the regular effect of the heat.

Solid inflammables raise degrees of heat in proportion to their quantities & inflamable principle

1st. The Peat is unfit for producing a great heat on account of a quantity of water it contains so every time the fire is mended the heat is ren-dered irregular. This substance is nothing else but an assemblage of roots of vegetables preserved from corruption by an antisceptic quality which the roots of most vegetables give out when put among water. Of all inflammable bodies however this needs the least quantity of air for its inflammation.

2 Wood & pit coal produce the greatest degree of all inflammable bodies. These substances contain a great quantity of inflammable matter hence they burn with prodigious violence. These substances I take originally to have been the same but the

one having suffered considerable changes in the earth from the other, accordingly they differ in the woods containing a greater quantity of water: but they differ principally in the nature of the smoke wc arises during the inflamation & the ashes that remain after it. Wood smoke is not found to hurt the colour of paintings upon glass, while that of pit coal tarnishes them considerably; glass too by the smoke of this last is rendered incapable of fusion. From what effect this is produced I cannot determine, probably it is owing to the sulphur contained in the pit coal. Wood ashes again are in small quantities in proportion, and so light as to be blown off with the air of the furnace, nor are they easily fusible, on the other hand those of pit coal are heavy, in great quantity & easily fusible: hence a great disadvantage of pit coal ashes if not carefully raked out they melt & consequently block up the furnace.

Wood contains less of △ than pit coal. The solid inflammables emiting a great quantity of smoke which is condensed on the bottom of your vessels & hinders the regularity of the process.

2ᵈ Of the Manner of regulating heat and of raising it the the highest degree

For this purpose a number of machines have been invented, generally known by the name of furnaces. These differ greatly both in form and size according to the uses for which they are employed. Those intended for raising a moderate degree of heat are simple, those for a more violent are more complex. Notwithstanding these differences in furnaces, there are a few general principles that take place in all of them, and which are derived from the quantity of fuel or the velocity of the air thro' the furnace. Upon the proper regulations of these circumstances all furnaces are constructed, & accordingly they are all composed of three apartments

1st. The Ash or pit chamber where the consumed

parts of the inflammable substance made use of are re-
cieved.

2^d^. or midle part where the fewel lyes upon an iron
barred grate allowing a free passage to the air.

3^d^. The chimney or vent to convey away the smoke

When a quantity of inflammable
matter is put into a furnace
and set on fire immediately
a stream of air rushes from
the bottom of the furnace up
thro' the fewel, & out thro' y^e^
vent, and upon the proper
regulation of this air depends the degree of heat pro-
duced by the fewel. The holes B where the air
is let in to the ash pit, have as many plugs neatly
adjusted, which are called Dampers. The plate of
Metal is called the Regester, and according as we
open more or less of these holes we admit a greater
or a smaller draught of air, hence a greater or
less degree of heat. These holes are commonly so
constructed that every subsequent hole admits double

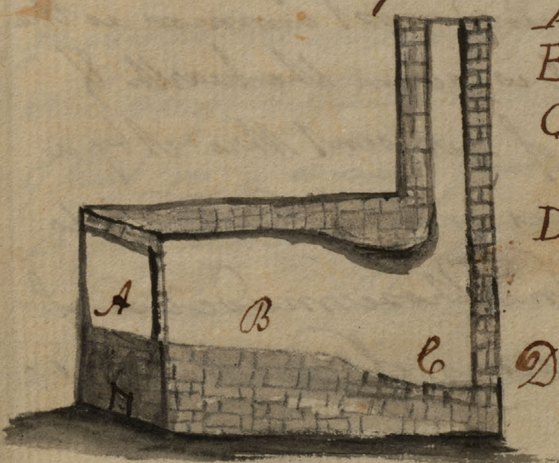
the quantity of air, i.e. that they have double the area of the former. There are two ways of regulating inflammation i.e either by the way we have been describing, viz the fuels attracting the air by itself, or, by the assistance of a pair of bellows as in the large way of working: This last method is never made use of by Chemists in the Laboratory. In all cases where we want to increase the heat we lengthen the vent. (hence the air is drawn in with more force & passes with greater velocity) by adding the top E, but this addition is limited for if we carry it so high as to give time for the smoke's becoming as cold as the external air, then our intention will be wholly frustrated, and the heat produced no intenser than it was before. It is a very difficult matter to raise a great degree of heat in a small furnace, because of their exposing so great surface in proportion to the quantity of matter they contain. This effect the Chemists have endeavoured to remedy by lining them with spongy bodies which do not easily transmit heat; for this purpose they generally make use of charcoal dust, but as this substance is inflammable it must not be allowed to come in contact with the fuel, hence they coat them over with clay and sand. Great care is necessary every time that fewel is added, lest by suddenly diminishing the heat, you burst your vessels. To remedy this Charring has been made use of, which is burning the inflammable substances made use of till all their water be dissipated. The wood ashes, and those of pit coal are used for this purpose, the first burns very fast, the second extremely slow.

There are a vast variety of furnaces but I confine myself to these in the laboratory of the Chemist The simplest of which and most common is the forge, where the fewel is set on the hearth & consumed by a stream of air sent thro' it by a pair of bellows. Furnaces may be divided into the essay. Melting, and those made use of for the various operations of distillation

The Essay Furnace. In it we perform all the operations where the Muffle is required, it consists of the same number of chambers as the melting one having a hole in its side for taking out and putting in the vessels.

The Melting furnace is the most useful, and is intended for raising a degree of heat to melt metals even of the most refractory kind. All the difference that need be between this and the one above, is that here a crucible is made use of to melt the substances, in the other a Muffle for the purpose of Scorification and Cupellation.

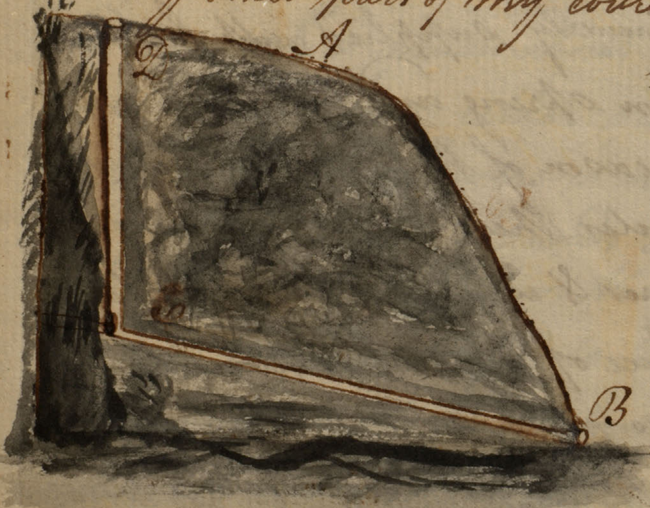
There is another kind of furnace called the Reverberatory



A. Where the fewel is placed
B. Where the metal is laid
C. Where it runs down when melted
D. Where a hole is cut thro to let it out. when red lead is to be made the bottom of the furnace is to be more levelled and

the lead raked out thro: at the passage D. In both cases the flame of the fuel passes over the metal and produces the desired effect. I might mention several other furnaces, as the glass one, the Balneum arenae &c, but these you'll fine sufficiently well delineated in books.

Having briefly mentioned these particulars, I should here conclude my first part; but here I shall mention some phenomena wc happen in Mines when digging for metals, as this subject comes in here as properly as any other part of my course.



Suppose AB the declivity of a hill, in the bowels of wc metal is contained. The Miners cut in at the foot of the hill B, making the entrance forward gradually to ascend in order that no water may incommode them during their researches, but that it may all run out from C

to B. Yet when they have got in a considerable dis-
-tance they are like to be destroyed with bad air w^c^
blows out their candles. & renders it a matter of imposi
-bility to carry on their work without having recourse
to the following contrivance. They find on y^e^ outside
how far in y^e^ mountain they have already gone,
then digging a perpendicular shaft such as from D
to C making it to join with their entrance, by which
ingenious contrivance they are not only supplied with
a current of fresh air, but also an easier method of
extracting the ore from the mine. In Summer and
winter they are continually supplied with fresh
currents of air, but in Spring and Autumn the air
stands still. The reason of this is obvious if we
consider that in winter the air above ground is 32
while both in Summer & winter it is 53 in places
far beneath the surface of the earth, hence the air
in the mine being so much warmer will be greatly
rarified consequently lighter, so that the air above
at D during the winter season presses down &
is forced to pass out at the bottom of the hill by B

This is succeeded by a fresh stream which descending to warmer regions is rarified, and is thrust forward by another &c. and so on in in continual succession. In Summer again the current takes the opposite course, for this reason that then the external air is warmer than that below ground by 10 degrees. Now there being less air at the top of the shaft D than at the bottom of the mine C the air below is forced to ascend & stream out at the shaft. The cause of the air's standing still during the other seasons of the year is very evident also. The air both external and internal is much about 53: hence there being no resistance from either side the miners would be extremely ill off, were it not for their kindling a fire at C, which expands the air and causes a fresh supply. When they dig farther into the hill they are obliged to have recourse of setting down another shaft as from E to F.

Having made these remarks, I end my first division of this course viz. The general effects of heat. You may see from what has been said that its effects is one of the most entertaining and extensive subjects in Nature. It appears that heat is the principle of activity in ~~nature~~ the universe, for if it were diminished to a certain degree all animal & vegetable bodies would be destroyed. The air itself would be converted into a solid body, and all Nature would be fozen up with cold. If again it were the reverse, heat would put all into confusion; our water would be converted into vapour, the whole universe would be melted & reduced to its original chaos. But how different from this are the effects of heat under proper management. Thus by the generous warmth of the sun a quantity of water is evaporated thro' the day, and is again by the cold of the night converted into dew for the ~~nofreshment~~ refreshment of drooping plants. A quantity of vapour is also raised to the higher regions forming clouds which after they have wandered thro' the airy regions descend in form of rain, hail & snow, which assist in nourishing vegetables & animals and form springs, rivers, lakes &c. The hills and mountains attract this vapour as it flies hovering in the Atmosphere, Without the aid and assistance of Mountains, animals and plants would die for want of moisture. Tho' the advantages of these irregular piles, & seemingly useless protuberances are not conspicuous to vulgar eyes, yet this does not make their usefulness less true, yet numbers dispute it. Their summits are designed by the grand architect of the world to stop, attract, and collect the vapours fluctuating in the Atmosphere. The intermediate spaces betwixt their summits are ~~as~~ so many basons prepared to recieve the vapour when condensed, and their bowels are so many store houses or reservoirs of water for the fountain heads of rivers, for we always find these to have their rise from the side of some mountain, tho' they appear there to be but small stripes, yet they gradually increase as they bend their course to the sea from whence they came, and from whence by the heat of the sun they are evaporated to undergo a continual circulation.

The effects are not confined to the great operations of nature: it is likewise the life of plants by giving them different vicissitudes of heat, that oscillation which is necessary for their life, nor are the effects of heat less wonderful on animal productions: thus by heat the egg is converted from a dead lump of matter to a living Animal.

Part II.

