before smaller than those behind; because the body of the carriage will then certainly move more upon a level, and therefore be more easily drawn. A Carriage should be loaded equally on both wheels. The Proper height of the wheels should be that their axes be precisely in a line with the horse breast; which may be easily understood by any person who understands the doctrine of the resolution of forces.

3. Carriages with 4 wheels are more advantageous than those with 2. If the fore-wheels of a waggon sink into the mud, half of the load only is to be drawn out. But if the two wheels of a Cart sink into the mud, the whole weight is to be drawn out. Desaguliers's estimate is, that 4 horses in a waggon are equal to 6 in a Cart. — 4. broad wheels are more advantageous than narrow; because they do not sink so deep into the ground.

Narrow wheels may be considered as constantly going uphill. In clayey roads, however the broad wheels clog too much. Another advantage they have; which is that they make the roads better, instead of cutting them into ruts. —

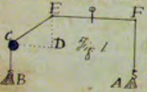
The wheels on a carriage should be made dishing. Wood is strongest in a perpendicular situation. When the carriage is a slant, the spoke from being dishing, is perpendicular. It is extremely advantageous that the carriage should be fixed on springs. — 1. when the wheels come to an obstacle, the carriage, fixed on springs, jolts forward, & thus assists in surmounting it. 2. The springs raise the centre of Gravity: now the nearer the centre of Gravity is to the obstacle to be overcome, the more difficult will that obstacle be to overcome; & vice versa.

The Lecture was concluded ~~upon~~ with

Some observations upon the comparative strength of men & horses which it is not necessary we should mention.

Lect. 13th Part 3rd Of Oblique Forces.

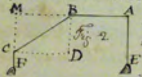
That is a direct force which draws the point, to which it is applied, in the direction of the line in which it can yield. If it acts in any other direction it's called an oblique force. – Hitherto in considering the mechanical powers, we have supposed them to act directly. We are now to consider them as acting obliquely.



Let there be a ballance EF; at the end F of which let the weight A be suspended so as to act perpendicularly; at the other end E, let the weight B be made to act in the oblique direction CE, by means of the Pulley C, draw the Perpendicular

ED; the horizontal line represents the force lost by the weight B. The weight A will counterballance the weight B, if B be to A, as CE is to ED: now ED is the Sine of the angle of obliquity ECD; & EC is the radius: therefore the weight A will counterballance the weight B, if B be to A, as the radius is to the sine of obliquity. Hence it appears that just as much as the line CD exceeds the line ED so much greater is the proportion of the force lost; i.e. the proportion of force lost increases with the obliquity of the action.

If a crooked Lever ABC be so placed on its prop B so that the arm AB be horizontal



and the arm CB inclined. The weight E will counterbalance F, if F be hung upon that point in CB which is cut by an horizontal line CD equal to BA. For invert the angle CDB into the position BMC, and it is plain that if F were suspended at M it would then balance an equal Weight at A. If therefore the lever ABC were bent in such a manner, as that DC should be twice or 3 times as long as BA, in the former case 1 oz at C i.e. at a distance on DC = 2 or 3 times BA wd balance 2 oz at A; in the latter, 3 oz. The power therefore at A would in the former case lose half its intensity; in the latter, two thirds.—

If 3 Powers, acting in oblique directions be to one another, as the respective sides of a triangle formed by the concourse of 3 lines drawn parallel to the directions of the Powers—those powers will balance each other. For instance, if three powers drawing the point A in the directions AB, AC & AE, be to one another as the sides of a

Triangle ADC or ADE made up by the concourse of the lines AD, AE, & ED or AD, CD, & AC, which lines are parallel to

the directions of the Powers; they will balance each other, & the point A remain unmoved. Let CD be parallel to AE, then CD will represent the force acting in the directions AE: Let BA be continued in the direction AD and let the three sides AC, CD & DA be to one another as 2. 3. 4. If then a line be stretched over BA, over AC & over AE (which is the same thing as CD); and if to the first be hung 4 oz: to the second 2 oz; and to the third 3 oz: Then there will be an equilibrio.— The proportion may, by aid of the last figure, be made clear without the aid of Experiment. See Helshams Lect:

Let there be two stands AB, & DC with a pulley over each of their heads A & D. Let a cord b. D d A a go over the Pulleys. Let 1 oz be suspended at b. another at a; & a third at d: owing to ye

obliquity of the action the 3, a, & b, will not raise but a very little distance, the one on the

Middle, d. — add another wt at b, & a; they will raise d a little higher, for instance to the second Point: increase a, & b, by adding another wt; d will be raised to the third point, a distance from the 2d. less than from the second to the first: continue to increase a, & b; and you continue to raise d; but every time a less distance. The reason is, that the action of a, & b, becomes more & more oblique; and eventually the power will diminish in its force, & in its effect, in proportion to ye obliquity of ye direction in which it acts. —

Part. 2d. — of Friction. — No bodies can be so perfectly polished but that there will be numberless little protuberances and Cavities. When one body passes over another its protuberances sink into the Cavities of that other, & this latter's protuberances are received into its Cavities —

This is the cause of Friction. Were a body perfectly smooth, still there would be some little friction, arising from the principle of cohesion, see Lect. 2d. — Friction is considered as of 2 kinds. 1. When the same parts of the moving are made to touch successively different parts of the body over which it moves: 2. When the moving body continually presents different surfaces to the body on which it moves. — The first kind may be illustrated by the sliding of a Book upon a Table; the second by the rolling of any body, as of a billiard balls for instance along a Plane. — In treating of friction, the four following questions are to be considered. 1. Whether it be affected by the nature of the surface; 2. by the quantity of surface; 3. by the quantity of pressure; 4 by the Velocity.

1. The nature of the surface is a

120 material consideration. Their roughness or smoothness considerably increase or diminish it. In rough surfaces the protuberances are much more prominent & the cavities much more deep, than on smooth ones. Now, upon these protuberances & cavities friction depends. Friction is, therefore, sensibly affected by the surfaces.- Oil fills up the cavities of surfaces. It therefore decreases friction. In wood its effect is greater than on metals. Water has a contrary effect on wood. It increases the friction. We suggest the following reason for this: Water is known to enter into the pores of Wood, and swell it; the protuberances of the wood are thereby enlarged.

2 The generality of Philosophers lay it down that friction is not affected by the quantity of surface. Among others Helsham attempts to demonstrate it. Some late

121 Experiments have led to a contrary Conclusion. The experiments are made upon a very nice machine; and were invariably in favor of the latter opinion. -

3. It has been found that friction is affected by pressure, tho it does increase in proportion to the pressure. The experiments was made upon the same machine we have just now mentioned.

4 Friction is increased by velocity. In sledges the friction is equal to $\frac{1}{3}$ of the weight; in carts to 30; the diameter of ye wheel being 6 feet, that of the axle 4 inches; To estimate the quantity of Friction of any body of the same weight & nature, let the rubbing parts be + into the Velocity.

Friction is less in dissimilar than in similar bodies.- In similar bodies the protuberances & cavities fit more nicely. There is a remarkable circumstance attending friction. It produces heat. But how, Dr Madison confessed he had no Idea

End of the 2d. Part.

122 Part 3d Lect 14 of Electricity

The earliest discovery of this branch of natural Philosophy, which is recorded in the history of the Sciences, was made by Theophrastus a Grecian. Fifteen hund'd years elapsed, and no farther improvem't took Place. In 1600. Dr Gilbert published a treatise, de magnete, in which were several electrical experiments. Theophrastus had observed that amber & the lyncurium has the property of attracting & repulling light substances, but Dr Gilbert discovered that this property was common to many other substances as well as amber. after Gilbert the science made slow & gradual advances. It attracted the attention of Bacon, Boyle, Otto Guericke, Newton and particularly Mr Hawksby. He discovered first the power of glass. after Mr Hawksby

123 the science remained 20 years in a state of quiescence; Sir, I Newton saw Important discoveries about that time engrossing the whole attention of the learned. At length Mr Gray again rescued it from darkness. Since his time many great men have bestowed on it, their attention. Among these, Franklin, deserves the highest rank. This great man was no less conspicuous for his attachment to the rights of man, than for the genius he possessed of investigating natural causes, & observing the phenomena of the physical world. Eripuit cœlo fulmen Sceptrumque Tyrannis.

Definitions & explanations. The name Electricity is derived from a greek word (ηλεκτρον) which signifies amber. It is a certain fluid differing from every other. The word sometimes signifies the effect & sometimes the cause. It resides unnoticed in bodies. The quantity, inherent

in each, is called the natural quantity.
The attraction & Repulsion observed in
electrical experiments are called electrical
appearances. When a body is made to ex-
hibit these appearances, it is said to be
excited. In order to produce this effect,
the body is commonly rubbed. Whatever
rubs is called the rubber. The contrivance
to determine the quantity of electricity pro-
duced is denominated the electrometer.
The first maxim in Electricity, is that
all the bodies in nature are divided into
two classes Electrics & non electrics. —
Some bodies are capable of being made
to exhibit electrical appearances: Some
are not. Those of the former description
are called electrics: Those of the latter,
non electrics. Some bodies are capable of
conducting the electric fluid: others
are not. Hence bodies are divided also
into Conductors & non Conductors. —

conductors are not capable of being excited
Electrics do not conduct. Hence conductors
& non Electrics, Electrics & non conductors,
have been regarded as synonymous terms.
This division however is imperfect. No
body in nature being a perfect electric; none
a perfect conductor. It has been supposed
that every body in nature possesses its share
of electricity. Hence the terms conductor
& non conductor are preferred to electric &
non Electric. — Any contrivance which
may excite an Electric is termed an
electrical machine. Whatever receives
the electricity thus excited, is termed a
prime conductor; which is said to be
insulated when it rests entirely upon
non conductors. — The bodies belonging to
the Classes of conductors & non conductors
follow in the order of their perfection.
Conductors, — Gold, Silver, copper, brass
Iron. Tin. Quicksilver. Lead. Semi-me-
tals, ores, charcoal. animal fluids

all fluids, air & oils excepted. The effluvia of flaming bodies, Ice, Snow. Saline substances, Stony &c. Smoke. The vapours of hot water. The different degrees of perfection of these conductors vary extremely according to their tempe-rature. Wood exhibits a most curious phenomenon. When green it is a conductor; when baked a non-conductor; when reduced to charcoal a conductor, & a non-conductor when reduced to ashes. Electrics. Glass & all Vitrifications. Precious stones. resins. amber. sulphur. Baked wood. Bituminous substances. Wax. Silk. Cotton. all dry animal substances. paper. white sugar & sugar Candy. air. Oils. Calces of metals & Semimetals. The ashes of animal & vege-table substances. all dry substances. All very hard stones. Heat has the effect

of rendering some of these Electrics good conduc-tors. They should be perfectly dry, or they will be troublesome to excite.

