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Notes of Chemical Lectures.

Delivered at the Royal College of Chemistry

by

Professor Frankland.

Session 1869 — 70

George Mercer Dawson.

Sulphuric Acid. – Cont:

Sulphuric acid is much used in making "salt cake" one of the intermediate products obtained in alkali works, in the manufacture of Soda from Common salt. It is also used in large quantities in the manufacture of Superphosphate of lime, for agricultural purposes, from bone charcoal & Apatite. The remaining compounds of S with O & Ho are comparatively unimportant.

Selenium & Tellurium, resemble S very closely. The atomic weight of Selenium is 79. that of Tellurium 128. It is found sparingly with S in the free state, and also combined together with S, with the metals, as in the iron pyrites of Fahlun in Sweden. Tellurium is also found but rarely in the free state, but more abundantly in some Transylvanian gold ores. The Hydrogen compounds of Se & Te are the exact analogues of SH_2 (SeH_2, TeH_2).

Sulphuric acid. Continued. The acid is not allowed to attain a specific gravity higher than 1·6 in the lead chambers, as above that it begins to act upon them more, and also absorbs the nitric peroxide. It is then drawn into leaden pans, and, either evaporated by heat employed below them, or by flames passing over their surface, as in a reverbatory furnace. The bottom heat soon destroys the pans while by surface heat more of the acid is lost. It is evaporated in these pans to specif. grav. 1·75. and as it comes from this process is technically known as "brown acid" and may be represented by the formula $SO\,Ho_4$. It cannot be further concentrated in the lead pans. This is performed in retorts, or stills of glass or platinum. It is raised to a specif. grav. of 1·815 (SO_2Ho_2) & is then improperly called "rectified acid" part of it, in this process distills over with the OH_2 and forms a

weak solution which is used for supplying the lead chambers with liquid. The glass stills are very often broken by the bumping, or accidental splashing of the acid, so that a platinum one is usually found most economical in the end. Although the first cost is from 4 to 6 thousand pounds.

Carbonic disulphide (CS_2) Carbon does not readily burn in sulphur vapor, but if the vapor be passed over ignited charcoal it combines with it and forms CS_2, thus

$$C + S_2 = CS_2.$$

It is much less volatile than CO_2 the corresponding O compound. It is always produced in the manufacture of Coalgas, & it is one of the most difficult products to get rid of. Coal (with contained iron pyrites) heated to redness looses some S, which vaporizes & combines with the C & forms CS_2

Parliamentary limits are set to this impurity but they are almost always exceeded.

It is a colourless liquid with a very high refractive & dispersive power. Insoluable in water. Highly inflamable. Miscable with Alcohol & ether. And the analogy of CO_2

Bromine. 30. Is present in sea water, & in certain brine springs. It is obtained in the "Bittern" which is left, when NaCl has been crystallized out. It is also present in the waters of the dead sea. Also in small quantities in some molluscs.

It is manufactured from bittern, in Germany and Austria. By concentration the Magnesic Sulphate crystallises out. It is then treated with Cl & Sodic Bromide decomposed into NaCl and free Br. The Br may be distilled over, but forms compounds with Cl. It is thus found better to dissolve

it out from the water by agitation with ether. This solution is drawn off by a siphon, and treated with $NaHO$ & OKH. It combines with them forming Bromide (bromate) of Na or K. The ether is then decanted off & then used again. The bromates are decomposed by heating to redness. It is then treated with MnO_2 & SO_2 HO_2 & free Br obtained.

Monday Novr 22nd 1869.

Bromine is a non conductor of electricity. It is soluable in alcohol & ether, & but very slightly so in water. The affinities of Br are not so strong as those of Cl. Cl therefore is capable of expelling it from its compounds. Bromine like Cl bleaches, but not nearly so powerfully as that element. It is very poisonous. It supports like Cl the combustion of many of the metals. If a fragment of Arsenic be placed on the surface of a few

drops of Br contained in a test tube. It ignites spontaneously & burns brilliantly. The vapour of Br when inhaled is extremely irritating. The compounds of Br are almost exactly parallel with those of Cl.

Hydrobromic acid is formed like HCl by the direct union of its elements. If H & vapor of Br be passed through a red hot tube HBr results. It is most conveniently prepared by treating potassic bromide, with phosphoric acid. Sulphuric acid cannot be used as it acts upon, & decomposes part of the HBr produced, liberating free Br.

$$3\,KBr + PO\,Ho_3 = PO\,K_3 + 3\,HBr.$$

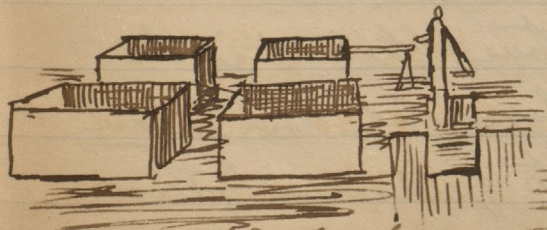
It may also be prepared, (in a way exactly analagous to that employed in the preparation of HCl) by the action of SH_2 on Br

$$2\,SH_2 + 2\,Br_2 = 4\,HBr + S_2.$$

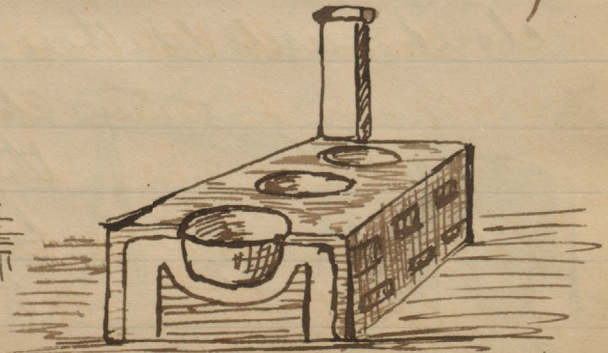
The compounds of Br with O & Ho, are also parallel to those of Cl, with the same substances

Iodine 127 is found in combination with potassium, in some mineral waters, in very small quantity in sea water, also in sea-weeds & sponges. They do not speak concentrate it from the sea water, & it is from them that the commercial supply is obtained. Kelp, or the ashes of sea-weeds was formerly employed for the production of Soda, & Iodine obtained as a by product. The reverse is now the case, as sodic carbonate is so much more cheaply produced from common salt.

By the old process for obtaining iodine from sea-weed they are first placed in pits dug in the earth, & there allowed to smoulder at the lowest possible temperature (to prevent the KI from volatalizing.) The ashes, or Kelp thus obtained is levivated. The more readily



Levivating tanks



evaporating pans.

crystallizable salts, are then removed by evaporation as the $CONaO_2$, NaCl. & next the sulphates of potassium & sodium. (the crystals being removed by a collinder) The residue is then evaporated to dryness. (It is important that all the NaCl should be removed as otherwise the Cl would be set free in the subsequent process & combine with the I.) The potassic iodide thus obtained is put into lead, or iron lined with lead stills, mixed with MnO_2 & SO_2HO_2. The mixture is then distilled at a very low temperature to prevent the waters being evaporated & condensed with the Iodine. The vapor of I is condensed in large earthen receivers, & afterwards purified by drying & redistillation. In the new process the seaweed is not burnt, but roasted in closed vessels like those employed in making charcoal. The charcoal thus obtained is then lixiviated, and is said to yield nearly twice

distilling apparatus for I.

as much as by the old process. In the old process so much of the KI is lost by volatilization. It is however doubtful whether all the salt can be obtained from the charcoal. As when NaCl & sugar are carbonised, not more than 60 percent of NaCl, can be obtained from the charcoal by any amount of washing. Iodine has almost a metallic lustre. a specific gravity of 4·945. It volatilizes at ordinary temperatures slowly. The vapor has a beautiful purple colour its specific gravity of 4·95. I is a non-conductor of heat & electricity. It has an acrid taste, & an odour like though weaker than that of Cl. It is also poisonous. It dissolves readily in OH_2 holding iodides in solution. Even the $\frac{1}{450.000}$ part of I in OH_2 can be detected by the starch test. Its compounds are like those of Cl & Br but its affinities are weaker. The colour produced in starch by I disappears at the boiling point of water, but reappears on

Cooling.

Hydriodic acid. may like HCl & HF, be formed by the direct union of its elements, thus

$$H + I = HI.$$

It may also be produced by $PO Ho_3$ like $H Br$, and by the other procures used for hydriobromic acid. It is most easily prepared by P. I. $Ki + OH_2$. a solution of these made & the Phosphorus then added. Cl & Br. decompose HI. I forms compounds with metals also similar to those of Br & Cl.

One compound of I, Mercuric iodide shows a very curious dimorphism. When first precipitated it is of a yellow colour, but when more precipitant added. becomes red. When the red salt is spread on paper, & dried, & then heated it changes its crystalline form & becomes yellow. This yellow salt however immediately becomes red, by retaking its old crystalline form, on the application of pressure or drawing across it a glass rod &c.

Fluorine differs much more from I Br & Cl than they differ from each other but still belongs to the same group. It occurs widely as flour-spar. (CaF_2) also in small quantities in bones, feathers, urine, milk. It is such an intensely negative element that it has never been satisfactorily isolated. It has been obtained by passing Boric fluoride over red hot red lead. Also, and more satisfactorily by Messrs Knox by heating mercuric fluoride readily to redness in vessels constructed entirely of fluor-spar, & passing Cl over it. forming mercuric chloride & fluorine, as a gas. It is not quite certain however that Cl was not in combination with it. F forms no compound with O. It combines with H to form Hydrofluoric acid analagous to HCl, HBr, HI. It must be prepared in a leaden, silver, or platinum retort & condensed in a U shaped tube of the same metal. It is used

for etching glass. & forming patterns upon it by eating away a coloured layer, & exposing the clear glass. &c. It is formed by the action of SO_2HO_2 thus

$$CaF_2 + SO_2HO_2 = 2HF + SO_2CaO''.$$

It may be obtained free from water, by distilling by phosphoric anhydride. It is a colourless, invisible gas. Exceedingly irritating when respired. A dilute solution acts on many metals forming fluorides. It also attacks silica & its compounds (as glass) And forms compounds with boron and silicon.

Silicon is always met with in combination & that with one element namely O. It is always tetrad. Silicon was first isolated by Davy by acting on SiO_2 with potassium

$$SiO_2 + 2K_2 = Si + 2OK_2$$

This is not a good practical process. It is more easily prepared by using a double

fluoride of silicon & potassium; thus-

$$SiK_2F_6 + 2K_2 = Si + 6KF$$

or a chloride of silicon & sodium - thus,

$$SiCl_4 + 2Na_2 = Si + 4NaCl$$

It is amorphous, as prepared by these processes, and appears as a dark brown powder, not acted upon by ordinary acids, but dissolved with decomposition by hydrofluoric acid & OKH. When heated it combines with O & burns brilliantly, till it becomes coated over with a glass of SiO_2 when the combustion ceases. It may be obtained graphitoidal, black, crystalline & with high lustre, by igniting with Al & treating with HCl. It was thought to be also obtained as diamond silicon, (comparable to that form of B & C) but this form has been proved to contain Al.

Tuesday 23rd Nov.

Silicic hydride. has not been obtained free from H. Its formula is SiH_4.

Silicic Chloride ($SiCl_4$) May be obtained by making silicic anhydride (SiO_2) & Charcoal into little pellets with linseed oil, when these are heated to redness, the SiO_2 is obtained mixed with the charcoal from the decomposition of the oil in a very minute state of division. These pellets are then put into a porcelain tube, & heated intensely, while a stream of Cl is passed over them. $SiCl_4$ results. Neither C nor Cl alone, can decompose SiO_2 but both combined do so.

$$SiO_2 + 2C + 2Cl_2 = SiCl_4 + 2CO.$$

It is a very volatile liquid, & as thus obtained always contains an excess of Cl dissolved. This is readily removed by agitating it with Hg which combines with the Cl, & leaves the $SiCl_4$ unaltered. It is very readily decomposed by water, even the moisture

in the air sufficing; & gives rise to white fumes of SiO_2. Thus.

$$SiCl_4 + 4OH_2 = SiHo_4 + 4HCl.$$

Silicic fluoride. Prepared by heating together silicic anhydride. calcic fluoride, & sulphuric acid thus. $SiO_2 + 2CaF_2 + 2SO_2Ho_2 =$ $SiF_4 + 2SO_2Ho_2Cao$".

By contact with water silicic fluoride (SiF_4) gives silicic ($SiHo_4$) & hydrofluorsilicic (SiH_2F_6) acids. SiH_2F_6 is used for the seperation of Ba & Sr in qualatative analysis.

Compounds of Si with O, H, & the metals

There are two acids formed from Silicic anhydride (SiO_2) Tetrabasic silicic acid $SiHo_4$ & Dibasic $SiOHo_2$. Silicic anhydride, occurs uncombined, as quartz in all its varieties. It may be obtained artificially by fusing quartz, or any of its compounds, with $CONa_2$ & COK_2 dissolving the product, in water, & adding HCl when part of the Silica seperates as Silicic acid

which is slightly soluable in water. If this however be evaporated to dryness, with excess of HCl it changes to SiO_2.

Calcic silicate, is used for preserving building stones, which are going to decay, and also for making artificial stone, of any shape. Sand, or whatever is used as the basis of the stone is made into a paste with "water glass" (soluable silicate of Soda) ~~of pot~~ this is firmly stamped into mould, taken out, & put into a bath of Calcic Chloride ($CaCl_2$) By its action Silicate of lime is precipitated in the stone, & NaCl produced. This has to be got rid of by immersing the stone in baths of warm, water, & constitutes the greatest difficulty in the process. If any is left in the stone, it efflorescs out, after the setting of the stone, by rain & C & gives a very ugly appearance.

Zirconium & Titanium, are put in the same group as Si, & are very similar to it in properties, though more allied to the metals in appearance

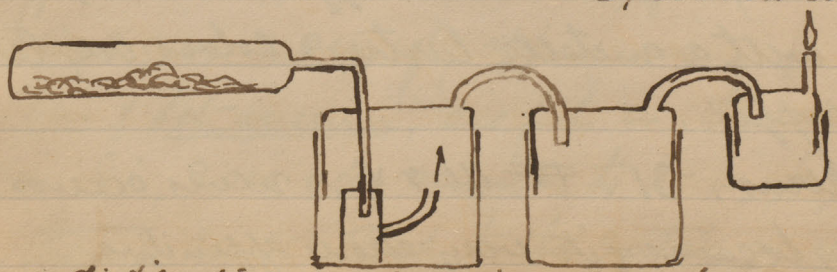
There is however, no distinct line between the metals and non metals, they run into each another.

Tin 118 is malliable, sparingly ductile, & melts at 220° Cent. When rapidly bent, it emits a peculiar creaking sound, probably from the motion of the particles upon each other, & becomes so hot as to be not easily born by the hand, & easily to ignite P. It gives a peculiar smell when rubbed. It has very little affinity for the O in the air. Used for tin plate, making &c.

Titanium. 50 resembles Tin in many of its properties. It is met with in small quantities in some iron ores, & is found crystalized as Titanic nitride, in the fissures of the furnaces used in the reduction, when they are pulled to pieces. In its compound with N it appears as bright crystals with a metallic lustre, & colour very like that of copper.

Phosphorus. 31. ~~##~~ III & V. never occurs native, because of its very strong affinities.

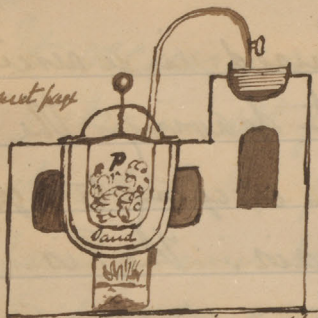
It occurs combined with lime in apatite, & also in all fertile soils, from these it is absorbed by plants, & accumulated in the bones of animals feeding on these plants, as tribasic calcic phosphate ($P_2O_2Ca''_3$). P is manufactured chiefly in Birmingham & also in Germany & France. Bone ash which may be represented by the formula $P_2O_2Ca''_3$ is digested with SO_2Ho_2, & the product filtered through Cocoa-nut matting. The filtrate is evaporated to a syrup, & then 1/4 its weight of Charcoal in powder added. The mixture is then very thoroughly dried & introduced into earthenware retorts & distilled at a very high temperature. The C acts upon the monobasic calcic phosphate (P_2O_4Ca'') & reconverts it into tribasic, which liberates



distillation & condensation of Phosphorus.

three 2/3 of the P. This is condensed in a series of vessels containing water as in the drawing. The CO always contains enough P when escaping to ignite spontaneously when exposed to air. The P is purified by redistillation, it is then melted under ~~warm water~~ water & passed through wash-leather. The colour is removed by NH_4HO & Potassic bichromate dissolved in $SO_2 HO_2$. The P thus purified & bleached is melted in a copper vessel with a number of tubes leading out from it into water, the P solidifies in these, & can be drawn out, & cut off in sticks. P is a soft, nearly transparent, wax-like solid. melts between 43 & 45° Cent. Vapor is abnormal even at a heat of 1000°. It evaporates with tolerable rapidity in vapor of water, when boiled in that fluid, & in the dark appears as a lambent flame at the mouth of the flask. The flame however possesses very little heat.

Process for making melted P into sticks.



old method of preparing amorphous

Wednesday 24th Novr

Phosphorus even oxydises slowly under water. It lights by slight friction. It is slightly soluable in Ether & more easily soluable in Benzol & turpentine. It is also soluable in the fixed oils, more especially in olive oil. From these solutions it slowly oxidises, in contact with air giving out a steady glow of light. By far the best solvent for P however is CS_2. If this solution be put upon paper, (the paper ought to be porous like blotting paper, & words may be drawn on it with the solution) the CS_2 rapidly evaporates leaving the paper colourless. When the whole of the liquid has gone, however, the P left in a very fine state of division, oxidises so rapidly as to take fire spontaniously, & burn, charring the paper.

It is a very curious fact that very small quantities of the vapor of certain liquids, & gases present in the air, prevent the slow oxidization of P. Olifiant gas, & the vapours of Turpentine, ether & naphtha, does

Neither will the slow combustion, through, occurring at all temperatures in air, take place, in pure O, tho it be raised fully to 60 Far. P is very poisonous, even the vapours, affecting those employed much with it, as match makers, with Caries of the jaw. Its chief use is in the production of matches. An emulsion of P & Gum Ac in glue is used to tip the matches, after they have been already dipped in S.

P occurs in several allotropic forms, the most important of which is red, or amorphous phosphorus. P is often partly changed into this form when it is burned, especially when with limited access of air. It is also produced, when melted P is burned under hot water by a stream of O gas. It was formerly thought to be a low oxide of P. The mode usually employed, of preparing this substance, is to heat P in closed vessels at a temperature of from 230° to 250° Cent, for 40 or 50 hours. This operation was formerly carried on in an iron vessel in a sand bath, with the lid screwed on,

old method of obtaining P. see last page

& a pipe passing from the top into a vessel of water, to allow the escape of any gases that may be formed. It is now however performed, merely in iron vessels with a small hole in the lid, for the escape of gases & for ascertaining the temperature. The heat however must be very carefully regulated, as if it rises to 260° the P immediately reverts to the ordinary condition with evolution of great heat, which volatilizes the P instantly, & causes a dreadful explosion.

When the conversion is complete the amorphous P is taken out & boiled with caustic soda, as long as any PH_3 is evolved from the free P present in the mass. (The ordinary P may be removed more easily by dissolving it out by CS_2) The amorphous P is then washed, dried on warm plates, & packed in casks.

It possesses <u>properties</u> very different from those of ordinary P. It is incapable of inflamation by any ordinary friction. It is not volatile, infusable, & insoluable in CS_2. It is now used to some extent in the manufacture of matches, especially

the "safety matches", which depend on the properties of amorphous P. It does not light by any ordinary friction, as said before; but ignites immediately when very slightly rubbed with $ClOKo$.

The matches are tipped with $ClOKo$ & sugar, which cannot be lit by friction, but as the side of the match box is coated with amorphous P, lights immediately on being applied to it

There are <u>three compounds of P & H.</u> a liquid, a solid, & a gaseous.

Solid phosphuretted hydrogen $P(P'''H)''$ $P(P'''H)''$

Liquid " " P''_2H_4

Gaseous " " PH_3

The gaseous phosphuretted hydrogen may be prepared by heating hypophosphorus acid. thus

$$2\,PO\,H_2\,Ho_1 = PH_3 + PO\,Ho_2$$

phosphoric acid.

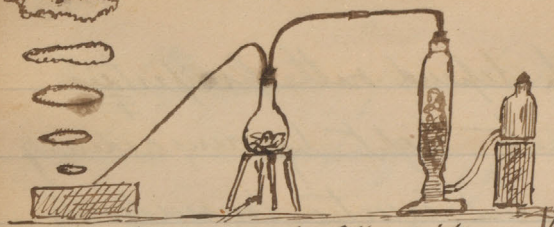
Also by heating phosphorus acid. thus,

$$4\,PO\,H\,Ho_2 = PH_3 + 3\,PO\,Ho_3$$

By heating P with OKH or NaHo thus,

$$3\,ONaH + P_4 + 3OH_2 = 3\,PO\,H_2\,Nao + PH_3$$

sodic hypophosphite



apparatus for preparing PH_3, with a hydrogen generator, to first expel the air to avoid explosions.

As prepared by OKH or $NaHo$ it is spontaniously inflamable from being mixed with a small quantity of liquid phosphuretted hydrogen. It gives rise in burning to beautiful rings of phosphoric anhydride (P_2O_3) It has a peculiar garlic odour, & a bitter taste. It has a very slightly alkaline reaction with litmus paper, & forms salts exactly analogous to those of NH_3 which indeed is its analogue. It is however a far more feeble base. It forms a combination with iodic acid thus. $PH_3 + HI = (PH_4)I$. It may be procured by passing PH_3 over Iodine in a tube. It is only thus, in the nascent condition that these bodies will unite. PH_3 has a specific gravity of 1·2092. & one litre weighs 17 centis It is slightly solvable in water & freely in Cupric sulphate. When pure it ignites at 260° Fahr. It is a peculiarity of this gas that its igniting point lowers as the gas expands, thus it may be

mixed with O at ordinary atmospheric pressure, but if in collecting it over Hg for instance, the pressure be diminished, it explodes with great violence.

Liquid phosphuretted hydrogen ("P_2" H_4) may be prepared by passing P vapours over quicklime heated to redness. The calcic phosphate thus prepared is afterwards decomposed by ~~pass~~ putting it into water, or dilute HCl giving rise to globules of "P_2" H_4 which rise to the top & take fire in the air. It may thus be prepared in a retort & condensed in a carefully ~~prepared~~ cooled receiver. 1 part of the vapours of "P_2" H_4 in 500 of H renders it spontaniously inflamable.

Solid phosphuretted hydrogen may be prepared from calcic phosphate (like the liquid) by the addition of strong HCl. & even in the production of the liquid some is usually produced. When spontaniously inflamable phosphuretted hydrogen is exposed to sunlight or diffused daylight it deposits the solid, & looses its spontaneous inflamability. Some of this solid however is probably uncombined P. The solid

requires a heat of 230° Far to inflame it. At higher temperatures it decomposes. It also reduces metals.

There are two compounds of P with Cl PCl_3 & PCl_5 there is also an oxychloride & a sulphochloride

The PCl_3 may be obtained by burning an excess of P in Cl, thus; $P_2 + 3Cl_2 = 2PCl_3$.

PCl_5 by burning P in an excess of Cl, thus; $PCl_3 + Cl_2 = PCl_5$. Both these substances decompose by contact with water into phosphoric acid (PO_4H_3) & Cl. They are made use of in reactions in organic chemistry.

P also combines with N forming a phosphoric nitride.

P & S also combine in several proportions when melted together.

Thursday Nov. 25.

P_2O_5?

P_2O_3 changes by contact with water into metaphosphoric acid.

$$P_2O_3 + OH_2 = 2PO_2H_3.$$

This action is so violent that P_2O_3 hisses on contact by the production of heat. It is volatile at high temperatures.

Glacial or metaphosphoric acid, is distinguished by coagulating albumen, & precipitating silver solution (NO_2AgO_7) white & gelatinous. These reactions are important as distinguishing (PO_2Ho) from tribasic phosphoric acid & hypophosphoric acid.