Of Mixture in General

This part is neither so extensive nor so useful as the first, because the effects of it are but few, yet these few are of very great importance as to discovering the different qualities of bodies. Altho all bodies are capable of the first four effects of heat Expansion Vapour, Fluidity & Ignition yet all bodies are not subject to Mixture. E.G. Oil will not unite with water nor quicksilver with water nor Water with sand. It is true even in these bodies we can produce by agitation something like Mixture yet when allowed to stand they separate one from another assuming their original form & appearance

Chemical Mixture is "when two bodies upon "being mixed run into one homogeneous compound "and remain in union for any length of time". That momentary appearance of union occasioned by agitation, mentioned above is only Diffusion. If we add to these diffused bodies a third of a glutinous nature, such for example as Gum Arabic, the whole becomes milky because the particles of the oil (supposing it to be oil & water) are coated over with the Gum hence the water is entangled. This remains long enough to appearance in union, till it be used for several medicinal purposes. They get the name of emulsions. Hence diffusion and Mixture are different, for we can in the first always trace the vestiges of the qualities of each of the compounds but if they were perfectly mixed no such thing could be observed. It is said by adding an Alkaline salt, water and oil will go into perfect union. This however is a mistake, Soap being formed with the oil and Alkali and Soap never forms with Water a transparent fluid, but a milky one which shews it is only diffusion. Tho the effects of Mixture are by no means so general as those of heat, and tho' a great number of bodies cannot be mixed with one another yet I would advise all of you to pay very strict attention for you'l find them to be of very great importance because the knowledge of a number of Chemical opera-tions depends upon it especially all those where Chemical attraction takes place.

The general effects of mixture may be reduced to a few heads. Bodies unite by Chemical mixture two ways, some unite calmly and without efferves-cence or commotion, while others run together with great violence & sometimes heat, w^e are all marks of union taking place. Under these two heads may be reduced all the effects of Chemical mixture E. G. of the first Spirit of Wine and water: Of the second I shall shew you three instances. 1st. where heat is produced without any great commoti-on. 2d. where a great commotion is produced with-out any heat. 3dly Where a solid and a fluid are united together with prodigious violence. The 1st. When I mix vitriol with water a con-siderable degree of heat is produced and if the weather was not so cold it would raise a small hissing noise. The 2d. When I pour the acid of Nitre on a volatile Alkali. The 3.d When I throw this substance which is harder than marble yet of the same kind into the Marine Acid, it is immediately rent asunder & is dissolved with a prodigious commotion.

This noise attending the union of several bodies is called Effervescence, it is owing to the great ~~one is~~ ge[illegible] ~~[illegible]~~ violence wherewith the particles of bodies run together. But this is hypothetical, for we find it arises from the separation of an elastic fluid from one of the bodies, without wc separation no solution could take place; The body dissolved is called the solvend, the liquid in wc it dissolves the Menstruum. which last word is an invention of some of the antient Chemists, because they concluded a perfect solution could not take place in less than a month.

Universal Effects of Mixture

Bodies chemically united acquire very different properties from what they had before.

1. The first and most remarkable property wc bodies assume after Union, is an alteration in bulk, in conse-equence of wc their specific gravity, is not in a medium betwixt the two bodies in a separate state. E.G. I have in this Florence flask a quantity of water upon wc I pour slowly a quantity of Alcohol. this last swims on the top of the water. Having carefully marked the height of the two ingredients on the outside of the flask & upon shaking consequently bringing the whole into Chemical Union, I find that they occuppy a less space than what they did before. This rule of bodies in consequence of Mixture occupying less Space than they did before they were united is not altogether universal. One exception is that in mixing 4 oz of copper with as much tin, we have 9 oz of a compound. Here it becomes heavier after Che-mical Union.

2d. Compounds of this kind are very differently affected by heat, they will neither fuse, evaporate, nor Ignite in a ratio as to the ingredients. i e they will bear a greater degree of heat when mixed than what they did before when separate.

3d. The two bodies produce a compound that is not disposed to have the same appearances upon being again thrown into a Menstruum. E. G the compound formed from Spirrit of Salt & an Alkali no longer effervesces with acids.

4th That their attraction for water, is considerably altered, and their effects on the human body are likewise entirely changed. E. G Spirrit of Salt & the Volatile Alkali wh are both very caustic substances in a seperate State yet when ~~mixed~~ united become so extremely mild as to be useful in several medicinal cases.

Thus it appears by union that bodies lose their natural effects for a new one.

To effect separation of these bodies Chemically united must therefore be a difficult thing, we cannot do it with heat. It can only be done by adding a third substance wh has a nearer attraction for one of the bodies than they have for one another with wc it will unite & set the other free. E.G. camphor united with Spirrit of wine will be set free by the addition of water because the spirit of wine has a nearer attraction to the water than it has for the camphor. Water & oil of vitriol can be separated by adding a salt obtained from vegetables by burning wc unites with the vitriol & sets the water free; This salt also separates the calcareous spar from the spirrit of sea salt, which was mentioned to have united with such violence.

When two bodies chemically united are separated by the addition of a third which has a nearer attraction for one of the bodies than these bodies have for one another a muddy liquor is produced called Magistery The operation is called Precipitation and the substance that falls to the botton Precipitate.

We next proceed to enquire into the cause of mixture & separation; Upon what principles in bodies do these appearances depend.

The phoenomenon of Mixture has been the basis of many chemical theroies, but from the earliest era's of chemistry down to Lord Verulans time these theories have been all very unsatisfactory.

1st Some concluded all the phoenomena of Mixture to depend upon a saline principle. 2 Some asserted that the particles of the solvent were like small wedges w^c insinuated themselves between the particles of the solvend, and that these wedges entering with violence into the hollows between the particles was the cause of the phoenomena appearing in Mixture. This Mechanical way of supposing and reasoning does not answer in Chemical inquiries. How can we account for the incredible force of a small quantity of Nitre, sulphur and charcoal dust when made into that mischievous thing, gun powder, I say how can we account for a small quantity of it when plugged up in a large stone, and set fire to with a hot iron, when it rends the stone into pieces driving it to a prodigious height. No mechanical reasoning here can ever lead us into the unknown cause. A 3^d. Way of accounting for mixture is by Mechanical division. Ramouli and others say that bodies resolve into their first constituent parts. Thus the cause of the mixture of the Spar with the Marine acid is owing to the stone's falling down into its constituent parts.

These I have just mentioned to shew you what groundless hypothetical notions the ancients had of it

The great luminary of this world Sir Isaac Newton was the first that discovered any real notion of mixture he proposes to account for it in a very different way from any that went before him. He simply and modestly queries, * "whether may not the small particles of matter "have a power of attracting, and acting one upon another" To understand this we must first inquire into the cause of attraction. The attraction that subsists between matter is of four kinds, Cohesion Gravitation Magnetism, and Electricity, and we may add Chemical.

The 1st, by wc the small parts of matter are made to cohere together. This kind is not so perceptible as the rest to the eye, it reaches only to a very small distance the substances must be brought into contact with one another, and it is for want of this attraction that quicksilver and sand will not unite.

2d This kind Sir Isaac Newton denominates Elective attraction or attraction of choice when substances rush together and cannot again be disunited

* Vid: Newton on Optics.

till a third body be added that has a nearer attrac-tion for one of the two, than these have for one ano-ther. This is Chemical attraction, w^ch is stronger than the attraction of cohesion. E.G. The attraction of the particles of the marble together is not so strong as the attraction between the marble & the spirit of salt, since they are torn asunder, & intimately dissolved a-mong the acid when thrown into it. The violent effervescence that attends the mixture of some bodies has been sup-posed by Newton to evidence their stronger attraction, & the dashing together of the marble w^t the Spirit of salt produced heat by the friction. But Sir Isaac was wrong for D^r Black has shewn that effervescence de-pends upon accidental circumstances, & that strong effervescence is no proof of their stronger attraction for many bodies rush strongly together without effervesance. It depends says he on the separation of a quan-tity of elastic matter, & if we separate this matter from the Spar before we throw it into the Marine acid we shall have no effervescence produced yet they shall rush together as quick as before.

we likewise find cold produced by the effervescence in-stead of heat.

This theory of Sir Isaac Newtons was not so well recieved thro' the world as it ought to have been a great deal of literary envy subsisted among other nations. Accordingly they set themselves to work in order to pilfer from this great man, & so to couch his expressions in other words, that people might honour them as the inventors of so great a light to Chemistry as the knowledge of Attraction is.

The French were the first & the first of all began with throwing away the word Attraction & in its place put Affinity w^h by the by does not convey so just an idea of this phoenomenon in bodies Many objections might be raised against the word here applied if we were going to quarrel for words. The French defined affinity, for in all French authors you find affinity instead of attraction to be an occult quality which subsists among the particles of bodies What I mean by Attraction is the tendency which bodies have of running together, I do not assign activity or inactivity to be the cause.

This species of attraction viz Chemical must certainly be very strong, as the hardest bodies are soon brought down by it, and that the particles into which bodies are divided by this union are extremely minute will appear from experiment. I take ℔iii of pure destilled water into which I put one grain of the metalline salt of silver dissolved in aquafortis this will diffuse itself through the whole as may be seen by adding a drop or two of an alkali, the whole will become milky, the metallic salt being decomposed by the alkali.

There are two or three observations to be made with regard to this species of attraction. 1st. Chemical attraction does not act upon large masses of matter as the other kinds do it takes place only among particles too minute to be observed with the eye.

2d. When bodies are acted upon by this attraction this minuteness of particles is occasioned.

3d. It does not operate at any distance as the others do, nay it is requisite that they should not only be in perfect contact, but some degree of squeezing or agitation is necessary. By calculation the particles mentioned 2d. & exemplifyed above when the grain of silver is precipitated, are said to exceed 48 millions. N. B. In order to produce corpuscular attraction the particles of bodies must be squeezed together. E G two pieces of lead.

From what has been said you will percieve that there are some rules wd are necessary to be attended to in the mixture of bodies especially the following ones.

1st. That one of the substances to be mixed must be in a fluid form (for two solid bodies may be laid apparently in contact with one another yet they do not really touch because on account of a quantity of elastic matter upon their surfaces) at least (disposed to go into that state when mixed.