Of the different methods of exciting Electrics.

The first & most obvious method of exciting Electrics is by rubbing. The friction disturbs their natural quantity. Many other me-thods have been employed for ye purpose of excitation such as ~~[illegible]~~g, evaporations heating, cooling &c. Electrics will exhi-bit electrical appearances when rubbed. The rubber then is a material point to be considered. It should be a conductor. A Leather is commonly used, which is covered with an amalgam, made of mercury & Zink, or, when Zink cannot be procured, tin. The manner in which the Electric fluid is excited is a subject of curious speculation. As yet it rest upon the uncertain foundation of con-jecture. Dr. Franklin supposes that the electrical fluid is contained in the minute Pores of the electric; that by friction these pores were opened; & that by their closing again they pushed out the Electricity. The points presented by the prime conductor took it off; accumulated it thereon; it being unable to pass off owing to the insulated condition of the prime conductor. — This hypothesis however applies only to the excitation produced by rubbing; & is on that account insufficient. Again it has been supposed that the Electricity lays on the surface of the Electric, in the manner of a fine sand; and that it is by friction collected into one part of ye body, or rather of its surface. This hypothesis is insufficient for two reasons, 1 For the one objected agt. Dr. F.s. 2. If it were true one would imagine that in rubbing an Electric, what was

gained in rubbing it one way, was destroyed, or replaced in its natural situation by rubbing it the other. No Electrical appearances therefore would be exhibited. The contrary of which takes place. — It is certain however, that the electricity is not created by friction; for if the rubber be perfectly insulated none can be collected. Connect the rubber with the general mass, & some is immediately collected: the electricity is therefore, extracted with the general mass. — It appears also that electricity is the effect of matter in motion: we can see it, hear, smell & taste it: it makes holes if any yielding body opposes its ~~body~~ passage: it melts the hardest metals; & fires inflammable bodies.

Of the Electric Spark, & of communicated Electricity. — "The electric fluid may be accumulated on a body & then confined

If the air be very dry, it will be retained for 18 or 20 hours; & was there near it no conducting substance, it would be retained forever. The Spark follows ye shortest course & best conductor; yet it will prefer a long course & a good conductor, to a short one and a bad one. When an Electric is excited, it parts not with all its electricity at once, because it cannot conduct the electricity to the touching point. were there a perfect conductor with electricity, with electricity accumulated on it, the fluid might be all taken off at once: but there is no perfect conductor. Even the best conductors, therefore, do not loose all their electricity at once. If an insulated conductor touch an electrified body, it will exhibit electrical appearances. If for instance a person standing on a cake of wax, or on a stool with glass feet touches the

prime conductor, sparks may be taken from him.

"If you wax some fair life beauty stand
"And touch the sparkling rod with graceful hand:
"Thro her fine limbs, the mimic lightnings dart,
"And flames innocuous eddy round her heart.
"O'er her fair brow the kindling lustres glare
"Blue rays diverging from the bristling hair;
"While some fond youth, the kiss ethereal sips
"And soft fires issue from their meeting lips."

Darwin."

Similar surfaces will acquire equal quantities of electricity; the larger surface more than a small one; the smooth more than the rough. — The electric Spark is always accompanied with a cracking noise; because (we presume) of the resistance it meets with in passing thro' the atmosphere. It takes an angular direction: It is conducted thro' the watery particles in the air, which, not laying regularly, produces that direction.

Sect. 15th Part 1. Of the two Electricities, or of the different manner in which bodies may be Electrified.

Let there be two persons insulated, one whereof communicates with the rubber insulated & the other with the prime Conductor. Both these persons will appear to be electrified. Their electricities however will be very different. One will also be directly the contrary of the other. If any person touches him that communicates with the rubber, electricity will appear to pass from the former to the latter. If he touches the person who communicates with the prime conductor electricity passes from the latter to the former: as if one were overcharged and the other undercharged.

The following is a general law concerning the electrical fluid, viz. That it consists of particles which though attractive of other bodies, are strongly repulsive of

each other. Present an insulated light substance to either the person who communicates with the prime conductor, or to him who communicates with the rubber; it will be at first strongly attracted by both, but will be presently repelled, & after being repelled, will not be attracted again. This experiment proves that when an electrified body communicates its electricity to ~~any~~ other body, both thereby receiving electricity of the same species, they repel each other, & the fact proves the repulsive quality of the electrical fluid.

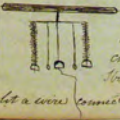
If a wire or a pointed body be presented to the prime conductor, a lucid globule will appear upon the point of the wire. If it be presented to the insulated person, touching ye rubber a lucid pencil of rays will be observed, diverging to the person. This will be more conspicuous in the dark. Julius Caesar in his commentaries, mentions, that a globule of the description just given, settled upon ye point of the soldiers Spears.

These two different electricities are distinguished by the terms positive & negative Electricity.

That which is exhibited on the prime Conductor is termed positive; that exhibited by the person touching the rubber is termed negative. They are also termed the one plus, & the other minus: and because the first is allways exhibited by excited glass, it is called vitreous; & because the latter is produced by excited wax or other resin, it is resinous electricity.. The same bodies may be made to exhibit different electricities by means of different rubbers; & the same rubber may excite in different bodies the same electricity. If two bodies are rubbed together that which is the best electric acquires the positive, the other the negative electricity. If their degree of smoothness be different, the smoother will acquire positive, the rougher negative electricity: or perhaps, a compound of these principles may afford the best general Rule:.

Yet this rule will not allways hold. See Cavallo.

There are two laws respecting electrical attraction & repulsion. The first respects the quality of repulsion in the electric fluid & has been already mentioned. The second, is, that similar electricities repel, and dissimilar, attract. Let two insulated balls be either negatively or positively electrified; they will repel each other. Let one be electrified positively; the other negatively; they will attract each other & afterwards shew no signs of electricity; that which was positive, it seems, discharging itself into the exhausted receptacle of the other.. Let there be a metalic bar suspended to the prime conductor to which are fixed three bells, & two metallic balls: the outer bells suspended by chains; the balls & middle string by silk strings: & let a wire connect the middle bell with



the earth. Let then the machine be put
in motion. The bells will quickly begin to
ring. The reason is this. — The two outer
bells become electrified: they therefore at-
tract the balls: these become also electri-
fied, and are repelled; and in their turn
attract the middle bell; to which they
communicate their surplus of electricity.
The wire carries the surplus off: the balls
are again attracted by the outer bells, again
are repelled; again attract the middle
bell; again communicate to it the sur-
plus of electricity it has acquired; which
is carried off by the wire as before.
Former electricians, observing how differ-
ent substances, such as glass & rosin,
produced different electricities, thought
that there was a real difference in their
natures. The opinion of Dr. Franklin
was that there was but one kind of
electricity: & that the phenomena ex-
hibited by bodies differently electrified
result from an undercharge in the one
case & an overcharge in the other; or

which is the same thing, that a body is posi-
tively when it has more than its natural
quantity, & negatively when it has less. This
theory is ingenious; it is probable; it is worthy
Dr. Franklin & there is but one fact which
opposes it; all other phenomena being favour-
able to it: But this is indeed a stubborn fact.
We can readily conceive, that the repul-
sive quality of the electrical fluid, will ne-
cessarily produce a repulsion between two sub-
stances positively electrified. We can con-
ceive, that (on account of the known prin-
ciple of fluids that they tend to preserve
& endeavour to restore a disturbed equili-
brium) the body electrified positively will
attract the body electrified negatively. —
But why do two negatively charged bodies re-
pel each other? Can the repulsive property
of electricity operate to produce this effect?
One would naturally suppose that as two
bodies with precisely their natural quan-
tity are indifferent to each other; much more
would two with less than their natural
quantity be indifferent to each other. Ca-
vallo attempts to solve this difficulty

Whether his argument be clear or conclu-
sive I shall not undertake to determine
I do not comprehend its force. Dr. M.-
accounts for it in this way. When a body is
negatively electrified, he supposes it to be
surrounded with a corona, or kind of at-
mosphere of its own, that is positively elec-
trified: There is a repulsion between
these positive coronas; whence the two ne-
gative electricities repel. He mentioned
an experiment he had made to confirm
it. He did not himself seem to be satisfi-
ed with the result. But without any
experimental proof either for or against
this Hypothesis, it will not bear investiga-
tion. Grant that the bodies negatively
electrified have their positively electrified
coronas. Grant that these coronas cause
their repulsion. It is just to suppose that
those bodies which are positively electrified
have their negative coronas. Let me
ask then why these negative coronas
repel each other? which is the same

thing as to ask why the negative electricities
repel. The difficulty is therefore yet unsolved.