Phosphoric acid ($PO Ho_3$) may be prepared by boiling metaphosphoric acid. It may also be prepared by placing a number of sticks of Potassa in tubes open at both ends, placed together in a funnel. The P_2O_3 produced absorbs water & drops down as a mixture of phosphorus & phosphoric acid. It is most commonly prepared from bone ash, by the action of an excess of concentrated SO_2Ho_2. It is diluted & then filtered to precipitate the insoluable sulphate of lime. & it must be evaporated diluted & filtered several times to get rid of the last traces. It is then fused at

315° in a platinum crucible, treated with water & evaporated to dryness in vacuo. When PO_3H is heated to 213 it produces hypophosphoric acid ($P_2O_3H_4$). PO_3H gives no coagulation with albumen & a canary yellow precipitate with NO_2Ag. Sodic phosphate is now used instead of dung by calico printers, but it is found that the analogous arsenic (sodic arsenate) salt, gives better results.

Pyrophosphoric acid, does not precipitate albumen, & precipitates NO_2Ag white & granular. Its salts are permanent, but the acid itself changes gradually into the tribasic acid by the assumption of a molecule of water.

Arsenic, by its physical characters is assimilated to the metals. It readily conducts heat & electricity. It is sometimes like S met with in the free state, but more often

in combination, with S or O. It is present in almost all iron pyrites. And in large quantities in arsenical iron pyrites, or mispickle. It occurs combined molecularly with Co in Cobalt glance, & also in cobaltic arsenide & sulphide. It is also evolved in small quantaties by volcanoes. In the preparation of such metals from ores large quantaties of As are oxidised into As_2O_3 (Arsenious Phosphoric anhydride). The flues of the furnace are constructed to condense this, by being led underground for long distances, sometimes 1, 2, or even three miles. From Arsenious anhydride metallic As may be prepared by mixing it with charcoal, & putting it in a hessian crucible, with another placed on it mouth downwards, the reaction goes on thus. $As_2O_3 + 3C = As + 3CO$

The As condenses in the upper cool crucible. As has a steel grey colour, & a lustre not unlike that metals! It very soon becomes tarnished in air.

Its crystals are rhombohedral. Its specific gravity is 5·8843. It sublimes without liquifying like CO_2 its melting point being higher than its boiling. If it be sealed in a tube, however, & thus prevented from volatilizing it may be melted. It combines with H to form a compound analagous to that of H with ~~Ammon~~ N & P. NH_3, PH_3, & AsH_3. Its volume is anomalous like that of P two atoms being contained in the standard molecule. $\underline{AsH_3}$ can only be obtained pure by acting on an alloy of Zn & As, thus

$$As_2 Zn''_3 + 3SO_2HO_2 = 3SO_2Zn'' + 2AsH_3.$$

It may however easily be prepared by producing H from Zn in the ordinary way, with SO_2HO_2 & adding As to the solution. Thus prepared it is mixed with much free H. This gas is inflamable & when it burns with a limited access of air, as when a cold plate is held in the flame, the oxidisation is not complete, & free

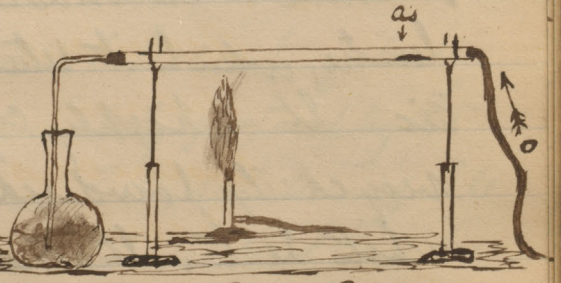
As is deposited. thus; $4AsH_3 + 3O_2 = As_2 + 6OH_2$
This very delicate reaction is called Marshes test. If the tube delivering this gas be heated by a lamp, all the arsenic is deposited as a mirror within it. The current of gas however must be very slow. This method may even be used quantatively when small quantaties of As are present. The tube being weighed before & after the experiment. When very small quantaties are present, an approximate quantatave determination may be made by putting a carefully measured part of the solution, into the apparatus, & afterwards, comparing the intensity of the mirror, with others previously obtained, by acting on known small quantities, in the same apparatus. AsH_3 is condensible at $-40°$ F to colourless & transparent liquid.
This compound of As (AsH_3) goes to prove that H cannot be a metal, as has been

stated, all the other compounds of the metals & As are opaque & metallic.
The specific gravity of AsH_3 as compared with air is 2·695 with H 39. It therefore weighs 39 eighths. It is slightly soluble in water, & very poisonous. It is neither acid nor alkaline, & in this seems to differ from Ammonia. But in organic chemistry this analogy comes out very strongly.
As unites with Cl like P to form $AsCl_3$ analogous to PCl_3 but no representative of PCl_5 is known.
Arsenic forms an extensive series of compounds with O.

Arsenious	Anhydride	As_2O_3
Arsenic	do	As_2O_5
Arsenious	acid	$AsHO_3$
Arsenic	do	$AsOHO_3$

Arsenious Anhydride is dimorphous, it forms sometimes prisms & sometimes

octahedrons, the prismatic variety breaking up into octahedrons & becoming opaque, after some time. Prisms sublime if As_2O_3 is fused in a long closed tube, & then put in hot sand for some time. The different forms possess slightly different properties. The prismatic being most soluable in water &c. As burned in a stream of O gives As_2O_3 in white fumes part of which volatilizes sublime in the tube & part pass away with the gas, their complete condensation being very difficult. This experiment may be performed in an apparatus of this kind a lamp being used in the first instance to inflame the As.



Hydric cupric arsenite (Scheeles green) $AsHoCu_6$ is produced when an Arsenite, as that of K is added to a solution of SO_2 Cu_6.

Monday Nov 29th.

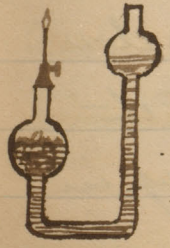
Realgar ($'As''_2 S''_2$ or $\begin{cases} As\ S'' \\ As\ S'' \end{cases}$) is found native, & may be prepared by heating S with As_2O_3. It is used as a pigment, & as an ingredient of ~~Bengal~~ Indian lights which are composed of Sulphur, potassic Chlorate & Realgar, The realgar & S are oxidised at the expense of the O of the potassic Chlorate & the arsenious anhydride heated to incandescence in this flame is the cause of its great brightness.

Antimony $^{122}_{11}$ is found native & also oxidised, & in combination with S, as Antimonious sulphide. It has been known since the fifteenth century, & was discovered by Basil Valentine. It has a brilliant metallic lustre, which it retains for a long time in pure air. It is highly crystalline & foliated, and very easily powdered. It is volatile at a white heat. It is always more or less mixed with As even in the medicinal preparations The Sulphide which has a metallic lustre

& Crystalline structure, may be freed from earthy impurities by melting it, & then reduced to the metallic state, by mixing it with half its weight of iron filings & heating. The iron abstracts the S.

[Metallic Sb raised above its melting point by heating it in a spirit lamp flame with a stream of O, & then poured out upon a large sheet of paper turned up at the edges gives rise to a very beautiful pattern in black lines & dots, surrounded by a halo of white incrustation. The black parts vaporized & the white parts Sb_2O_3 Antimonious anhydride]

Antimoniuretted Hydrogen (SbH_3) is the analogue of PH_3 & AsH_3. It has not been obtained in a state of greater purity, than 6 per cent of it in ordinary H. And as ordinarily prepared by the action of SO_2HO_2 or NO_2HO on Zn & solution of Sb not more than two per cent can be got. It may be produced & the formation of a mirror on porcelain, as shown, in the same apparatus, as that sometimes



used for Marshes arsenic test. The mirror produced by Sb, (when SbH_3 is heated to redness passing through a tube &c) differs somewhat from that of As, it is not so transparent as that of As. It also possesses much greater lustre, & may be further distinguished, by its insolubility in Chloride of lime, (or the corresponding sodasalt) by which As mirrors may be dissolved. Sb is also less volatile & when heated in a tube to form a mirror usually forms them on both sides of the flame. And further by changing the mirror into Sulphide by passing SH_2 & afterwards passing dry HCl, the chlorides of As & Sb respectively are formed, that of Sb however completely volatilizing. A proof of the composition of Antimonuretted hydrogen, is that when it is passed through NO_2 Ag_2O $SbAg_3O_3$ is produced. The remaining compounds present so close an analogy to those of As, P, & N, that it will not be worth while to take them up in detail.

There are two Chlorides $Sb Cl_3$ & $Sb Cl_5$.
Like P, Sb, can exist in two allotropic conditions, & the evolution of heat when one passes into the other is even more striking than in the case of the similar change in P.
Allotropic Sb, may be obtained under certain conditions, at the negative pole of a battery, immersed in solution of Sb butter of antimony, & tartar emetic. It is a botryoidal metallic mass, in a very unstable condition, the particles hanging as it were on the brink of a precipice, over which the slightest impulse will send them. Thus the scratch of a knife &c will immediately cause the Amorphous to assume the crystalline form with great evolution of heat, & vapour of And evolution of $Sb Cl_3$ which has been included, in the deposition. The heat generated is equal to the melting point of tin, & easily inflames gun-cotton twisted round it

Bismuth. 208 occurs native & combined with As & & S. It generally contains traces of As. The native is the only variety used for obtaining the metal for the purposes of the arts. Bi is like Sb & As triad & pentad. Bi is a whitish crystalline metal, & conducts heat & electricity much less readily than most of the metals. It is most used for preparing fusable alloys. Three are composed of Bi 8 Pb 5 Sn 3 melts at the boiling point of water.

The differance between Metals & Metalloids

There are many physical differances between the metals & non metals, the principal of which are the power of conducting heat, & electricity & of reflecting light. The power of reflection may be well shown by reflecting a beam of electric light, first by a plate of silver & then by one of S. The reflecting power of metals is almost the same at all angles. & is very

perfect. Not of metaloids, as S is much the best at acute angles of incidence, & worst when reflected vertically. Some metalloids as I, reflect however better than some of the metals.

The metals also possess great opacity, & the non metals as a rule are more or less transparent. A thin film of Hg allows no light to pass, while Br for instance, lets the light pass, & colours it a deep red. But even the metals are transparent when in very thin films. gold lets green light pass, & silver a deep blue light.

The metals conduct electricity very readily, while a piece of S introduced into the circuit immediately stops the current.

There are also chemical differences. O forms bases with the metals, but acids with the metaloids, no non-metal forms a decided base. The differences between the metals & metaloids are only relative, & in many cases overlap. Thus graphite, a Carbon in the graphatoidal state

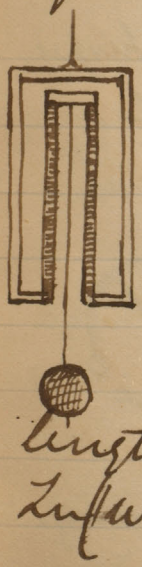
as gas coke conducts electricity well, & is used for producing the electric light

Tuesday Nov 30th

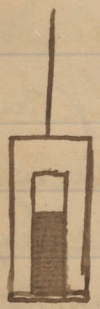
The physical properties of the metals to heat & light are those which bear most importantly on their chemical characters. Metals contract by cold & expand by heat very markedly, & generally when brought back to the same temperature, reassume the same dimensions. This is not the case however with many the soft metals, as Pb, which becomes gradually enlarged by alteration of temperature, & when in sheets, as in sinks &c, it becomes corrugated, from this cause. When Pt wire is melted into glass, as in endometers &c it is necessary to choose the glass, whose power of expansion is most similar to Pt. This condition is best fulfilled by German glass which is a silicate of soda & lime, & contracts least. English glass contains also

plumbic silicate, & changes more by change of temperature. The relative expansibility of metals may be well shown by soldering strips of two, (as copper & iron) together. When heated the copper expands most, & therefore bends the rod, being itself on the convex side.

The expansion & contraction of metals causes clocks & watches to gain or loose according to temperature, this same property is nevertheless used to correct its own effects. Thus in that form commonly called the gridiron pendulum. It is composed of steel & Zn, the Zn expanding most, is so arranged, & proportioned as to length, as to expand upwards, as much as the steel contracts downward, & thus keep the centre of gravity always the same. Thus when the iron by lengthening tends to make the clock slow, the Zn which contracts two or three times as much, as



iron counteracts the effect. The same may be accomplished by the mercurial pendulum, which has a cylinder filled with a certain quantity of Hg for its weight. When the iron rod expands downwards, the Hg expands upwards, & thus always keeps the centre of gravity unchanged.



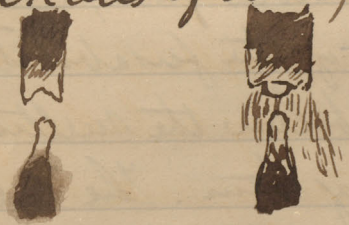
In watches & chronometers it is effected by making the balance wheel of two strips of different metals soldered together, & cutting it in two places to allow these strips freedom of motion, weights are put at the ends of the arms, & by the proper regulation of these, & the compound wheel, it is so made as to swing always in equal times. The contraction of metals is shown in the riveting of boilers the rivets being put in red hot & afterwards contracting draw the plates together with great force. Also in the manufacture

of Armstrong guns, which are composed of a number of cylinders placed over each other, the inner ones cold, & the outer red hot, thus holding together, against the force of the powder very strongly

The temperature of fusion in metals is very various, & ranges from that of Hg which may very well be melted in a furnace of ice to that of Iridium, which can hardly be melted in the electric arc. (Purity shown, & obviously that it was much more refractory than Pt.) It is a curious fact, that alloys often melt below the sum of the fusabilities of their constituents, & even below the melting point of the most fusable of them. The so called fusable alloy, is an example of this.

All metals are volatile, when sufficient heat is applied. Some even at ordinary temperatures as Hg. In the development of Daguerreotypes, the silver plate after being exposed, is developed over hot Hg, but if the Hg be not heated, & the plate left for some hours the development will take place just the same.

The volatility of the metals, & the colours of their incandescent vapours, may be shown by placing them in a kind of crucible of gas Cake, & making this the positive pole & in the production of the electric light. The image of the poles being cast on the screen the positive one is seen to wear away, & the negative to collect a sort of knob upon it, the bubbles boiling out of the carbon, are probably silicates of bases, with which it is impure.

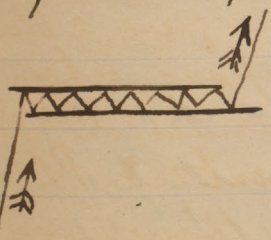


1 Carbon points in screen
2 Crucible with globule of melted lead throwing off incandescent vapours.

Lead & Zinc give a blue coloured vapour, when it is thus rendered incandescent & Pt also a blue though of a different shade. Copper, & silver a bright green.

(The light may also be collected by a horizontal slit, & thrown by means of a lense, on the screen as a bright round patch, this shows the colours very distinctly.)

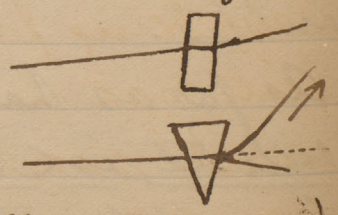
The colour of light reflected by metals is also very different, though not often manifestly so till it has been reflected a great number of times. This may be observed by looking into the bottom of a deep polished vessel of any metal, where the light has been reflected by the sides a great number of times. It may be well shown by reflecting the light from the electric lamp between two parallel plates of a metal as Ag or Cu, as shown in the diagram. By



changing the angle of incidence the reflections may be had any number of times, and the light thus comes a coloured disc on the screen. Thus treated. Cu gives a crimson disc, Ag yellow, Au red, Fe violet, Zn blue.

As far as has yet been ascertained, the colour reflected is complementary to that transmitted, in metals, thus Ag transmits blue, reflects yellow

Air transmits green, reflects red.
The colours of ignited metals, is usually white, but Copper is ruddy & gold green.
The colours of the ignited vapours of metals, is supposed to arise, from the particles being set free, & when in this state their oscillating at a certain rate, & effecting rays of light having the same rate of undulation. certain intensities of light are thus wanting in certain substances, & on this depends Spectrum Analysis.
The action of the prism, is to bend a ray of light from the course previously pursued, this is called refraction, & takes place, when the light goes from a dense medium to a rare, away from a perpendicular to the surface.
Light is however of different refrangabilities & in being thus passed through a prism, the rays having the greatest intensity



of vibration are bent more & the light thus spread out into a spectrum. White light has been said to consist of a certain number of primary colours, but in reality consists of an infinite number of separabilities. Light is supposed to be ~~propagated~~ distinguished by the undulations of a hypothetical luminiferous ether, which may however very well be the tenuous continuation of the atmosphere in space. The rate of vibration is immense though very different, in intensity. Thus red light vibrates 482 millions of millions of times in a second, while violet is not quite double. (704 millions of millions) The eye is only adapted to ~~take in~~ perceive this compass of light, though we know that the spectrum is much longer in both directions, the most energetic actinic rays being past the violet, the most active heat rays past the red. The ear can appreciate sounds varying in intensity from 1 to 128, & thus takes in 7 1/2 octaves of sound, while the

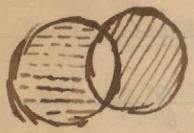
eye can perceive not quite one octave of light. Prisms may be either of glass or of hollow glass filled by different liquids.

When light is passed through certain liquids & solutions, certain intensities of light are absorbed & thus the spectrum produced from it has gaps, thus in permanganate of potash spectrum, all the green is wanting, & so these substances may be recognised by this operation of this kind. &c

Complimentary colours mixed, (as blue & yellow), produce white, when blue & yellow paints are mixed green is produced, but this is only because the yellow neutralizes the blue, & permits the green matter in it to become apparent.

A disc of light with another partly overlapping it may be produced by the Nichols prism, & as this is rotated, one goes round the other, & changes colour as it goes, the ends are also changing but always remaining complimentary

ary to the outside one, & the overlapping portion always remains white.



If the spectrum from the electric lamp be reflected from a mirror, & the mirror rapidly oscilated a streak of white light results, with but a little colour at each end, when it remains stationary for an instant. The image only remains on the retina for 1/10 of a second, & when made to alternate more rapidly than this the colours blend & produce white.

Wednesday December 1. 1869.

Sunlight, when examined spectrascopically is found to be not so perfect, so to speak, as electric light, or other light produced by incandescent solid bodies. It has numerous dark bands. White light may consist of ~~a great~~ an infinite number of colours, as the electric light, or of only two complementary colours, as ~~blue &~~

By operating light by the spectroscope we can determine what its constituents are.

The spectra of solid & liquid bodies are continuous almost without exception, & even that of gases is so when they are under pressure, thus the spectrum of H is continuous when under a pressure of from 10 to 20 atmospheres. We may picture to the mind, that in the solid & liquid, that is to say in the denser states, the particles of matter are not free to move, but when expanded into gases & light vapors they ~~take up~~ assume an oscillatory motion of some particular rate of speed, of which alone they are capable. Thus Magnesium gives a brilliant light partly from its incandescent vapors & partly from particles of magnesia, heated to ignition. Although it appears white to the eye, this light examined by the spectroscope, gives certain definite bright bands, only; representing light of certain refrangibilities, caused by the swinging of the particles of Magnesium

vapor at certain rates of speed, peculiar, to themselves, & of which alone they are capable.

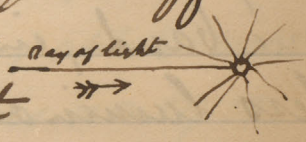
This appearance may be illustrated by the analogy of sound waves. If a string played upon by a fiddle bow be lengthened & shortened, a sort of sliding sound is produced, while if the string remain the same, a constant definite note is produced. The carbon points may be said to give a "sliding light" while Magnesium &c gives definite notes.

The first axiom of spectroscopic science may be said to be, that, Every element in a state of luminous vapour emits rays peculiar to itself. The metalloids [many of them already gaseous require very high temperatures to render them self-luminous. Lithium & Strontium are indistinguishable to the eye, in flames, both giving a red colour, but when analyzed by the spectroscope it is found to be composed of lights of different refrangibilities giving bands in different parts of the spectrum.

Nearly all metallic compounds are decomposed below the point of incandescence of their vapours. Thus the compounds of the metals give the same spectra, as the metals themselves, the temperature of ordinary flames not being high enough to raise the metaloids combined to incandescence. Cuprous Chloride gives a spectrum however, different from Cu, it being able to exist at the temperature employed. This is only the case with a very few substances. As long as no combination takes place, the spectra of any number of substances may coexist. This may be shown by exhibiting the spectra of Cu Zn, & Sn respectively by the electric lamp, & then that of a bit of a halfpenny, which is composed of these three substances. Even the Zn can (at first) be distinctly seen, although only about 1/2 per cent of that metal entersinto the alloy.

$\frac{1}{5{,}000{,}000}$ of a grain of Na can be detected by the spectrascope. The detection of Na is specially

easy, partly because of its very low atomic weight (23) (other things equal, quantities in proportion to combining weights give same effect) & partly because the whole effect is concentrated in two ~~very bright~~ lines, in the most luminous part of the flame. Thallium also gives a very concentrated effect, ~~but~~ having only one band, in the green. But this being a less luminous part of the spectrum, & thallium also having so high a combining weight (204) such small quantities of it are not apparent. White light passed through the vapor of a metal ~~or~~ is sifted from those ~~bands~~ refrangibilities of light, which the vapors itself would emit if incandescent. This is theoretically explained by saying that the particles of Na, for example, are capable of oscilating at one particular rate only, (one note) which corresponds to, & is capable of producing yellow light of a certain quality. If now a ray of yellow light of this

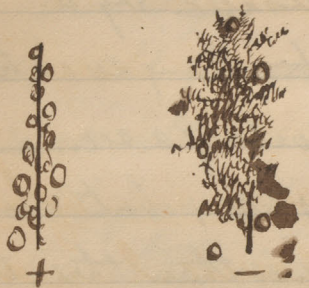
particular intensity, be passed into vapor of Na its vibrations is taken up by the particles of Na, passes through them, & is again propagated to the ether on the other side of the vapor. But the particles being vibrating in all possible directions, the ray, which was at first straight, is now given off in all possible directions, thus: 
so that compared to the rest of the spectrum, this intensity of yellow light now appears dark. This may be shown by passing the light through a vessel of nitric peroxide, & then analysing by prism. nearly all the more refrangable rays are destroyed & by passing the light through Sodium vapor (produced by heating Na sealed in a tube, first filled with H & then rendered vacuous) when the yellow band of Na is represented by a black one. The solar light has passed through a number of such vapors, & thousands of black

bands are cut out of it. Thus the existence of certain substances in the sun has been proved. The same is the case with the fixed stars, & nebulae. The effect of impulses of light striking a particle may be illustrated by a suspended ball. When the ball ~~has been~~ is hung so as to swing seconds, impulses at intervals of a second cause it to describe a longer & longer arc; but when the impulses are more rapid or slower than this, the ball not being able to respond to them remains almost stationary.

Thursday Dec 2nd

When the electric current is passed through a solution of a compound, it is separated into two bodies, or classes of bodies, one going to the positive & one to the negative pole. The metals, (in solution) thus treated go to the negative pole, & appear when magnified to be deposited in beautiful crystalline

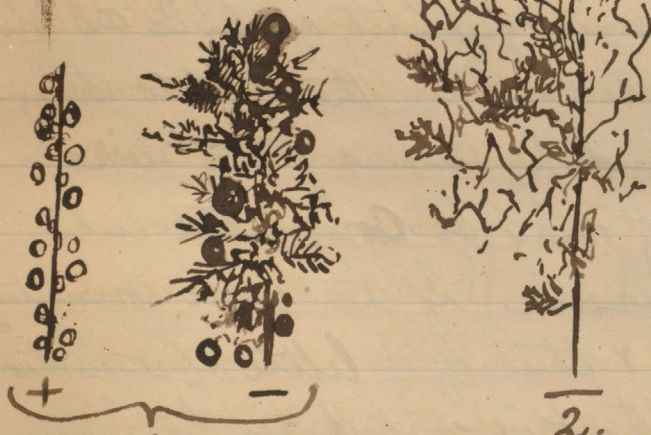
forma. This may be shown by attaching the microscope to the electric lamp, & throwing the image of the two poles of the battery, contained in a small glass cell upon the screen.