2d: That when we are to dissolve a solid in a fluid, the more surface we expose of the solid the better because the sooner will the solution take place, hence comminution or the reducing of bodies into powder dispose them to unite a great deal faster. Several other operations are used for this purpose, such as pulvarisation trituration, levigation & Elutriation &c (vid Macqr) Elutriation or washing over is the mixing of the powder with water, letting it stand for a long time or a short according to the fineness you want your powder, the longer you let it stand. the more of the gross particles will fall to the ~~bottom~~, & the finer will the powder be which you wash over, you may have it by this means from No 1 to 6 seconds of time. and in this manner may you regulate its fineness

3d: That the bodies mixing should be frequently agi-
-tated else the solid part will be apt to fall to
the bottom or if lighter it will swim on the top.
Hence the solution could only continue for
sometime, because the side next the menstru-
-um has given out a sufficient to saturate as
much of the liquid as lies immediately around
Agitation as it brings the fresh parts of the
solid in contact with the Menstruum it great-
ly promotes Chemical Mixture.
E.G. Drop a piece of blue Vitriol into a
glass of water; first after a day or two a
blue ring will be formed round the solid body
this in length of time gradually rises larger
-till it tinges the whole of an uniform colour
4th: Heat should be employed. It may
appear something singular that I mention
heat, as a help to the mixture of bodies when
before I mentioned its effects in separating them

But without heat it would appear that no mixture at all would take place, as the property of bodies mixing diminishes as heat does Hence we should be led to suppose, that if there were not heat in this world there would be no mixture. We see that hot water dissolves more salts than cold does (common salt alone an objection to this theory) and if the heat be diminished a quantity of the salt is thrown out, and still more if we farther diminish the heat

The 3d Attraction of Gravitation is that power by wc distant bodies tend to one another In this we have daily instances of bodies falling towards the earth. By this power of attraction in the earth it is that bodies on whatever side fall perpendicular to its surface consequently on opposite sides they fall in opposite directions all tending towards the earths centre, where the force of gravity is as it were accumulated. By this attractive power bodies are as it were screwed from the surface of this globe on all sides, and are hindered from falling off. And as it acts upon all bodies in proportion to the quantity of matter they contain, it accordingly constitutes their weight. All bodies that we know of have gravity or weight. for that there is no such thing as positive levity even in smoke vapour or fumes is demonstrable by experiments in the air pump which shews that altho' the smoke of a candle will ascend will ascend to the top of a receiver when it contains air, yet when that air is exhausted the smoke falls down to the bottom. So if a piece of wood be immersed in a jar of water the wood will rise to the top of the water, but if the jar is emptied of its water the wood falls to the bottom.

4thly The Attraction of the Magnet or Loadstone which draws iron and steel only, and it constantly turns one of its sides to the North, & another to the South when suspended by a thread that (does not twist, and it communiccates all its properties to a piece of steel when rubbed upon it without any of its substance being lost; this kind of Attraction is confined to a small distance. 5 Electrical Attraction. Several bodies particularly amber glass, jet. sealing wax. agate & almost all precious stones, have a particular property when heated by rubbing of attracting light bodies.

But to return. In consequence of these observations (page 168 — 149) several Operations of Chemistry have taken their rise such Digestion. Circulation & Cohobation.

1. of Digestion. When I pour a fluid on a solid & expose them to heat in order to dissolve that solid I am said to perform this operation Three (days is necessary in a heat not surpassing the human, frequently agitating the whole to promote the solution. This operation is generally carried on in a sand heat, in a vessel called a mattrass, which is a round bag having a

long neck, and made of glass. The substances operated upon are mostly of the vegetable kind, the solvent is generally water wine or Brandy. When wine a small degree of heat is only necessary.

2d. Of Circulation. Here a much greater degree of heat is necessary, because the materials require to be converted into vapour, have room to circulate to the top of the vessel to fall back and to be condensed The vessels used are a Pelican (vid. Macqrs Chemistry) but I have always found that two Florence flasks answer the purpose fully better

3d. Of Cohobation. If we have a solid substance that is difficultly soluble in a fluid, we put them into a retort applying heat, & after a quantity of the solvent is come over into the reciever and condensed, we pour it back again on the solvent in the retort & so on alternately till all the solid be disolved. For more on these subjects vid. Macquer.

When I add to a compound a third substance that has a nearer attraction with some of these that make up the compound than they have for one Another, and so bring on the process of Precipitation what is the reason of this curious phoenomenon?

It is owing to Elective attraction. Chemistry consists almost entirely in a thorough knowledge of these different attractions, it is therefore of the utmost importance to be well acquainted with them. To give you an idea I shall here prefix an example; Suppose Aquafortis the liquid whose attraction for certain substances we want to examine. The Principle of inflammability is what has the nearest attraction to it of any, hence in the column it stands immediately below. The Fixt Alkali comes next and can be separated by nothing but the principle of inflammability. Quicklime again when joined with Aquafortis can be separated by neither of the two above it, and so on with all the rest.

Aq. fortis
P of infl[y]
F. Alkali
Q. Lime
Iron
Lead
Copper
Q Silver
Silver

The substance that stands lowermost in the column (Viz Silver) can be separated by the addition of any of the intermediate substances between it & Aquafortis.

The Apparatus for mixture are generally calculated as much as possible to hinder the more volatile parts of the bodies from escaping I mentioned the particular vessels when I described the Operations.

Having now finished all that I have to say with regard to the general effects of heat and Mixture. We come now to apply what we know of them to practice, or the objects of Chemistry (discovered by heat and Mixture)

The Objects of Chemistry

We enter now on the more particular doctrines of Chemistry. But before we proceed it will be necessary to have an arrangement of these bodies we are going to examine.

Every body that presents itself is the object of the Chemists enquiry. But the Elementary principles of bodies should first of all come under his observation i e there are some simple bodies which when variously combined form all ye compounds in the Universe.

Vegetables are either directly or indirectly the food of all animals. The soil supports the plant and remits water to it. Soil is the great repository in wc Nature has treasured up earth to answer the best demands of her offspring for from it Minerals, Animals and vegetables draw their subsistance. Earth is a-rranged in a regular manner, in the substance of every species & genus of minerals, is carried in a liquid form into all the parts of vegetables enters the Lacteals on the internal surface of the Intestines of animals, and passing in form of Chyle thro' the Lacteal sac and Duct, mixes with the blood in the left subclavian vein, is carried to the heart & from thence circulates thro' every part of the body, and as need requires is deposited and consolidates the substance of the Animals. This is conclusive from our observing the growth of Animals vegetables, and even minerals themselves Water is the vehicle wc carries Earth its circulatory round from the soil to vegetables, from vegetables to Animals, from one animal to another & at death the animal goes to its primitive earth. Water is raised into vapour, carried thro' the upper regions of the air, tossed about by the winds attracted by the hills descending to refresh all animate and inanimate beings upon the globe. If it was not for this spontaneous volatilization of water into vapour it would always remain below, because it is heavier than air, hence it would never rise of itself into the atmosphere, but must remain till it be evaporated, by being either united with something lighter than air, or so strongly attracted upwards as to overcome its own gravity, and be impelled to ascend thro' the yielding atmosphere.

As all animals live either (directly or indirectly upon vegetables, hence the principle of the vegetable passes into the animal, and all the alteration it undergoes is a different arrangement of its particles.

Therefore it would appear that there are certain principles in nature w^c make up or constitute any individual animal, and that these animals are the same in shape that they were a thousand years ago. Hence as far as we can learn, the Elementary particles of bodies are permanent, subjected to no change, immutably the same, & not subject to decay, This we find to be the case by comparing the Descriptions given of animals many ages ago, with those of the same species we have at present. The same is observable also in the vegetable kingdom; the oak tree for instance is the same as it was at the creation. Indeed Monsters are exceptions, but these are so exceeding-ly rare as to be no exception against the truth of this argument. Morover we find that these same elements must be few in number, because all bodies treated after the same manner yield nearly the same principles. E.G. Vegetables yield a quantity of water, oil, and aerial Matter.

It remains to query what these principles are. All Philosophers have agreed that there are elements or first principles; but all Philoso-phers have not agreed as to what these ~~prin-ciples~~ elements are. Upon this subject the human ima-gination is left to ramble at large.

One Set. The Philosophers with Aristotle at their head affirm that these principles are four in number Viz Fire, Water, air & Earth w^c are believed and followed by authors at this day.

Another Sct. The Chemists those that searched a-
-ges for the philosophers Stone unwilling to follow
any system that was not the production of their own
brain, seemed very little disposed to have any thing
to do with the philosophers elements; hence they
set themselves to work in order to erect new principles
They all agreed to throw away the former. and even all
agreed to have new ones, Viz Salt Sulphur and ☿, but
they did not all agree as to the properties of these —
principles, they differed widely concerning the two
last, Some mentioning Sulphur after one way
some another, some ascribing to it properties which
another denied it. In fine they defined it every
thing but what we mean by Sulphur. The same way
they wrangled about ☿, and tho' they had fixed these
three to be the primary elements of all bodies yet
they kept up an intestine war among themselves
concerning their properties.

Dr Gibson of London strenuously asserts &c
endeavours to prove that there are five elements
Viz Earth water. air Fire & Frost in his book

upon the elementary particles of bodies.
All these theories are unsatisfactory, and we are as far from knowing what these principles are as ever. Certainly if we knew them nothing could be more proper than to begin by describing them, for to be acquainted with the ultimate particles of bodies we should think ought to pave the way to clear demonstration by evaporating the misty clouds of error & hypothesis, wc too often accompany the science of Chemistry.

Yet supposing we were fixed upon elements if we did not know their properties, we should run ourselves into mazes so intricate that we could never get ourselves disentangled from. Suppose we could analyze all bodies into elements, yet if we could not reproduce the body by joining them again, certainly we must conclude that something is wanted. E.G. We can analyze a vegetable into, air, water, oil, & earth wc we should conclude to be the primary principles of the vegetable, yet if we cannot reproduce the vegetable by uniting these together, we cannot say that these principles are a vegetable, we can only ~~say~~ afsert that a vegetable contains in it a certain quantity of these its component parts In all cases where a body is apparently decomposed, if we cannot reproduce that body again by the juncture of its parts into w^c it was decomposed then we must conclude that something is wanted.

It has been generally believed that water & air were really principles that were not reducible into any other parts, yet from experiments we find that this conclusion is wrong. For water is found to contain a quantity of Earth as is afserted by Van Helmont & confirmed by Boyle Boerhaave thinks that all the earth w^c is contained in the water, is owing to the dust falling into it, w^c is tofsed about by the wind But Maargraff found that this earth was of a chalky nature hence could not proceed from the particles of dust, and adds if you distill the pure water you shall find a quantity of earth; therefore this author concludes that water is changeable into earth. Lavotte a French

Chemist asserts that the earth found after the distil-
lation of pure water is more off from the vessels in
wh it was distilled, for says he the vessels lose
their weight in proportion to the quantity of
earth found in the water. But Margraaf confutes
this opinion, by observing that earth remaining
after the distillation of pure water is unvitrifiable.

Air again is as far from being (perhaps)
Elementary as water. Nay it has been found
that air is compounded of two or three parts,
one of which is only for preserving animal
life, the other detrimental, the superabundance
of wh noxious parts occasions the unwholsome-
ness of towns, from the country where the
nutritious parts most abound. So far are we
uncertain about these principles; they at least
are disputable.

From these circumstances it appears that
the decomposing of bodies to principles is yet
unknown, at least as we said before very
uncertain. Hence the impropriety of conducting
a chemical enquiry on so tottering a basis

Upon this account Macquer trusting too much to his elements is faulty. He sets out with describing, first, principles, and under his second degree of simple arrangement, he places Salts as a compound of earth, and Water w^c is groundless.

From our ignorance of first principles I think it will be better to lay them aside and not pretend to be wiser than what we really are. Let us therefore begin & examine bodies as they are presented to us by Nature

All Chemical bodies may be divided into Seven classes Viz Salts. Earths. Inflammable sub-stances, Metals, Water, air and Organized bodies i.e. Animal & vegetable Substances.

It is necessary to fix upon one of these to begin with before we proceed to the rest, and as Salts appear the most useful at the same time being most simple, we shall enter upon them, whose properties if well understood will render all the rest more easy.