Part 2. Of Points. — If you present a
point to the prime conductor, the electricity
will by it be drawn off silently and in
small quantities at a time. If you pre-
sent a knob, the electricity will be drawn
off in greater quantities at a time & with
a noise. The former is the more gentle, the
latter the more violent method.

Sect. 16th of Electricity communicated to Electrics

If an insulated conductor be brought near
to an electrified one the following remark-
able phenomena will take place. The
end adjacent to the electrified conductor will
acquire an electricity contrary to, and the end
more remote, the same with that of the conductor.
If, however, the one conductor be brought
within striking distance of the other, it
will immediately receive in every part, the
same electricity as that of the electrified
conductor. If an electric, a glass tube for

instance, be brought near an electrified conductor (say positively) the end next the conductor, will also be electrified positively for an inch or two; it will then for about the same space be electrified negatively; then positively; then negatively again; and so alternately; becoming every time weaker & weaker, till it entirely vanishes. These remarkable phenomena can only be accounted for upon the following general law; that bodies adjacent to an electrified body are apt to acquire an electricity contrary to that of the electrified body. This accordingly has been laid down as a general law.

When one side of a body possesses a positive and the other side a negative electricity, it is said to be charged; when the equilibrium is restored it is said to be discharged. – If one side of an electric be presented to an electrified body, that side will immediately receive the kind of electricity it contains, while the opposite side, if it communicate with conductors loses an equal quantity & becomes differently electrified.

(In order to prove this let two electrometers be fixed one on the side communicating with the general mass. the other ought presented to the prime conductor. Let the electric be charged. Both electrometers will appear affected by the electricity. present a stick of sealing wax excited to the electrometers: one will be repelled by it, the other attracted. the electricity of the sealing wax is negative: now negative electricity repels negative & attracts positive: one side of the charged electric, therefore, is negatively, the other positively electrified.) – Moreover if the electric be insulated so that one side cannot lose its electricity as the other acquires it, it cannot be charged. The electric most generally used is glass. Owing to its unconducting nature the electricity can with difficulty be diffused over it. It is therefore coated, when to be used, with some conducting substance, tin foil for instance. This coating should not be placed too near the edges of the glass; or the electricity may discharge itself. A repulsive power is certainly exerted thro' the glass;

which therefore should be thin. If it be very thick, it cannot be charged at all. To what degree of thickness the repulsive power may act, has not yet been determined. When the electricity rushes to restore the equilibrium, it meets with some resistance which occasions the explosion or spark. If this spark pass thro' the human body, it causes a disagreeable sensation which is called a shock. When an electric is charged, it cannot be discharged, unless some communication be formed between its positive & negative sides. If the glass is very thin, it may be broken by the strong attraction of the two different electricities which affects its sides. The power of giving the shock, it is observed resides only in the glass, not in its coating. (Let a piece of glass with loose coating be charged; let then the coating be thrown off: they must then certainly lose all the electrical power they possessed: let them be again put on the glass: the glass it will be found is capable of giving the shock.)

The Leyden phial is only a bottle coated inside and out, in order to be charged: it is the same thing as a coated pane of glass

in a different shape. As one side of the coating collects electricity & becomes positively electrified; the other loses just as much & becomes negatively electrified. The coating should not be too near the mouth, for the same reason as it should not be too near the edges of a pane of glass. The reason why a heated electric cannot be charged is that it is a conductor: the electricity is continually conducted to the edges where it restores the equilibrium. A phial may be charged in various ways, as the following problems will show. But we will premise that the electrometer will show when the ~~electrometer~~ bottle is charged; for it will immediately rise.

Problem 1. To charge a bottle by its own electricity. Let the rubber be insulated. Let the bottle be suspended by a wire which communicates with the inside. Let a wire be tied around the outside, and be made to communicate with the insulated rubber. In this case the rubber can extract no electricity from the general mass. When the machine is put in motion the inside becomes positively electrified. The electricity leaves the outside of the bottle, passes thro' the wire to the rubber, from thence is accumulated on the prime conductor, whence it is collected in ye bottle.

Prob. 2. To charge a phial positively inside, and negatively outside. Present the wire communicating with the inside to the prime conductor. The inside becomes positively electrified & expels the electricity from the outside provided that the outside be connected with ye general mass. This is the most usual way of charging a bottle.

Prob. 3. To charge a bottle positively outside & negatively inside. Place the outside coating on the prime conductor. The wire communicating with the inside must be connected with the general mass by some conducting substance, the human body for instance. The outside becomes positively electrified & expels the electricity from the inside.

Prob. 4. To charge air. Suspend a plate by the prime conductor, place under it another insulated: the intermediate air will be electrified. The current which the electric fluid takes in order to restore the equilibrium, is always thro' the best conductors, and the shortest route; but it will prefer a long good

conductor, to a short bad one, as we have already observed. The velocity of its passage is inconceivable. It has been found to pass thro' many miles in an imperceptible space of time. But the force of the shock is diminished by the length it goes. The force of the shock depends upon the quantity of electricity, the conductor, and the point from which it flies off. The greatest force of electricity is exhibited by a battery. This is so constructed as to unite the power of many jars. In this manner a shock may be given which is made up of the combined force of the whole. There is a battery in the apparatus of [illegible], which can give a shock sufficiently strong to kill a turkey.

Sect. 17th Of the effects of Electricity upon plants & vegetables; of medical, animal, magnetic, & atmospherical Electricity

Part. 1. Of the effect of electricity upon vegetables. Some have supposed that a vegetable kept in a state of positive electricity has its growth quickened thereby; and that to keep it in a state of negative electricity produced the contrary effect, of retarding its growth. It has been thought by some that a spark produced the former effect. On the other hand it has been thought to destroy the vegetable entirely. But it is now very generally supposed to have little or no effect at all either one way or the other. A violent shock certainly destroys both animal & vegetable life.

Part. II. – Of medical electricity. – In the early stages of this science it was regarded as a panacea, or cure-all. The general application of it to every disease, the imaginary cures attributed to it; the real mischief it produced by being used either in improper cases, or in improper manner and the remarkable inconstancy of its effects; after a while brought the practice of medical electricity into ridicule & disrepute. Some physicians afterwards, by a judicious use of it, retrieved its character. Cavallo contains many observations upon this subject, with many cases of its use and beneficial effects. The disorders in which it has been found useful are the following. Viz. – Rheumatic disorders; (draw off the electricity by a wooden point thro' flannel). – Deafness; (draw off the electricity from the ear by a wooden point).

Toothache: (the manner of application the same). – Swellings containing no matter; (same application). Inflammations of all sorts, of the eyes &c. (in inflammations of the eye the operation should be as gentle as possible in order to avoid irritation; a metal instead of a wooden point, should be avoided). – The gutta serena; (use first a wooden point, and then a series of gentle shocks). – The fistula lacrymalis; (use a wooden point). – Palsies; (use a wooden point, or draw sparks thro flannel from the parts affected). – Ulcers, cutaneous eruptions, schrophulous humours, cancers; (use the wooden point). Abscesses; (the electricity to be sent thro the parts affected by means of two directors). – Dropsy; (the same mode of application). – Pulmonary inflammation (gentle shocks). – Nervous head ache, and the gout; (use the wooden point). Agues; draw sparks thro flannel). – Some other diseases are mentioned in which electricity is beneficial. It must carefully be avoided in cases of pregnancy. – There are many methods of applying electricity. Formerly large shocks were used. Now when shocks are used at all, they are very moderate. There is a method of giving small regular periodical shocks. The mode of drawing off. 8

throwing on electricity by means of points, is now used. The Patient is fixed upon an insulated stool and connected by a conductor with the prime Conductor. Electricity is thus accumulated on him, without the possibility of escaping; apply then a point to the part affected, which will draw off the electricity, & produce a sensation like that of a very gentle wind blowing on the part. Either it may be drawn off or thrown on. To throw it on, let a wire be fixed to a prime conductor, let the other end be wrapped round a glass tube; let a person holding the tube apply the point of the wire to the Patient standing conveniently, and the electricity may be thus thrown on. There are grades in the violence of the application of electricity, which may be resorted to, as occasion requires. The electricity may be drawn off or thrown on by a metal point which is the gentlest mode; or by a wooden point, whose operation is not so gentle; or by taking sparks; or by giving moderate shocks; & by increasing them as occasion requires.—

Part, III.— Of Animal Electricity. It has been found that some animals are capable of giving a sensation similar to the electrical

shock. This property is called animal electricity. The Torpedo, the Gymnotus electricus, & the Silurus electricus are found to possess it. It is remarkable that the fish cannot affect any body which is a non-conductor of electricity. As soon as a Conductor is brought near it, it approaches and gives a shock. The shock is greater if both sides of the fish be touched at once.— The ancients thought that this shock was beneficial to patients in some diseases. Why the animal was endowed with this power, we know not; only for the purpose of securing its prey.

Part. IV. Of Magnetic Electricity.— It has been found that the ordinary effects of electricity do not interfere with magnetism; for a magnet placed upon a prime conductor will continue to play freely: a strong shock, however, will invert the poles of the needle, or render a common needle magnetic. The end in which the shock enters turns to north always. Dr. Watson thinks that this effect of a shock arises from the blow it gives the metal, not from the power of the electricity. The explanation of these phenomena hereafter to be mentioned requires that this idea should be given up.

Part, V.— Of Atmospherical Electricity..