$SnCl_2$ thus treated gives beautiful pond like crystals of Sn on the negative pole, while Cl is evolved copiously at the positive. Bubbles of H also come off at the ~~positive~~ negative pole from the decomposition of part of the water. (The appearance & arrangement is rudely shown above.) When the current is reversed (poles changed) the Sn immediately dissolves away in the nascent Cl & deposits again on the opposite pole. After the current has been reversed several times the substance crystallizes more beautifully, the reason of this very curious phenomena has not been explained.

Plumbic Acetate may also be well be decomposed in this way, & produces very beautiful

frondosa cristata. When the current is
divided however, as long as any of the previous
deposit remains undissolved, the crystals form
in quite a different way, long & branching,
(not unlike some trailing lycopodiums) as
shown below at 2. [This is a very
curious fact]



2.

The production of heat
by chemical union.
may be pictured in
two ways. First
that particles having
a rapid proper motion
come into collision
& are thus brought to rest, with evolution of
heat. or Second that particles at rest, are
drawn together by their mutual attractive force
& by collision produce heat. It does not
matter how we picture it to the mind, but
Under certain conditions this energy instead

of becoming evident as heat, appears as electricity. When Zn is dissolved in dilute $SO_2 HO_2$ & changes into $SO_2 ZnO$" heat is evolved; but, if a piece of Platinum foil, be connected to the Zn by a wire & both immersed in the acid, very little heat is evolved but a current of Electricity results, & the same quantity of Zn is dissolved The current passes between the metals through the liquid, & round by means of the wire. This electricity may be converted into heat by several means. If the wire connecting the plates be thick & thus offer little obstruction to the current, heat is evolved in the liquid, but if a very thin wire be used, the liquid in the battery remains cool, while the wire soon becomes hot & glowing, & with a strong battery it may be fused, even if it be Pt. El-is thus converted into heat either in the cells of the battery, or in the wires conducting it.

In both cases it is immediately converted into heat & dispersed, but the force generated may instead be stored up for an unlimited time. Thus if water be decomposed by the current the heat is stored up in the liberated O & H., & the force otherwise immediately evolved as heat associates itself with the particles of O & H.; & may at any time be evolved by causing them combine. In either case the ultimate result is the same. [(It would be interesting to know which is the most stable, or normal condition of force.)] Processes of decomposition like those described above, are called electrolysis, the substance decomposed called the electrolyte. It takes place strictly in accordance with Chemical combining proportions, or equivalents, & the number of active bonds, thus Zn, a dyad, is liberated in the proportion of 65 parts by weight, to every 2 of H.

The laws of the decomposition of Chemical Substances by electricity are, as follows.
(as ascertained by Faraday & in this table modernised)

1. The liquid condition is necessary to electrolysis
2. Electrolytes must be compounds & Conductors of the electric current. These compounds generally consist of a conductor & a non-conductor of electricity
3. All compounds which suffer decomposition when dissolved in water, do so when fused.
4. The electrolyte is ~~impelled~~ resolved into its two constituents, which impelled in opposite directions, are eliminated at the opposing surfaces of the two electrodes, & never in the intervening liquid.
5. O, Cl, Br, I, & acids appear at the positive electrode, whilst, H, Metals & the alkalies are evolved at the negative.
6. The quantity of electricity which passes through the electrolyte, is always directly proportional

to the quantity of the electrolyte which is decomposed.

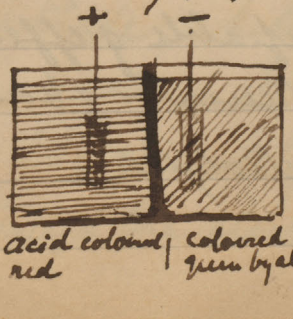
7. All compound molecules possessing the same active atomicity to be overcome; require, if decomposable the same quantity of electricity to decompose them Therefor if the same electric current be passed through a number of metallic solutions in succession, the metals will be reduced in the ratio of their atomic weights, divided by their active atomicity

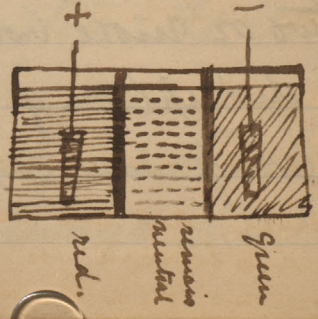
8 The quantity of electricity which a compound molecule requires to decompose it, is equal to the quantity which that molecule evolves, when decomposed in the generating cell of the battery

9 The quantity of electricity evolved by the union of two or more bonds, is capable of effecting the disruption of the same number of bonds, in any compound capable of electrolysis.

Note to rule 1. There must be mobility of particles, to allow electrolysis to take place.

Note to 4. This may be shown by a solution of NaCl coloured by indigo, placed in a cell, & thrown upon the screen by the electric light & microscope. The Cl liberated at the positive pole bleaches the solution. It may also be shown by electrolysing a solution of sodic sulphate coloured by red cabbage in a cell, in which the poles are separated by a diaphram of blotting paper. The solution in which the positive electrode dips, by the liberation of $SO_2 H_2O_2$ becomes yellow, while on the other side of the diaphram it is rendered green by the soda. It may be further proved by dividing a cell filled with the same solution into 3 parts by blotting paper diaphrams. The solutions at





the two side divisions are coloured respectively Red & green, while the centre retains its original tint. (Figs 1 & 2.)

Electrolysis

Weights of various chemical compounds, requiring for their decomposition equal quantities of electricity.

Water	$O''H_2$	9.0 Grms
Hydrochloric acid	HCl	36.5 "
Argentic Chloride	$AgCl$	145.5 "
Cupric Chloride	$Cu''Cl_2$	67.2 "
Cuprous Chloride	$'Cu_2Cl_2$	99.0 "
Plumbic chloride	$Pb''Cl_2$	139.0 "
Antimonious chloride	$Sb''Cl_3$	76.2 "
Plumbic iodide	PbI_2	230.5 "
Plumbic acetate	PbA_2	162.5 "
Cupric sulphate	SO_4Cu''	79.7 "
Zincic sulphate	SO_4Zn''	80.5 "
Stannous chloride	$Sn''Cl_2$	94.5 "
Ferrous chloride	$Fe''Cl_2$	63.5 "
Ferric chloride	Fe'''_2Cl_6	54.2 "

Twice as much copper is liberated in Cupric chloride, as in cuprous, because there is only one bond to liberate in the cupric chloride (the bond connecting the two atoms of Cu is not (of course) now separated)

There is a very close connection between Chemical & electrical force, as evinced by the quantity of electricity needed to decompose a certain number of bonds being always equal.

When a metal capable of decomposing OH_2 is electrolyzed, as soon as the metal is liberated at the negative pole, it acts upon the water & decomposes it, liberating H.

The metals have a very various specific gravities the heaviest & lightest substances being included among them, ranging from lithium & iridium. This may be well shown by a series of models of the different metals, of the size of a block weighing a pound.

The Cohesive power, tenacity, hardness, & brittleness of the metals is also very different. Li, Na, Rd, &c are hard enough to scratch glass, Na & K are soft enough to be moulded in the fingers. The crystalline metals are often very brittle. The criterion which the different varieties of

iron can bear, depends partly upon the crystalline structure. Their order of strength is as follows, beginning with the strongest wrought iron, grey cast iron, & white do.— The order of strength in resisting a crushing weight is exactly the reverse. The tenacity of iron & steel, is greatly surpassed by that of Co & Ni.

Ductility & malleability arrange the metals in nearly the same order, these properties depend also on the tenacity possessed.

Gold can be hammered out into leaf 280,000 of an inch thick. Iron 2·500 of an inch.

Monday Dec 6th.

By referring to the table of atomic weights, it will be found that the strength of affinity of the non-metallic elements are inversely as their atomic weights when looked at in their natural groups. Thus in the group, Sulphur, selenium,

tellurium, the strength of affinity is in the order here written, but the combining weights are in inverse order, thus 32, 79, 128,
Also in the group, Fl, Cl, Br ~~I~~. 19, 35.5 ~~127~~. 80, 127. The precise reverse of the obtains with the metallic or negative elements. The stronger the combining affinity the greater the combining weight. Thus Na, K, Rb, Li, Cs is the order of strength of combining weights for the metals of the alkalies ~~and~~ and that of the atomic weights agrees with it. Also in the alkaline earths Ba, Sr, Ca, Mg.

The metals may be classified according to various principles, that of the order in which they are precipitated in analytical research being the most useful. That proposed by Thenard is however a good one & depends upon their affinity for O as shown in their behavior towards water

Thenards classification of the Metals.

I Metals which decompose OH_2 at 0° Cent
Potassium, Sodium, Lithium, Barium, Strontium
Calcium.

II. Metals which decompose water at from 60° to 100°
Magnesium, Manganese.

III. Metals which decompose water at a red heat.

α Those which decompose readily at ordinary temperatures	β Those which act feebly on acids.
Iron, Nickel, Cobalt	Tin, Arsenic, Antimony.
Zinc, Cadmium	
Chromium, Aluminium	

IV. Metals which decompose OH_2 at a white heat, whose oxides are not reducable by heat alone
Copper, Bismuth, Lead.

V. Metals not acting on water at ordinary temperatures, but whose oxides are reducible by heat alone
Mercury, Silver, Gold, Platinum.

Most metals absorb O when moist, slowly. O acts more readily, is probably in a condition of greater activity when dissolved in water. And

as substances even attract a film of moisture when the air is not saturated with it, they are very often in this favourable condition for oxidisation. The attraction of moisture especially by glass & porcelain may be proved from the fact, that if a porcelain crucible be washed & then carefully dried out with a cloth, it is found to be lighter when again put in the balance. Under these circumstances some metals tarnish only, while others rust this often depends upon how many oxides the metal forms. Thus Zn forms only one oxide & only tarnishes the film of tarnish formed protecting the rest of the metal from the effects of the O. While Fe when it once begins to rust, goes on rusting deeper & deeper The first product of the action of the air on Fe is probably Ferrous Carbonate a oxide. This however does not form a permanent film as it is capable of further oxidisation, & changes into ferric hydrate which is ordinary iron rust. This is capable of yielding O easily, even to

Fe, this it does, & thus is far from protecting by giving up O helps on the decomposition.

Metals which oxidise at ordinary temperatures usually inflame at a red heat.

The affinities of the metals for Cl are very similar to those for O, but being stronger, many metals are spontaneously inflamable in that gas.

Gold, Silver, Platinum, Rhodium, Mercury Bismuth & (Copper) not having very strong affinity for O or the electropositive elements generally occur native,

Other metals having more powerful affinities for O & electropositives, usually occur in combination with O, S, or As. also in combination with insoluable silicates &c (as Malachite.)

The metals of the alkalies & alkaline earths never exist as oxides, the oxides themselves being so powerfully negative; but as salts. And occur as, rock salt, gypsum, Feldspar &c.

They are characterised by the simplicity of their

Compounds, & are the most difficult of reduction of all the metals. The reduction of the first of them being only effected in 1807 by Sir Humphry Davey.

The Cofounds of the alkalies being mostly soluable the great reservoir of them is the water of the ocean, they also occur abundantly in some mineral springs. They also posess spectra of considerable simplicety, especially if not too highly heated.

Potassium occurs insoluable as silicate in rocks & soils, & also soluable, as potassic Carbonate, in soils, & in the juices of plants, more especially in the more succulent parts of them. The chief commercial supply of potash has been & yet obtained from plants, it is necessary to their growth, & is found in them in a somewhat concentrated form. It is obtained from them by burning timber in pits, the ash thus obtained is treated with slaked lime, & then

lixiviated, the ley thus obtained is boiled down & the mass remaining is raised to fusion, & then poured out. This constitutes American potash & commonly contains about 80 per Cent of potassic hydrate. It may be purified by redissolving & crystallising out the more valuable salts. It is converted into potassic Carbonate by placing it on the sole of a reverbratory furnace. The Current of CO impinging on its surface combines with it to form CO_3K_2 (Pearl ash) this however always contains as impurities potassic Chloride & Calcic sulphate, which are very hard to get rid of. If wanted pure CO_3K_2 must be prepared from lixiviating the product of potassic tartarate when ignited, (black flux) which consists of CO_3K_2 mixed with C. As thus prepared it is called salts of tartar.

The Organic source of potash is now rivalled by an inorganic one, which promises to ultimately supercede it. It is found that certain layers in

some German salt mines, consist to a large extent of potassic chloride. The formation of these layers may be accounted for by supposing a sea, like the Dead sea in modern times, receiving the drainage of a large extent of country & afterwards by some alteration of level cut off from other supplies. The result would be, that as it dried up the least soluble salts would crystallize out first & the potassic & magnesic chlorides would be the last to do so, & thus form a seperate layer. This substance which has been called Carnallite can be readily changed into the Carbonate by the same process as that used for reducing a like change in NaCl.

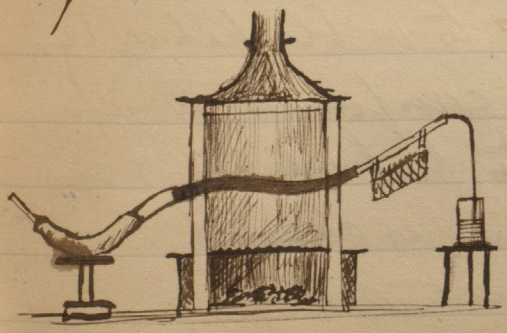
Composition of Carnallite (two analyses)

KCl	27·44	24·27
$MgCl_2$	35·03	30·98
$NaCl$	—	4·82
$CaCl_2$	—	2·82
$SO_2 CaO$	—	1·05
Fe_2O_3	—	0·14
OH_2	37·53	35·92

The Metal potassium may be obtained from the carbonate. It may be obtained from OKH by electrolysis & was thus first made by Davey. The potassium comes off at the positive pol & the hydroxil at the negative this is however by no means a good process, as the temperature caused by a battery of sufficient strength, is so great that most of the potassium formed is immediately decomposed.

$$2\,OKH = O_2 + K_2 + H_2 \cdot (HO_2)$$

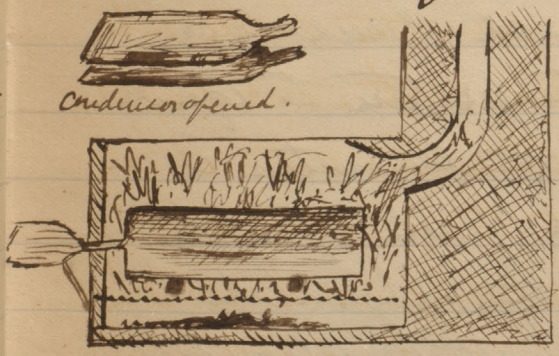
The process of Gay Lucasse & Thenard, which consisted in deoxidising OKH by metallic iron heated to whiteness in a gun barrel, soon superseded that of Davey. The apparatus used is shown below, the OKH is melted in the slanting portion of the tube as soon as the gun barrel has been raised to whiteness & runs down among the iron filings & borings contained in it. Most of the H liberated goes off by the tube dipping below the water, while the K condenses in the bent tube



This process though an improvement on Davy's was not a good one. It is now superseded by one similar to that employed for the ordinary metals. Pot Cream of tartar is ignited & the black mass thus obtained, consisting of potassic Carbonate & Carbon, Not being sufficiently porous is mixed with charcoal in large grains, to the extent of about 1/3 or 1/4 of its bulk. This mixture is then introduced into any convenient vessel as a Mercury bottle. This is placed in a furnace, heated by wood (the S in coal corrodes the iron bottle) An iron tube passes from the bottle into a condensing vessel filled with Coal naphtha (which contains no O & thus does not act on the K) This tube is apt to be blocked up by condensed potassium & a compound which that metal forms with the produced CO, so that a sort of corkscrew is arranged so that it may be cleaned out without

disturbing the apparatus. The most modern & improved form of this apparatus has a differently shaped condenser which is merely immersed with naphtha, & made flat to allow the cooling action of the air. The reaction begins when the bottle is heated to full whiteness & is known to have commenced when on looking in by the tube the vessel is seen to have an emerald green colour, caused by the vapour of potassium, & also by the CO burning with a purple flame.

The reduction of K is attended with considerable difficulty & great danger, when not carefully done. The compound of K & CO formed is not dangerous as long as it remains perfectly dry, but when the apparatus has been left sometime, & the Oxycarburet of potassium formed becomes damp



it is liable to excedingly violent explosions.
The potassium thus obtained is far from pure, being mixed with this compound, also potassic carbonate & hydrate. It is subsequently rectified.

The Atomic weight of K is 39 & the probable molecular weight double (78). It melts at 55.5° & boils at a low red heat. Atomicity 1. It is pasty at 25.5° but at the freezing point brittle. It crystallizes in cubes, & has a colour & lustre like Hg. It has a great affinity for O & decomposes OH_2 with great readiness causing a sufficient elevation of temperature to ignite the liberated H, & when the combustion is complete the OK^{H}_{H} formed floats upon the surface of the water in the spheroidal state & then combines with it explosively.

Tuesday Dec 1st

Potassium is capable of liberating C from its compound with O (CO_2) which may thus be said to be a supporter of Combustion. The reaction when K is burned in a stream of CO_2 is as follows $2K_2 + 3CO_2 = 2CO.K_2O_2 + 3C$

Potassium combines with Cl. Br. I & F.

The Potassic Iodide is the only one of importance. It is prepared by digesting iron filings & Iodine in water. Ferrous iodide is then formed, & the Fe easily replaced by adding potassic Carbonate. Potassic iodide crystallizes in the cubical system & is isomorphous with Na Cl.

Potassic hydrate, an important compound of K with hydroxil. It is formed by acting on potassic carbonate by Calcic hydrate. A quantity of $CO.K_2O_2$ is dissolved in not less than ten times its weight of OH_2. If the solution be too strong the potassic hydrate reacts upon the Calcic Carbonate formed & retakes CO_2. The solution ought also to be boiling when the $Ca\,H_2O_2$ is added

so that the CO Cao" formed may fall in a crystalline powder & not remain suspended in the fluid. The clear liquid is decanted off & boiled down in iron, as if wanted pure, in silver vessels. When the water has been driven off the OKH is raised to fusion & then poured out & allowed to harden, or very frequently cast into sticks in silver moulds.

With acids OKH gives salts of Potassium

Potassium forms three compounds with O

Monoxide analagous to OH_2, OK_2

Dioxide analagous to $_2OH$ $\left\{\begin{matrix}O\\O\end{matrix}\right.^{K}_{K}$ $(_2OK)$

Tetroxide $\left\{\begin{matrix}O\\O\\O\end{matrix}\right.^{K}_{K}$

OK_2 may be prepared by acting on OKH by metallic potassium; thus,

$$_2OKH + K_2 = 2OK_2 + H_2$$

$_2OK$ may be formed by burning K in a current of O, with OH_2 it decomposes with violent effervescence & yields O $2\left\{\begin{matrix}O\\O\end{matrix}\right.^{K}_{K} + _2OH_2 = _4OKH + O_2$

Potassium forms a series of Compounds with S like those with O, but more Complete.

Dipotassic sulphide SK_2 Dipotassic disulphide K_2S_2 Dipotassic trisulphide K_2S_3. Dipotassic tetroxide K_2S_4 Dipotassic pentoxide K_2S_5. Dipotassic hexoxide K_2S_6? So called "liver of sulphur" consists of a mixture of several of these higher oxides. SK_2 is sometimes wanted in the laboratory & is prepared by heating the sulphate with powdered charcoal; thus.

$$SO_2K_2 + {}_4C = SK_2 + {}_4CO.$$

Sodium, occurs as NaCl in large quantities dissolved in the sea, & as solid strata in the earths crust. It is also found combined in insoluable silicates, & in small quantities in all spring water. There are large deposits of Rock salt in some parts of England, but nothing in comparison to the immense quantities which are found in Poland.

Sodium may be obtained (as was first done by Davey)

by the electrolysis of fused NaHo. The fused mass being in a crucible & the negative pole being a charcoal pencil. This however is not a good or easy process for obtaining the metal. This metal is manufactured on the large scale chiefly at Newcastle, & as very similar to that employed for Potassium.

A mixture of the following ingredients is made

Dried sodic carbonate	717	this is made into
Powdered charcoal	175	a stiff paste with
Finely powdered chalk	108	oil & calcined in

iron pots. Very finely divided carbon is thus brought into intimate contact with the mixture. The mixture is then put into earthen retorts & the Na distilled over. The proportion of Sodium thus obtained is almost as great as would be theoretically anticipated. The process is much easier than that for K, as Na forms no compound with CO, similar to the very dangerous oxy Carbide of Potassium.

The reactions of Sodium, are very similar to those of K but less energetic. On water it fuses, & runs about with a hissing noise, caused by the libration of H, but does not raise the temperature sufficiently to ignite the H_2 in cold water. On boiling water however it ignites & also in cold when it is floated upon a piece of filter paper, thus allowing only a limited access of OH_2.

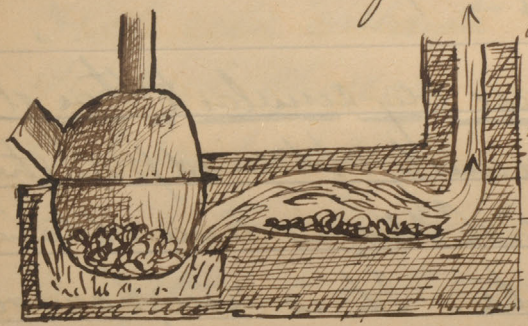
The Compounds of Na are very similar to those of K Sodic carbonate was formerly obtained from the ashes of sea weeds, just as CO_3K_2 is now obtained from those of land plants. It is now however only thus obtained as a by-product of small importance, in the manufacture of I.

Leblancs process for producing CO_3Na_2 from NaCl is now universally used. The NaCl is first transformed into SO_4Na_2 by the action of concentrated SO_4H_2 (spec. grav 1·6) taken as it flows from the sulphuric acid chambers (which

are usually in connection with the Alkali works. (This preliminary charge is an objection to the process, but no other has been found which can supersede it.) (product called salt-cake)

$$2NaCl + SO_2HO_2 = 2HCl + SO_2NaO_2$$

the HCl which results is condensed in coke towers. The operation is carried on in an iron vessel of this shape, which would be



much corroded if the process was completed in it. Before it is finished however the mass is scooped into the hole of a reverberatory furnace, conveniently situated & in this the HCl is completely driven off. The sulphate is next reduced to sulphide by mixing it with chalk (or limestone) & carbon (as coal dust) placing it in a reverberatory furnace & fusing it. The carbon acts upon the SO_2NaO_2, removing the O; ~~[illegible]~~, & leaving Na_2S this as soon

as formed is acted upon by the CO Caö, & sodic Carbonate, calcic oxysulphite & Carbonic oxide result.

$$5\,SO_2Na_{2}O_2 + \cancel{2\,CO}\ 20C = 5\,SNa_2 + 20CO;$$

$$5\,SNa_2 + 7\,COCaö = 5\,CO\,Na_{2}O_2 + 5\,CaS'',2CaO + 2\,CO_2.$$

If this oxysulphite did not form the process would not work, it would stop short at the stage before. The product thus obtained is called black ash. The sodic carbonate (soda ash) is obtained by dissolving it out by OH_2 the oxysulphide of calcium being insoluable.

The greatest disadvantage of Leblanc's process is the <u>loss of S</u> in the $SO_2\,Ho_2$ used, which goes away in the waste oxysulphide. A process has however been devised, & is now coming into extensive use whereby 1/2 of the S may be saved. <u>The oxysulphide of calcium</u>, (which usually forms large mounds round the alkali works) is exposed in vats to the action of the air, which

partly changes it into soluable sulphide? & hyposulphite of lime. To this solution is added an excess of HCl (as obtained from the cake towers) which gives a copious precipitate of S. This is collected & melted (best in vessels containing superheated steam). This process used to take place naturally in streams running from the alkali works & poison the neighbouring air with quantities of SH_2.