In treating upon the objects of Chemistry, I shall follow the same order as I did with the agents, viz 1st Consider the generall effects of heat upon them 2dly The effects of Mixture upon them, with that Substance you are already acquainted with. Water It will only be necessary here to make you acquainted with the method of getting water pure, leaving its peculiar properties to be mentioned in its due order: Pure Water can be got at a distance from towns either as it falls in form of snow or rain or we can render it pure by distillation

Some Chemists have confined their arrangement to animal, vegetable & mineral substances, but this method would lead us into many difficulties as there are some bodies we cannot by appearance determine whether of these three classes they belong to. Thus Salts can be got from all the three kingdoms This Method is followed by Macquer. The Salts obtained from minerals he ranks under that class Those obtained from vegetables under vegetables &c But I think it far more convenient to describe them altogether. and as it is of the utmost consequence that you understand them before we proceed to another class, I advise you all to pay the utmost attention.

Of Salts in General

We shall first consider their general properties and then proceed to mention their particular differences

The Characteristic marks whereby Salts may be distinguished from all other bodies. are "their solu-"bility in water, both fusible & volatile by heat, un-"inflammable, and sapid to the taste. But this common Chemical definition is too prolix: the so-lubility of salts in water being the most distin-guishing mark from all other bodies. Salts being no inflammable is excepted by some authors, which exception is only with regard to one salt whose inflammability is owing to some foreign matter in it. When salts are in their purest state they appear in form of small solid bodies, sometimes transparent. and are easily crumbled down when rubbed. They may be made pure by dissolving them in warm water, and allowing them slowly to concrete into crystals. This melting point varies greatly in the different salts some melting at 213 while others require a a very intense degree. The most fusible of all is the Nitrous Ammoniac, which consists of the Volatile Alkali and the Nitrous Acid, it melts a very little above the boiling point. All other saline substances require a greater degree of heat to melt them; and the one which takes the greatest is Vitriolated tartar. This substance was long supposed unfusible, but Margraaf found lately that it melted and not at so great a degree as was expected if the vessels employed be closely luted. Great caution is however to be observed at the melting of it for if it be heated too fast it will explode with prodigious violence.

They also differ remarkably with regard to their vaporific points. Some of them being so volatile as to be converted into Vapour by the common heat of the air; others take a great degree, and are evaporated with the greatest difficulty; hence the names Fixt and Volatile, but these terms are merely relative. The most Volatile is Hartshorn: the pungency of its smell is occasioned by the spontaneous vapour w^c always takes place if the bottle is not well stopped. One of the most fixt is Common Salt, on the evaporating of w^c depends a considerable Manufactory Viz The glazing of Earthen ware.

These are the general observations with regard to heat upon ~~Salts~~

With regard to Mixture. When a quantity of water is poured upon a salt, that salt is either partly or wholly dissolved. Other bodies are soluble in water as Lime Plaister of Paris &c, but this Solution with regard to salts is very small. Salts differ remarkably likewise as to their solubility in water. Some having so great an attraction for it. that they cannot be exposed to the air a moment without attracting water an so becoming fluid. These are called Deliquescents When a salt melts by exposure to the air it is said to run per Deliquium.

The first thing observable after throwing a salt into water is a milky appearance, owing to the separation of a quantity of air from the Water without wh no solution would take place; the salt separates the air from the water as the solution advances; but however the whole air cannot be got from it by any other means but by agitation in vacuo. If we separate the air from water by boiling, before we throw the salt into it no such Milkiness appears. The quantity of air contained in water is always a fifth part.

2dly In general. The quantity of salt that dissolves in water is in proportion to the temperature of that water, the more salt dissolves the hotter the water & vice versa; common salt alone being an exception to this general rule it dissolving equally in cold & hot. When water has taken up as much of a salt as it can it is said to be saturated. yet after a quantity of water is fully saturated, it will take up or dissolve as much more of an other kind. and after it will take up no more of this second kind of salt it will take up a considerable quantity of a third, and so on till the Menstruum be nearly destroyed for want of fluidity. The Solvent power of water so far from being diminished by being saturated with one salt is rather increased, for it will take up more of a second salt than what it would have done when pure.

3.dly That after the solution the mixture is generally colder, and that some salts require a great quantity of water to dissolve them, and others a very small quantity.

To get salts from their solutions there are several ways employed.

1st. By Evaporating to dryness: In this case the salt is obtained with all its impurities with w.ch it was formerly blended and w.ch it took up when mixing with the water. It is obtained by this manner in form of a spungy mixed mass.

2.d By their separating from their solutions when cooled. E.G. Dissolve 12 oz of Saltpetre in a lb of boiling water and allow it to cool slowly, it will throw out 9 oz of crystals, because 1lb of water only dissolves 3 oz of it. This process is called crystallization of a salt. Evaporation to a pellicle has generally been said to be a standard to the heat when a salt is wanted from its solution in form of crystals, but it should not be carried just so far and great care must be taken in the cooling, for if it be allowed to cool too fast, the salt will crystallyse irregularly. The figure of the crystals is a great mark whereby we distinguish salts from one another. As to the different figures of the crystals vid. Vol 4 of the Essays of the Royal Academy (Smiths Lir. Libry) and Lewis's Dispensatory page 458, where you'l find them very accurately delineated. All Salts of the same kind crystalyse into regular figures. Thus crystals of Nitre, are hexagonal prisms, sea salt cubes, Alum Octohedral masses: Sal ammoniac shoots into thin fibrous plates like feathers.

Again different salts are disposed to crystalize at different degrees of heat, from the solution Thus, the solution of Glaubers Salt must be cooled, while others separate into crystals while the solution is pretty warm; hence common salt can be separated from Salpetre in the same solution (by the by this process is necessary to fit this salt for gun powder) as saltpetre commonly contains in it a quantity of sea salt. Thus take the solution of them & evaporate by heat, the common salt will separate when the mixture is warm w^c^ can be taken off, while the crystals of the Salpetre will not separate till it is cold; however by this first crystallization Saltpetre is not sufficiently purified for gun powder, as it still contains some of the sea salt, hence the necessity of dissolving it a second & even a third time in warm water. Common Salt will not separate into crystals suppose we evaporate it never so much. Crystals of salts contain besides saline matter a quantity of water w^c^ in many is so considerable, as when assisted with a small degree of heat, to dissolve the salt entirely so as to have all the appearance of melting, but it only here undergoes the watry fusion. E.G. lb^i^ of Sal Glaub contains near about half a lb of water. In a very small degree of heat this salt undergoes the watry fusion, but it requires a violent degree to fuse it. By exposure to a dry air Glaubers Salt loses its crystallyne form crumbling down into a powder owing to spontane-ous calcination as it is called, in this case the salt has lost a great part of its weight by having lost its water, but they still retain their medical properties, and bulk for bulk they have double the strengh they had before. If we have salts upon our hands that have undergone this calcination, we need not hesitate to use them but we would not chuse to purchase them in this form for of adulteration, wc trick cannot be played upon them in the form of crystals. When a salt contains a little water in its composition if exposed to heat alone it crackles & makes a noise. This is called Decrepitation, and is owing to the water in the salt expanding by heat and bursting it.

Some attention ought to be paid to the vessels in w^c we crystallyse. These are fitted for the purpose that expose but a little surface to the air in proportion to the quantity of matter they contain; the segment of a glass globe answers very well.

As to the cause of crystallization authors have given various opinions, but the real cause is not rightly understood; the common opinion was, "That Salts crystalized into certain fi-"gures because the ultimate or primitive atoms "of the salt were of the same figure." But this is a mere supposition since we have no proof of the figures of these atoms, or even allowing that these atoms were of such regular figures would it follow that they would arrange them-selves constantly after one & the same manner, nor is it possible that a number of Hexagonal prisms could by any arrangement make a large one.

Sir Isaac Newton says that it is owing to attraction betwixt the Atomical particles; but there is something else necessary to constitute such regularity; for if there was nothing but attraction the particles would run confusedly together without form; Something rather like polarity i.e. Similar ends of particles (Imagination may assist) may attract and others repell hence a regular Shape is always formed

Having made these genneral observations we come now to consider them more particularly

Of Salts in Particular

Salts may be divided into simple & compound

1st. Those that appear simple in our processes not that they are ultimately so.

2dly Those that can be separated into compound parts, and can be united again, having all the properties of the salt before it was decomposed

Of the Simple Salts

These are divided into Alkalis and Acids.
The Name Alkali has been applied to this class from the Arabic name of some Marine plant, called Icali, by us Kelp, wc produces that salt
Alkaline salts do not exist ready formed in Nature. at least very rarely; Fire and Mixture are the agents that produce them. There are fewer Alkalis than acids. being only three of the former viz two Fixt, and one Volatile Alkali wc last continually emits vapours in the common heat of the air, if the vessel be not closely stopt

Of Alkali's

These are pungent fiery substances so corrosive when fine as to destroy Animal flesh like a hot iron; when diluted, they impress a biting sensation on the tongue, said to be like an urinous flavour the meaning of which expression I dont rightly understand. They have all an attraction for water & when very pure may may be said to be deliquescent, they are not acted upon by vinous Spirits.

they change the blue leaves or infusions of vegetables to green; this is what chiefly characterizes these salts. The blue leaf of the violet hastily dried and kept in a dark space will answer the end of trying these salts; or take the flowers of it and rub them upon paper, which paper dipt into the solution of an Alkali will be changed to a green colour: This is called test paper. Red roses are also turned by an Alkali into green. The purple colours of plants likewise suffer the same change.

Alkalis are easily distinguished from Acids w^c are sour & change vegetable infusions to a red.

Chemists distinguish the two fixt Alkalis by the denominations of Fossile & Vegetable. The first is got from the bowels of the earth, the other from the vegetable kingdom.

Of Fixt Alkalis

1st The Fossile

The fossile fixt Alkali has all the properties of Alkaline salts in general. It has got the name of Fossile from being found sometimes ready formed in the bowels of the earth. At present we shall only mention the effects of heat upon them and the figure of its crystals.

Fixt Alkalis endure a great deal of heat, they are chiefly useful in promoting the fusion of earths these particularly of the flinty kind in making what is called Crown or Window glass. As this class of Alkalis is presented to us by Nature they have a remarkable attraction for water, they never deliquate are easily crystallized and contain a great quantity of water 1lb containing 1/2 of it, their crystals are Rhomboides sticking together. This Salt is got in great quantities after the inundation of the Nile in Egypt, when that river again retires to its channels the inhabitants sweep it from the surface of the earth & give it the name of Egyptian Natrum. It is also found on the Pike of Teneriffe, which surprises us how it can exist Naturally there. We find immense strates of it combined in mountains, some times in the water of Springs, hence their medecinal efficacy in curing certain disorders, but it is got in greatest quantities from the sea herb Kali, growing on the coasts of the Mediterranean. That w^c is got from this plant by burning is used for the purposes of art, particularly the making of glass. When thus obtained it contains besides the Alkali, a quantity of charcoal dust, sea salt, and Sulphur in small proportions; yet in this case it is pure enough for the purpose of glass making as the heat purifies it thoroughly. It is also pure enough for the purpose of soap making, because by that process it is also cleansed from its impurities. For Bleaching it would require to be purified. The inhabitants of Tripoli in Barbary use the pure kind of this alkali as a purge, and the natives of the Canary islands dip paper into a solution of it, & burn this for Match paper.