The most important discoveries in electricity are to be mentioned under this head. It had been long believed, that the Electricity & Lightning were the same; but it never was positively ascertained 'till Dr Franklin undertook to prove the fact. – The following analogies led to the conjecture of their identity. Viz – Lightning is conducted by the same substances as Electricity: it strikes at the best & nearest conductors; so doth electricity: it hath a sulphureous smell; so hath electricity: it fires certain substances, so doth electricity: it melts metals; so doth electricity: it reverses the magnets; so doth electricity: it destroys animal & vegetable life; so doth electricity: their colours are similar; and all the phenomena of the one, may be represented in miniature by the other. These facts led to the almost certain conjecture of their identity; but Dr F. wd be contented, only with absolute certainty. He published his opinion, and the mode he intended to adopt to prove it. The French Philosophers, with their usual diligence in the pursuit of truth, a month before Dr F. brought down the lightning from the Clouds by means of

the electrical kite. Experiments have actually been made both by Dr F. and them, with the lightning thus procured; which proved it the same with electricity. – The kite is of simple formation. – The sparks got by the French philosophers were remarkably large. They might be heard a hundred yards: sometimes they exploded like thunder. Dr Richmann was struck dead by a spark he received from his kite by some imprudence in his management.

The clouds are generally electrified either positively or negatively: how they become so, is a question of which as yet there is no rational solution. Thunder is supposed to be the effect of electricity, rushing to restore the equilibrium, from a positive to a negative Cloud; sometimes it strikes from the Cloud to the Earth sometimes from the earth to the Cloud. Clouds are by some supposed to be more frequently electrified negatively than positively. This idea however is controverted.

Houses may be protected from Lightning by means of a conductor, rising above them. They should be pointed, so as to draw off the electricity in small quantities, & thus to disarm the Cloud of its fury. The point should be plated because Silver is a better conductor than

152 sion, of which conductors are generally made. The conductor should descend along the side of the building, run into the ground, in a direction receding from the foundation. —

The aurora Borealis seems to be the effects of electricity flashing thro' a rarefied medium. Many causes have been mentioned by Electricians which induce a belief that it is an Electrical phenomenon; among others, it affects the magnet; mostly not because it gives a blow to the metal. Those meteors which appear in the Heavens are supposed to be electrical Phenominas. Water Spouts, earthquakes &c &c. have been explained in the same way. But Philosophers are going too far in this way.

The science of electricity is yet in its Childhood. Ye youthful Philosophers, who burn with the Love of truth, & who are enamoured with the beauties of nature! here is a noble field for you.

End of the 3^d Part

153 Lecture 18^th. Part 4^th. Of Pneumatics

That branch of Natural Philosophy which treats of the nature and properties of air is called pneumatics. The air is that thin transparent substance which surrounds our globe; and which together with the cloudy vapours, & other substances it holds in suspension, is denominated the atmosphere. When we know that without it, our existence could not be continued; that in it, we live, move & have our being; — the air is an object ~~really~~ truly interesting to us, and a subject which from its importance has a strong claim to the attention of Philosophy.

The properties of air are 1 Fluidity; 2. Gravity 3 Elasticity. That air is a fluid is evident from the facility with which it admits the motion of bodies thro' it; from the easy motion of its particles among each other from its yielding to the slightest pressure; which circumstances make the definition of a fluid. But it differs from any other fluid in the four following respects: 1^st it is compressible and the compression is equal to the compressing force 2^d it is incongealable: 3^d It is of different densities at different distances from the surface of y^e Earth

4th. It is elastic. Air exists in all bodies in some one degree or other. It has been usually numbered among the elements. But our atmosphere is far from being such. It not only is composed of different species of air, but holds in suspension many different substances. Atmosphere air purged of these extraneous substances is what is called elementary air. Air is found in all bodies in a state of fixity: in some a greater quantity is contained than in others. This lecture will be confined to the weight of air, & to a few observations respecting Barometers. —

Part I. Of the weight of the air. Immerse a tube hermetically sealed at one end into water; the water will rise but very little way into the tube; the compressibility of the air enables it to rise a little way; but the air cannot escape, nor can the water be made to exclude it from its place. This is one among innumerable ~~instances~~ experiments which prove that air is a body. But as a body, it may be naturally supposed to possess gravity or weight, and that it really does has been sufficiently demonstrated: it has been actually weighed. There is a

contrivance by means of which the air may be exhausted out of a bottle: weigh the bottle thus exhausted: then let in the air again, it will be found to weigh more: a quart of air weighs nearly 16 grs: but this weight is different according to the different state of the atmosphere. — A quart of water weighs 14621 grains: divide 14621 by 16: the quotient is 914. The weight of water therefore is to that of air as 914 to 1. The weight of the air is abundantly clear from the Torricellian experiment. Immerse a tube exhausted of air, into a cup containing mercury; the mercury will immediately rise to about 29½ inches in the tube. Formerly it was supposed to have done so because "Nature abhorred a Vacuum" But this abhorrence of nature for a vacuum would carry it no higher than 29 inches in general, and at most not higher than 31. Why then does the mercury rise? — The pressure of the air upon the mercury in the cup occasions that rise; so if the air, (external) be taken off the mercury in the cup, it will immediately descend from the tube. The 29½ inches of mercury, therefore, suspended in the tube by the pressure of the air upon the mercury in the cup, must be equal to a column of air, of the same diameter with y^e mercury in the tube, & equal in height to that of the whole atmosphere. Now mercury is 14 times as heavy as water. A column of water, therefore, of 32 feet will be supported by the pressure of the atmosphere. A column of air, then, extending to the height of the atmosphere is equal to a column (of the same diameter) of water 32 feet high: but water is 914 times as heavy as air: 914 × 33 = 5 miles the height of the atmosphere supposing it to be of an uniform density. – A column of mercury 29½ inches high = 15 lb. – This weight the pressure of the air supports. – This pressure then is equal to 15 lb upon every square inch. – A man of middle size contains, it is calculated, 14 square feet = $^{\text{Inches}}$ 144. The pressure of the atmosphere he sustains = 30 240 lbs: which would be an insupportable weight were it not counteracted by the internal air.

Part 2. Of the barometer. – A barometer is a machine to measure the weight of the air. It is nothing more than the Torricellian experiment. A column of mercury

suspended in a tube exhausted of air, by the pressure of the external air. This pressure is not the same in different states of the atmosphere. It is sometimes greater & sometimes less. It sometimes forces the mercury to the height of 31 inches, and the mercury sometimes falls as low as 27. – The space between the lowest point to which the mercury falls, & the highest to which it rises is called the range of the barometer. In America, it is between 31 & 28: In Europe, between 31 & 27: in the mean height is 29½ inches. By the help of the Barometer we may foretell changes in the weather, rain &c. it rains if the atmosphere is very light; which the Barometer notifies. When the atmosphere is dry & heavy it expands the lungs, & makes the body feel light: when the air is light, the contrary ensues. Hence we are apt to suppose the air is heavy when it is light, & light when it is heavy. There are different Barometers. see Rowning. The simplest is the best. For a description of the air Pump see Ferguson.

Sect: 19th Of the Elasticity of the air

This property of the air has been already mentioned, as one of those which distinguished

from every other fluid. The elasticity of the air is that property by which it contracts itself into a smaller space, when an additional pressure is laid upon it; recovers its former dimensions when that additional pressure is taken off; expands into a much larger space when the original pressure is diminished; & were that pressure entirely removed, would expand, (for what Philosophers yet know) ad infinitum. —
To prove that the air does possess this quality is extremely easy: to account for it is extremely difficult.

1. To prove the elasticity of the air. — Take a bladder with very little air in it; put it under a receiver: which exhaust. the small quantity of air in the bladder will expand & distend the sides of the bladder. it will be observed to do this as the operation of exhausting is going on: the pressure of the air in the receiver is less & less at every action of the pump: at every such action the bladder will be seen to puff out

more & more: which demonstrates that the air possesses an elasticity which answers exactly to the definition given of that property in the preceding page. See Ferguson.

2. To account for the elasticity of the air, some have supposed that the particles of air were in the shape of small branches or twigs of trees, which being pressed together, contract, & which when the pressure is removed resume their former shape: some have thought of these particles resemble locks of wool; & others that they resemble the springs of watches: thence they infer the elasticity of those particles; & thence account for it. —
The great Sir, I. Newton thought this hypothesis insufficient to account for the elasticity which seems so boundless. He supposes the particles of the air to be endued with an infinitely repulsive property, which operates with a force inversely as their distances from each other. All these accounts, however are mere Hypotheses; and as such we may give them what credit we please. It will be more useful to determine the laws which air observes in exerting its elastic force.

1. The Elasticity of the air is inversely as

the space it occupies, or directly as its density. The density is proportionate to the compressing force. Hence the air becomes less & less dense as it recedes from the earth; the inferior parts of the atmosphere having the weight of the superior parts upon them. Were the atmosphere of an uniform density, its height it is computed would be 5 miles. According to Dr. Coles, if the altitudes be taken in an arithmetical proportion, the rarity of the air will be in geometrical proportion. By this rule the atmosphere is computed to be from 45 to 50 miles high.

2. The elasticity of the air produces the same effects as its pressure, & is equivalent thereto. Let a tube be immersed in a phial half full of mercury; let the mouth of the phial be made air tight, so that no air can get in or out; let the tube be open as well at the upper end, as at the lower; let the whole be put under a tall receiver & the pressure of the air be taken out by exhaustion; the elasticity of the air in the Phial will drive the mercury as high

in the tube as it stands in the Barometer. "For action being equal to reaction the force "which the spring of the air exerts in endea"vouring to expand itself, is equal to the force "with which it is compressed; just as it is "in the spring of a watch, which exerts no "force but in proportion as it is wound "up; consequently, a quantity of air in such "a state of contraction, as it wd. be compress"ed into by the weight of the incumbent "atmosphere exerts a force equal to that "weight." — 3. The Elasticity of the air is augmented by heat & diminished by cold. Let a tube be immersed in a phial half full of water; the mouth of the Phial be air tight; apply your hands to the sides of the Phial; their warmth will so increase the elasticity of the air in the Phial as to drive the water considerably higher in the tube; take away your hands; the air will gradually become cooler & cooler, & its elasticity less & less; for the water will gradually subside.