Lithium Li, is met with in nature in the minerals, Lepidolite, Spodumene & petelite. also in some waters, & in the ash of some plants as tobacco. The metal is best obtained by the electrolytic method. Lithic chloride is used, & fused in an earthen crucible. The poles of a battery are then introduced into the fused mass; the positive being a coke pencil, & the portion a platinum like iron wire. The Li collects on the wire in small masses. Lithium is harder

than potassium though not so hard as lead. Is the lightest known solid floating even on naptha. It can be pressed, but not drawn into wire not possessing sufficient tenacity. It burns brilliantly in air & O showing when there in combustion, a very different colour from the red of its salts, which is so like that of Sr. When becoming cool however it exhibits the characteristic red. It decomposes water but not so readily as K or even Na, not even igniting the H when in contact with boiling OH_2.

Wednesday Decr 8th

Caesium & Rubidium resemble K & Na very closely & generally occurs associated with them. They are seperated from K by precipitating all three with $PtCl_4$ dissolving the potassium salt, the those of Cs & Rb being almost insoluble. The metals are then turned into

carbonates & the Caesic Carbonate dissolved out by absolute alcohol. Rubidium is positive towards K & Caesium to Rb, so that Cs is the most positive element known

Thallium Tl. 204 Occurs in small quantities in some iron pyrites, especially some Belgian & Westphalian samples. It also occurs in some native sulphurs, but these were probably derived originally from pyrites.

It is obtained in small quantities from pyrites imported from Norway to this country for the manufacture of $SO_2 Ho_2$. The pyrites is burned, as already described in kilns & the S led away by flues as SO_2. The thallium accompanies this gas, as Thallic oxide, but soon deposits as a fine dust in the flues, together with ashes, &c. There is sometimes as much as 5 or 6 per cent of Tl in this dust, but generally not more than 1, 02. The dust

is first treated with OH_2 which dissolves the oxide of Tl. The solution is then precipitated by HCl (Thallic chloride) The chloride is changed into the sulphate & when Zn is introduced into this solution metallic Tl deposits. The Specific gravity of Tl is greater than that of Pb being 11.9: It is soft like lead, marks paper, & becomes encrusted with oxide in the air, this oxide is strongly alkaline. It melts at 550° Far, & produces the most simple spectrum which we know, consisting only of one line in the green. When heated strongly it burns, like antimony. It decomposes OH_2 at a red heat. SH_2 precipitates thallic solutions as a sulphite, insoluble in SAm_2. Thallium as would be expected from its high combining weight, has greater combining energy than Ag. The Chloride Bromide, Iodide, & Chloride are insoluble. Its atomicity I & per haps III. Thallic carbonate may be formed by exposing the metal under a layer of OH_2 for some time. The oxide is formed & combines with the CO_2 in the OH_2. Thallium has been proposed for obtaining a very dense glass of high separable power more so than that obtained with Pb.

Silver[108], is a very widely diffused element & is obtained in large quantities chiefly in Peru Mexico, Liberia, Austria, France & England It is most usually found combined with S as SAg_2. This is generally associated with large quantities of other Sulphides, as galena which always contains more or less Ag, & Blende. Ag also occurs as horn silver (AgCl) & still more rarely as a molecular compound of the Bromide & Chloride. It is also found native.

The processes for reducing Silver from its ores, are of two classes, which may be designated as (1) imbibition (2) Amalgamation. These processes are closely allied in the first Ag is dissolved in Pb in the second by Hg.

(1) If there be a sulphide it must be first reduced to oxide, by exposing it, heated to redness to a stream of O. If the Ag be contained as sulphide among galena. Oxides of Ag & Pb are thus formed. These are mixed with charcoal & reduced by

heat. If the ore is very rich it may at once be cupelled, that is to say exposed in a current of O at a red heat, Litharge forms & is skimmed off, while the alloy becomes richer & richer in Ag (Ag not oxidising directly at any temperature) till finally nothing but a globule of pure Ag is left. If the lead however contains less than 3 to 4 ounces of Ag in the ton it must be first enriched by Pattinsons process.

This is carried on as follows.

9 large iron pots are arranged in a row, (one in the centre, & four at each side) 5 tons of Pb are melted in the centre pot, & allowed to cool slowly. Now as the alloy of Ag & Pb is more fusable than Pb alone. Pure Pb crystallises out, & as fast as it does so is removed by a copper colander, into the first pot to the left, till what remains is no more than 1/4 or 1/6 of the original. This residue, is then ladled out into the first pot to the right, & a fresh charge put into the centre pot. The vessels to the right & left are operated upon in the same way,

tile when the material arrives at the Casting pot to the Right, it contains as much as 300 ounces of Ag to the ton, while that at the left only has about 1/2 an ounce to the ton. The argentiferous Pb is then expelled with steam. This process is employed in Norway & universally in this Country.

(2) The Amalgamation Process. This is the process usually employed in Mexico.

The ore is ground & washed & mixed with from 1 to 4 per cent of Na Cl. The mixing being accomplished by the treading of mules or horses which is continued for some days, some "magistral" (roasted copper pyrites) is then added, (this contains cupric sulphate) & next a quantity of Hg. The mass is then again thoroughly mixed by the tramping of mules, & allowed to stand 16 to 20 days; a second & afterwards a third dose of Hg is added. And finally the Hg is collected & distilled off

leaving a mass of Ag in an impure state. For every 100 parts of Ag obtained about 150 of Hg are lost. The process is purely empirical. The rationale is as follows. The Ag is converted into AgCl by the NaCl but being incapable itself of liberating the Cl, the $SO_2 Cuo$ forms cupric chloride & yields one atom of Cl to the Ag, being converted into cuprous chloride $Cu'_2 Cl_2$. The AgCl dissolves in NaCl. The Hg often displaces the Ag & forms calomel ($Hg_2 Cl_2$) & the Ag combines with the extra Hg present forming amalgam

$$2\,AgCl + 4\,Hg = {}'Hg'_2\,Cl_2 + {}'Hg'_2\,Ag_2$$

Ag is a white metal with a yellowish tinge. It takes a high polish. It melts at about 1000° Cent, is malleable & ductile & can be drawn out to wire 1/10 000 of an inch thick. Ag dissolves a large quantity of O when fused, about 22 times its volume. This is suddenly expelled on solidification & sometimes throws the Ag about. Ag sulphurises at ordinary temperatures but does not oxidise. It is

not effected by pure water. It is acted on by hot Concentrated SO_2H_2 & thus resembles Pt NO_2H_2O readily dissolves it, & at red heat it decomposes HCl.

Standard silver in England consists of 11·1 Ag & 0·9 Cu. The copper makes it much harder. The French standard is lower being in the proportion of 9 of Ag to 1 of Cu.

Comparison of the Spectra of elements, there is a certain apparent connection between the atomicity of the metals & their spectra. The fewer the number of bonds (power of combining with a certain number of donsy H) the more simple appears to be the spectrum, this may be especially observed between monads & dyads. The power of vibrating to different intensities seems to depend to a certain extent ~~upon~~ directly upon the number of bonds.

Thursday Dec 9th

Barium 137. ". Found largely in nature as basic sulphate (heavy spar) which constitutes the gangue of many metalliferous veins.

Baric oxide may be prepared by calcining the nitrate, In contact with OH_2 it is converted into basic hydrate with great evolution of heat; thus. $BaO + OH_2 = Ba Ho_2$

Baric peroxide, prepared by passing O over BaO or $Ba Ho_2$ heated to dull redness. Or by heating basic oxide in a crucible to redness & gradually adding potassic chlorate. by the action of Heat BaO_2 splits into BaO & O. By the action of steam at the same heat at which it was originally formed it yields O & Basic hydrate. On This depends a process proposed by Gay Lucasse for the preparation of O. Baric oxide was heated in a current of air, & when it was converted into BaO_2 the air shut off & a current of heated steam passed instead, the O carried away with the steam being collected in

gas holders. This process however has not succeeded on the large scale, because of the great quantity of fuel required.

By the action of acids on BaO_2 hydrogen is formed. The salts of Ba are easily prepared from the native carbonate.

Strontium 87.50 occurs in nature in a manner exactly analagous to Ba, as carbonate strontianite & sulphate celestine.

Metallic Sr is only prepared with great difficulty. The best process is by electrolysing fused strontic chloride. Sr is malleable & of a pale yellow colour. Its compounds closely resemble those of Ba & are obtained by analagous processes. Strontic is more easily decomposed by heat than basic carbonate & calcic carbonate with even greater ease than the order being as follows Ba hardest to decompose Sr, Ca,

40. "

Calcium occurs abundantly in nature, as Calcite, Gypsum, Fluor spar &c.

The metal may be obtained by processes similar to those employed for Ba & Sr. It is white, & has a bronze colour. It is ductile, tarnishes in the air, & burns readily when heated to redness in air or O. Calcic Oxide is prepared on the large scale by burning limestone ($CO_2 CaO$) mixed with Coal.

The salts of Ca are similar to those of Sr & Ba. Calcic Hydrate is formed by the action of OH_2 & CaO. Chloride of lime appears to be Calcic Chloro hypochlorite. Hypochlorous acid is monobasic its formula Cl HO. Ca is dibasic, & it may be supposed that one bond of each atom of Ca is satisfied by Cl & the other by Cl HO, thus.

Cl
|
Ca
|
O
Cl

The theory of its being such a compound is made probable as if it contained calcic chloride & hypochlorite, the $CaCl_2$ would cause it to be deliquescent.

It is prepared by exposing Calcic hydrate in a stone chamber arranged as stone shelves &c to an atmosphere of Cl, gradually admitted so as not to allow the temperature to rise much.

Ba, Ca, Sr, all form dihydric dicarbonates when the carbonates are exposed in solutions containing an excess of CO_2, thus if CO_2 be passed through lime water it at first occasions a ppt which afterwards dissolves in the excess of CO_2 as $\begin{cases} CO\,HO \\ CaO \\ CO\,HO \end{cases}$ This compound & a similar one of Mg make waters "hard"

Magnesium. Is found abundantly as Calcic & magnesic carbonate, in Dolomite $\begin{matrix} CO \\ CO \end{matrix}\begin{matrix} Ca \\ Mg \end{matrix}$

Brucite is a natural hydrate of Magnesium.

The metal is now manufactured on a somewhat large scale, by fusing together a mixture of Magnesic chloride, potassic chloride & Sodium. It is prepared by distilling

in a current of H. It is brittle at common temperatures but malleable & ductile at a red heat. Heated to its melting point it burns with great brilliancy, & gives of light of a high actinic quality. The intensity of the light of Mg as measured by its chemical power is about 1/36 of direct sunlight. Its visual intensity is only about 1/574 of sunlight. A negative copy of an engraving has been taken by Mg in about 50 seconds. Mg gives off by far more light ~~the~~ weight for weight than any other substance. The spectrum of Mg contains besides its own peculiar spectrum of bright lines, a continuous spectrum due to the ignited particles of Magnesia. Magnesium at present costs about 1oz a guinea an ounce

Weights of Mg & other materials, giving an equal quantity of light.

2 1/2 ounces of Mg	£1 " 6 " 3
20 lbs of stearine candles	1 " 0 " 0
440 Cubic feet of Gas	1 " 9½

Mg generates very little ~~light~~ heat compared to the ammount of light which it gives. Candles give about twice as much heat compared to the light given as gas. Mg gives 265 times less than gas. From this it follows, (even supposing that Mg converts all its force into light, which is by no means the case) that only 1/265 of the force of gas is liberated as light, the rest being given off as heat. Mg slowly decomposes OH_2 at ordinary temperatures. It forms only one oxide. Magnesic hydrate is very slightly soluable in OH_2. The order of solubility of the hydrates of this group is as follows, Ba, Sr, Ca, Mg. Magnesic salphate, is prepared from Dolomite. Calcic salphate being insoluable they are easely seperated. SO_2 Mgo" is now however almost exclusively prepared from a native carbonate imported from Greece. It differs from the salphites of Ba. Ca Sr. by its great solubility.

Zinc occurs as oxide, or red zinc ore, as carbonate, Calamine, & sulphate, blende. It has been known in Europe since the 16th century, and in China India & from time immemorial. Zn is reduced by a somewhat peculiar process. If the ore be oxide, which is seldom the case it may be mixed with charcoal & at once introduced into the crucible. If it be calamine or blende, it must be oxidised by heating on the sole of a reverbatory furnace. The oxide & charcoal are then placed in a closed crucible, which has a tube passing up through the bottom nearly to the top, & above the surface of the mixture. Below it nearly touches the surface of a vessel of water. When

heat is applied the Zn rises in vapour & passes down the tube, becoming condensed & falling into the water in drops. (Spelter)

Zn is a bluish white metal & is capable of receiving a good polish. It is tough at ordinary temperatures, but brittle when exposed to cold. Its vapour burns brilliantly in atmospheric air. It is attacked by almost any acid.

Zincee Hydrate may be prepared by acting on the sulphate by OKH or NaHO. The property of Zn in protecting Fe, in galvanized iron depends upon the Zn being the positive in that combination, And thus being attacked in preferance to the Fe. The opposite obtains with tin plate where Fe being the positive, when once it becomes exposed the galvanic influence causes it to be attacked in preferance to the tin which thus helps to rust it.

Zn enters into several alloys. It only forms one oxide, which may be obtained by burning Zn, or passing hot steam over it.

Monday Dec 13th 1869.

Cadmium Cd". 112. Is almost universally associated with Zn, & all Zn ores contain more or less of it. It is more volatile than Zn and comes over among the first products of the distillation in the reduction of Zn. This is technically termed by the workmen "brown blaze". This may be collected & afterwards further purified by fractional distillation, or distilling it several times & always saving the more volatile portions. This is then dissolved, & the Cd & Cu (which is always present) precipitated in the acidified solution, by SH_2. The precipitate is washed, redissolved & converted into Carbonate, then the $CdCo_2$ is dissolved in excess of the precipitant & the Cadmic Carbonate, which is insoluable, remains pure. The Hydrate may be obtained by precipitating any solution of the salts by OKH or $NaHo$. Cadmic sulphide precipitated by SH_2 is used as a pigment, & varies in shades of colour, according to the strength of the solution employed &:

Mercury. Hg = 200. Is found native, & as cinnibar (sulphide) chiefly in Almaden, in Spain; in Pennsylvania, California, China & Japan. The ore is usually mixed with much earthy matter, but is sometimes as much as 80 or 90 feet thick in the vein. Mercury is reduced from the sulphide, by first converting this mineral into oxide by roasting in a current of air. The oxide at the temperature at which the operation is carried on immediately decomposes into Hg & O. The volatilized Hg passes on & is condensed in Cool receivers. By another process, the ore is mixed with an equal weight of quicklime, & heated in earthenware or iron retorts. The S combines with the lime as Calcic sulphide & the Hg in the first instance combines with the O from the lime, but is instantly liberated & passes off as vapour. Thus

$$HgS + CaO = CaS + HgO. \quad HgO = Hg + O$$

Hg is liquid at ordinary temperatures & does not tarnish in the air. It does not decompose sulphuretted hydrogen. From these qualities it is very useful for collecting gases, especially such as are acted on by water, & which without the aid of Hg it would be impossible accurately to determine. Its specific gravity is 13.59. It melts at -40° & boils at 360° Cent. It is malleable, & soft when solid. When boiled with $SO_2 Ho_2$ it is slowly acted on. It is however very readily acted on by $NO_2 Ho$ & forms either mercurous or mercuric nitrate, according to the excess of Hg or acid &c. It is largely employed for the amalgamation of silver & gold in seperating these metals from their ores, also in the construction of philosophical instruments & for the manufacture of mirrors. The "silvering" of glass for this purpose is accomplished by spreading out a sheet of tin foil of the size of the mirror required, & after having cleaned the,

surface of the In from oxide, & converted it into amalgam; by rubbing with Hg. The foil is covered with a large quantity of Hg & the glass, as it were, floated on, in such a manner as to push before it the film of oxide, which rapidly forms, & bring it in contact with a perfectly pure surface. Pressure is then applied, & the excess of Hg squeezed out. Leaving the glass in intimate contact with the amalgam of Hg & In. If left long enough the amalgam would completely dissolve in the excess of Hg. Mercury is sometimes a pseudo monad, as in mercurous chloride Hg_2Cl. Both oxides of Hg are salifiable & it therefore has a double series of salts.

<u>Copper</u>. Cu". 63.5. Occurs as Copper glance, (cuprous sulphide) Ruby, or red, ore cuprous oxide. Malachite, (basic cupric carbonate containing Ho, it has the formula CO (O Cu" Ho), & may be called, Dicupric carbonate dihydrate)

& Copper pyrites, which is perhaps the most important ore. It may be represented by the following constitutional formula with some probability $Fe^{II}S$ & $Fe^{II}S(Cu_2S_2)$. Copper glance contains about 78·5 per cent of Cu. Copper pyrites from 30 to 63 per cent, & ruby ore 88·9? The smelting of Cu is carried on chiefly at Swansea, to which place ores are brought from all parts of the world. Cu has a high lustre & a reddish tinge, which changes to deep crimson when many reflections are taken from its surface. Specific gravity 8·8. It is sometimes a pseudo monad, like Pt. It is very ductile & malleable, but hard, elastic & sonorous. It is very little changed in dry air, but rapidly oxidises & sulphurises in moist. The oxide thus formed, further changes into Carbonate when in contact with pure air: but in cities is converted into Sulphide. Patina. Cu is insoluable in vegetable acids, if air be excluded. Thus when vegetable substances containing acids

are boiled in Copper vessels, some is dissolved but if the substance be allowed to cool or stand cold, in the dish it rapidly dissolves Cu & becomes very poisonous. The reason of this is that when the watery mass is boiled, all the O is expelled, but when cold, O is dissolved, & brought closely in contact with the Cu, which oxidises, the oxides being immediately removed by the vegetable acids. The Bronze coinage is composed of 95 Cu + Sn & 1 Zn. Cu is very valuable in alloys. Speculum metal an alloy of Cu & Sn reflects 63 parts of the light incident upon it, & is used for reflecting telescopes. — Alloys of Cu, Zn, & Sn. —

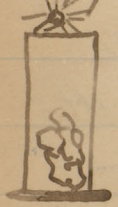
	Cu	Zn	Sn
Bronze for statues	91·4	5·5·3	1·7
" " medals	90·0	0·0	10·0
" " Cannon (gun metal)	90·0		10·0
Speculum metal.	66·0		33·0
Dutch metal	84·7	15·3	
English coin	70·29	29·26	0·17
Bell metal for large bells	80·0		20·0
Muntz's metal, for sheathing ships	60·0	40·0	

Gold. Au "+! 196.7. Almost invariably occurs native. Sometimes crystallizing, often in rolled nuggets. It also frequently occurs, in very small quantity in iron pyrites. It is frequently found alloyed with Ag & sometimes with other metals. It is separated from the rock, or earth in which it is found, by mechanical means. It is yellow in colour, though nearly crimson when many reflections are taken from it. When pure it is about as soft as lead. It suffers no change by exposure to air or moisture at any temperature. No single acid save Selenic affects it. But it is readily dissolved by aqua regia. It also combines with Cl, Br, & I, at common temperatures. It forms two classes of compounds, as a monad, & as a triad. Its compounds are unstable from its want of positive energy. Aurous Chloride, Au Cl. Auric Chloride $Au Cl_3$.

Thorium, Niobium, Tantalum, Zirconium, are tetrads of little importance, & great rarity.

Alumminium, Al IV. 27.5. There is more Al probably, in the earths crust, than any other metal. Its most common ore is Clay (alluminium silicate) Alum, the most important of its salts, if formed by the decomposition of Iyritous Clays. (To be noteced more fully further on.) By adding potassic or sodic Carbonates to solutions of Alumminium, ~~a solution~~ a precipitate of alumina is obtained. If this is mixed with charcoal in a fine state of division & heated to whiteness, & Cl then passed over. The affinity of C for O & Al for Cl, both pulling (as it were) in the same direction, effect the decomposition Alluminic Chloride being formed. This when heated with Na gives metallic alluminium. Another plan said to give better results, is to form the double chloride of alumminium & sodium (2 Na Cl, $Al_2 Cl_6$) by heating together Alumina, charcoal, & salt. Heated intensely & Cl passed over. This is then treated in the same way as the other.

Al is white, malleable, ductile, about as hard as Zn, & very sonorous. It is of a highly positive character. But does not oxidise in the air. Its specific gravity is very low 2·6. It does not oxidise at a red heat, but when heated to intense whiteness in O burns with great evolution of Heat & light. If a piece of the foil be put in a jar of O & a piece of ignited Charcoal dropped in, it instantly inflames. Al resembles Fe, Cr, &c but is not a hexad.



Tuesday Decr 14.

Alum, may be represented by the following constitutional formula.

$$\left.\begin{array}{l} SO_2\,KO \\ SO_2 - \\ SO_2 - \\ SO_2\,KO \end{array}\right] ('Al_2'''O_6)^{VI},\ 24\,OH_2$$

It is a Dipotassic alluminic tetrasulphate. If in this formula K be replaced by M, representing any monad metal, it may represent all the alums of which there is an extensive series. Iron, Manganese, Chromium, Ammonium &c

each other
being able to replace the ~~K~~. Potassium &
Ammonium alums however are the only ones
made on an extensive scale. They are used as
mordants in dying, the only useful ingredient
for this purpose however is the Alumina, the K
& Am being wasted in the processes. For instance
in dying red with madder, the mordant used is
the basic alluminic acetate, formed by acting
on alum with & printing with the
mixture on the cloth, in the patterns which are
desired, the cloth is then "aged," as it is called
by hanging the cloth up in the air, or much
quicker by hanging it in a current of steam, this
removes part of the acetic acid & renders the salt
basic. It is important that the alum used
as a mordant should be free from Fe, as in
some cases, (as with madder) the resulting
colour is quite different when Fe is present.
Alum is readily purified by crystallization
as it is so very soluble.

Potassium alum used to be prepared from natural earths & rocks containing it, as some lavas & trachites in Italy, especially near Solfatara. It is formed by the action of the SO_2 evolved by volcanic vents, on these rocks, which contain Al & K. The SO_2 is first oxidised to SO_2H_2 & this acting on the rocks forms the alum. The "Roman Alum" as it is called, is prepared by dissolving out the salt from the rocky masses & crystallizing. It is quite brown from oxide of iron, but this is not injurious as it is quite insoluble. Alum is also found in Nature in a remarkable Potash alum lake in New Zealand. This however has not yet been utilized.

The artificial manufacture of alum, from shales, was first carried on at Whitby, and in the vicinity of Glasgow. The shales are those of the Carboniferous formation, & contain alumina & iron pyrites. It is made into large heaps & allowed either to decompose slowly from the action of the weather for three or four years, or it is fired upon brush-

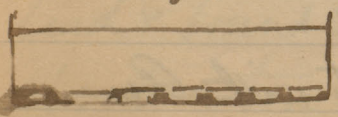
wood which being lighted communicates sufficient heat to the heap, to cause the combustion to be carried on by the carbonaceous matter & pyrites contained in the shale. This is the best way, & by it the heap may be as fully oxidised in 1 years as by the old process in 4 or 5. The FeS_2 takes O & forms $2SO_2$ Ho_2 one of these takes the Fe & forms FeO SO_2 Ho_2 & the other takes part of the Al. When this has taken place the mas is lixiviated & the SO_2 Ho_2 FeO seperated by crystallization. To the Aluminic sulphate is now added SO_2 Ho_2 or KCl & alum is formed. Ammonia is now generally used instead of K as it is cheaper & can easily be obtained from the ammoniacal liquor of the gas works. Ammonia alum also contains 11·9 per cent of alumina, while potash only has 10·2.

A better process, & one coming almost universally into use, & by which the salt

is entirely derived from the coal measure rocks, has been invented by ~~Mr Pierce~~ Mr Spence.

The shale is acted on by $SO_2 HO_2$, & to prepare it for this the ore is ~~prepared~~ calcined as follows.