Fixt Fossile Alkalis stand two or three days in fusion before they crystallyze, but when it begins they run into Crystals very fast, probably owing to a quantity of moisture w^c it may have to absorb, before it can crystallyze.

Kelp wc is the sea weed which grows upon our coast, and much of the same Nature with the Mediterranian Kali, yields likewise an Alkali nearly of the same kind, but in far less quantity. The reason of wc difference I suppose is owing to the Scottish clumsy way of operating. They pay too little attention to the drying of it, and they burn it very fast, hence they dissipate a great quantity of the Alkali. A Gentleman in the North of Scotland of my acquaintance writes me, he has found out a way of procuring more Alkali by adding a quantity of common fern.

This Salt is also found on plaistered walls in damp places. The fine white filaments wc are seen to spring out from wet lime walls is this kind of ~~salt~~ alkaline Salt, and gets the Name of wall Nitre, being one of the purest Species of it. How it is generated I don't know since we find it upon walls when not the smallest drop of sea salt, has been mixed with the plaister. I am disposed to think it is from the animal substance, hair, that is mixed with the plaister acting on the lime; and what seems to confirm this supposition, I can find no Alkali where the plaister has not been beat up with hair.

When we want it perfectly pure for Chemical purposes, we must free it from the sea salt of which afterwards.

2d. The Vegetable

The Vegetable fixt Alkali has got this name by way of eminence, because almost all land plants yield it, some in a large proportion others in a small. As this one agrees in many things with the Fossile I shall only mention wherein they differ.

They are equally acrid and rather more so than the last, they also promote the fusion of flint and as they are commonly purer than the Fossile, hence it is made use of for finer glass, such as looking glasses. It differs from the last in being deliquescent; hence the necessity of keeping it close stopt up. It is with great difficulty crystalized & cannot be got in form of crystals but by a particular process: it is never found naturally in form of crystals, the only way of getting it so is by evaporating a solution to dryness allowing it a current of air, else it will not do and the greater the stream the easier it crystallizes. When got by this method they are of an irregular triangular figure. – Remark that Chemical books will be apt to mislead you concerning this substance for it it has but lately been rightly understood.

As to its origin it exists no where ready formed in Nature, and the purest we can get for Chemical purposes, is from burning Saltpetre, hence the fixed Nitre. When it is used for any of the arts, it would be too costly to take it from this salt, hence they obtain it from burning different plants. All plants yield it, the Mustard tribe excepted (and the pine, which last yields so small a quantity that it is not worth Mentioning. Formerly the Chemists imagined that the Alkali obtained from the different land plants differed also in properties, therefore they gave it the names of Salt of wormwood, of Broom of Lavender &c but now it is well known that all plants yield the same fixt Alkali.

Its origin has been disputed: whether it originally existed in the plant or whether it was produced by burning. The first is found to be the case. The Oak, hazel and elm yield it in the greatest quantities, but tobacco yields it purest of them all.

Some differences are observable in preparing this salt, various ways of performing the process occasions our getting it in different quantities, and pureness. When the wood is burnt with a slow fire, the more Alkali is obtained.

The process is thus — Take a tub; bore several holes in its bottom covering them over with straw on the inside, and having put in the ashes of your burnt vegetables, pour water upon them. This Water dissolves the salt and carries it thro' the holes in the bottom to a proper receptacle. The Straw hinders the earth and other impurities to pass along with the alkali. After having got your alkali in a solution, evaporate the water and you have the salt, which is vulgarly called Pearl ashes most of w^c is brought from Germany.

In America they prepare a more strong fixt Alkaline Salt. They take a tub without holes in its bottom, and having stratassed it on the inside with straw, they put in a quantity of wood ashes, and then over them a proportion of lime according to the causticity they want it, above all they pour water at different times as long as the materials will absorb it, and till once it will appear to swim on the top. Then they pierce the vessel and draw off the lee.

(the straw entangling the impurities as above) Then they put it into iron pots and evaporate it as above. This they call Pot Ash. But it is very impure and cannot be used for bleaching, because it corrodes a small quantity of iron from the vessels in which it is evaporated, therefore it would destroy the linnen. In Hungary they evaporate it in ovens, hence it does not iron mould the cloth.

Another way of obtaining it from vegetables is by setting fire to the plants and covering it up as we do charcoal. By this means we get a mild salt that crystallizes and contains in it a great quantity of aerial matter, with sometimes a small quantity of Vitriolated Tartar.

The purest fixt Alkaline Salt is obtained from burning Tartar. Wrap up a quantity of that salt w^d^ concretes on the sides of wine casks in a piece of paper, and throw it into a hot vessel where it is evaporated to dryness, its elastic matter separating forms a very fine species of this kind of Salts. — The Fixt Alkaline Salts dissolve mostly in water. The American pot ash is completedly soluble in Water.

3.d Of the Volatile Alkali

This one differs more from the two others than they do from one another. The Volatile Alkali gets its name from its great disposition to evaporate, emmiting steams in the common heat of the air, wc is sufficiently evident by by their pungent smell, and hence their use in faintings by stimulating the nervous system. This Salt is easily got in a solid form, dissolves readily in water tho in their Natural State they are not deliquescent. When in a solution we cannot again obtain the salt by evaporation, because of its volatility it would fly off; we can only get it by distillation in close vessels.

As to its origin it exists no where ready formed in Nature being obtained from Animal and vegetable substances in a state of putrefaction. These plants yield it we give no fixt Alkali. viz the Mustard kind, which volatile Salt is probably the cause of their pungency.

As fixt Alkalis are produced from the ashes of vegetables by burning, So the Volatile Alkali is likewise produced from animal substances by distil-lation in close vessels, from the horns, bones and hair of animals, from silk &c. Salt of hartshorn is a name very often given to the Volatile alkali's because it was concluded originally only to be obtained from the horns of the hart: but the horns and bones of every animal contain it.

The process to get a Volatile Alkali. — Cut the horns &c in small pieces, put them into a Still add a quantity of water and Lute well your joinings, then distill in an open fire, gradually increased. First a phlegm rises then a Spirrit, and lastly the Volatile salt accompanied with an oil. In the Still there remains a black coal, which burns to white-ness in the open air is calcined hartshorn. The oil must be separated from the alkali else it will be unfit for Chemical purposes, tho' it may do very well for Medicinal ones.

This may be done by adding an acid w^c has a nearer attraction for the volatile Alkali than the oil has; hence the acid unites with the alkali and sets the oil at liberty.

The Spirit of Sal ammoniac is the purest of this kind, and is somewhat more acrimonious than those that are produced directly from ~~vegetables~~ animal substances, because they always contain a certain portion of oil, if not carefully separated from them as above.

Putrid urine gives a very pungent volatile alkali, w^c differs in nothing from that obtained from the other parts of animals: about 16 or 18 lb yields one lb of Volatile Alkali, but this proportion varies according to the food of the animal.

These are all the things I have to mention with regard to the first, class of simple Salts, Alkalis. We proceed therefore to the second

The Acids

This class is more extensive, as we have not only got to mention the effects of heat and Mixtures upon them, but also their property when joined with Alkali

Of Acids in Generals

Acids are Divided into Fossile and Vegetable

Their characteristic marks are "Sourness a "great attraction for water hence they always "appear in a liquid form, in spite of all our "endeavours to the contrary, and they change "the blue infusions of vegetables into red". Their attraction for water is greater than Alkali as they attract moisture from the air, yet they cannot be called deliquescent. as we cannot get them in a solid form.

All acids produce heat with water and with snow cold. This class may be throughly distinguished from all other bodies by the following properties.

1. They cannot for a moment be kept in a

solid form; nay so remarkable is their attraction for the moisture of the air, that they have been used as Hydrometers by placing some very concentrated acid on a ballance and observing how much heavier it grows by the moisture imbibed in a given time. But this scheme is faulty as it only makes us acquainted with the manner the air is disposed to part with its Moisture

2d That when diluted with water the acid can again be got pure by Distillation, because the water comes over leaving the acid behind This is called Rectifying or Concentrating because it is less in bulk, or Deflegmation i.e. separating the phlegm and making it more clear These processes however are limited to a certain pitch, nor can we obtain the acid entirely free from Water

3d. By intense cold some of the acids are made to lose in a great measure their attraction for water, and at 72 Degrees below 0 in Fahrenheits scale, they become solid and crystallize. By this we see that acids like all other salts would appear in a solid form if the heat were far enough diminished. We can easily deprive acids of their attraction for water by adding an alkali, then the acid shall have all the properties of acids in general.

4th: They all unite with alkalis with effervescence w^c is a test to discover the acid, but not the alkali; for all acids effervesce with alkali; but all substances that effervesce with acids are not Alkali's because Earths, and some metals also raise an effervescence when mixed with an acid.

5th: Concentrated acids have a prodigious power of dissolving animal & vegetable substances, corroding the flesh of animals like a red hot iron.

Hence since they are so acrimonious, no wonder they are such instant, and mortal poisons. But when diluted with 50 or 60 times their proportion of water, they prove useful and salutary medecines in putrid as well as other diseases.

6th: They change the blue and purple infusions of vegetables immediately to a red: They even produce a change upon a blue violet that has been made green with an alkali; the acid making it first blue its native colour, then changes it into a red. Violets are best for discovering acids, and the purple infusions of vegetables are the best for testing alkalis.

The most remarkable of this class are the Vitriolic, the Nitrous, and Marine Acids

Of Acids in particular, and

1st The Vitriolic

This Acid gets its name from its being originally wholly got from vitriol or copperas, but now it is scarcely ever got from this substance, tho' it still retains the name. The ⊕+ when pure is colourless and transparent like water (transparency being a sign of purity in acids) it is near twice as dense as water & apears sluggish when you shake the vial: hence it has got the name of oil of vitriol wh is a very improper one since it has none of the properties of an oil. It has a stronger attraction for water than any other of the ⊕+, if poured on it suddenly even in the ordinary heat of the air the mixture becomes boiling hot, hisses & emits a great quantity of fumes. The chief characteristic marks whereby we may distinguish this acid from all others, is, "It emits no vapour, is "without smell & has the nearest attraction &c. It is also the most fixt of all the &c, and the processes of concentration, rectification and deflegmation may be carried farther with it than any of the rest, so far as to make it assume a solid form when it is called the icy oil of vitriol, however it cannot be kept long in this state.

NB. When Chemists speak of the spirit of vitriol they mean the + diluted with its weight of ▽

It is very necessary we should know the effects of Δ upon +

If we add the ⊕+ to any thing that is slightly Δ^{ble} for instance an oil, such as oil of olives, it will be changed into a dark brown substance mixing with it & having its properties considerably altered. According to the quantity of the oil + added the colour of the + will be brown or blackish. If this + be aded to a more inflammable oil such as turpentine, an explosion follows the + going off in form of vapour with terrible violence separating a quantity of elastic matter, and leaving a black coloured mass behind. In trying of this curious experiment, great caution is necessary to be observed in pouring the + upon the oil. This last being poured into a phial, slowly run the x down the side of the glass, when it will gradually spread itself on the surface of the oil forming a blackish ring where they come in contact. This caution is requisite for if it were poured on hurryedly it would mix with the oil and occasion an explosion in your hand & perhaps be productive of bad consequences. When you get it thus introduced put it into a place where you can shake it, causing the explosions taking place without being in the least danger yourself.