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* In Lecture 18th. I omitted to make any

observations upon the difference in the pres-
sure of the atmosphere at different times.
This is indeed remarkable. It is not easy
to tell whence that difference arises. For
altho the atmosphere may expand into a
greater bulk, the quantity of particles it
contains, cannot thereby be increased. Some
have supposed that the watery particles,
suspended in the atmosphere, were not so
many at one time as at another; & that
this difference with respect to them, occa-
sioned that in its weight. But this hy-
pothesis is contrary to known facts. When
it rains; when the atmosphere contains
the greatest quantity of watery particles, the
barometer stands lowest; the air is lightest.
Dr. Halley attributes the difference in the
pressure of the atmosphere, to the effects of
the wind. The wind blows the atmosphere
from one part of the earth to another, & thus
makes the quantity of air greater over
one place than over another; & its pressure
differs accordingly. If two winds blow in op-
position to each other, at the point where they
meet the atmosphere will be heavy: if two

winds blow from a particular place, there
the atmosphere will be light. Some circum-
stances respecting particular countries are
mentioned to confirm the hypothesis. — I
have heard it suggested, that, as we know
that the gravity of bodies diminishes as they
recede from the earth; as air is a body; as
rarefaction increases the bulk of the atmos-
phere & makes it ascend higher; that increase
of height renders the superior parts of the
atmosphere lighter, than when they were
nearer the earth. Hence the difference in
the atmosphere's pressure at different times,
& temperatures.

Lecture 26th In three Parts

Part 1st of Air necessary to Combustion. — Put
a lighted candle under a receiver which is so fixed
to the plate of the air pump that no external air
can get into it. The candle will burn a short
time and then go out: this proves that combustion
cannot be supported, without a free circulation
of air. But if combustion be thus destroyed
by confined air, we should be induced to sup-
pose, that if the air in the receiver were to
be rarefied the candle will go out much

ceiver; which accordingly is the case. If the air be entirely exhausted out of the receiver, the candle will not burn a moment. Combustion then will be supported but a short time in confined air; a still shorter time in rarefied air; and not at all in vacuo. The most inflammable bodies will not flame in a vacuum. By a contrivance, Dr Madison put a piece of red hot iron under the receiver; exhausted the air out of it; and then dropt gunpowder upon the iron: the powder did not flame but melted.— If air be necessary to combustion, it is presumable that a condensation is favourable to it; which is said to be the case. The greater the quantity of air, the greater must be that of the principle it contains by which combustion is supported; and the smaller the space into which that principle is contracted, the more convenient must it be to feed the flame. It is said that combustion actually diminishes the quantity of air. It can do this in no other way, than by consuming the principle in the air by which it aids combustion. To prove that it does diminish the quantity of air the following experiment has been made.

Take a large glass receptacle, with a hollow globe at one end, gradually diminishing into a long neck; plunge the neck into a bowl of water & observe how far the water rises in the neck; then take the receptacle out of the water & introduce a candle into the neck of it, put it again into the water; while the candle is burning, the water will be seen to rise gradually; the candle will at length go out, & the air in the receptacle will then be no longer fit for combustion; observe then the water; it will have risen considerably higher, than it stood before the candle was introduced: whence is inferred, that it consumes a part of the air. To my mind the experiment is not satisfactory, as it was made in the lecture room; for as soon as the candle was introduced, the air in the receptacle was expanded: after the neck was plunged into the water, I saw bubbles of air rising out of it; so that I am inclined to think that the quantity of air was not diminished by the combustion of the candle nor was a part of it consumed: but the expansion occasioned by the heat of the candle caused a part of the air to escape: clear hence the bubbles which were seen.— But whether Combustion does or does not consume a

Part of the air which feeds it, one thing is certain, that it disqualifies the air for the purposes of further combustion, & of respiration. It may be pleasing to Philosophers who have nothing else to engage their attention to enquire how it does this, but those whose occupations are different must be contented to know ye fact.

Part 2. Of air necessary to animal respiration. That air is necessary to respiration we shall not attempt to prove; for every person must be sensible of the fact. To deprive an animal of air to breathe on, is to deprive him of life. The body of an animal inhales, as well as expires air. Different animals are somewhat remarkable in this respect. In those who have two ventricles in the heart, it is remarkable, that they live a shorter time than those who have only one, without air; young animals longer than old ones &c. Aquatic animals live longer than amphibious, & amphibious longer than terrestial, without air. It is calculated that a man requires a gallon of air in a minute. as confined air extinguishes the candle that is put under a receiver; so it is fatal to

the lamp of life. A dreadful experiment wh. corroborates this opinion, has already been made at Calcutta in the east indies. But there are other processes by which air is contaminated besides combustion & respiration, such as fermentations, putrefaction, &c.

Many conjectures have been made concerning the manner in which air performs the important office of supporting animal life. The ancients thought it acted as a certain Pabulum Vita. The idea was natural. Some have supposed it produced its beneficial effects, by carrying off the Phlogiston of the blood: but the doctrine of Phlogiston has been entirely exploded: but more of this hereafter. Modern chemists have produced a more rational theory. Atmospheric air is composed of two kinds of air oxygene or pure air, & nitrogene or phlogisticated air. In the act of respiration the oxygene is absorbed. What remains is incapable of supporting farther respiration. The same thing takes place in the case of combustion. To absorb the oxygene is to vitiate ye air. Hence it is clear that air is in a state fittest for respiration when it contains most of the oxygene. — It may be asked why has not the whole atmosphere been contaminated by the continual process of respiration combustion &c &c. Nature is wise. She hath provided against this evil. The winds drive the atmosphere with violence against the ocean. Thus it is cleansed of its impurities. The rains descending literally wash the air. But above all, there is a wonderful reciprocity between the animal & vegetable kingdoms. Animals inspire pure air; expire impure air: vegetables inhale impure air, & expire pure air: thus are they serviceable to each other. The air in subterraneous places is apt to be impure owing to its being confined: In marshes where there cannot be a free circulation, the circumambient air is vitiated by the putrefaction of vegetables. We shall conclude this part of the Lecture with some observations upon damps. These are of two kinds, the Choke damps, & the fire damps. Choke damps are composed of air which has lost its vivifying spirit. They deaden flame & destroy life. Fire damps are composed of [illegible] Sulphurous particles, or Nitrous

oleaginous Particles. They take fire and explode like gun powder. Damps are frequently fatal to those unhappy wretches who work in Mines.

Part 3 Of air necessary to Vegetation

Plants inhale and exhale air. To do this they are provided with what are called their trachea, which are placed along their surface, but more especially in their leaves. I have already mentioned that they inhale impure air; yet there are some kinds of noxious air which is fatal to them. As Nature has done every thing for the best, I should suppose that either confined air or rarified air is detrimental to vegetation. This is said to be really the case.

Lect. 21[st] Of Calorie & Heat

In Lecture 8[?] the nature and laws of affinity were mentioned & explained. That Principle if suffered to operate without any other principle to counteract its effects, would tend to consolidate every substance in the material creation. Fire is the agent employed by the author of the creation to counteract that principle. This fire is an extremely subtle, insinuating fluid. It enters more or less into the composition of all bodies; and by that means, produces all that variety of consistence in which they are exhibited to our consideration. Fire is also one of the principal agents the chemists employ in every process of decomposition & in every enquiry by analysis. These considerations evince the importance of becoming acquainted with an agent so useful, so powerful & so universal; an agent the instrument of his wisdom, who rules the universe; an agent which enables man, his creature to examine more minutely his works, to adore his wisdom and to praise the majesty of his Power.

*In fire there are two things to be considered; heat & light: of light we shall speak when we come to that part of the course which treats of optics: heat is the subject of the present Lecture.- The word heat is used here because it is generally understood; but its signification is not so definite as the accuracy of

Philosophy requires: it is sometimes employed to express the sensation which fire produces upon the human body: sometimes it is used to express the cause by which that sensation is produced. To remedy this inconvenience, a new word caloric has been introduced; a term which expresses the cause of Heat.- We have said that caloric enters more or less into all bodies. There are many methods of disengaging it from them. Before we mention them, it may be remarked, that bodies possessing caloric, part with it more or less readily.- If a body be heated and put into a cooler medium, it acquires the temperature of that medium: if a cool body be put into a warm medium, it acquires in like manner the same temperature ~~like medium~~. But this temperature is acquired by some bodies sooner by others: whence it is inferred that some possess a greater affinity for caloric than others.