It is arranged in ~~long~~ ridges about 50 feet in length & 4 by 6. At one end of each brush is placed & lighted, the combustion is carried on through the length of the pile by the carbon contained in the shale itself. It is better in ridges than in large heaps, as the heat generated in them is apt to fuse the shale & thus defeat the calcination. The shale after having been thus treated is placed in large leaden pans, capable of containing 6000 gallons of $SO_2 HO_2$ & acted on by it, ~~by~~ with the aid of heat. In these it is heated to from 105° to 108° Cent, & kept at this temperature for some hours. The pans are provided with a kind of false bottom, of tiles, laid upon bricks,



to allow the acid to circulate freely. Great difficulty was at first

found at this stage of the process; from the great ammount of heat which was lost by the evaporation of OH_2 from the surface of the pans. This is now very simply obviated by pouring a few gallons of coal tar upon the surface. The $SO_2 Ho_2$ used is that obtained from the sulphuric acid chambers of specific grav 1.6

When the action is complete the solution is run off & Ammonium sulphide distilled into it from ammoniacal liquor. The steam which comes over with this, condensing in the liquid, & giving out its latent heat, soon raises it to the boiling point. The Am_2S changes to $SO_2 Am_2$ & liberates a great quantity of SH_2

$$SO_2 Ho_2 + SAm_2 = SH_2 + SO_2 Am_2$$

Slaked lime is sometimes added to the liquor from which the SAm_2 is distilled in which case it comes off as $Am Ho$ & thus obviates the formation of SH_2.

When the solution is saturated with Am

(known by the increase of its specific gravity) it is run off & crystallized a mass of dark brown alum crystals being obtained. The mother liquor being returned to the pans.

The crystals are then washed with a saturated solution of alum, & this also returned to the pans. They are then dissolved by passing in steam which condenses in sufficient quantity for that purpose. This solution is then rapidly cooled in small tanks, continual agitation being kept up, & the alum thus obtained as a mass of fine crystals ("alum meal"). This is again washed with a saturated solution of alum & the washings from this are used to wash the first crystals. The crystals are then again dissolved by steam, & the solution being allowed to settle for two hours, is run off into the "roaching vats" which are made of staves lined with sheet lead & bound together by screws. They hold about a ton & are from 5 to 6 feet high

These are allowed to stand at perfect rest for from 10 to 14 days, by which time the crystals have formed in sufficient quantity around the sides & bottom to allow of the staves & lead being taken away, the crystals supporting the liquid inside. The crystallization takes place very slowly because of the great amount of latent heat evolved by the $6H_2$, 24 molecules of which go to every molecule of alum & entering into its crystals in the form of ice. As all water of crystallization does.

This property of alum has been very ingeniously applied to the manufacture of fireproof safes. The interspace being filled with alum & sawdust when heat ~~has~~ is applied the $6H_2$ must first be melted, & afterwards completely driven off in the form of steam before the temperature of the interior can be much raised. Milners safes have instead cylinders full of $6H_2$. But in alum

a further advantage is obtained as the OH_2 is in the form of ice.

Platinum. U & N is chiefly obtained from the Ural Mountains which furnish 5 times as much as all other sources. It is also found in Brazil & Peru & in very small quantities in the auriferous sands of the Rhine. The Pt is seldom found in large nuggets. The ore from the Urals is ~~taken~~ thus treated.
One pound of ore is is put into aqua regia contained in a porcelain vessel, & heated for some hours till all the Pt Osmium & Iridium are dissolved out. The solution is then nearly but not quite neutralized by ammonia, when $PCl_4, 2AmCl$. falls as a granular yellow ppt. The double salt of Iridium, (& osmium)? which is almost always present remains in the solution when acid is in excess. The precipitate is calcined & Pt remains behind as

a spongy mass. This is heated to intense whiteness in a reverbatory furnace & welded together.

This method is partly superceded by a process in the dry way. Pt, Os, & Ir, are fused with lead in a reverberatory furnace Os & Ir subside as insoluable alloys, while Pt remains fused with the Pb. The Pb is next cupelled & the Pt obtained, fused & refined upon a bed of lime, by a number of gas flames fed by streams of O.

Pt is white & possesses considerable lustre. It is about equal to Cu in hardness. It absorbs O when fused, like Ag, but to a much less extent. Its specific gravity varies from 21 to 22. It is attacked by no single acid, but by many nascent elements, such as P or Si. It condenses O upon its surface, especially when in the spongy state & thus causes the combination of O & H. Its most important use is in the construction of stills for concentrating H_2O_2

II & IV.

Lead is sometimes, but very rarely met with native in volcanic rocks. Galena is its chief ore (PbS). Two processes are in use for its reduction. The first depends upon the greater affinity of Fe for S. Galena is fused with Fe (in scraps) & the lead thus liberated.

$$PbS + Fe = FeS + Pb$$

this process is somewhat used in the Hartz, but never in England. By the second the reduction is effected by the mutual action of Plumbic sulphide & sulphate. Half the ore is first roasted at a temperature which converts it into sulphate, & then galena suddenly added. Torrents of SO_2 are evolved & the Pb of both compounds so liberated; thus, $SO_2Pbo'' + PbS = 2SO_2 + 2Pb$. Pb melts at 335° Cent & boils at a white heat. Its atomicity is II & IV, but sometimes ascends triad. It is malleable & ductile though not possessed of great tenacity. Flexable & inelastic. It contracts upon

solidification & thus is not suitable for the production of fine castings. nor rifle bullets. In these last a hollow space is apt to be left, which changes the position of the centre of gravity & causes them to deviate. This is obviated by forming them from rods of Pb by pressure. Pb rapidly tarnishes in moist air & is acted upon by pure OH_2.

Wednesday Decr 15th

Lead is acted on by some waters, & the distinction of waters acting on lead and not acting on it is not well understood. It may however be set down as a rule, That water free from O cannot act on lead, That water containing some quantity of CO_2 cannot act on lead, That water containing minute traces of Phosphoric acid cannot act on lead. It was originally supposed that sulphates present in the water, caused

its action on Pb. But it has been found that no inorganic salts present in water affect lead. Distilled water acts very readily on Pb. its action seems to be this, The OH_2 absorbs O from the air & bringing it closely in contact with the Pb causes its oxidation, this oxide being alkaline rapidly attracts CO_2 from the air & becomes $CO_3 Pbo$". (This may be well shown by placing two strips of Pb in jars, one filled with distilled OH_2 & the other with OH_2 charged with CO_2. After a few days the distilled OH_2 will become full of small silky crystals of $CO_3 Pbo$" while the other jar will remain quite clear.)

If however the distilled OH_2 be previously passed through animal charcoal, it looses all power of acting on Pb, this probably arises from the solution of minute traces of Phosphates during time.

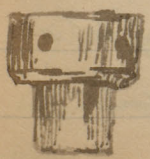
The Water supplied to Glasgow from Loch Katrine that supplied to Manchester & some other towns acts powerfully on lead. The action on health of waters thus charged, does not seem to be so

injurious ~~to lead~~ as supposed. The Loch Katrine water has been supplied to Glasgow for 10 or 12 years, and no case of lead poisoning has as yet occured. The non action of many waters, on Pb which could not formerly be accounted for, is found to depend upon very minute traces of Phosphoric acid, on careful analysis. Calcic & magnesic carbonates if present in some quantity render the water powerless. It is probable that after a time the pipes become coated with some substance which protect them from further action. This is the case, at any rate in Manchester. Lead used for roofing is also sometimes corroded in a very curious manner. An example of this occurred in the Dining hall & Library of Lincolns Inn, which was covered with lead, placed upon oaken planks, about 20 years ago. It was recently found that this roof, especially in the dining hall, was completely corroded away. This was especially the case with

those parts of the Pb, which were opposite interstices in the planks. The reason is probably as follows. The moisture from the breath &c condensed on the Pb & absorbing O & CO_2 from the atmosphere, acted as before mentioned. It may have been also greatly assisted by the acetic acid, with which oak timber is nearly always impregnated. This would set up a continued corrosion of the Pb, at when the acetate of Pb was formed it would take up CO_2 from the air & the acetic acid would seize on a fresh portion of Pb, forming basic acetate, & so on. Pb ought not, therefore to be placed in contact with oak timber.

White lead is chiefly manufactured in London & Newcastle, by a process invented in Holland & called the Dutch process.

The Pb used is first cast into rough gratings, so as to expose a large surface to the air. These



gratings are then put into earthenware pots of the form shown, resting upon the

ledge, or shoulder. Into the bottom of each pot is then put from 4 to 6 ounces of strong acetic acid. Hundreds of these pots are then arranged in rows, side by side, & the interstices having been filled with spent tan bark a layer of planks, is placed over them, on this another layer of pots next & so on, till a heap containing about 1200 pots, & from 50 to 60 tons of Pb is formed. The tan bark ferments & raises the temperature, which favours the oxidation, especially in presence of the moisture which it also causes. The oxide thus formed is acted on by the acetic acid, (the volatilization of which is helped by the high temperature) & changed into basic plumbic acetate. This is changed to carbonate by the CO_2 (also produced by the fermenting tan) & the liberated acetic acid takes up a fresh quantity of Pb, to be again acted on in the same manner. After from 4 to 6 weeks the process is complete & the gratings are taken out converted into

pure carbonate of lead. And in the conversion of the 50 or 60 tons not more than 100 lbs of acitic acid are required. 100 lbs of this white lead take only 8 lbs of linseed oil to moisten it. If it be precipitated from solutions it is much more crystalline, & consequently does not "cover" so well, & requires about double the quantity of oil to moisten it.

Glass, may be defined as a compound of SiO_2 & B_2O_3 when fused with a base. Boron glasses may be at once put out of consideration, as, though it forms glasses of very high refractive power, & weight, its expensiveness prevents it from coming into use. The properties of the ~~bases~~ glasses depend upon the nature of the bases, with which the Si is combined. Good Glass ought to be fusable only at a high temperature, insoluble in OH_2, not acted on by acids, colourless & transparent. These properties are not possessed by a silicate of any single base.

Silicates of K & Na possess most of these properties, but are soluable in OH_2. Earthy silicates possess many of these qualities but are opaque. But if a glass be made of these silicates mixed (alkalis & alkaline earths) & Plumbic oxide added, all these good qualaties may be obtained. Soda glasses are more fusable than Potash glasses & have greater brilliancy. Alumina forms colourless glass but adds greatly to its fusability. Plumbic oxide also adds much to the fusability, & makes the glasses soft, easily cut, & capable of a high polish. Oxides of Iron make the glass more fusable, but, & especially when present as ferrous oxide colour it. Many oxides are used to impart colours to glass. Bohemian glass is chiefly used for ornamental purposes Flint glass is chiefly manufactured in England & used for glass dishes &c. Crown glass is ordinary bottle & window glass.

Ferrous silicate has a strong green colour, & to neutralize this Manganic oxide or As_2O_3 is added. They act by supplying O & thus oxidising the ferrous into ferric ~~oxide~~ silicate. If the least excess of Manganic oxide however be used it gives the glass a purple tint, & even the Manganous silicate which is formed in oxidising the Ferrous silicate, slowly reabsorbs O & becoming reconverted into Manganic silicate changes the glass to a purple. This is especially the case when the glass is exposed to the action of sunlight. From these reasons the use of MnO_2 has been abandoned by almost all manufacturers.

A considerable quantity of "Cullet", or broken glass of the same quality, is always added to the mixture in the glass pots, as otherwise, the very high temperature required to fuse the mixture in the first instance occasions a great loss of alkali by volatilization. As from its non volatility the expulsion of other acids by SiO_2 is only a

question of temperature. From this reason it has been proposed to use $SO_2 Na_2$ instead of $CO Na_2$ in the manufacture of glass, but the temperature required for the expulsion of SO_3 is too high, in practice. If Charcoal however be added, which first deoxidises the sulphate to $SO Na_2$: the SO_2 is expelled at a much lower temperature.

When the glass is first fused it is filled with bubbles of CO_2 from the sodic Carbonate the temperature has to be raised very high to allow sufficient fluidity to permit their escape. It is afterwards allowed to cool to its pasty state, & then worked.

Rough statement of the chemical constitution of various glasses.

Crown $Na O Si O_3 + Ca O Si O_3$

Bohemian $K O Si O_3 + Ca O Si O_3$

Flint $Pb O Si O_3 + K O Si O_3$

Different varieties of Glass.

a Window glass, Sheet crown coloured.
b Painted window glass
C Cast plate
d Bottle
e Chemical. Bohemian
f Flint, or Crystal
g Optical.

Thursday 16th Dec 1869.
Lecture 40 —

Indium, 11 Has affinities with the group Ba, Sr, Ca, Mg, Zn, I occurs in some flue dust from Zn furnaces.

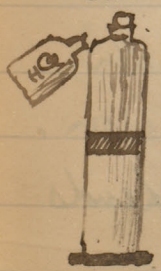
Vandium V. And belongs to the first section of these elements, By its atomic weight it would go between P & As. It was at first doubtful wether it was a metal or not, but it has been ascertained to be one, possessing somewhat the properties of as. It forms an oxychloride VOCl.

Hexads.

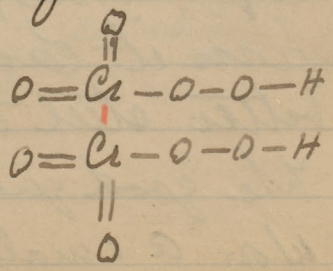
Osmium Iridium Ruthenium & Rhodium are usualy found associated in small quantities with Pt. When Ir is associated with Pt it causes it to be better able to resist the actions of acids. Ir is now intentionaly present in many platinum vessels for this purpose. It enables them even to resist the action of aqua regia for some time.

The Spectra of Hexads bears out the generalizations already made, that the spectra of the elements possessing fewest bonds are simplest. The spectra of Hexads are very complicated, there being for instance 360 iron lines, already determined in the suns spetrum. There are of course exceptions to this rule, Ba for instance giving a much more complicated spectrum than would be expected in a dyad. V Sn & Pb which give too simple spectra for tetrads.

Chromium. Cr^{VI}. 52.5. Occurs probably in greatest abundance in chrome iron ore. It is very rarely reduced to the metallic state, & has perhaps never been obtained quite pure. It may be obtained purest by the voltaic decomposition of chrome alum. Its specific gravity is 7.0146. It is a " IV & VI & possibly also octadic. It possesses a bright lustre & is not attacked by boiling NO_2Ho. It may be obtained in the pseudo octadic condition in perchromic acid, by the action of Hydrosil on lead Chromium. If Basic peroxide suspended in water be placed in a jar under a layer of ether, NCl added & the mixture agitated, the perchromic acid formed dissolves in the ether giving it a beautiful blue colour.



$$\left\{\begin{matrix} CrO_2(OHO) \\ CrO_2(OHO) \end{matrix}\right.$$



Manganese Mn II IV VI & also a pseudo triad & octad. 55. Occurs as pyrolusite manganocite &c. The metal is obtained by heating to the very highest temperature of the wind furnace, a mixture of MnO_2 & Charcoal, previously mixed with oil & Calcined. The hexadic condition is the only one well borne out by evidence. Mn is slightly magnetic at low temperatures very infusible, & very soon tarnishes in air. It decomposes OH_2 slowly at common temperatures & rapidly at a red heat.

Spezel eisen (mirror iron) is an alloy of Fe & Mn, containing 12 per cent of the latter metal. It is now purposely made in Germany, as it has been found, that from it can be manufactured a much better steel than that from ordinary iron. The good qualities of Indian steel depends upon a small quantity of Mn.

Manganic acid does not exist in its free state, but is only known by its Compounds. Manganate of potash may be formed by heating OKH & $Mn\,O_2$ in a stream of air.

Potassic Permanganate is easily prepared by ~~dissolving~~ potassic Nitrate, manganese dioxide, & potassic hydrate. ~~Dessi~~ Evaporating to dryness and exposing to a temperature just short of ignition. The Potassic permanganate is then dissolved out. It is very useful in some quantative analyses, performed volumetrically, as it yields O & becomes colourless in doing so. Thus the quantity of Fe (in the ferrous condition) present in a solution may easily be deduced from the amount of a standard solution of potassic permanganate decolorised by it, in passing into the Ferric state.

Iron. 56. Fe " IV & VI. Is found native in meteorites. Its chief ores may be divided into, sulphurous & oxygenous. The sulphur ores are not used for the manufacture of Fe, as it is so difficult entirely to remove the S. Some of the chief ores are. —

Haematite. (specular iron ore) $\begin{cases} FeO \\ FeO \end{cases} O . (Fe_2O_3)$

Brown iron ore, brown haematite $\begin{cases} Fe\,O\,HO \\ Fe\,HO_2 \\ O \\ Fe\,HO_2 \\ Fe\,O\,HO \end{cases}$

Brown iron ore, needle iron ore $\begin{cases} Fe\,O\,HO \\ Fe\,O\,HO \end{cases}$

Magnetic iron ore $\begin{cases} Fe\ddot{O} \\ Fe\ddot{O} \end{cases} Fe\ddot{O}$

Spathic iron ore $C\ddot{O}\,Fe\ddot{O}$

The metalurgical operations in the manufacture of Fe consist of two processes. 1st a roasting to expell volatile matters, & 2nd a smelting with charcoal or coak. Cast iron often contains P, As, Mg, Cs, Al, Zn, Mn, & C, as impurities derived partly from the fuel, & partly from the ore. It also invariably contains a small quantity of N, about 1·2 per cent, probably in combination with some of the metal. When cast iron is run into cold moulds & quickly cooled, it is that quality known as white cast iron. When cooled slowly it forms grey cast iron. On analysis these different kinds of Fe, even though from the same furnace, are found to contain different quantities of Carbon. The grey containing the least. This arises from the fact that when cooled slowly much of the C crystallizes out as flakes of graphite, which floating to the surface are got rid of to a great degree. Those which remain give it its grey appearance.

Grey & white cast iron also differ in physical properties to some extent. Pure Fe may be obtained by dissolving the metal in HCl & precipitating the iron as pure ferrous oxide. The metal has a somewhat grey colour is infusable except at a very great heat (about 1800° Cent) But may be welded, like Pt, at a much lower temperature. Fe is sometimes a pseudo "III". It rapidly oxidises in moist air containing CO_2. Bright surfaces can be preserved under NaHo solution as it absorbs the CO_2, the same is true with quicklime. This is the rationale of smearing the bright surfaces of machinery with quicklime & oil. The lime absorbs the CO_2. It oxidises readily however without CO_2 if in a very fine state of division, as it may be obtained when Ferric oxide is reduced at the lowest possible temperature in a stream of H.

When this iron is taken out of the sealed tube in which it is preserved it takes fire spontaneously in the air. This probably arises from the O condensing in its pores, & being thus brought very intimately in contact with the Fe. It may also be caused, or helped, by the heat developed by the condensation of O on its surface. [[May it not be caused by the burning of H already condensed in the pores, when brought into contact with the atmospheric O, causing sufficient heat to inflame the Fe. The Fe being kept in an atmosphere of H.)]] Ferrous salts are usually of a greenish blue tint. Ferric salts generally reddish brown. Ferrous pass very readily into Ferric salts. Ferric salts act as powerful antiputrefactives. Thus a little Fe_2Cl_6 added to sewage prevents its putrefaction in summer for some time. Ferric oxide corrodes & destroys organic matter. It appears to act by giving up O to them, absorbing more to be again given up. Thus acts as a carrier.

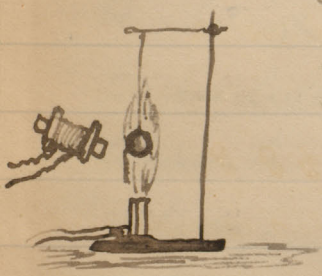
Cobalt 5·8·8. Co " IV VI? also pseudo triadic. Is usually found in combination with As. Cobalt glance is the most common ore. ($CoS_2 . CoAs_2$) The As is expelled by heating on the sole of a reverberatory furnace, & in a tilted crucible. The metal is of a reddish grey colour, & very infusable It dissolves readily in NO_2H. Its salts are generally pink when hydrated, blue when dry. (greenish when Ni present) & have from this property been used as a sympathetic ink.

Nickel. Ni. 5·8·8.

II IV VI? also pseudo triad

Occurs as sulphide in hair nickel. as Diarsenide in Kupfernickel. Ni is usually associated with Co. It fuses at a temperature higher than that required for Fe. It has a good lustre, & is ductile &

malleable. It is also attracted by the magnet & retains its magnetism like iron or steel. Iron or steel loose their magnetism only at a full red heat, while Ni looses its attraction for the magnet at a temperature much lower than this. This may be shown by suspending a ball of Ni by a wire, & heating it, when it becomes hot it is not at all attracted by the electro magnet, but if cooled again recovers this property. Ni is used for German silver & other similar alloys. When much Ni is added the metal becomes more like Ag. but too hard to work easily



— Compositions of various Ni alloys. —

	Cu	Zn	Ni
Nickel silver, English	60·	17·8	22·2
" " Parisian	50·	13·6	19·3
German silver	50·	25·	25·

George M. Dawson.
Dec. 17th 1869.

Organic Chemistry

Lecture I Feb 1st 1870.

Early research in Chemistry found two great Classes of bodies. Which were called Inorganic or Mineral, & Organic. ~~All~~ bodies belonging to inorganic were those which are comparatively stable & easily prepared from their elements. The organic on the other hand are very prone to change, & it was then thought impossible to produce them from their component elements except through the medium of vital action. This division is now however entirely broken down. & the beginning of this obliteration was when Wöhler in 1828 produced Urea from Ammonium Cyanide. Methods of producing organic compounds from inorganic materials, after this rapidly increased in number, & now a vast

number can be made without the action of life at all.

Organic Chemistry may be termed the Chemistry of the compounds of C. This division however includes CO_2 &c & all carbonates. It has been proposed as a modification to call it the Chemistry of Carbon compounds containing more than 1 atom of C. This however excludes some organic substances & includes some that are inorganic. ~~In organic Compounds~~ A better definition would be. One or more atoms of C united directly with one or more atoms of C, H, N, or O. Take for example Oxalic acid ($\left.\begin{matrix}CO\,HO\\CO\,HO\end{matrix}\right\}$). One atom of C is united to another of the same element. This definition excludes also Carbonic acid ($CO\,HO_2$ hypothetical). It also includes Cyanogen if a molecule of that substance be taken $\left.\begin{matrix}CN\\CN\end{matrix}\right\}$. & Formic acid is also embraced by it $CHO\,HO$. The old terms Organic & Inorganic are however still used.-

The term organic is frequently employed by Physiologists in the sense of organized, the Chemical use is quite distinct from this.
Chemistry is now approaching in exactness even the science of Astronomy. As the perturbations of known planets have enabled astronomers to calculate the position & magnitude of an unknown one, so Chemists can predict from the atomicity & other known properties of bodies, what compounds can be formed from them & how, & can produce them. & can even tell beforehand something about their boiling point specific gravity &c.
The number of elements entering into the composition of organic bodies is small, & the essential element is C. There are many bodies which consist of C & but one other element. In a great majority of instances this element is H. In some cases C is united to N alone as in Cyanogen ($\overset{C}{C}N$).
Many organic substances contain but three

elements C, H, & O: as sugar, acetic acid, gum alcohol Glycerine &c. C, H, & N form hydrocyanic acid. There are a great number of compounds containing four elements CHN & O. as quinine, urea, uric acid. Some contain other elements as CHS & N. & others such elements as Cl, Br, I, these however are always artificial. Though the number of elements concerned is so small the complexity of the formulae of organic substances is much greater than that of inorganics. & this arises from the number of atoms going to form a molecule. In organic chemistry no case of only two atoms uniting is known. There is only one case of an organic body containing only three atoms (HCy) & only one is known which contains but four (Cy) $\binom{CN}{CN}$.
The number of atoms is often prodigiously greater In Spermacety there is 98 atoms. In Stearine 173. In albumen 226. & in Protogon 384. This last is the greatest number known.

H has been said to be a metal, but it is not, for its arsenuret is a transparent liquid(?) It also forms a liquid oxide & in this respect differs from all metals [(The metal? H having itself so low a melting point, its oxide could not be expected to resemble in fusibility those of the other metals. The oxides of ~~some~~ metals are easily fusible)]

decomposition of steam by electric sparks.

O is the analogue of S, Se, Te but differs from them in a very striking manner. It forms a neutral compound with H & is permanently gaseous.

N is the analogue of P, Sb, As & Bi but departs widely from them in many properties. It does not readily unite with O. The chlorides of these substances are stable, but the chloride of N is ~~one of~~ the most unstable bodies known.