It is next to impossible to keep the ⊕+ pure and transparent for any length of time, because the least particle of inflammable matter fal-ling into the phial changes it considerably and is sufficient to tinge a whole pound of it yellow. If a bottle of it tho' never so well stopt be exposed to the rays of the sun it will become dark, owing to its attracting and absorbing from hence a quantity of the Δ. The ⊕+ is a very fixed substance, rising at the 600 degree of the Thermometer, but that wc joins with the Δ is extremely volatile, hence we can render it pure & as transparent as ever by setting it in an open phial over the fire, and evaporating that part of it wc is impure. This is also found to be the case when a small quantity of the Δ is joined with any other substance.

In distilling the ⊕+ wc has been mixed with the Δ there arises a very elastic fluid of the smell of burning brimstone, which is called the volatile or Sulphureous ⊕+. This is not nearly so acid as the oil it abolishing the colour of vegetables, making a red rose white instead of making it more bright as other acids do. Hence that trick may be accounted for of putting a red rose into a drawer and taking it out white to the great surprise of the spectators. The Δ is the cause of this curious phoenomenon, and hence the way of making silk stockings &c white, that have been rendered yellow with animal matter. A quantity of them being heaped together in a close room, set fire to a parcel of brimstone matches, the fumes will penetrate thro the whole of them and make them white. If we carry on the distillation above mentioned a little farther we get brimstone not distinguishable from pure Sulphur. The change of whiteness occasioned by the steams of sulphur upon animal & vegetable substances, is only temporary for after having been exposed to the air for a certain time the △ flies off in incoercible vapours

It has been proposed to catch these sulphureous steams by themselves, Stahl advises to dip cloths in alkalis, and hang it over the sulphur when burning

This elastic fluid has got lately the name of vitriolic air from some peoples calling every thing elastic air, but we might with as great propriety call every thing nonelastic water. When brimstone is produced from ⊕+ and the △ considerable alterations are produced upon the acid, the only resemblance ⏃ has not to the ⊕+ is its weak attraction for alkalis. Sulphur is several times combined with ∝ for several uses, as to assist the dissolving of metals otherwise extremely difficult of solution. This compound is called Hepar from its dark brown colour which resembles that of the livers of animals. Stahl imagines that it was with this Mixture Moses dissolved the golden calf, as the Natrum or Egyptian nitre forms with 🜍 an excellent Hepar.

Hepars are made by mixing 🜍 and ∝ together then melting them, or what is better, by melting one of them first and then adding the other. The deliquescent alkalis are the fittest, because they unite most readily with the 🜍. These compounds are remarkable for their rotten smell compared by all nations to that of rotten eggs. This smell every body knows that is conversant in Mineral waters such as those of Aix la Chapelle in France and Moffat in our country. Thes contain a minute portion of real Hepar dissolved in them upon wc their Medicinal efficacy depends. Others have this smell which does not ~~defend~~ arise from this hepar ready formed but from the fumes of the sulphureous acid passing thro the water, but this smell goes off upon boiling or upon two or three Days keeping hence their Medicinal efficacy must be but smell. It is no Difficulty to counterfeit ~~mineral~~ medecinal waters.

There are two ways of obtaining an hepar sulphu-ris, viz either in a solid or fluid form. When we want the first we are obliged to melt the one for if they were both in a solid form they would never unite on account of their par-ticles being at too great a Distance, from the sphere of one anothers atr. action; but when one is melted a surface large enough is exposed for the action of the one upon the other. When we want the second we must have the ∠ in a dissolved state, such as the solution of Pot-ashes with lime to w^c add a quantity of 🜍 and expose the whole to heat it mexes into a yellow or brownish fluid. This one is con-venient in most purposes where a hepar is employed. If to this fluid hepar I add the ⊕+ a disagreeable smell succeeds, at the same time a plentiful mission of unwholsome vapour, the brimstone is precipitated (the + having a nearer attraction for the £) and the Magistery is called Lac Sulphuris.

The solid Hepar dissolves in water communicating to it the rotten egg smell &c I have already mentioned. The Method of dissolving ⊙ with an hepar is, to put into a crucible a strata or layer of the £ & 🜍 then the ⊖ placing another layer of the hepar above and closely covering up the vessel expose the whole to heat.

The 8 will not combine in open vessels with 🜍, because the heat would dissipate it before they had sufficient time to act upon one another

Hence we take close vessels, and use sal ammoniac which is a compound of the 8 and ⊖+ mixing it with the Sulphur and a quantity of lime which makes a terrible strong hepar & when the bottle is opened emits white fumes that threaten instant suffocation, it gets the name of the volatile tincture of 🜍 — These are the principle things I have to mention with regard to this + and the △.

With regard to its origin — The ⊕+ is never found ready formed in Nature; it is sometimes however found in Springs dissolved with a small quantity of ♂, which seems to be owing to spontaneous decomposition of it from the △ which happens more readily if the 🜍 be along wt the ♂.

Formerly this Acid was wholly obtained from Vitriol of copper, but now it can be got in a more convenient method in double quantity, and at half the expence from 🜍 by burning. The Chemists that first invented this method of getting the ⊕+, did it by burning brimstone Matches under a large glass bell the fumes rising were condensed on the inside of it, and trickling down were received into a vessel appropriated for the purpose This got the name of Spiritus Sulphuris per campanam: but this way is faulty a great quantity of the vapour escapes from under the bell. A better method of obtaining it and in larger quantities was first invented by Dr Roebuck of Edinburgh and which was long kept a secret, tho' now made public. That gentleman having considered that ⊕+ makes no impression upon ♄ even in its most concentrated state invented vessels of this metal for the process. As the French method of conducting this operation is very good, that Nation probably taking it originally from Dr Roebuck, and as it goes on in the same manner I shall give a short description of it. The 🜍 mixed with a small quantity of Nitre is first burnt in a sort of stove made of ♄ from which runs a lead pipe to another large vessel of the same metal about 18 feet wide into this large cooler the vapour is carried by the pipe, and in order that the vapour should not fly off when conveyed thither, they have contrived a Jetteau of water to be thrown in, in form of a shower of rain, which carries and condenses the ⊕+ along with it. In this manner the smell is hindered from spreading and they can frequently burn a ton a day without the least inconvenience.

The Nitre that is mixed with the + is of no hurt to its being used in Manufactories, but when it is wanted pure for Chemical purposes then it must be distilled, and then the ⊕+ will come over and the Nitre behind.

The quantity of nitre added is about 9 lb to the 100. By adding a small quantity of nitre to ⊕+ rendered black by the △ and evaporating the acid will be got pure and transparent the nitre seperating the △ from the + they both fly of together. Here remark that the proportion of Nitre must not be too great. NB Thro this course when we talk of the ⊕+, we mean, that which is obtained from 🜍 and purifyed by Distillation, or from whatever substance it is got we mean it in its purest state, except otherways mentioned.

This + can also be got from alum, and some kind of Marles, but these yield it in very small quantities.

2 The Nitrous

This + when very strong appears in the form of an orange coloured fluid, emiting vapours of the same colour. It gets this name because it is obtained from Nitre.

I shall not here mention in what this differs from, the foregoing acid, they agree in so very little, it will answer better to mention their respective differences. The ⊕+ differs from the ⊕+ in being extremely volatile, wheras this last is very fixed. It is denser than ▽, but not so dense as the ⊕+. A vessel that holds 10 oz of ▽ will hold 15 of the ⊕+ and 19½ of the ⊕+.

We should here first mention the effects of heat upon it but it differs in nothing by being distilled (except its rising at a less degree from the ⊕+.)

It will be proper however to mention the effects of △ upon it before those of Mixtures.

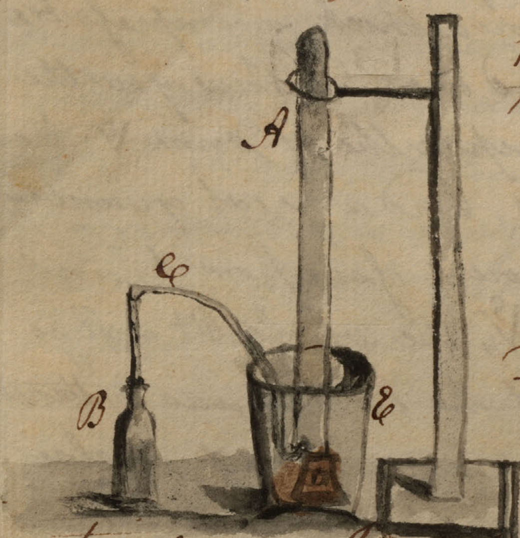
The ⊕+ has a greater attraction for △ than the ⊕+ has. It has so much that when it comes in contact with oils, it instantly bursts out into flame. If you put for example 6 oz of the oil of turpentine into a segment of a broken retort then pour quickly on it as much of the ⊕+ it flames immediately. If one part ⊕+ be added to the foregoing, the flame will be more violent. Concerning the cause of this phoenomenon Chemists have differed, Some imagining that it was owing to the oil's giving out so much of △ to the ⊕+, hence say they the stronger this + the better for the purpose and the cause of ⊕+ making it burn better is owing to that + atracting a quantity of ▽ from the ⊕+, & so allowing it to act better upon △ in the oil. This opinion however is quite unsatisfactory. I am rather of opinion that by the union of the

+ ⦶+ with the oil an elastic fluid is formed wc coming in contact with Δ in the oil easily fires it, it being accompanied with a great deal of heat.

That this fluid is elastic we can easily percieve by adding ⦶+ to a less inflammable oil or Spirit ∇S for instance, when no flame will arise, yet we can see a change from a thick incompressible fluid to an elastic ~~fluid~~ one. To shew you the experiment I here pour upon the ⦶+ some ∇S; the + is converted into fumes, and a great quantity of dark red elastic vapours issue from it, and if I continue adding the ∇S, the whole ⦶+ will go off carrying along with it the Δ that was contained in the ∇S, and what remains is nothing else but a strong vinegar, which was produced by a separation of one of the ingredients of the ∇S not of the ⦶+ as some have supposed. This elastic vapour, they distinguish by the name of Nitrous air; when the Nitrous acid is combined with the Δ no such thing as sulphur is formed, therefore Macquers existence of Nitrous sulphur is entirely hypothetical.

This vapour that arises of a red colour by the union of the △ with the Nitre is permanently elastic; and I can prove the colour to be occasioned by the air around mixing with it; at the same time I shall prove it permanently elastic.