The most obvious instance of a body parting with caloric is this: when a heated body is cooling in the air, the air surrounding it will exhibit an undulatory motion resembling the appearance made by the smoke of

* Fire is such an accumulation of caloric as to generate ignition: it is the active state of Caloric.

two liquids (of water & brandy for example) of unequal densities: This ondulatory motion clearly results from the passage of some substance from the heated body to the air. — We will now mention the methods of disengaging caloric from bodies in which it is fixed. — I. The method of affinities. — If two bodies containing their natural quantity of caloric be mixed together; if they have for each other a stronger attraction, than they have for caloric, they will combine; supplant each others caloric with a mutual operation; the caloric will be disengaged; heat will be produced. While the caloric is disengaging, the volume of the mixing bodies will not increase in proportion to their respective bulks; which proves they actually usurp the place of the caloric they displace — I shall subjoin a few instances of disengagement effected by this method. 1st Mix Water with vitriolic acid: they have for each other a stronger attraction than for caloric: it is therefore disengaged. 2d Mix water with quicklime, nitrous acid, iron, or certain mineral substances; and Caloric is disengaged. 3d Mix 2 parts of Spirit of nitre 1. of Oil of

Vitriol. 3 of oil of Turpentine; they will burst into flame. — II. The method of Friction: & Rumford on: The heat produced by the working of large machines. that the first of these disengages caloric: that produced by hammering iron, is an instance, the second does the same thing. Chaptal thinks that much of the Heat produced by these operations, arises from the caloric extracted from the surrounding air. Rumford in order to examine the truth of this remark, made the following experiment. A Vast heat is produced in the boring of a Cannon: Rumford caused that operation to be performed under water: the same heat was produced, that had been when the operation in the open air: hence he inferred that no caloric was extracted by friction from the air on which it operates. We may ask yet whether it was not extracted from the surrounding water? * — III. Method. "Fermentation and in general every operation "which changes the nature of bodies, may disengage caloric, because the new compound "may demand and receive a greater quantity of it." When compounds absorb caloric, cold is produced in the surrounding bodies, whence it is extracted for absorption: when they give it

* See the end of this Lecture

out heat is produced in the surrounding bodies, to which it hastens, if I may so say for an asylum. — The capacity of bodies for containing caloric may be easily illustrated. I They contain it in their intestices. Let a number of small balls (shot, for example) be put in a bottle; pour water upon them; the water will occupy the vacant spaces between the balls. Let those balls represent the particles of a body; let the vacancies between the balls, represent the intestices, between the particles, and let the water represent the caloric. — But if these balls be reduced to any other than a Spherical Shape (that of slugs, for example) the vacancies between them will be less; they will contain less water, the more compact; and in the same manner if the particles of body be of a shape, which enables them to come closer together, they will contain less caloric and be harder. Fluids have a greater capacity of containing Caloric than solids: hence the particles of the former are usually supposed to be round; those of

the other flat. — II. Immerse different woods in water: some will absorb more than others: the softer more than the harder: so caloric finds greater room in some bodies, than others; in the softer than in the harder. I presume: the only difference is, that water is incompressible except in a very small degree, whereas caloric is very elastic. —— We may contemplate caloric in three different views; Specific Caloric, free caloric, & combined Caloric. It is necessary that we comprehend clearly the ideas attached to each. 1. By Specific caloric, we understand the different degrees of caloric, requisite to bring several different bodies to the same temperature. This difference evidently depends upon the different capacities of bodies to receive caloric. 2. By free caloric, I understand that state in which it exists independant of other substances. Its powerful and universal tendency to unite with every other body renders it nearly impossible to obtain it to retain it in a state of freedom. 3. By combined caloric, I understand that state in which it exists after it has insinuated itself into other bodies, and become suspended, fixed, and incorporated in them. —

Free caloric allways endeavours to preserve an equilibrium; owing to its affinity to all other substances, & to their capacity to receive it. — With the aid of this principle, many Phenomena are explicable; among others the sensation of heat. We may observe in general that no sensation can be produced without motion, it being remarkable that it is, impossible to conceive how matter can operate upon matter, without the interposition of material Particles. Heat is the effect of caloric passing thro' us or over us: Cold of the passage of Caloric from us. Thus when a person lays his hand upon a heated body. Caloric passes to restore the equilibrium from it to his hand; and a sensation of warmth is experienced: when he lays his hand upon a cold body, caloric for the same reason passes from his hand to the body; and a sensation of cold is experienced; when he lays his hand on a body of the same temperature with it, caloric neither passes from, or to it; no equilibrium being to be restored; and

no sensation is experienced. — some bodies have a greater capacity of receiving Caloric than others or rather of conducting it; and it may be remarked, in general, that the conductors of electricity, are also conductors of Caloric, and vice versâ. Water however is one exception to this rule: It is a conductor of electricity: Ct. Rumford, it is said has demonstrated, that it is a perfect non-conductor of heat; — that, altho heat is produced in a very considerable volume of water, by the application of fire to one part of it yet the water does not conduct the caloric in the manner that a metal does; but that the caloric is lodged upon the particles of the fluid, floats upon them, is wafted upon them to remoter parts of the mass of water to be heated. — Air is a non-conductor of electricity (See Sect 14.) so also it is of caloric: The best way therefore to keep a body warm would be to surround it with air, for then the quantity of Caloric, which the body naturally possesses, could not escape. The reason why some clothes are cooler, than others, arises from their capacity of more readily conducting Caloric. Thus Woolens are themselves, non-conducting substances, and besides contain a large quantity of air hence their warmth. — Some bodies give less resistance to caloric than others. It readily penetrates metals: they transmit it with equal facility: Wood & animal substances receive it to a degree of combustion; liquids till they become vapour. — The temperature of vegetables, fossils and dead substances is the same with that of the atmosphere which surrounds them: that of insects is a very little above that of the atmosphere: that of fish the same as that of the water they swim in; except that of the cetaceous kind, or of whales, which have the same temperature as a man. — Man can live in all Climates, from the torrid to the frigid zone. I have seen it somewhere remarked, that the hog resembles more nearly our species, in this* as well as most other respects, than any other animals whatever. — The most general effect of caloric is that of the dilation of metals, or of any other substances, into which it enters. It enters into the interstices of water & expands its particles. When it departs, those particles

* This is a libel ~~upon~~ upon our species. This libel is not mine: Instructor made it.

come together again; the bulk of the body they constitute is contracted. There is hardly an exception to this law in nature. Among ye fluids I know of none: Air, mercury, oil of turpentine, water expand more or less, in longer or shorter times, according to the order mentioned. The greatest state of expansion of wh. liquids are susceptible, is when they are boiling. They receive heat, till they are converted into vapour. The denser a body is, the more may it be expanded. As to the time in which different substances are made to undergo their greatest expansion, I know of no rule by which we can be governed. If we say, that the denser they are the sooner they reach this state, there are certain facts which stare us in the face: water is more dense than spirit of Wine, yet water acquires this state later than spirit of wine. If we say, that the less dense a substance is the sooner they acquire this state (viz. that of greatest expansion) that stubborn thing fact still makes against us: mercury is more dense than water yet it acquires this state sooner than water: and water is more dense than linseed oil yet it acquires

this State sooner than linseed oil. - The great-
est expansion generated by heat we know of
is when glass or diamond is made thereby to
assume an uniform state. - Some Chemists
lay it down as a general law, that all bodies
are dilated by Caloric: they contend there
is not an exception in nature. Lavoisier
contends that exceptions, usually remarked
are apparent and delusive. It is certain that
when water becomes ice, its bulk is consi-
derably increased. it is no less certain that
in passing from water to ice it emits caloric:
Why then does its bulk increase? He would
answer, that the bubbles of air formed in the
ice, increase its bulk more than the loss of
Caloric diminishes it. The bulk of the ice
is decreased when it becomes water, yet it
in becoming so absorbs Caloric: why does it
decrease? The Caloric it absorbs does not
increase its bulk, as much as the air it
emits diminishes it. The increase in the
bulk of water from freezing, and the dimi-
nution of ice thawing, cases, in the one of
which heat is ~~diminished~~ emitted, in the

other absorbed; do not, we may conclude mili-
tate against the general law that caloric dilates
bodies. - Iron after having been heated, expands
while it is cooling. - Pure clay contracts upon
the presence of caloric. These facts perhaps may
be reconciled to the general law above men-
tioned, by supposing that something is allways
expelled from these bodies by caloric: and that
that expulsion diminishes their bulk more than
the absorption of caloric augments them. -
Water increases from the temperature of freez-
ing to that of boiling, 1/5 part of its volume. -
Mercury increases 1/6. -
It is this free caloric, of which we have been speak-
ing, which affects our senses, and the Thermometer,
and hence it has been called manifested, and
Thermometrical heat. For the admeasurement
of Caloric, certain instruments have been
contrived, called Thermometers & Pyrome-
ters: Thermometers are instruments to measure
heat. Pyrometers to measure Fire. - Ther-
mometers are founded upon the expansion &
contraction of bodies by the accumulation and
absence of caloric. It was invented by Dreb-
bel, & first used by Sanctorius. - It

182 was first formed of water & air; & was the
the apparatus mentioned. Sol. of — Spirit
of wine was next employed in the place of
mercury in the Thermometer now in common
use, which is much the best kind. It was pro-
posed by Dr Halley. To construct it, a
glass tube is prepared with a bulb at ye end
the bulb is then exposed to the vast heat of a
blowpipe. By this means all the air is ex-
pelled from the tube out at its open end
plunge the vacant tube into mercury & the
mercury will rise into the bulb & the tube to
the quantity you want. expose the open end
of the tube to a blowpipe, & hermetically
seal it. plunge the whole into a freezing mix-
ture and mark the point to which it subsides
for the freezing point: plunge it into a boiling
mixture & mark the point to which it rises for
the boiling point. Then divide the intermediate
space into any number of degrees you wish.
* The thermometers now in common use are
* Farenheit, Reamurs, & Celsius's. In
Farenheits scale the number of degrees
* between the freezing & boiling points is 180.

183 * The freezing point being at 32°.* and the boiling
at 212°. both the numbers are above 0. or the
point from which the degrees are numbered [illegible]
-ways. In Reamurs scale the n[illegible]
degrees between these two p[illegible]
the freezing point is at [illegible]
Thermometer. the [illegible]
100 and the [illegible]
Mercu[illegible]
you[illegible]

* [illegible] point 32 33° was that the greatest degree of cold known [illegible] Hot Point

"freezing point according to the case". Fluids
"are generally used, because they dilate more
readily than solids. Quicksilver (or mercury)
...ferred to other fluids, 1. from its sen-
...ty; 2, for the regularity of its
...cause it does not easily^d dilate:
... there are the following
...termine the actual
... in bodies, but
...Calorie in them
... of Calorie
... real
... de-
... at

"seen already; and upon not but iron; or thirty." —

II. Wedgewoods clay Pyrometer. This is construc-
ted upon the principle that pure Clay contracts
upon the application of Calorie; and for this pur-
pose, it is immaterial, whether that contraction
is the mediate or immediate result of that ap-
plication. By this contrivance we may mea-
sure degrees of heat as high as 2187, computed
by Farenheits scale. The method of Lavoisier
and De la Place to determine the quantity of Calorie
emitted by heated bodies, in order to acquire the tempe-
rature of the surrounding substances, is highly satis-
factory. It is simply this. A globe of ice is so con-
trived, that a heated body may be introduced into a
Cavity inside, and there confined so as not to touch
the sides: Let it remain till the temperature of the
heated is reduced to that of the ice: a part of the ice
will thaw: collect the water carefully; and it will
be an exact measure of the quantity of calorie absorbed
in the ice, and emitted from the heated body.