C is the analogue of Si, Sn, Ti, but there is an immense difference between them. CH_4 is

combustable but very difficult to inflame
SiH_4 is spontaniously inflamable. CO_2
is gaseous SiO_2 is absolutely non volatile.
Thus C, N, H & O. differ widely from the other
elements in the properties of their compounds
this is further the case with their combining
weights which are comparatively very low.
(1. 16. 14. 12)
O in organic bodies may be detected by
heating the substance to bright redness in a
close vessel when it is evolved as CO_2 or OH_2
C & H may be detected simultaneously by
burning the substance ~~with~~ in a stream of O.
They appear as CO_2 & H_2O.
N is usually detected by heating the substance
with soda-lime (caustic lime slaked with
a strong solution of NaHo) when Ammonia is
given off. A very delicate test for minute
quantities is to heat the substance in contact
with Na. Sodic Cyanide is formed

& may be tested for by dissolving adding Fe_2Cl_6 SO_2FeO" & HCl. If nitrogen has been present it gives prussian blue.

These methods are easely transformed into quantatative ones by weighing the substances employed & the resulting compounds.

The Analysis of organic bodies is divided under two heads. Proximate & Ultimate Proximate analysis is usually only qualatative & the Chemist generally avails himself of fractional seperation. this may be carried on in various ways.

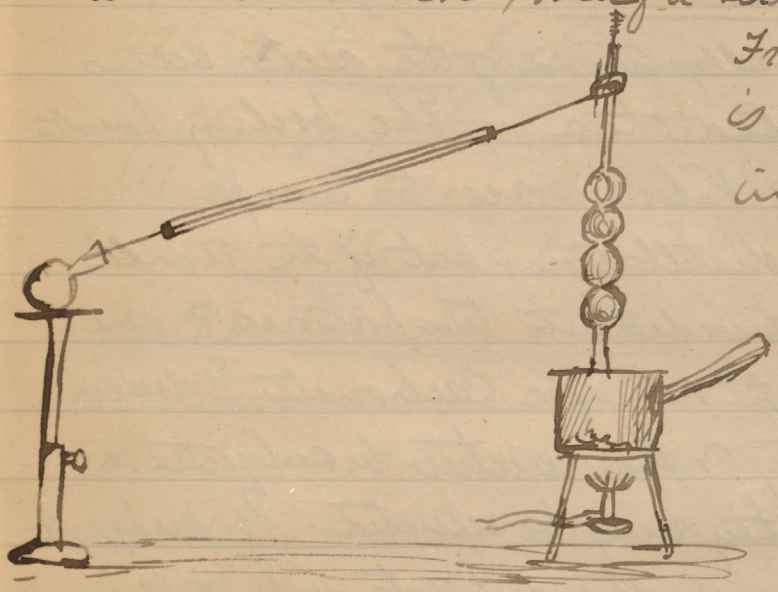
Fractional crystallization. Highly crystalline bodies of different degrees of solubility can be seperated to a certain extent by a crystallization & Completely by a series. Shown by the seperation of Potassic Chromate & Chlorate, the Chlorate can be nearly all crystallized out before the Chromate begins to seperate & the crystals may be washed free from the chromate solution.

Fractional precipitation depends upon the different solubility of the precipitates? It may be illustrated by using a solution of Mercuric & plumbic Iodides & enough potassic iodide to precipitate the Hg. The Pb then comes through pure & may be titrated by a fresh portion of KI. A slight excess is always employed & thus only 1 product obtained pure.

Fractional distillation is perhaps the most important & most used. Where the boiling points of liquids is considerably different (as 18° or 20° Cent) they may thus be very easily separated. Amylic alcohol, for instance boils at 132° & ether at 35°. When heated in a water bath the Amylic alcohol does not boil but the ether passes over freely & only a small ammount of the alcohol is carried over with the ether vapour.

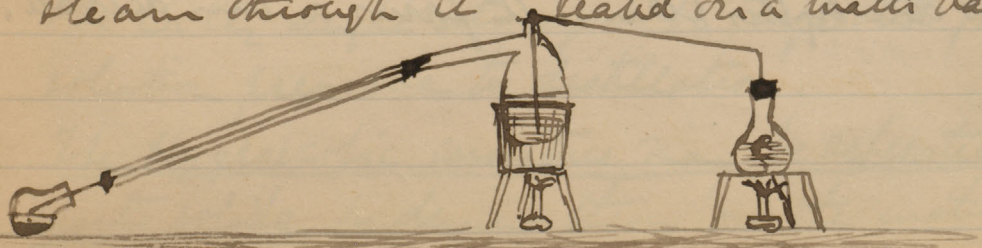
Many rectafications may be saved by using

a still head composed of a series of bulbs.



Fractional distillation is sometimes conducted in vacuo, as this separates the boiling points of liquids more. When the pressure of the atmosphere is increased the boiling points approximate more closely.

Steam has the property of taking up considerable quantities of the vapour of some liquids, even when the boiling point is much higher than that of OH_2 (for instance 300°) This may be shown by distilling turpentine by passing a stream of steam through it - heated on a water bath.



Fractional Saturation. The seperation of acids, especially those of the acetic series may be effected thus. The boiling points of Propyonic & Valeric? are too near for seperation by distillation, but if the mixed solution be divided into two portions & one saturated with potassic Carbonate, & mixed with the other; & the mixture be subjected to distillation, they may be seperated. If propyonic was less than 1/2 the distillate will still consist of a mixture of the two acids. But in the retort pure potassic Valerate? will be found. If more than enough potassic Carbonate be present the distillate will be nearly pure propyonic acid. Acetic however, though the most volatile of the series does not pass over by this plan. It forms a bin acetate.

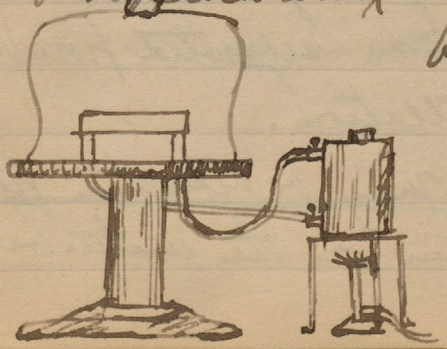
Lecture II. Feb. 2. 1870

Ultimate analysis is accomplished by changing the C in the substance into CO_2 The O into OH_2, the N as NH_3, or in the free state. The substance to be operated on must first be thoroughly dried. that the OH_2, hygroscopic or otherwise may not vitiate the result. In the case of liquids this may often be accomplished by adding to them some substance, as $CaCl_2$ which has a powerful affinity for OH_2 but does not effect them. $CaCl_2$ does not however answer well for drying the alcohols as it dissolves in them & cannot be seperated before distillation; & when the mixture is subjected to distillation the heat causes the $CaCl_2$ to loose its hold on part of the OH_2. The $CaCl_2$ ought always to be seperated from the solution previous to distillation.

The Hygroscopic moisture may be seperated from most solids by drying them on the water bath

this temperature of 100° being generally sufficient. For a few the heat obtained by an oil bath is necessary. This is sometimes replaced by an air bath, which by means of several false bottoms is kept at a pretty even temperature.

Some substances however will not bear a temperature as high as 100° without volatilizing or decomposing. The best way of drying these is by placing them in vacuo in the presence of $SO_2 Ho_2$. Sometimes, but very rarely it is necessary to apply heat, as well as the drying action of the $SO_2 Ho_2$ in vacuo. This may done up to a temperature of about 70°? by a hollow copper vessel introduced into the Bell-jar & supplied with a hot water current from a boiler, as shown below. The moisture having been expelled by one or other of these means,



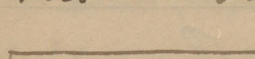
the substance is put into a tube & weighed after the part of the substance intended to be employed has been put into the combustion tube the tube & its remaining contents is again weighed & the difference is the weight employed.

Fluids are introduced into thin glass bulbs of know weight, sealing the aperture & weighing again.

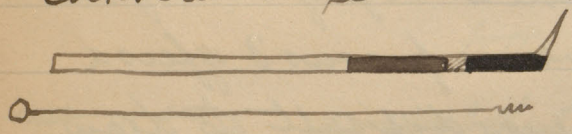
The O which the substance employed requires for its combustion, & conversion into CO_2 & OH_2 is either supplied by Cupric oxide, & Plumbic Chromate, which has been carefully washed, fused, & powdered: or by passing over the substance a stream of gaseous O. The Cupric oxide is almost invariably used, except for substances as coals, which contain a great quantity of C.

The Oxide is met with in three forms, 1st as a fine powder, as obtained from the ignition of cupric nitrate. The ignition must be carefully conducted, carried on for at least 3 hours & at the close raised to bright redness.

2nd as scales obtained when Cu is rooled, or hammered. or purposely oxidised by heating in a muffle furnace. 3rd & this is perhaps the most convenient form. As it is obtained by heating scrap copper in a reverbatory furnace preparitory to the manufacture of SO_2 Cuo". Cupric oxide has however one great drawback it is very hygroscopic, the two last mentioned qualaties of oxide are much the best in this respect. It must always be heated to redness before using it for an analysis. The tube used in combustions is manufactured in Germany, a suitable length is taken & drawn out at one end to a point as shown & sealed. It is then rinsed out with a little of the recently ignited oxide, which is much better for the purpose than OH_2 in most cases, as it both mechanically cleans, & dries the tube. A few inches of oxide are then introduced, & then the substance to be



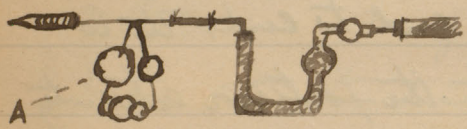
analysed; next a few more inches of oxide, & then the substance can be thoroughly, & without loss mixed with the oxide, surrounding it by a corkscrew-shaped wire. Most chemists still however use the plan of quickly mixing



the substance in a small warm dry mortar, & rinsing this out with fresh oxide. There should always be an inch or two of oxide free from the substanc at the extremity of the tube. When the substance has been thoroughly disseminated through the oxide, a few more inches are put in & in this the wire is rinsed. The tube may now be filled to within an inch or so from the end. The oxide is best preserved in a tube sealed at one end & tightly corked at the other, & for facility in introducing it into the combustion tube, it should either be of such a size as to pass over, or slip into it.

The OH_2 produced by the H in the substance ~~equal~~ operated upon is collected in a U shaped tube filled with strongly dried, or fused $CaCl_2$. The fused is on the whole to be preferred for though the dried is more porous & offers a larger surface it is more difficult to draw from it the last of the CO_2. Instead of the $CaCl_2$ a smaller U tube filled with pumice soaked with SO_2HO_2 (the pumice having been previously treated with SO_2HO_2 & heated to dull redness to expell chlorides &c) may be used. It has the advantage of being smaller, & can also be used more frequently without changing the SO_2HO_2. When necessary it may be renovated by heating to boiling & passing a stream of air through it. The CO_2 formed from the C in the substance is collected by the potash bulb apparatus. The bulb A should be able to contain in 2/3 of its bulk, the whole of the solution of potash, in case of any drawback from

absorbtion or cooling. It should also at the tube which gives final exit to the gases be furnished with a small tube filled with dry caustic potash to intercept any moisture taken up in the potash solution. Both the potash bulbs & the drying tube should be weighed before the commencement of the operation & the increase of weight after its completion gives the amounts of CO_2 & OH_2.



When many analyses have to be made in succession the far most convenient apparatus is the modification, with the stream of O. It may be called a breech loading combustion tube. The substance is introduced at the back in a porcelain boat, & seperated from the cupric oxide by a plug of asbestos. Behind the boat is placed a glass coffer or bulb which nearly fills the tube, & so concentrates

the slow current of air or O as to prevent back distillation. A great advantage by this process is that the residual mineral matter in the boat may be weighed.

At the beginning of the operation all the oxide is heated to redness from end to end, it is then allowed to cool at the portion extremity of the substance introduced in the boat. A slow current of air is at first passed as O would make explosive mixtures with the vapour; & when the operation is nearly done a current of O is substituted. This completely oxidises the last of the Co. The current of gas should at the maximum speed pass at the rate of 3 bubbles in two seconds through the potash bulbs. The O should be passed till it will rekindle a match held at the aperture of the potash apparatus. & by this means any of the Cobalt oxide reduced is reoxidised for the next operation.

Both the O & air used must be dried & purified from CO_2 by passing through a $CaCl_2$ tube & a potash ~~XXXX~~ apparatus.

A few inches of Copper turnings (which have been heated in a current of O to burn off them & then in one of H to reduce any oxide) are put at the end of the tube furthest from the substance, to decompose any compounds of N & O which may form. The N may then be determined, not completely, but with sufficient accuracy. Traces of nitric oxide may pass over but no other oxide of nitrogen.

Organic Compounds sometimes contain S, Cl, Br I, P & As. Good results may be obtained from any of these substances by the use of the apparatus above. The Cu absorbs them all.

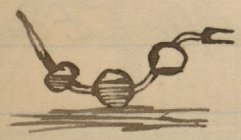
Care must be taken however not to allow the O to unite with the Cu as it often expells them. (The reason for absorbing the oxides of N is that they might remain combined with the KHO.)

Thursday Feb 3.
Lecture III.

At the close of the combustion the fine end of the tube is broken off & air slowly drawn through to carry to the absorbing apparatus the last remnants of OH_2 & CO_2.

N as well as C & H admits of direct estimation. The process most used by ~~parents~~ Chemists is to convert the N into NH_3 by by heating it with Soda-lime. The C is changed into various gases which escape unabsorbed. Lime or soda alone would equally liberate ammonia, but lime looses its OH_2 at the high temperature necessarily employed, & soda fuses & attacks the glass. Soda-lime however, prepared by dissolving one part of NaHo in water & with this slaking 2 parts by weight of $Ca HO_2$ & drying the mixture, holds its water at any temperature & does not fuse. The substance in which it is wished to determine the N, is weighed, by employing a tube as in the former case.

& about 1/2 gramme mixed, in a mortar with 10 or 12 grammes of Soda-lime. An inch or an inch and a half of pure soda-lime is put into the bottom of the tube, & then that containing the substance, the mortar is then rinsed with soda-lime & the rinsings introduced, when this has been completed the tube should not be more than 2/3 full. The remaining portion is filled up with soda-lime, & heat as before gradually applied, beginning at the anterior extremity. A slightly different bulb apparatus is employed & filled with dilute HCl (about half water). The



bulb between that holding the acid, & the apparatus should be large enough to contain the entire liquid, in case of any absorbtion backward.

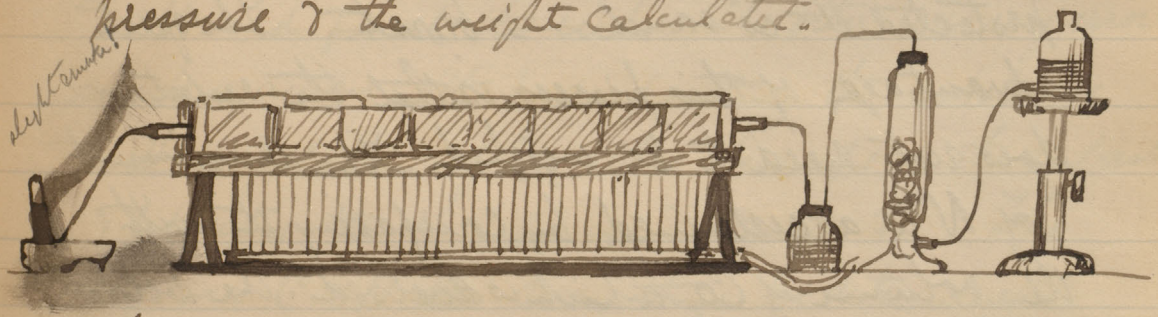
The NH_3 is absorbed & converted into Ammonic Chloride. The Am is precipitated by $Pt Cl_4$ as $Pt Cl_4$, 2 NH_4Cl, care being taken to add an excess of $Pt Cl_4$. The solution is evaporated to dryness, &

washed with a mixture of 3 parts of alcohol & one of ether. This removes the $PtCl_4$ without at all dissolving the precipitate. The precipitate is put into a filter dried at 100° & weighed & after having been carefully washed with the mixed fluids. The filter is again weighed (after having been carefully weighed at the same temperature) & the difference gives the weight of the $PtCl_4, 2NH_4Cl$

This process is very simple & effective when the N present is in combination either with C or H but when present in some combinations with O it does not yield good results. Most of the other processes are not so simple but give more accurate results.

A very good plan is to determine it in the oxide of copper combustion by placing a plug of bright copper turnings at the extremity of the tube. This reduces & allows to pass off free all the N which may be collected as a gas. It is obvious however that the air must be

completely removed, this is accomplished by passing through the apparatus before it is heated a stream of CO_2. It should be passed from 1/2 to an hour to ensure the complete expulsion of the air from the pores of the Copper oxide. This is known by collecting a portion of the gas & noticing if the absorbtion is complete when NaHo is passed up into the tube containing it. The gas which has been collected at the close of the combustion is corrected for temperature & pressure & the weight calculated.



There is another mode, very ingenious, which was invented by Bunsen, is not however used much on account of a difficulty. The substance in very small quantity, & mixed with a little Copper oxide & bright copper. A current of H is then passed through

& when quite full of the gas one end is sealed. The N is then pumped out by an air pump & the other end of the tube sealed.

The tube is then heated to redness, but here the difficulty for unless great care be taken the tube is burst by the gasses produced. Bunsen particularly remedied this defect by embedding it in a mass of plaster-of-Paris & heating it embedded thus. but even when thus protected it is sometimes burst. The great advantage of this process is that the substance does not need to be weighed. The ammount of N is ascertained by comparing it with the volume of CO_2 which is evolved. the volume of C having been determined by a previous experiment.

By Another & simpler process. the tube is filled in the usual way with the substance copper oxide & metallic copper. The tube

is then completely exhausted by Sprengels air-pump & the gaseous products analysed. This process is particularly well adapted for operating on very small quantities, as from 2 to 3 milligrams. And thus very suitable for operating on the small quantities of organic matter obtained in the analysis of CH_2. These residues however generally contain Carbonates, & N, as Am & nitrates. It is necessary to eliminate these & the Carbonates. The N as Ammonia is ascertained by Nasslers test & allowed for at the end. The other sources of error are done away with by evaporating the substance with a solution of SO_2 this decomposes the carbonate & liberates the N held in nitrates &c. The organic C & N may thus be determined. there is no way of determining the exact weight of N.? but the proportion of C & N enables one to judge whether the organic body be vegetable animal. There is no method of ascertaining the H_2O in such samples.

The S in organic compounds may be determined by heating them in a combustion tube with potassic Chlorate & sodic carbonate. The contents of the tube are dissolved out, & the SO_2Ho_2 which has been formed & combined with the $CONa_2$ is precipitated by $BaCl_2$. The precipitate is dried & weighed.

The most correct method however is to mix the substance with enough NO_2Ko, & sugar or starch if necessary to make it-self combustable. The mixture is introduced into Lewis Thomsons thermal coefficient apparatus (as before described) a slow-match lighted & submersed. The ~~chlorid~~ sulphates formed combine with the bases in solution are precipitated by $BaCl_2$ & weighed.

Cl, Br, I, &c are determined by ignition in a combustion tube with Soda-lime. The Iodide, Chloride, Bromide &c formed is precipitated by NO_2Ago. Washed dried & weighed.

Method of calculating the C, H, & O in an organic compound, from the CO_2, OH_2; & O by difference

C - 12 or 3
O - 32 or 8
44 11

$$\frac{CO_2 \times 3}{11} = C$$

H - 2 or 1
O - 16 or 2
18 9

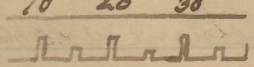
$$\frac{OH_2 \times 1}{9} = H$$

the quantities thus obtained are reduced to percentage quantities. & the O ascertained thus

$$100 = (CZ + HZ + NZ) = OZ$$

Gases to be submitted to analysis must be kept over Hg, & may be so preserved several months. Their volume must also be determined over Hg. This is done in the eudiometer. The most simple perhaps is that of Bunsen, which determines by the absorbtion. By another instrument the volume is determined by explosion with O. The absorbtion tube must

be carefully graduated to millimetres. The tube must then be calibrated by the introduction of measured quantities of Hg, & a table formed from for the tube. The process of graduating the tubes is to introduce them end to end, (one already graduated, & the other to be operated on) into a frame constructed for the purpose. They are then clamped, & by using a wooden rod with a blade which fits into the graduations at one end & a point at the other which may scratch through the coating of wax on the tube to be graduated, at the other the graduations are easily transferred. When the tube has been completely graduated it is etched by Hydrofluoric acid. A sheet of metal cut into slits so as to allow every 10th scratch to be made longer, is used at the graduating end.



Lecture IV. Feb 7th 1870

On the proximate & altimate analyses of gases.

The method of Bunsen, & his eudiometer are very exact, but their great drawback is that the require for their performance a room maintained at an equal temperature, & from which everyone is excluded. The gasses must be measured, either when perfectly saturated with moisture, or when perfectly dry; in practice the former is most easy. Unless in contact with pure distilled water the gas does not become perfectly saturated, that is to say they do not abstract sufficient moisture from strong saline solutions such as are used in this analysis. Thus if a strong saline solution has been introduced it is difficult to remove it, so that the gas will become perfectly saturated with aqueous vapour. Bunsen as already used his reagents either solid, in the form of bullets, or soaked into bullets of Coke. [The coke bullets being

made by mixing 3 parts of coke powder with 1 of coal, pressing the mixture into a bullet mould, introducing the ends of a Platinum wire for heating)

By Another plan however, which works much more easily, the substances are not acted on at all in the eudiometer tube, by the reagents, but are transferred by a capillary tube to another vessel, which is called the "Laboratory Chamber", A, there acted on, & returned into the eudiometer & measured.

The Eudiometer tube may also be surrounded by a jacket of water which maintains the temperature tolerably even, especially if (as in the apparatus invented by Dr Frankland) the water circulates by a syphon arrangement. In this instrument the tube is closed at both ends (with the exception of the capillary tube leading to the "Laboratory Chamber") & vacuous. The observations are consequently quite independent

of the barometer. The mercury also being contained in a U shaped tube, with a little water over both columns, the tension of the aqueous vapor need not be taken into account, as it balances itself.

Gases, for the purposes of analysis, can be divided into two great Classes.

I. Gases which may be directly determined.

II. Gases which cannot be directly determined.

Class II may be divided into three sections

1st Gases absorbed by crystallized sodic phosphate ($PO\,Ho\,Na_2O_2$) HCl, HBr, HI.

2nd Gases absorbed by potassic hydrate, but not by sodic phosphate. CO_2. SH_2.

3rd Gases absorbed by neither of the above reagents. O, N_2O_2. CO, C_nH_{2n}. C_2H_2 &c

Those determined indirectly are CO. H. Marsh gas. Ethylic hydride, Ethyl, Propylic hydride, N. N_2O. &c

A very common mixture of gases is H, CO, N, & Marsh gas. Three of these are combustable, in the ordinary

sense of the term with O. So in the process of analysis for this mixture, the gas is mixed with an excess of O, placed in a eudiometer tube, having platinum wires sealed in, & exploded by the electric spark. Previous to the explosion the volume is read off, & also after the explosion has taken place. The mouth of the eudiometer tube is pressed during the explosion against a caoutchuc, block or slab, in case some of the Hg should be forced out, & with it some of the gas. That the slab should not carry down air with it when introduced ~~to~~ under the Hg bath. It is moistened, best with a solution of Corrosive sublimate, to which the Hg adheres.

The data which are obtained from this experiment (leaving out of consideration the N, which is determined by the residue), are as shown on next page.

Volume of combustable gas = A.

Volume of contraction on explosion = C.

Volume of CO_2 produced by explosion = D.

From these data the relative volumes of almost any gas of Class II (Indirect) may be determined

$X = H \quad Y = CO_4 \quad Z = CH_4$

$X + Y + Z = A.$

$1\frac{1}{2} X + \frac{1}{2} Y + 2Z = C.$

$Y + Z = D.$ (as of YZ both give their own volumes of CO_2.)

Finally you get

$$X = A - D$$

$$Y = \frac{3A - 2C + D}{3}$$

$$Z = \frac{2D - 3A + 2C}{3}$$

4. Operating on 10 volumes of gas the data were as follows.

$A = 10$

$C = 16$

$D = 7$

$H = 10 - 7 = 3$

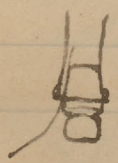
$CO = \frac{30 - 32 + 7}{3} = 1.66'$

$CH_4 = \frac{14 - 30 + 32}{3} = 5.33'$

10.00

In the determination of the specific gravity of gases or vapours. either atmospheric air or H is taken as unity, & all the data required are the weights of equal volumes of the gas operated on & air.