Here is a glass tube A close at one end



from w^c I must extract all the air, thus I fill it with water. then I pour it out again, and as the last drops are running out I clap my finger to hinder Any of the atmosperical airs entering, on the open end; to be certain that it contains none. I put it into a glass of ▽ before ever I dislodge my finger; if the ▽ mounts to the top of the tube then it is free of air but if there be any still remaining it will hinder the ▽ from ascending, by repeating the former somewhat more carefully free it from air; having managed matters thus far I place it among water, the tube A filling to the top. The open end of which I lodge upon an inverted crucible **D** which stands in the bottom of the vessel **E** this last containing the water, the crooked tube C runs from the bottle B w^c^ contains the strong O+. The elastic vapour rising is carried, by C into the tube A where it mounts thro' the impending column of water raising little bubles as it ascends. In a short space the aerial matter occasions the ▽ to subside and does gradually as long as I keep the crooked tube C in A. But whenever I take it out the ▽ stands still, and this elastic fluid keeps its place above the ▽ and permanently so. That the air of the atmosphere changes changes it into a red colour, I shall likewise shew you when I raise up the tube allowing some ▽ to run out at the same time allowing an entrance to the external air, which ascending immediately converts the whole into a reddish colour.

This Nitrous air has no effect upon vegetables, unless when common air is mixed with

with it and then it changes them to a bright red colour. This shews that the ⦶+ when saturated with the △ has no effect upon the colour of vegetables without air; it is easy to be perceived that this + promotes the inflammation of bodies because it draws from them the △. If this + saturated with the △, be exposed to the air, the air sucks it up, contracting therewith into a little space; but if the air be already saturated with the △, such as the bearing the inflammation of inflammable bodies, then no change will be produced. Hence some imagine the purity of the air may be determined. Dr Priestly tells us that air which gives the brightest colour to this elastic Nitrous air, is purest; but this will not hold for the air may be rendered exceedingly impure by the effluvia of putrid bodies upon wc it has no effect. Hence from this method nothing conclusive can be determined, but as to the quantity of the △ whether it is more or less satturated therewith.

This air is called also Dephlogisticated air when full of the △, and so rendered extremely elastic.

These are the principle things with regard to the ⦶+ and the △.

Mixture with Water

When the ⦶+ is mixed with ▽ various are the changes produced, according as the + is more or less saturated with the △.

1. If the ⦶+ has been perfectly saturated wt the △ no change will be produced with ▽.

2. If the + contains none of the △ as little change will be produced with ▽.

But if the + be in a medium the ▽ will be of a green colour. Here when I pour in equal quantities of this ⦶+ and ▽ and shake them together, the whole immediately becomes green producing a sensible degree of heat and still emitting vapour. If a I add a very small quantity more of ▽ the colour will be entirely abolished; the caus of this acid's changing ▽ to a green colour has afforded no small admiration to Chemists. Some thought it was owing to a quantity of ♀ dissolved in the +; but this is false, for if it were true how could we account for a very small quantity additional ▽ making it entirely transparent. Various have been the opinions, but all entirely unsatisfactory till it was lately found out to be owing to the presence of a certain quantity of the △.

Stahl mentions that ♂ changes ⦶+ to a blue or green colour according to the quantity of the △ it contains.

The ⦶+ in its pure state is too strong for any useful purpose, therefore it is diluted with ▽ wᶜ enables it to act better upon several bodies. When the ⦶+ and ▽ are joined equal quantities it is called Aquafortis; in this state it dissolves many of the metals perfectly, tho' it would not do so when pure.

As to its origin it exists no where ready formed in Nature, being wholly obtained from Saltpetre. The best method to get it is by adding to every ℔ of Nitre, ½ ℔ of the ⊕+, when it comes over such as I have here. Formerly it was got by a different method, Viz by adding copperas to the Nitre instead of the +, but in this way a great heat was requisite besides the operator was in danger, that performed the operation according to the quantity of ▽ that they distilled it with, it was called double or single Aquafortis.

3^d The Muriatic

The ⊖+ differs more from the others, than they do from one another. In its strongest state it is not perfectly transparent, appearing always of a yellowish colour emitting whitet fumes that are extremely elastic, and difficultly condensed; Tho the vapour that arises from this + is not so disagreeable as the last, yet we should be very cautious of smelling it, for the steams are very apt to corrode and hurt the lungs.

Effects of heat upon it. — It is so extremely volatile that if it were not mixed with ▽ it would always appear in form of vapour, hence it has been said to yield a Muriatic air like the others. We can obtain it in a permanently elastic state by adding oil of vitriol, or by emitting it with a little of the Δ. It differs remarkably from other + with regard to its effects upon inflammable bodies. When it is combined with a little of the Δ (remark. it will not combine with much) it will not part with it when exposed to the air, nor is its colour altered thereby as the ⊖+ is. The Muriatic aerial Matter extinguishes flame and when in quantity destroys animal life: it is also more perfectly imbibed with ∇ than any of the other two; the fumes likewise dissolve ice and produce a bluish flame when set fire to with a candle. When we have combined the Muriatic air with a quantity of the Δ, we can make it take up as much more as will make it inflammable. This quality can be given it directly by ♂. The Specific gravity of the ⊖+ is less than either of the other two. A bottle that holds ℥j of ∇ will only hold about 13½ of this +, because there is always a quantity of ∇ mixed with it, else it could never be got in a manageable form: if it was pure it would be denser than the ⊖+ as it would then be as 13 to 17, since it must always contain equal quantities of + and ▽.

It differs also remarkably in being more volatile than any of the other two, in its not being so corrosive near, when applied to animal or vegetable bodies, even in its strongest state; we can keep a little on our hand without hurt; this we could not do with either the ⊖+ or ⊖+'s.

This weak corrosive quality of the ⊖+, answers well, when we want to demonstrate the vessels of the Liver, for example in Anatomical inquiries for the knowledge of the animal body. Having injected the arteries veins and biliary ducts of that organ with wax coloured black for the arteries green for the veins, and white for the biliary ducts. Then put the liver into a quantity of the ⊖+ which slowly corrodes away the flesh till it arrives at the vessels, leaving them untouched and laying all round bare to the eye. Hence the different vessels can be easily demonstrated, for the + in no ways changes the colour of the wax, it only makes it a little thicker of consistence. Therefore when we try this method it will be necessary to inject the wax a little more fluid than usual else the vessels will become too brittle. If we think the + corrodes the flesh too fast, we may dilute it else it would be apt to hurt the vessels: this only takes a little more time. As the ⊖+ is so mild it is also preferred to eat out iron moulds in cloth preferable to others, because it does not hurt as they do.

With regard to Mixture this + has but little attraction for ∇, and no wonder as it is already possessed of so much; by mixture with ∇ little heat is produced, and the yellow colour of the + is changed to a more transparent one, in proportion to the quantity of ∇ added. The yellow colour is not natural to it being occasioned by a minute proportion of the Δ. This + has but little attraction for the Δ, as it will not unite with several substances till the Δ be taken away.

Its attraction for & is weaker than any of the foregoing, hence it stands in the fourth space immediately below ⊕+ which separates it from an ∝, and is itself separated by the ⊕+

Origin. It is obtained from sea salt by mixing it with ▽ and distilling. Formerly it was obtained by mixing copperas with the salt, and exposing the whole to heat, but in this last way a great degree of heat is requisite, besides a small portion of the ♂ is apt to come over with the ⊖+. in this process the ⊕+ is left behind with the ∝ of the salt, because of its being far less volatile. Clays Earths &c and all that contain the ⊕+ have been used instead of copperas to obtain it. —

By Mixing these three acids one with another different Menstruums are produced, for instance Aqua Regia is produced by mixing the ⊖+ & ⊖+ together. We may also make it by adding to nitre a quantity of Sal Ammoniac, but when got in this way it is always more impure; however this method is often used when an Aqua regia for dissolving ⊙ is wanted. Further these +s may be mixed in different proportions as to the Metals we are going to dissolve, equal parts of the ⦶+ and ⊖+ is found to dissolve ⊙ best; other metals dissolve best in two parts of Nitre and one of the strong Muriatic.

These are all the fossile +° that are commonly known, and you'l find them by far the most active bodies in Chemistry. They are always employed in investing the properties of bodies. The ⊕+ is never mixed with the other +° for a menstruum. Alone it dissolves ♂, Zinc & ♀.

Of the Vegetable Acids

You remember that +° were divided into two kinds the first we have already given a short sketch of. We proceed now to the second. Vegetable acids differ both in strength and purity from the Fossile. They get this name because they are always obtained from the vegetable kingdom, in which they either exist naturally or are formed during the process.

These Acids strictly speaking are also divided into three kinds.

1 From vegetables in which the + exists naturally, as Lemons, Oranges, Sorrel &c.

2. From vegetables by fermentation, sweet bodies kept in an equable degree of heat yield this +.

3. From vegetables by distillation; all yield a quantity of + which did not exist in them before but arises from a different arrangement of its parts nor can we distinguish from what vegetable the + was obtained all vegetables yielding it the same; this Method is called Chemical Analysis.

The vegetable +s that have been of most use and longest known are the fermented & Native, therfore to these we shall pay the most attention However before we begin it will not be amiss to mention four general observations.

1st. They are all very mild being not equal to to the weakest of the F. +s, tho diluted with 40 times their weight of ▽. As for the ⊕+ they are not equal to it, tho' it were diluted with 80 times its weight of water. The reason is because all the V. +s contain a great quantity of ▽.

2d. They all contain besides ▽ some foreign mat-ter, such as oily glutinous particles. As we see in vinegar that has been kept for any length of time deposites a viscid matter. This renders them more impure, than the F+s which contain none.

3d. They are all destroyed by heat, flying off in permanently elastic vapour; leaving some oily particles, and a quantity of earth behind. they can be made to endure an igniting heat by adding an ∝ and using close vessels.

4th They produce no deleterious effects upon the human body, when given internally or applied externally. They prove excellent medicines and salutary additaments to our foods.

The Fermented Acids are those which are obtained from sweet tasted substances by the process of fermentation. These are two in number Viz Vinegar and Tartar.

Of Vinegar

This + has been long known to Chemists by the name of the ÷, which name is never applicable unless when it is deprived of its impurities.

Again when it is deprived of a quantity of its ▽ it is called Spirrit of vinegar.

Common Vinegar contains a quantity of oily & mucilaginous matter, wc can be separated from it by exposure to heat in close vessels, because of the different volatilities of the parts. In this process the distillation must be carried on with caution for if the heat be increased above the boiling point of ▽, the consequence will be an empyreumatic smell; hence the operation is extremely tedious for we cannot distill it in any quantity, without giving it this disagreeable taint, and this smell hurts its medecinal quality, nor can we deprive it of it by any means, but by exposing it to frost sufficient to freeze it, wc frees it effectually. By distillation vinegar may be concentrated a little, but much less than any of the rest because of its nearness ~~to~~ in volatility to ▽. However we have one method of rectyfying it, viz by allowing it to stand a frost air, the icicle formed will be wholly ▽ wc may be taken out, and thrown away; But even this process is limited, for the + itself soon arrives at its freezing point, consequently will freeze along with the ∇.

From Verdegrease (wc is a compound of vinegar and copperas) crystallyzed we can obtain a very strong vinegar, so strong that bulk for bulk it is not much weaker than the ⊕+ itself. Thus by putting the Chrystals into a retort & exposing them to heat, what comes over into the reciever is called Spiritus Aeruginis or Spirit of Vinegar. The French call it spirit of Venus, as Venus is the name they give to ♀.