Heretofore we have been speaking of Calorie in a state of
freedom. Let us now consider it in a state of combi-
nation.

Chaptal says that if calorie be applied to water,
they will unite; they will dissipate in Vapour:
But in this case it exists in a state of simple

mature, not of combination; and the caloric will desert the water as soon as any substance for which it has a greater affinity is presented to it. Caloric however sometimes performs true chemical combinations in so much that it becomes imperceptible & neutralized in the substance with which it is combined. It is then called latent heat, Calor latens.— The several cases of the combinations of caloric, with other bodies, are reducible to the two following principles.—

I. Every body that passes from the solid to the liquid state, absorbs a portion of heat, which is no longer sensible to the thermometer, but exists in a true state of combination.— To prove this plunge a thermometer into a vessel filled with pounded ice: it will descend to 0.* immerse the vessel into boiling water: the thermometer will not rise during the liquefaction of the ice: the ice therefore in liquefying absorbs heat.— Put a pound of water heated to the 60.* upon a pound of ice. The melted mixture will possess the temperature of 0.* 60.* of Caloric will, therefore, have been absorbed.— So great cold is generated, that is so much Caloric is absorbed from the surrounding bodies, by

* Of Reaumur.

melting ice with strong nitrous acid, as to sink the thermometer 40.+— Take 11 parts of sal ammoniac; 10 of common nitre; 16 of Glauber's salt, dissolve them in 32 parts of water by weight; & the mixture in dissolving, will produce so much cold, that is absorb so much caloric from the surrounding bodies, as to freeze mercury.

II. All bodies, by passing from the solid or fluid, to the aeriform state, absorb caloric, which becomes latent; and it is by virtue of this Caloric, that they are maintained, and placed in that state.— Before a solid assumes an aeriform state it must have become a liquid; and in so doing heat is absorbed from the surrounding mass. But when a liquid passes from its present state to the aeriform, cold is produced in the surrounding mass; that is heat is absorbed from it; & this heat can only be absorbed by the process going on.— It is upon this account that evaporation & perspiration &c produce cold.— A warm current of air, is best adapted to cool the human body because it can absorb the moisture; moist air is more nearly saturated with it.— The cold produced by perspiration is so great, that an animal which freely perspires will live in

+ Farenheit

a temperature of boiling water. But that he perceived he
would die. Lavoisier lays down the following ge-
neral propositions, respecting the appearance & dis ap-
pearance of caloric. In every combination in wh
caloric has been absorbed, when the substances absorb-
ing it are restored to their former state, that Caloric
is emitted; & whenever, in changing their nature
bodies emit caloric, they absorb it, when restored to
their former situation.
The principles of modern Philosophy afford an
highly satisfactory explanation of combustion. Air
is requisite to combustion; we have already proved it
The part of the atmosphere which feeds combustion
is the oxigene. This oxigene is composed of Caloric
& air. Every combustible matter possesses a good
attraction for this air; but untill it has acquired
a certain temperature this attraction does not
operate: as soon as it does operate the air is
absorbed and the caloric it contained is dis-
engaged, and becomes free thermometrical heat.
The heat, therefore proceeds not from the combus-
tible substance, but from the air it decompose
in the operation of combustion. This theory of
combustion is directly the reverse of the old theory
of Stahl. "According to him all inflammable
"bodies contain a principle which he calls

"Phlogiston, or pure fire. This principle is certainly
"to be exhibited alone because its great tendency
"to combination cannot to adhere so forcibly to
"the principles it may be united with as not to
"quit them, but in its passage to other princi-
"ples to which it may have a greater affinity. The
"affinity of Phlogiston to pure air is taken to be
"greater than its affinity to most substances
"that contain it. Upon a proper increase of tem-
"perature in the inflammable substance, and
"the pure air contiguous to it, a rapid decompos-
"tion takes place. The Phlogiston quits the
"substance to unite with the air, and the pro-
"cess goes on, if a sufficient quantity of air be
"present till the body is deprived of the whole
"or most part of its Phlogiston, at which time
"it is said to be calcined or burned". The
following discovery led to the rejection of
Stahls theory. A piece of metal was calcined
in a certain quantity of air: it was found that the
Calx had increased in its weight, while that
of the air had diminished; and that the air
had lost just as much as the calcined metal
gained, which proves the absorption of the air.
The calx was in the same air, restored to its

former state: the metal was reduced to its origi-nal weight; and the air acquired what it had lost. – In order to get over this stubborn fact, the followers of Stahl were obliged to suppose that the Phlogiston was a principle of absolute levity, (that is that it repelled in stead of attracting the Earth); that when the metal has lost this phlogiston, as they suppose it does, when it has become a Calx; it consequently become heavier; having no phlogiston to buoy it up. – Can this unnatural conjecture stand in competition with fact? I call it unnatural conjecture, because it is contrary to the universal law of gravitation. The superiority of modern chemistry is evident. The new theory is founded on fact: but the existence of Phlogiston has never been proved. – The four following principles include the new theory which is shewn to be directly the reverse of the old. – I. Those bodies which Stahl thought to contain most Phlogiston, to emit most, & consequently to be most combustible; modern Philosophers contend absorb most air, disengage from it most caloric, & are therefore most combustible. II Whenever the first thought something was emitted, the last proved

something is absorbed. III. What the first thought a combination of Phlogiston, the last prove to be a disengagement of oxygene. IV. Those sub=stances which the first thought compounds as possessing Phlogiston; the latter proved to be simples & capable of absorbing oxigene.

A question referred to, of which the following is the answer: – Water is composed of two parts caloric & air; had the caloric been extracted from it, the water would have been decomposed: no such effect however took place: therefore no such cause, no absorption of its caloric, operated. – For the question see Page 173.

Table of degrees of heat at wh different Substances melt –

Tin (of Fahrenheit)	408°		Veal's fat	106°
Lead	504°		Sheeps d°	144
Iron	869		Bees wax	140
Olive oil	36		Spermaceti	180
Butter	88		Pitch	186
Hens fat	68		Rosin	240
Dachs d°	86		Sulphur	244
Vipers d°	96			

P.S. We should have mentioned in the foregoing lectures, that some bodies have an apparent repulsion for caloric on can of very smooth surfaces of Metals. —

Lect. 22d - Introductory to Airs

In this Lecture we shall speak of the formation of aeriform fluids and of the effects of the pressure of the atmosphere. -

Bodies when heated are subject to the general law of expansion. This law according to Lavoisier and some other Philosophers, as we showed in the preceding lecture, is universal: certain it is that there are but very few exceptions to it.

If we compare this law, and the principles contained, developed & established in the preceding Lecture with those which are exhibited in Lecture 8d we shall thereby be enabled to explain many phenomena, otherwise not easily accounted for. If a person who has not bestowed a thought upon the subject, be asked why a body is solid, he will no doubt think the question extremely simple; yet he will not be able to answer it. Two principles pervade the material world; attraction ever upon an exertion to draw the particles of bodies into closer contact: and caloric a subtle fluid which insinuates itself between the particles of bodies, overpowers the bond of their union and forces them afar from each other. Now upon the proportion these two forces bear to each other,

depends the varieties of consistence which the material world presents. If the attractive force preponderates the body remains solid; and it is harder or softer according as the quantity of matter it contains is greater or less. If the caloric preponderates, the body becomes fluid; & the fluid is denser, or thinner as the caloric preponderates more or less. If the quantity of Caloric be ~~more or less~~ greatly increased, the body assumes the aeriform State. - Altho' this theory may not boast the unimpeachable truth and certainty of mathematicks; yet it has this merit, that it concords with every fact, & satisfactorily explains every phenomenon to which it may be applied. - Water presents a singular phenomenon, which strongly corroborates the explanation just given of the various consistence of bodies. - If water be reduced below the temperature of 32° (Farenheit) it will become solid: If it be raised above that temperature it will become liquid: If above 212°, aeriform. Bodies are therefore considered in these three States; because they are really reducible to them by an application of caloric. - But since the Caloric produces this powerful repulsion in the particles of bodies, as soon as it has overcome their attractive force; it is clear that were there not some third cause in operation, a solid would pass instantaneously from a fluid to an aeriform state as soon as it was (became) no longer a solid; and that we should have no such thing as a permanent liquid in nature. This third cause is the pressure of the atmosphere. When the solid has been exposed to such a degree of heat, as to become fluid, its caloric must be so much encreased, that its elasticity proceeding from that increase, should be sufficient to overcome the pressure of the atmosphere,– before it can assume the aeriform state. To prove that the pressure of the atmosphere performs this office, the following experiment has been made–. Put Ether or any other evaporable body moderately heated, under the receiver of an air-pump: take off the pressure of the air: the Ether will evaporate. In this experiment, no alteration was produced other than the taking off or the diminishing of the pressure of the atmosphere: it is therefore conclusive in favor of the idea above stated, that the existence of the permanent liquids is owing to the pressure of the atmosphere.–

From what has been said it is manifest that the aeriform state of bodies is thus effected. Caloric combines with every body, to which it has access, makes it so elastic as to overcome the Pressure of the atmosphere; & the body then assumes the aeriform state. When it has assumed that State, it takes the generic name–Gass. The body with which the caloric combines to produce a Gass, is called the base of the Gass produced: the caloric acts as a solvent.– The science of Chemistry was for a long time retarded by a certain confusion & inaccuracy of Chemical terms. The french Philosophers have introduced a new nomenclature. It leaves nothing more to be desired. The principles upon which it is formed, are conformable to the severest precepts of logic. We proceed to give a summary of them.– 1. Of the denomination of simple substances: 2. of that of Compounds. In the denomination of simples, those, which, tho' they are arbitrary, yet, from long use, convey determinate ideas, are preserved unchanged; such as sulphur, phosphorus, &c.– But if the old denomination be vicious, the new nomenclature assigns another, deduced from the principle characteristic property of substance.