For ascertaining this a flask with a very fine neck, accurately fitted by a glass stopper is used, it is filled, as nearly as possible with the gas (perfectly dry) over mercury. The stopper is then introduced, but beside it is put a fine wire, so that a thin column of Hg shall remain, & allow the enclosed gas to suit itself to the temperature & pressure.



The flask is then left for some time in a still room, to which no one has access. The height of the thermometer is then carefully read, from an instrument placed near the bottle. The wire is then withdrawn & the flask weighed. The gas is then exhausted from it, by an air-pump

& this is repeated several times till the last traces of gas are withdrawn. It is then weighed full of air. The volume of the flask is then taken by ~~means of~~ filling it with Mercury, & taking the weight of the ammount required.

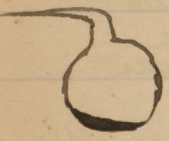
The Specific gravity of vapours, is determined on exactly the same principles, though in a modified form. Two methods are in use, that of Gay Lussac's, & Dumas. That of Dumas is most used by Chemists, but Gay Lussac's is perhaps on the whole the best, & most accurate. It is especially useful as only very small quantities (as a centigramme) of the substance suffice. While for Dumas's ~~the~~ some quantity is needed & the errors are Cumulative, which is not the case with the other.

By Gay Lussacs method the fluid is introduced into a small glass bulb drawn out to a Capillary point at one side. This is as nearly as possible

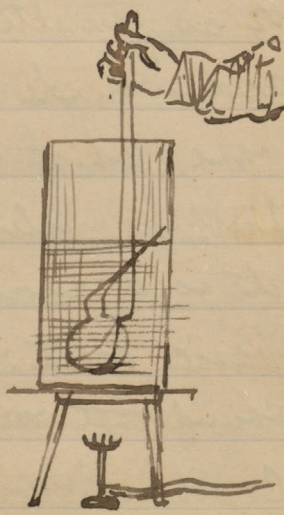
filled. It is then introduced under a eudiometer tube full of mercury, or the mercurial trough, & the point broken off by pressing it against the inside of the tube. Both pieces are then allowed to ascent through the mercury. The eudiometer is then transferred to some liquid in a cylinder, (the mouth being kept closed by some mercury in a cat-gut spoon as shown) This liquid should be heated, & have its boiling point much above that of the fluid operated on. For ether & such volatile fluids, water suffices, but for those requiring ~~hot~~ temperatures above 100°. Oil, or Spermaceti (by which the temperature may be carried nearly to 300°) must be used.

By Dumas' method a globe of thin glass is drawn out to a ~~thin~~ fine point ~~by~~ at the neck. The globe is then heated & some quantity of the liquid drawn in when the contained

air again contracts on cooling. The globe



is then introduced, gradually, by means of a wire frame with a handle into a ~~boiling~~ vessel of boiling water, or hot oil. The enclosed liquid beginning to boil drives out all the air, & when this has been perfectly accomplished, & no more gas issues from the orifice, the capillary end of the tube is quickly sealed by a blow-pipe flame. The temperature of the CH_2 or oil used being known the flask is cooled & weighed & from these data the specific gravity determined. After the globe, with the contained vapour has been weighed, the tip of the tube should be broken off under mercury, & if the experiment has been successful the mercury should fill the globe. The weight of the Hg required gives the size of the globe.



Lecture V Feb 8th.

Rational, Empirical, & Constitutional formulae.

Take as an example Acetic acid. Its per-centage composition is.

C	40·0
H	6·6
O	53·4

If these numbers be now divided by atomic weights, we get

$\frac{40}{12} = 3{\cdot}3 = 1$

$\frac{6{\cdot}6}{1} = 6{\cdot}6 = 2$

$\frac{53{\cdot}4}{16} = 3{\cdot}3 = 1$

& the empirical formula, or the formula reduced as much as possible without breaking the atoms will be CH_2O.

The rational formula expresses the number of atoms in a molecule, & may be either this number or any multiple of it. To determine this the acid is made to combine with some well known base, which should be a monad, & for this purpose silver is found to answer best, as it is a monad which forms few, if any basic salts. In the case of acetic acid it is found that twice the empirical formula combines with one atom of silver, & the rational formula consequently is $C_2H_4O_2$.

The next point to decide is whether it be, a mono, di, or tri-basic acid. This can not be inferred from the last experiment, as the positions of Ag & Acetic acid would obviously always remain the same, whatever the atomicity of the acid was. To decide this, an appeal is made to the vapour density. The specific gravity of its vapour is ascertained. If the substance itself be not volatile, some of its compounds usually are, & it may be inferred from these. By this means you find the number of atoms which are contained in a volume, equal to that ~~of~~ occupied by two ~~Grm~~ atoms of Hydrogen. For acetic acid this is found to be $C_2H_4O_2$.

If in working up an analysis of this kind the theory differs from the practise as much as 3/4 of 1 per Cent the results should be considered doubtful either from incorrect analysis, or impurity of the substance operated on. This is especially likely if the C be in excess, as all the processes tend to the loss of C, & excess of H.

Analysis of Benzoic Acid.

	Grammes
Benzoic acid burnt	0.35
Potash bulb after combustion	47.381
" " before "	47.500
	0.881 = CO_2

Chloride of Calcium tube

after combustion	15.458
before "	15.300
	0.158 = OH_2

$44 : 12 :: 0.881 : X \qquad X = \frac{12 \times 0.881}{44} = 0.2402$ Grms of C.

$18 : 2 :: 0.158 : y \qquad y = \frac{2 \times 0.158}{18} = 0.01755$ Grms of H

$0.35 : 0.2402 :: 100 : X. \qquad X = \frac{0.2402 \times 100}{0.35} = 68.62$ Per Cent of C.

$0.35 : 0.01755 :: 100 : y \qquad y = \frac{0.01755 \times 100}{0.35} = 5.01$ Per Cent of H.

Percentage composition of Benzoic acid by analysis.

C	68.62
H	5.01
O. by difference	26.37
	100.00

Calculation of the formula of Benzoic acid.

$12 : 1 :: 68.62 : x \qquad x = \frac{1 \times 68.62}{12} = 5.71$ or 5.71

$1 : 1 :: 5.01 : y \qquad y = \frac{1 \times 5.01}{1} = 5.01$ or 5.01

$16 : 1 :: 26.37 : z \qquad z = \frac{1 \times 26.37}{16} = 1.64$ or $164.$

Atoms of C	5.71	$\frac{5.71}{1.64} = 3.48$ or 7
Atoms of H	5.01	$\frac{5.01}{1.64} = 3.054$ or 6
Atoms O	1.64	$\frac{1.64}{1.64} = 1.$ or 2

$C_7 H_6 O_2$

$C_7 = 84$
$H_6 = 6$
$O_2 = 32$
122

$122 : 84 :: 100 : x \qquad x = \frac{84 \times 100}{122} = 68.85$

$122 : 6 :: 100 : y \qquad y = \frac{6 \times 100}{122} = 4.91$

$122 : 32 :: 100 : z \qquad z = \frac{32 \times 100}{122} = 26.22$

Percentage Composition

	Theory	Experiment
C	68.85	68.62
H	4.91	5.01
O	26.22	26.37
	99.98	100.00

Determination of Equivalent of Benzoic acid

0·6 Gram of Benzoate of Silver, left on ignition 0·282 Grm of Ag.

$$0\cdot282 : 0\cdot6 :: 108 : X. \quad X = \frac{0\cdot6 \times 108}{0\cdot282} = 229\cdot78$$

Equivalent of Benzoate of Silver 229·78

Silver	108
H	1
Benzoic acid	122·78

Equivalent of Benzoic acid

	Theory	Experiment
C_7 =	84	
H_6 =	6	
O_2 =	32	
	122	122·78

Determination of the Vapour Density of Benzol.

Globe + air at 15.5° Cent & 0.760 mm Bar 50.0000 grms

Capacity of globe = 400cc

400 cc of air weighs 0.4894

Weight of globe 49.6106

Globe + benzol vapour at 110° 50.5294

Globe 49.5106

400 cc of Vapour at 110° weigh 1.0188

$$\frac{400 \times (273+0)}{(273+110)} = 285.11$$

400 cc of gas cooled to 0° occupy 285.11 cc

285.11 cc of Benzol vapour weigh 1.0188 grms

205.11 cc of H " 0.025544 grms

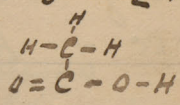
$$\frac{1.0188}{0.025544} = 39.88 \text{ Vapr density of Benzol.}$$

Benzoic acid	$C_7H_6O_2$	122	$61\ \frac{122}{61} = 2$
Analine	C_6H_7N	93	$46.5\ \frac{93}{46.5} = 2$
Benzol	CH	13	$39\ \frac{13}{39} = \frac{1}{3}$
	C_6H_6	78	$39\ \frac{78}{39} = 2$

Besides the rational formulae which may be found by these means, we want to know how the elements are combined with each other. This is attended with much greater difficulty, & chemists at various periods have held very different views upon the subject, according to the views of organic chemistry which prevailed at the time. To return of Acetic acid as an example it may be supposed to be constituted ~~of off~~ in any of the following ways.

$C_2H_4O_2$. CH_4CO_2 . $COCH_3OH_2$.

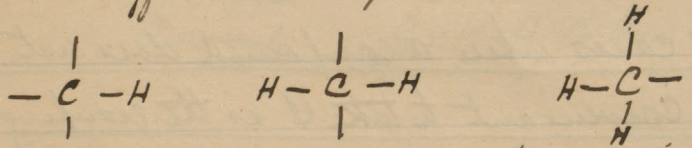
CH_3 $COHO$. or graphically



methyl oxalyl

The formulae thus found are called constitutional formulae, & constitute the most important part of the history of organic compounds. & Without such formulae you have little or no chance of producing a substance artificially. By using various reagents to break up the acetic acid, (especiall O) we find that it is constituted as shown in the last of the above formulae

The essence of organic Chemistry, is the study of compound radicals, Liebig has even so defined it, but this would not be quite correct. Looked at from this point of view, it is unsatisfied, & clues are found, (as in acetic acid) C is the all important element, & in probably every organic compound its atomicity is tetrad. It is obvious that it being a tetrad a vast number of compound radicals may be formed from it. Thus one atom of C with H gives 3 different compound radicals.



Of triad, dyad, & monad atomicities, respectively. In every compound the sum of the atomicities gives an even number. For artiad atomicities will of course remain even if double, & perissads become so by the same process.
The sum of the atomicities of any molecule, are at least twice as great as the atomicity of the most polyad element, contained in the molecule

An organic compound radical consists of one atom of C, with part of its bonds saturated, & it is a monad, dyad, or triad, according as one or more bonds remain free. These compound radicals perform functions in organic chemistry exactly analogous to those of monad, dyad & C elements in inorganic Chemistry.

Formulae should express on what general plan compounds are built up & how the atoms exactly the position of the atoms, must in fact be constitutional.

In All cases where a compound does not contain N it is convenient to take C as the grouping element

The Types of organic compounds are as follows.

1 Monodelphic as CH_4
2 Diadelphic as $\begin{Bmatrix} CH_3 \\ CH_3 \end{Bmatrix}$
3 Ammonic type $N'''H_3$
4 Ammonic chloride do $N^{v}H_4Cl$

In addition, the following are sometimes required

5 Triadelphic type as $\begin{Bmatrix} CH_3 \\ CH_2 \\ CH_3 \end{Bmatrix}$

6 Double monodelphic type, as $\begin{Bmatrix} CH_3 \\ \bullet \\ CH_3 \end{Bmatrix}$

7 Condensed diadelphic type, as $II\begin{Bmatrix} CH_2 \\ CH_2 \end{Bmatrix}$

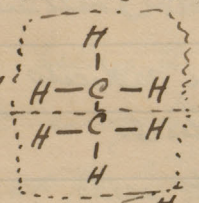
Compound organic Radicals.

	Monads		Dyads	
Methyl	$\{CH_3$ / CH_3	or $\{Me$ / Me	Methylene	CH_2 or Me″
Ethyl	$\{C_2H_5$- / C_2H_5-	or $\{Et$- / Et-	Ethylene	C_2H_4 or Et″
Propyl	$\{C_3H_7$ / C_3H_7	or $\{Pr$ / Pr	Propylene	C_3H_6 or Pr″
Butyl	$\{C_4H_9$ / C_4H_9	or $\{Bu$ / Bu	Butylene	C_4H_8 or Bu″
Amyl	$\{C_5$-H_{11} / C_5-H_{11}	or $\{Am$ / Am	Amylene	C_5-H_{10} or Ay″

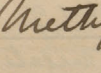
Methoxyl	CH_3O or Meo
Ethoxyl	C_2H_5-O or Eto
Propoxyl	C_3H_7O or Pro
Butoxyl	C_4H_9O or Buo
Amoxyl	C_5-$H_{11}O$ or Ayo

Et is convenient to call these by symbols as in inorganic chem (Ko)

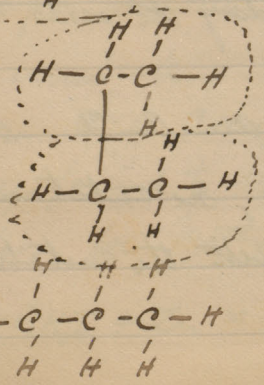
Methyl



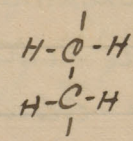
Methylene



Ethyl



Ethylene



Lecture VI Feb 9 th 1870

Classification of Organic Compounds

1 Organic radicals
2 Hydrides of Organic radicals
3. Alcohols
4 Ethers
5 Haloid ethers
6 Aldehydes
7 Acids
8 Anhydrides
9 Ketones
10 Etherial salts
11 Organic Compounds containing triad or fivefold Nitrogen
12 Organo-metalloid bodies.

The organic radicals perform the same functions as the metals

The Hydrides resemble H

The alcohols are hydrates of the radicals, & analogous OH_2

The ethers are oxides of organic radicals

The Haloid ethers are compounds with Cl, Br, Cyanogen &c

These first five classes are positive

Aldehydes hydrides of negative radicals

Acids hydrates of negative radicals

Anhydrides, the anhydrides of the acids

The Ketones

11 Closely allied with Am, Am Cl.

The Organometalloid bodies, are substances in which C is directly united with the metals.

By constructing tables of the bodies in various families, & arranging them in order, it is found that the various steps bear very close ~~relation~~ & simple relations to each other.

× × ×

Such series are known as "Homologous series"

Organic radicals must be divided into positive or basylous, & negative or chlorous. The positive radicals are, monad, dyad, & triad, like the elements

Methyl $\begin{cases} CH_3 \\ CH_3 \end{cases}$ The family all correspond to the formula $\begin{cases} C_n H_{2n+1} \\ C_n H_{2n+1} \end{cases}$ The ordinary alcohols belong to this series, & it is consequently the most important. The organic radicals may be obtained free, in two distinct ways.

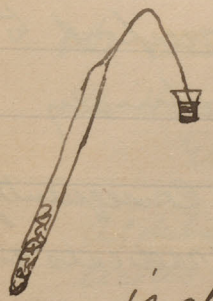
First by eliminating the separation of H by Zn, by operating on their compounds with Zn. The Iodides are found to be the best compounds to operate on, the reaction for Methyl is.

$$2C(C_nH_{2n+1})H_2I + Zn = ZnI_2 + \begin{cases} C(C_nH_{2n+1})H_2 \\ C(C_nH_{2n+1})H_2 \end{cases}$$

a considerable portion invariably falls to pieces in the operation, thus

$$\left\{\begin{matrix} C \\ C \end{matrix}\right\}(C_nH_{2n+1})H_2 = \left\{\begin{matrix} C \\ H \end{matrix}\right\}(C_nH_{2n+1})H_2 + (C(C_nH_{2n+1})H''$$

Ethylic Iodide is a sort of organic hydriodic acid. The operation of seperating ethyl, is performed by taking a strong glass tube, drawing it out to a capillary point at one end, introducing Zn & sealing up the other end. The capillary portion is bent round, so that by rarifying the air a portion of the iodide of ethyl may be drawn up.



The tube is then completely sealed & heated to about 130° in an oil bath. The Zn then takes the I & Ethyl is liberated. The Ethyl is at first in the form of a gas, but the accumulated pressure soon liquifies it. Other gases, products of the decomposition do not do so, & consequently, if the point be broken off, & the first rush allowed to escape, the ethyl which boils at quiety may be collected pure, over water, it burns with a luminous flame.

There is a remarkable special process, applicable to the production of Ethyl but not to the rest of the series. If Iodide of ethyl be placed in an inverted vessel full of Hg, & exposed to the action of daylight, the Hg gradually unites with the I & Ethyl is liberated in a pure state

The second general method of preparation, is to expose some salt of the fatty acids, (those of potassium best) to the action of electrolysis. The nascent O acts on the fatty acid. The ethyl is liberated at one pole, & H at the other.

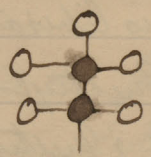
$$2\begin{cases} C(C_nH_{2n+1})H_2 \\ CO\,Ho \end{cases} + O = \begin{cases} C(C_nH_{2n+1})H_2 \\ C(C_nH_{2n+1})H_2 \end{cases} + {}_2CO_2 + OH_2$$

Thus with potassic acetate H is liberated at one pol, & the O combines & forms Methyl.
The two first of this series. (Ethyl & Methyl) the rest, known, are liquids.
Ethyl, is a gas, it has a slight etheric odour, one litre weighs 29 Centis. If at 0° Cent it be subjected to two atmospheres pressure, it

condenses to a colourless liquid. It is nearly insoluble in OH_2, but alcohol takes up 18 volumes of it. Giving it up again when mixed with water. It forms CO_2 when burnt with O. No true compounds of Ethyl are known, for when it is attempted to combine it with some element, the element either acts on the H, or the temperature required is so high that the ethyl is decomposed. This is true of all the rest of the series, thus the compounds cannot be reproduced.

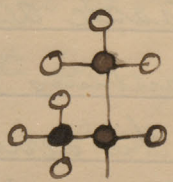
Normal, Secondary, & Tertiary Compounds

normal



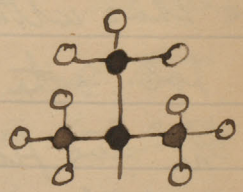
ethyl

secondary



β propyl or isopropyl

tertiary



(Phenylic alcohol, usually called Carbolic acid)

Organic Radicals

Class 1 Basylous or positive radicals.
Class 2 Chlorous or negative radicals.

Basylous or positive radicals.

Monads
- Methyl or $(C_n H_{2n+1})_2$ series
- Vinyl or $(C_n H_{2n-1})_2$ "
- Phenyl or $(C_n H_{2n-7})_2$ "

Dyads
- Ethyline or $C_n H_{2n}$ series
- Acetyline or $C_n H_{2n-2}$ "
- Phenyline $C_n H_{2n-8}$ "

Triad
- Glycosyl or $(C_n H_{2n-1})'''_2$ Series.

Lecture VII. Feb 10th 1870.

The Compound monad, basylous radicals of Methyl have been divided, as we have seen into. Primary, Secondary & Tertiary, The Normal, & primary compounds contain C united with 2 atoms of H

CH_3 = Me

$CMeH_2$ = Et. One of H replaced by Me connected by the C.

$CEtH_2$ = Pr stile normal

But we obviously may have a body, in which 2 of H are replaced by 2 of Me

CMe_2H, Pr β Beta propyl or isopropyl is a secondary radical, for the atom of C is now only united with one of H.

If now we develop Pr, & express it in its full form, we find that it admits of having its atoms of C arranged in a vertical series, this is always the case with normal Compounds.

$$\left\{\begin{matrix} CH_3 \\ CH_2 \\ CH_2 \\ CH_2 \\ CH_2 \\ CH_3 \end{matrix}\right. = \left\{\begin{matrix} CMeH_2 \\ CH_2 \\ CH_2 \\ CMeH_2 \end{matrix}\right. = \left\{\begin{matrix} CEtH_2 \\ CEtH_2 \end{matrix}\right. = Pr, \text{ or ethylated methyl.}$$

If however we try to perform this operation on the secondary radical $Pr_2\beta$

Complete molecule $\begin{cases} C\,Me_2H \\ C\,Me_2H \end{cases} = \begin{cases} CH_3 \\ C\,Me\,H \\ C\,Me\,H \\ CH_3 \end{cases}$

we are at once stopped. The Me cannot be arranged with its Carbon atoms in the series, & the only way is

$\begin{cases} CH_3 \\ CH(CH_3) \\ CH(CH_3) \\ CH_3 \end{cases} = Pr_2\beta$

If the radical cannot be developed ~~in a series~~ perpendicularly, with its Carbon atoms in a series it is either ~~*~~ secondary or tertiary.

Dyad basylous radicals, These are somewhat more interesting as they may be prepared in the free state, & can be made to combine.

The Ethylene or C_nH_{2n} series is the most important. They may be obtained,

1st By the abstraction of the elements of water from the normal monacid alcohols of the methylic series.

$\begin{cases} CH_3 \\ CH_2HO \end{cases} = \begin{cases} CH_2 \\ CH_2 \end{cases} + OH_2$

Ethylic, or common, alcohol. Ethylene.

The dehydrating may be performed by several agents. $SO_2 Ho_2$ is the best, if it be heated to about 130°C & alcohol allowed to fall on it drop by drop Ethylene ($\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right.$ or olifiant gas) is liberated. If alcohol be heated slightly with Phosphoric acid dehydration likewise takes place, phosphoric acid being formed, & $\left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right.$ (Ethylene) liberated. It may also be accomplished by passing the vapours of the normal monad radicals of the $C_n H_{2n+1}$ series over, lime, heated to redness

$$\left\{\begin{matrix}CH_3\\CH_2Cl\end{matrix}\right. = \left\{\begin{matrix}CH_2\\CH_2\end{matrix}\right. + HCl$$

The following are the known dyad radicals of this series

Ethyline	C_2H_4
Propyline	C_3H_6
Butyline	C_4H_8
Amyline	C_5H_{10}
Hexalyne	C_6H_{12}
Heptyline or Oenanthaline	C_7H_{14}
Octolyne or Caprifyline	C_8H_{16}

Nonylene	C_9H_{18}
Paranylene	$C_{11}H_{22}$
Cetene	$C_{16}H_{32}$
Cerotene	$C_{27}H_{54}$
Melene	$C_{30}H_{60}$.

This is a homologous series, each differs by C_1H_2 from the one before

All these bodies readily combine with Sulphurous anhydride, & with Cl, Br, I, & slowly with SO_2Ho_2.

These dyads may be transformed to monads, from which they were derived by the action of HCl, HBr, & HI acids, thus.

$$\left.\begin{matrix}CH_2\\CH_2\end{matrix}\right\} + HI = \left.\begin{matrix}CH_3\\CH_2I\end{matrix}\right\}$$

Ethylene — Ethylic Iodide.

& from this we Can obtain Ethyl by the action of Zn as before explained.

This series of dyads are isomeric so that from analysis no clue to difference, of Composition could be got.

All contain

C%	85.71
H%	14.29
	100.00

Ethyline (oligiant gas) $\left\{\begin{matrix} CH_2 \\ CH_2 \end{matrix}\right.$ Is liquid at -10°C
It is somewhat soluble in water, & this is a
point to remember in passing coal gas thro' water,
in its purification. It is soluble in alcohol
100 parts of that fluid taking 284·5·9 of ethyline.
It burns with a very bright flame. When
heated to redness (passed through a red hot tube)
it is decomposed, & yields.

$$\left\{\begin{matrix} CH_2 \\ CH_2 \end{matrix}\right. = CH_4 + C$$

This is another point of importance in gas-making.
It burns in Cl gas, & deposits its C almost
entirely, the Cl uniting only with the H. If
two volumes of Cl, & one of ethyline be mixed in
a cylinder & fired this is very well shown

Lecture VIII. Monday Feb 14th.