We may also obtain a strong vinegar by saturating the ✳ with an ∝, and distilling. When it is got in this very concentrated state it appears solid transparent extremely volatile, and emits white fumes. Yet even in this state it is a mild substance compared to ⊕+, and is harmless as to its effects on the human body. It changes the colour of vegetables infusions but weakly since an oz of it will not tinge so much as three drops of ⊕+ does; with ∝ it effervesces weakly, when joined with them and distilled there comes over a permanently elastic vapour, leaving behind a charcoal substance; an earthy matter, and something like an ∝ remains behind.

With regard to heat Vinegar appears more volatile than any of the +s when free from the Δ. Inflammable bodies are not disposed to have any remarkable effects upon the +, since they neither change its appearance, consistence, nor will they combine with it. In this vinegar differs remarkably from all other +s. It has a weaker attraction for ∝'s than any of the foregoing, hence it stands below the ⊕+

As to its origin it can be got from all sweet substances diluted with ▽ assisted by an equable continued degree of heat. It can be got from all substances that were once sweet however they may be changed by other processes. It may be obtained from wine, beer, sugar &c

By the by this last yields a very pure vinegar
Take 8 lb of ▽ and one of Sugar, add a little
burnt bread and allow the whole to stand close
for 8 or 9 days. If we want it stronger we
may lessen the quantity of ▽ to 6 oz but we
cannot lessen it any farther.

Of Tartar

This + differs from all the rest in its always appearing in a solid form, which combines difficultly with ▽, and when exposed to a degree of heat sufficient to convert it into vapour is changed this change happens before it is red hot. This + substance was formerly called Cream of Tartar because it was skimmed off the top of a boiling solution of crude Tartar and crystals when allowed to crystallyse, but these names are used indiscriminately. In close vessels, when a strong heat is urged, Tartar yields a small quantity of air, oil, ▽, and a pure 8 is left behind, commonly known by the name of Salt of Tartar, this is the sum total with regard to heat.

It was long a query whether the ∝ above mentioned is formed in the process, or whether it existed naturally in the Tartar, i e whether it was a new composition or not But Mr Maargraff found that the ∝ did exist naturally in it, and many experiments seem to prove the truth of this opinion. Tartar is proved to be composed of an + and ∝ in the following proportion, 16 oz consists of 6 oz of + and ∝ saturated, the other 10 is pure Tart: + which last is a sluggish red coloured liquid, and wc upon standing deposites small crystals. The Method of obtaining the Tart: + from Tartar. Dissolve a quantity of crystals in hot ▽ then add to the solution a quantity of lime or chalk, the + is then precipitated in form of a dun coloured powder called Tartareous Selenite. Upon adding to this powder some ⊕+, the chalk separates from the Tart + and we get it by itself. Tartar in its natural state has but little attraction for ▽, yet if we separate the ∝ from it and get the Tart: + as above we find then its attraction for ▽ is considerable.

As to its origin. It is a doubt whether it may be obtained from any sweet substance but the juice of the grape, we are certain that from wine we obtain the greatest quantities, and from some wine in a greater proportion than others. The Rhenish deposites the most, being sometimes an inch and a half thick. This substance is always found adhering to the casks, and the wines after depositing their Tartar become more agreeable and more wholesome. The colour of the Tartar resembles that of the wine, as there is a quantity of the colouring matter of the grape always deposited along with it. To get this substance pure dissolve it in hot ▽, clarify it & then pass it thro' a strainer, crystals are formed when it cools, and it is then purer than before, yet it still retains the taint of the wine and is not perfectly white; for this purpose redissolve it in ▽ in which some pipe clay has been mixed, this substance attracts the colouring matter of the grape and leaves the Tartar pure & white. after the above method they purify it at Montpeliers.

In consequence of its being a weak + its place of Elective attraction is below the 🜊

Thus much for the vegetable fermented acids, what I have further to mention will be chiefly, in what the others differ from these.

Of the Native Vegetable Acids.

These are obtained from fruits as lemons, oranges &c, sometimes from leaves, as the sorrel; by expression This + when kept any lengh of time is apt to turn musty however when we want to keep it long we must be careful to separate the pulp, and other oily matters from it and cork it close up. The addition of a small quantity of ∇^{S} will help to preserve it. Another more convenient method is to evaporate them to the consistence of a Rob, or Extract, when they may be kept for any lengh of time. The heat destroys a good deal their native agreeable taste. When we keep these Robs in a cold place where no air has passage to them 3 or 4 Months, they crystalize which crystals may properly enough be called the essential salt. A Native + is likewise got from apples, pears, nictarines, grapes, sloes &c.

Vegetables put in close vessels and exposed to heat an + distills but in a small quantity. This way of obtaining an + by distillation is seldom or never made use of.

So Much for +s whether obtained by nature or by art from the vegetable kingdom

There remains yet another + to be considered wc I did not chuse to rank either under the Fossile or vegetable since it does not seem to agree with either; It is known by the name of

Sedative Salt

which when looked at resembles (Tartar; it is a white spungy, flaky mass. The name of Sedative Salt was given it by Homberg, from his supposing it had an Anodyne quality in Medecine. It is as pure a saline compound as any of the +°. By repeated Sublimations we can apparently convert it into vapour, but when condensed the salt appears again. By heat it melts into a glassy like substance, which when allowed to cool crystalyses. This salt when mixed with bodies greatly promotes their fusion, when mixed with ⁎ it even promotes the fusion of metals. It has little attraction for ▽, has no sour taste owing to its not dissolving in ▽, for if it does not partly dissolve in our mouth we can have no sensation of taste. If we could make it have a greater attraction for ▽ we should then feel its sourness.

It agrees with other +° in changing the infusions of

⁎ Thus joined it is undestructible by heat vegetables and forming with ∝ a new compound salt but for ∝ it stands lowest of all the +s with regard to its elective attractions (see page 250). This however only holds true in the ordinary state of the air for if it be heated to a certain degree with Nitre it separates the ⊕+, this is owing to the ones being more volatile, for the Sedative Salt is a very fixed substance.

With regard to the Δ it has but little disposition to unite with it, any more than the veg +s; tho' it seems to have a little. A curious phœnomenon appears if we add a little of it to $\bar{V}^{s}$, and inflame them they burn with a beautiful green flame; when combined with the Spirit it varies in its properties a little.

As to its Origin. — We are very little acquainted with it. It is brought us from the East Indies combined with an ∝ in form of Borax; to obtain the Sedative Salt thus combined we need only add the ⊕+, which has a nearer attraction for the fossile 8, (the other part of the Borax) than the Sedative

Salt has, hence the ⊕+ joins with the α forming Glaubers Salt, & sets the Sedative Salt at liberty.

The Elective attractions of +s for αs stand thus.

Alkalis
⊕+
⦶+
⊖+
⁜
Tart. +
Sed Salt

The ⊕+ has the nearest, hence if any of the +s below, be joined with an α, it will set them free and join with the α itself. The ⁜ sets free the Tart:+ and is itself set free by the ⊖+ and this again by the ⦶+; The ⊕+ can only be separated from an α by ∆. I might have added to the foregoing several other +s, as another fossile + called the Spar +, obtained from the calcareous Spar but this will come in better when we mention that substance. The + of amber too which is obtained by Distillation in close vessels; but this + seems to be of the vegetable kind, as it resembles them in its properties and what seems to confirm this opinion, we often find pieces of vegetable mixed with the amber far below ground. I might have likewise mentioned some animal +s such as those thrown out by the stings of certain animals. Of this kind none are more remarkable than that which is obtained from the ant. It is an extremely stimu-lating substance, and has many singular properties. It is this + that gives us pain when we are bit by these insects. Yet this + tho' it has some singular properties yet it agrees in many respects with those obtained from vegetables. It is like them destroyed by heat, effervesces with Xs, and changes the colour of vegetables weakly.

Another animal + as we may call it is obtained from urine, which consists chiefly of a 8 and an + of a particular kind. The bones of animals contain the + also joined with earth. But this likewise is found to be of vegetable origin since Mr Maargraaff found that phosphorous could be obtained immediately from oat meal and other species of Farina, but of this when we come to treat of inflammable substances.

A perfect knowledge of the +s is so extremely necessary that upon them depends your understanding the following lectures; for we shall be perpetually speaking of them in discovering and determining the qualities of bodies. They are likewise of vast importance in several of the arts; without +s linnen could never be made so white, but we must be cautious of using them this way, and see that they be thoroughly deprived of the Δ, which would destroy the cloth. It was supposed formerly, that no + answered this purpose but those that were fermented, but any of the rest will do equally as well if pure. The ⊕+ as it has the property of being most fixed and obtained cheapest, is reckoned therefore the best and is commonly used. Proper attention must be paid that it be pure & properly diluted else the cloth will be hurt. Manufactorers pay too little regard to this circumstances. Formerly it was thought that 40 times the weight of the + of ▽ was sufficient to dilute it but in this state it is by far too strong, tho' linnen printers tell us that this degree of strength alone answers the purpose. What their design is in using it so strong, I cannot concieve, for it is evident that a much weaker + may be applied with advantage. The following does every bit as well. To 1 pint by measure of + add 3oo of ∇, which by weight is equal as one to 250. This must stand a night before being used, the common time allowed. The + should be quite free of 🜍 else part may be deposited betwixt the particles of the cloth and destroy it.

As to the effects of an + upon cloth, several opinions have been given. Some imagine it dissolves earth in the cloth; but it properly depends upon setting free a quantity of thick oily mucilaginous matter, which hinders the effect of the ∝ in the soap, because oil and ∝ have but little disposition to unite; hence the removing it will render the cloth much easier bleached.

Besides the +s are the basis of several useful colours as the Saxon blue, which is obtained by laying a piece of cloth into a mixture of the ⊖+ and Indigo. By +s we can separate ⊙ and ☽ from their ores, and by a mixture of +s we can dissolve those metals which otherwise bid defiance to the heat of our furnaces.

The ⊖+ is principally used in tin plates, without wc white iron could not be produced. — Tartar gives us various colours, and the Sedative Salt promotes the fusion of Metals.

The ⦶+ is used again for separating ☉ from ☽, whither naturally or artificially combined. With tin dissolved in it, it dyes a beautiful Scarlet, and upon its corroding quality the art of Etching depends; thus by throwing a composition of wax and oil along a Copper plate, then trace out the design with a needle, and throw upon it some aquafortis which eats out the design.

We have now ended our first division of Simple Salts, we next proceed to the second division of those that are more Compounded.

End of Volume First

Explanation of Chemical Marks

⊕+ The Vitriolic Acid
⦶+ The Nitrous
⊖+ The Muriatic
\+ Acids in general
∝ Alkali's in general
♉ The Volatile alkali
🜹 The Fixt alkali
△ The Principle of Inflammability
🜍 Sulphur
▽ Water
🜊 The Acetous acid
☉ Gold
☽ Silver
♂ Iron
♄ Lead
∇^{s}. Spirit of Wine
♀ Copper

⊕ Vitriol
⦶ Sal Nitre
⊖ Common Salt.

Finis

The Black flux.

℞ Nitr. pur. part 1.

Tartar part 2. tere simul et

in crucibulo inde, ferro candente accendantur

et aperto crucibulo in carbonem comburantur.

℞ Antim. at Nitr. fac. Calcin.

Black flux. pondera paria

Liquentur simul crucibulo et in conam

ferream effundantur.