196 Thus many paraphrastic expressions are avoided. Vital air is now called oxigene, because it is the basis of all acids; and the term is deduced from two* greek words, one of which signifies "acid", & the other "to make";— So also inflammable air is now called Hydrogen; because its characteristic property is that it is the constituent principle of water; from two greek words one of which signifies "Water" and the other "to make"— In the denominations of compounds, the new nomenclature endeavours to express the constituent principles. We make use of the terms sulphates, nitrates, muriates, to express the combinations of the Sulphuric nitric, or muriatic acids. To denote the substance with which the acid is combined, we add the name of the substance to the generic word; as Sulphate of potash, & the like.— The modifications of acids depend upon the proportion of their constituent principles: To express them, the terminations of the generic word are varied: If there be a great abundance of oxigene it is called an oxigenated acid; if less an oxigenous acid.— The Elasticity of the Gases arises from this Circumstance:

* Also the new names in the new nomenclature are taken from the greek language on account of the facility with which it may be combined, & of its expressiveness.

197 They are combined with Caloric in order to become such: now the Caloric is extremely elastic: the gass therefore it has produced must be so too. Here indeed the question returns upon us, why is the caloric elastic?— we know not. The fact is so; and that being supposed, we can readily account for the elasticity of the bodies into whose combination caloric has entered. It may frequently be difficult to distinguish Vapour from Gas. We have however a good Criterion of distinction. When a liquor or any substance is in a state of vapour, a change of temperature, the smallest coldness, will reduce it to its original state: thus a single drop of cold water will reduce the vapour of hot water into water. But a gass is permanently aeriform: a change in its temperature, does not render it less so.— The following principles are essential to the philosophy of the gasses. (They are extracted from Chaptal [illegible]— I.— Caloric with its combinations with bodies volatilises them, & reduces some of them to an aeriform state; so that, to reduce a body to a state of gass consists in dissolving it in caloric— II.— Caloric combining with various bodies with greater or less facility: some are constantly in a state

of Gass: others require higher degrees of heat to reduce them to that state – III. – Supposing that two bodies have an equal facility of acquiring Caloric, the one may require a greater quantity, than the other, to become gaseous; and caloric may be applied to them in different ways: besides there are other methods of reducing bodies to a state of Gass; such as that of double affinity &c. – IV. – Solids are capable of being reduced to a state of gass; but the quantity of caloric requisite for their solution varies according to 1.st to the force of aggregation with which their particles adhere: 2.d to the weight of those particles by which they are rendered more capable of resisting the elasticity of the Caloric: – 3.dly to the strength of that attraction between those particles & the Caloric. – V. Solids when reduced to an aeriform state, appear either as vapour or gass: the distinction between them has been already mentioned. ~

Sect: 23.d Of Some of the Gasses –

Part 1. of Hydrogene Gas – The Existence of

this gas has been long known to Philosophers. It was first called inflammable air, from the extreme avidity with which it takes fire, when in contact with vital air, or oxigene gas of which we shall presently treat: But as this is of itself, when separated from oxigene incapable of being inflamed this name is not suited to convey an idea of it. The term Hydrogen gass, therefore has been adopted in the new Nomenclature, because it is the constituent principle of water: the term it will be observed, is a compound of two greek words, the one signifying "water", the other "to make". It may be obtained from various substances. Vegetables, in Particular, afford it in great quantities. The method by which ~~they~~ it may be obtained are extremely simple. Put the Vegetable down a gun barrel: expose the closed end of it to an hot fire: fix a crooked tube in the muzzle, & make it air tight by a lute of clay, or other sub-stance, let the tube be immersed in a Vessel of water: after a while the air will be seen to rise out of the tube, in bubbles: they may be caught by holding a bottle filled with water, over the tube in which case it will expel the water & occupy its place. But the method of obtaining it, most deserving remark, is the decomposition of water: it is decomposed in the following manner: take a sulphuric acid & water & mix together one part of the first, three of the latter pour them upon zinc or iron: the oxigen of the water combines with the metal, and the Hydrogen escapes: the mixture should be made in some such receptacle as a bottle a crooked tube may be fastened in the mouth of it, & immersed in a vessel of water as in the method of extracting from vegetables by means of a gun barrel, & in the same manner as it was in that case may it be collected in a phial, or bottle — The Explanation or rationale of this process is extremely ~~simple~~ satisfactory — Water is made up of two constituent principles

Oxigen or Hydrogen In the above described process, the zinc is really reduced to an oxyde: The Sulphuric acid is, however not at all decomposed; no oxigenous gass is extracted from it: the oxigen, therefore, which reduces the metal to an oxyde could only have been extracted from the water; and as soon as this oxigen was extracted, the Hydrogen escaped — Water may be decomposed in many other ways such as pouring it upon heated iron &c &c

The properties of this Gass I shall now enumerate

I It has a disagreeable, stinking smell. — That which is obtained from mercury has scarcely any smell at all. If its water be taken from it, it is said it will lose its smell. If the crooked tube thro' which the gass is received, mentioned in the preceding page, be immersed in Mercury instead of water, the gass will be less offensive: a circumstance which corroborates the idea that the water it contains occasions this property. — II. This Gass is not fit for respiration. It appears that this property arises not from any thing in it noxious

to the lungs; for it has been frequently respired
but it contains nothing to feed the lungs: the
animal dies in it, as it were from hunger.
It is not at all changed by respiration: no
part of it is consumed, as in the respiration
of atmospherical air. — III. Hydrogene, tho'
when mixed with oxigene or atmospherical
air the most inflammable substance in nature;
yet it is of itself perfectly incapable of being
inflamed, as we have mentioned before. —
If you plunge a candle into a phial of this
Gass, it will be extinguished. Phosphorus
itself will not burn in an atmosphere of it. —
IV. It is lighter than atmospheric air. A
cubic foot of the former weighs 72 gr.; of the
latter, 740 gr. The barometer standing at
29.9, and the Thermometer at 60° of Faren-
heit, according to Mr. Kirwan, the weight of
this Gass is to that of atmospheric air as 84:
1000; that is, 12 times as light.
V. It exhibits various characters, according as
it is more or less pure. If it be obtained from
Vegetables, it is mixed with oil, and Carbonic

Acid. The color of its flame varies according to
its mixtures. If the inflammable air (of pit-
coal) be mixed with respirable air, it will
afford a blue flame; the Hydrogene mixed
with nitrous air, a green one; the vapour of
ether a white one. VI. It will dissolve Sul-
phur. In this case it contracts a stinking
smell and forms hepatic Gass, a term de-
rived from a greek word signifying Sul-
phur. Since we have mentioned this Gass,
we will say something farther respecting it.
Hepatic gass, then may be obtained, as just
mentioned, by dissolving sulphur in hydrogene;
By decomposing artificial pyrites formed by
three parts of iron and one of Sulphur, to which
Spirit of Vitriol is added. Sulphurated oxi-
genous gass may be obtained by dissolving the
Sulphures or hepars by acids. — Pyrites are
naturally decomposed in the Earth: they produce
this gass: "it escapes with certain waters, and
communicates peculiar virtues to them." The
most general properties of these gasses are I. They
render white metals black. — II. They are impro-
per for respiration. — III. They impart a green
Color to Syrup of Violets. — IV. They burn with

a light blue flame, and deposit sulphur by this combustion. — V. They mix with the oxigene of the atmosphere, and form water; at the same time that the sulphur that the sulphur, before held in solution, falls down. VI. They impregnate water, and are sparingly soluble in that fluid; but heat & agitation dissipates y.m again. See Chaptal s. 5.th 6th 1st.

Part. II. Of oxigene Gass. — This Gass, before the introduction of the new nomenclature, was known by the names of vital air, dephlogisticated air, &c., but these terms are now laid aside; the first is paraphrastical, the second not only paraphrastical but vicious: a new name, oxigene, has been introduced because this air has been discovered to be the base of acids. — (See Page 196.) This gass is never found in the atmosphere in a state of absolute purity, being allways mixed, combined, or altered by other substances. Yet it is a very general agent: it combines with other matter: from these combinations, we extract it. For instance if a metal be exposed to it, the metal becomes

saturated with it, is reduced to a calx, it is then termed an oxyde. The vital air may be extricated from these oxides by means of simple distillation. One ounce of red precipitate affords a pint. It may be produced also by a distillation of some of the acids, and that very easily. A pound of nitre yields 1200 cubic inches of oxigene. — It may be disengaged from its base by means of sulphuric acid: Take, for example an ounce or two of manganese: put it in a bottle pour, of sulphuric acid, enough a pound to make it a paste: fix a crooked tube in the mouth of the bottle; and immerse the tube in a vessel in a vessel of water in the manner described in Part I. of this Lecture: apply then a small coal to the lower part of the bottle: immediately oxigene is disengaged from the manganese. In like manner it may be obtained from many other substances, with the assistance of heat. All the acids afford this gass, more or less easily, in greater or less quantities, by distillation or some other means. The reason they do so is so obvious that it seems needless to mention. This gass is a main constituent principle in the formation of them. — Oxigene is