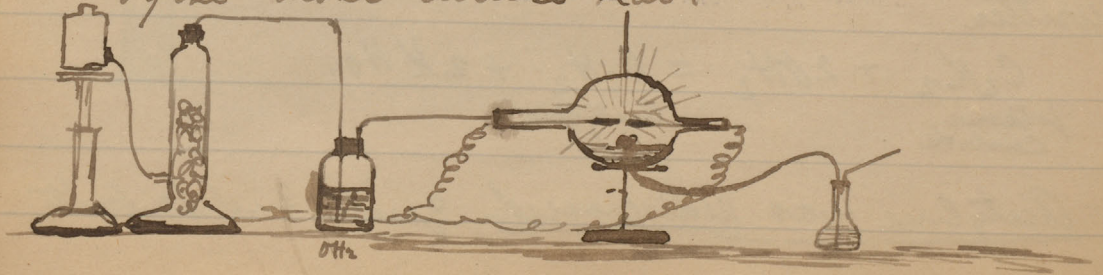
Acetylene is a diad, basylous, compound organic radical of great interest. It can be prepared from its inorganic elements, & is the start-point for a series of synthetical operations which enable us to produce organic compounds, & gives us an insight into the character & construction of the molecule.

It was first produced in 1836 by Edmund Davey. He found that when the residue from the retorts after the preparation of Potassium was treated with water, it effervesced, & gave off a gas which somewhat resembled Methyl, but that when mixed with Cl it exploded under the action of diffused daylight. The reaction by which it was formed may be thus written

$$\underset{\text{potassic carbide}}{C_2K_2} + 2OH_2 = \underset{\text{acetylene}}{C_2H_2} + 2KHO.$$

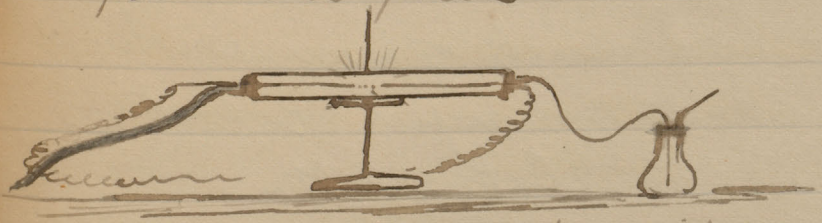
Acetylene was rediscovered, quite independently

by Berthelot in 1860, & then came into notice. By the original reaction it was practically produced from its elements. But this may be done still more directly by heating C intensely in an atmosphere of H. When this is done it is found that the C & H unite to form Acetylene C_2H_2. It is best accomplished by passing a strong electric current ~~th~~ between two points of C the heat thus generated (electric light) being extremely intense. The combination of C & H under these conditions is very curious, as it had been previously thought that heat was the greatest enemy of hydrocarbons. A somewhat similar instance however is seen in lamp black from which all the H cannot be driven by the most intense heat.



Sand is placed at the bottom of the globe to prevent its fracture by falling sparks. The gas as it issues is collected by an ammoniacal solution of Cuprous Chloride. It forms a reddish brown precipitate which has Cuprous acetylide, & by action on which pure Acetyline may be produced..

Acetyline may also be prepared by passing a stream of electric sparks, from an induction coil through the vapour of some higher hydrocarbon as Benzol, or Coal gas. The operation may be carried on as below the sparks passing either from Carbon or platinum poles.



The reaction may be written as for marsh gas

$$2CH_4 = C_2H_2 + 3H_2$$

4th process by heating the vapour of methylic chloride to low redness

$$2\,CH_3Cl = C_2H_2 + 2HCl + H$$

5 - by passing the vapour of chloriform over ignited copper

$$2\,CHCl_3 + Cu_2 = C_2H_2 \quad 3\,\underset{\text{Cuprous Chloride.}}{Cu_2'Cl_2}$$

6 by the action of calcic carbide on water, this is exactly analagous to the original process by Davey. $C_2Ca'' + 2OH_2 = C_2H_2 + CaHO_2$

7 from vinylic bromide one of the derivatives of ethyline, acetyline may be obtained by the action of alcoholic potash

$$C_2H_3Br + KHO = C_2H_2 + KBr + OH_2$$

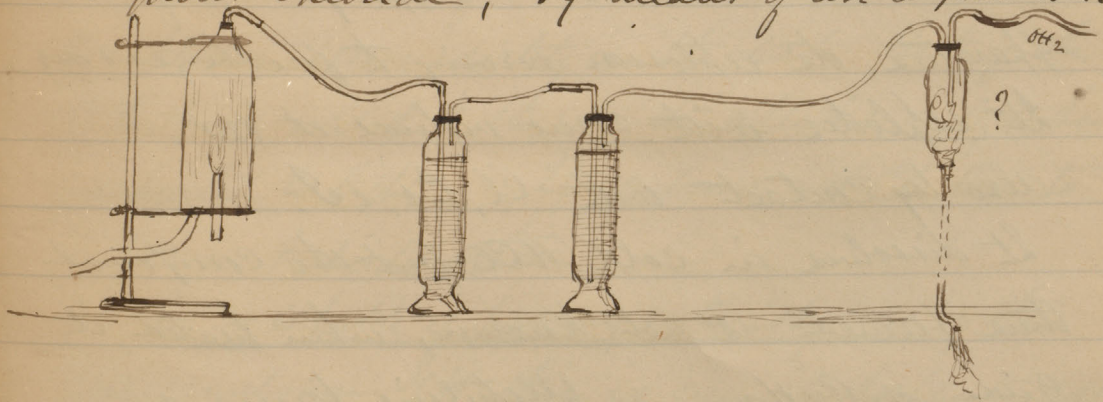
And lastly by a variety of processes where it is ~~the~~ a product of imperfect combustion.

$$\underset{\text{marsh gas}}{4\,CH_4} + 3O_2 = 2\,C_2H_2 + 6\,OH_2$$

$$\underset{\text{olifiant gas}}{2\,C_2H_4} + O_2 = 2\,C_2H_2 + 2\,OH_2$$

Give the blundering old Quilr up

A good method for obtaining it thus, is to make use of the imperfect combustion of air in coal gas. The air is burned in a small flame in an atmosphere of gas as shown below, & the products of combustion are drawn off at the top, & through two bottles of ammoniacal cuprous chloride, by means of an aspirator.



Other gases are always formed in this operation as well as acetyline, & hence the necessity for purifying it by causing it to combine with Cu. The proper name of the so called acetylate of copper is cuprocopyridic ether & the reaction by which it is obtained & acetyline prepared from it as follows.

$$2\,Cu_2Cl_2 + 2\,C_2H_2 + OH_2 = \begin{matrix} C_2Cu_2H \\ C_2Cu_2H \end{matrix} + 4\,HCl$$

$$\begin{matrix} C_2Cu_2H \\ C_2Cu_2H \end{matrix} + 4\,HCl = 2\,C_2H_2 + 2\,Cu_2Cl_2 + OH_2$$

Cuprous chloride.

Cuprosovinylic ether (Cuprous acetylide) is a red amorphous solid insoluable in OH_2. It explodes gently when struck with a hammer. It is the probable cause of the explosions of some gas meters & apparatus, as acetyline is always present in small quantities in gas, & may have combined with the copper fittings of such apparatus, its explosion serving to fire the gas & air. It explodes with some violence at 120°, & also by contact with Cl, Br, & I.

It dissolves in cold HCl but the compound thus formed is not known, when heated it gives off C_2H_2. Acetyline forms a corresponding compound with Ag of a grey colour it is formed by a similar process & yields acetyline in the same way

Acetylene (C_2H_2) is a colourless & transparent gas, possessing a peculiar & unpleasant odour. Its specific gravity as compared with air is .92. It is somewhat

soluable in water. When lit it burns with a very bright but smoky flame, & gives a most intense light. Part of the light of coal gas is no doubt from this source. When mixed with Cl it explodes under the action of even diffused daylight, or even under certain circumstances in the dark. If the Cl be added to the C_2H_2 it explodes immediately in the dark. But if the C_2H_2 be added to the Cl it explodes only when subjected to light. It combines with Cl, Br to form haloid ethers.

It is capable of passing into Ethyline by the assimilation of H, this is very important as it is the first step in the production from it of ordinary alcohol. If it be put into a flask containing granulated Zn & strong ammonia & heated Ethyline gas, recognisable by its less smoky flame comes off.

$$C_2H_2 + H \text{ (nascent)} = \underset{\text{Ethyline}}{C_2H_4}$$

Acetyline also combines with $SO_2H_2O_2$, & forms Vinosulphuric acid

$$C_2H_2 + SO_2H_2O_2 = SO_2(C_2H_3O)HO$$

Phenyline or C_nH_{2n-8} series of dyad radicals none are known unless acetyline be formyl as shown. It may only be an isomer

Phenyline C_6H_4

Triad Radicals (baryleus)

None are known unless acetyline be formyl as shown. It may only be an isomer

C_2H_2''' $\left\{\begin{matrix}(CH)''' \\ (CH)'''\end{matrix}\right.$

formyl

Chlorous or Negative Radicals

Every basative or basylous radical may be looked upon as the source of a chlorous or negative one, by the saturation of ~~one~~ two or more of its bonds. (formerly saturated by hydrogen) by an atom of dyad O. 190 substituted for 2 of H.

Ethyl	$\{C_2H_5-$ $\{C_2H_5-$	yields Acetyl	$\{C_2H_3O$ $\{C_2H_3O$
Allyl	$\{C_3H_5-$ $\{C_3H_5-$	" acryl	$\{C_3H_3O$ $\{C_3H_3O$
Ethyline $(C_2H_4)''$		" glycolyl $(C_2H_2O)''$	
Propyline $(C_3H_6)''$		" lactyl $(C_3H_4O)''$	
"	"	" malonyl $(C_3H_2O_2)''$	

But it is simpler to look at it from another point of view, by which the negative radicals are reduced to two

Cyanogen $\{CN'''$ $\{CN'''$ & Oxalyl $\{CO\,HO$ $\{CO\,HO$ (dry oxalic acid) both are known in the free state & are present as the acidifying principles of nearly all organic acids.

Lecture IX Feb 15th

These two ~~acidic~~ negative radicals may be looked upon as derivatives of Me. $(\{^{CH_3}_{CH_3})$ In Cyanogen the three atoms of H are replaced by an atom of trivalent nitrogen & $\{^{CH_3}_{CH_3}$ becomes $\{^{CN'''}_{CN'''}$, & in Acetyl the H is replaced by one atom of O'' & one of ~~OH~~ HO

$$N\equiv C-C\equiv N \qquad H-O-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-O-H$$

These two bodies are closely related & easily pass into one another. If Cyanogen be dissolved in water it soon changes into Ammonic oxelate

$$\{^{CN'''}_{CN'''} + 2KHo + 4OH_2 = \{^{CO(NH_4O)}_{CO(NH_4O)}$$

In presence of potassic hydrate cyanogen evolves Ammonia & produces potassic oxelate.

$$\{^{CN'''}_{CN'''} + 2KHo + 2OH_2 = \{^{CO\,Ko}_{CO\,Ko} + 2NH_3$$

& conversely when Ammonic oxelate is heated

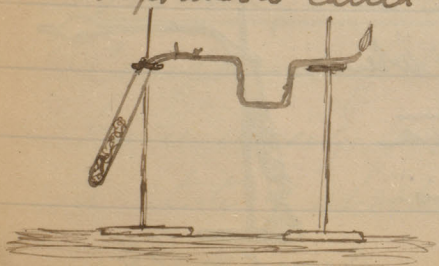
$$\{^{CO(NH_4O)}_{CO(NH_4O)} = 4OH_2 + \{^{CN'''}_{CN'''}$$

This easy transformation forms the clue to many important reactions.

Cyanogen was discovered in 1815 by Gay Lussac. It was the first compound radical ever observed & formed the beginning of the epoch, when organic substances were taken apart into organic radicals. It may be obtained by many processes, but one takes the precedence from its ease & the purity of the product. This is by heating mercuric cyanide. When Cyanogen is evolved.

$$HgCy_2 = Hg + Cy_2$$

It would be expected that the free Hg & the Cyanogen would both distill over & leave the tube empty, but such is not the case. A brownish-black substance remains in the tube. This is found to have exactly the same composition as Cy, & is in fact Cy in an isomeric form. It is probable that a great number of molecules are linked together by the bonds of N. This compound is called (paracyanogen)

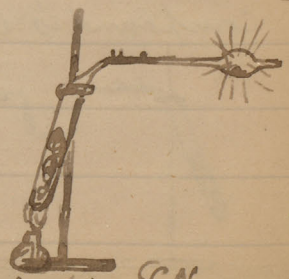


The production of Cy is best carried on in a tube drawn out & linked by a caoutchouc joint to a bent tube, which collects the volatilized Hg

Cyanogen is a colourless, transparent, gas. It has a curious odour, which reminds one of HCy. It burns with a peculiar & beautiful lilac flame. Which is due to ignited N. One litre weighs 26 grms. When burned it yields 2 volumes of CO_2 & 2 of N. One volume of Ht_2 dissolves $4\frac{1}{2}$ of Cy. Subjected to a pressure of about 5 atmospheres, & to extreme cold it condenses to a liquid (transparent) boiling at $-20.7°$ Cent. It bears a very high temperature without decomposition like acetylene, & has been detected in the hottest portions of iron furnaces, where it probably plays an important part in reducing the Fe. It is formed by the combination of the Ng the atmosphere, with the C, & K of the material in the furnaces. The potassic cyanide thus formed ~~yields~~ subsequently decomposes.

Potassium unites directly with Cy when heated in a current of the gas, & thus ~~the~~ Kingsley shews its radical functions.

$$K + Cy = KCy$$



Burning K in $\frac{C}{C}\frac{N}{N}$

Cyanogen may also be produced from Acetylene.
If N is burned (so to speak) in Acetylene Cy is the result.
This requires however the temperature of the electric spark

$$C_2H_2 + N_2 = 2CNH.$$

$$\left\{\begin{matrix}CH\\CH\end{matrix}\right. + N_2'' = 2\,CNH.$$

The reaction is exactly analagous to the production of Hydrochloric acid

$$\left\{\begin{matrix}H\\H\end{matrix}\right. + \left\{\begin{matrix}Cl\\Cl\end{matrix}\right. = 2\,HCl$$

Coal gas, Bengol vapour &c if mixed with N & passed through a tube in which a current of Electric sparks ~~are~~ is maintained, small quantities of Cy are formed. This may be rendered evident by passing the gasses through a solution of KHO which absorbs all the Cy. If this solution be then mixed with a proto & per salt of iron, & excess of HCl added Prussian blue results.

<u>Hydrocyanic acid, HCy.</u> is the most important Compound of Cyanogen, & may be obtained by a variety of processes. By only one however in a state of absolute purity. It should not however,

be prepared in this state except for purposes of scientific enquiry as it is exceedingly poisonous. Even the inhalation of its vapour in any quantity being followed by instantaneous death. The process mentioned is, passing SH_2 over mercuric cyanide

$$HgCy + SH_2 = HgS'' + 2HCy.$$

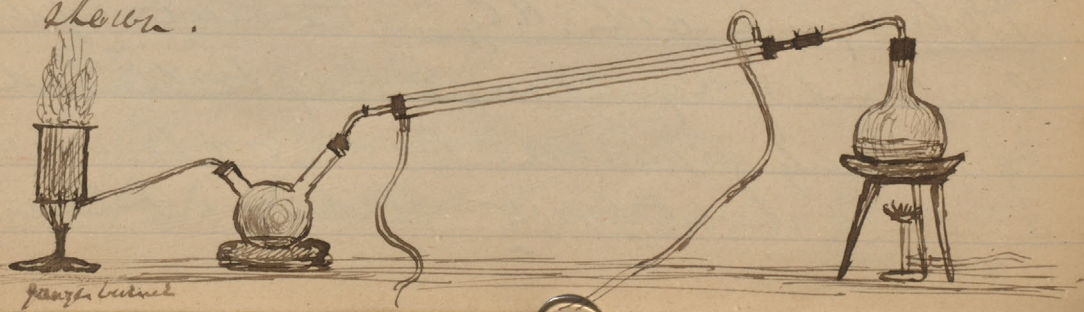
The resulting gas is conducted into a vessel contained in freezing mixture.

By The process by which it is almost always prepared

SO_2Ho_2 is made to act on, potassic cyanide, or ferrocyanide which is generally used, thus.

$$2KCy + SO_2Ho_2 = HCy + 2SO_2Ko_2$$

By this method the HCy is obtained in solution in OH_2. The gases which escape Condensation should be passed through flame in the manner shewn.



Hydrocyanic acid. HCy. is a limpid colourless liquid, which boils at 26·5° & freezes at −15°C. One litre weighs 13·5 Grms. It is exceedingly volatile, so much so that if a glass rod be dipped in it & exposed to the air the evaporation of a portion serves to freeze the rest which remains on the rod. The vapour when inhaled causes almost instant death. It decomposes easily & leaves a brown material which is probably paracyanogen. Its aqueous solution also decomposes, being changed partly into ammonic oxelate, & partly to ammonic formate. $CN'''H + 2OH_2 = \overset{H}{\underset{H}{C}}O(N^{v}H_4O)$. If however the solution be acidulated as by a drop of SO_2Ho_2 it is permanent. When on the contrary it is alkeline it decomposes very rapidly.

It is probable that two isomeric HCy's exist which depend for their difference upon the mode of junction of the N & C. The N may be either triad or pentad.

$N\equiv C-H$ or $C\equiv N-H$

Though these two forms of the acid are hypothetical their compounds undoubtedly exist. Thus there are two methylic Cyanides in one the C is united with the N in the other with the C. There is a very extensive series of Cyanides which may be divided into two great classes. Simple & Double. The double Cyanides may be looked upon as molecular compounds of the simple Cyanides, though in many cases the connection is undoubtedly more intimate. The Double Cyanides may be divided into those easily decomposable, & those not easily decomposed. The first are decomposed by dilute acids, the second even stand boiling with somewhat concentrated acid. It is probable that in one case the metal is combined with the C in the other with the N. All the double Cyanides contain exactly enough Cy to saturate all the bonds of their component metals.

Alkaline Cyanides are soluable in water, the remainder with the exception of that of Hg are insoluable. Their solutions smell of HCy it being gradually expelled by the CO_2 of the atmosphere. Most of the insoluable single cyanides dissolve in the solutions of the alkeline cyanides to form double cyanides. The cyanides of the alkelies when fused in the air absorb O & become Cyanates

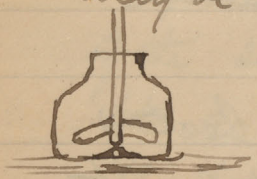
$$KCy + O = CyKo.$$

Cyanides usually evolve Cy at a red heat & leave Paracyanogen, & the metal or its Carbide.

The most imfotant doable cyanides are the Ferro, & Ferricyanide of potash. or yellow & red prussiate of potash

Potassic Ferrocyanide $K_4Fe''Cy_6$, may be formed by placing in contact with the air a solution of potassic cyanide mixed with iron filings. $Fe + 6KCy + OH_2 + O = K_4Fe''Cy_6 + 2KHo.$

On the large scale, however & for manufacturing purposes it is prepared, by strongly igniting together American, or caustic potash, & some highly nitrogenised animal matter, such as hoofs, horns, scraps of leather, or hair. The operation is carried on in iron pots about 18 inches high & having a rod passing into them by which the may be stirred by the aid of machinery.



The S which is always present in some quantity in the animal matter combines with the Fe of the vessels, & forms Fe S. K Cy is at the same time produced. When the mass is lixiviated the Fe S acts on the K Cy forming. SK_2 ~~ferrous~~ potassic sulphide, & $K_4 Fe Cy_6$ ferrocyanide of potassium.

Lecture X. Feb 16th

In this reaction a portion of the N of the organic body is transformed into Cyanogen (hydrocyanic?) this combines with the potash. The process

is however very wasteful, only 1/3 to 1/5 of the nitrogen of the organic matter is ever obtained as KCy. The remainder distilling off as ammonia & other volatile compounds.

K_4FeCy_6 is soluble in 2 of boiling, 8 of parts by weight of cold water, but insoluble in alcohol. When fused with potassic carbonate it gives potassic cyanide mixed with cyanate. This is the KCy of commerce.

$$K_4FeCy_6 + CO_3K_2 = 5KCy + CyKO + Fe + CO_2$$

If K_4FeCy_6 be acted on by dilute SO_2H_2O HCy is given off. If however, the SO_2H_2O be concentrated it is decomposed & yields CO. This forms one of the best reactions for obtaining it.

If acted on by HCl, Hydroferrocyanic acid is liberated. This is best accomplished in the presence of ether, when the H_4FeCy_6 falls as a whitish precipitate, which becomes blue by decomposition.

With Ferrous salts K_4FeCy_6 gives a white precipitate which rapidly becomes blue when exposed to the air.

With Ferric salts $K_4 Fe Cy_6$ gives a dense blue precipitate of Russian blue. The two reactions are as follows

$$K_4 Fe'' Cy_6 + SO_2 Fe'' = Fe Cy_6, Fe K_2 + SO_2 K_2$$

$$3 K_4 Fe'' Cy_6 + Fe_2 Cl_6 = 3 Fe'' Cy_2, 'Fe''''_4 Cy_{12} + 12 KCl$$

In the second reaction all the K is at once replaced by Fe; in the first, when the white precipitate is formed this is not the case, but as it gradually absorbs O Prussian blue is formed.

Ferricyanide. $K_6 Fe_2 Cy_{12}$. When the ferrocyanide is exposed to oxidising agents, it is changed into Ferricyanide. Thus by Cl.

$$2 K_4 Fe'' Cy_6 + Cl_2 = K_6 'Fe''''_2 Cy_{12} + 2 KCl.$$

The ferrous iron is changed to ferric (" to ""). This change is carried out on the large scale for the dyer. Calico-printer &c. A current of Cl is passed as long as it is absorbed. In the laboratory Br may be employed. The solution gradually deepens in colour as the red prussiate is formed.

Ferricyanide of potash gives Turnbulls blue with ferrous solutions, & no precipitate with Ferric. This is a good distinctive test between II & III iron, but care must be taken that the solution of $K_6 Fe_2 Cy_{12}$ has been recently made, as it tends to return to the ferrocyanide. $K_6 Fe_2 Cy_{12}$ crystallizes in red coloured rhombic prisms.

The remaining compounds of Cy are interesting from a theoretical point of view. It forms three isomeric compounds with Cl

$CyCl$	Cy_2Cl_2	Cy_3Cl_3
gaseous	liquid	solid

From potassic cyanate (before mentioned) Cyanic acid may be obtained, but unless kept in a freezing mixture it changes very rapidly into Cyanolide, an isomer. It belongs to a curious isomeric series

Cyanic acid	$CyOH$	= $CyHO$	
Cyanuric acid	$Cy_3O_3H_3$	= Cy_3HO_3	} differently combined.
Paluanuric? acid	$Cy_3O_3H_3$	= Cy_3HO_3	}
Cyanalide	$Cy_n O_n H_n$	$Cy_n HO_n$ a neutral body	

Potassic & other cyanides are capable of combining with S which takes the place of the O in the cyanates. If KCy be fused & S introduced potassic sulphocyanide is formed. It is exactly analagous to cyanic acid. $Cy K \overset{\equiv}{O} = Cy KS$. CyKs gives a blood red colouration with Ferric salts.

Cyanogen by the action of alkalies is transformed into oxatyl, as before stated.

Oxatyl $\begin{matrix} CO Ho \\ CO Ho \end{matrix}$ is dry oxalic acid. In combination with H &c it forms a vast number of organic acids. These when written rationally present, often, exceedingly complex formulae, which almost defy arrangement. But they become simple when looked upon as the compounds of oxatyl. Oxatyl is a white amorphous substance when it crystallizes from water it is oxalic acid. Oxalic acid occurs largely in nature in many plants. Its acid potassium salt is found in wood sorrel ($\begin{matrix} CO Ho \\ CO Ko \end{matrix}$) its sodium

salt is present in many sea plants as the salsoda &c Its Calcium salt is present in rhubarb, some lichens, barks &c & also in the urine. It forms one species of Calculus, called the mulberry calculus.

Oxalic acid may be produced in a variety of ways It is the product of a vast number of organic compounds, when subjected to oxidation. It is so to speak the last skeleton of an organic compound the last stage before it becomes reduced to its inorganic constituents. Till very lately it has been formed, for manufacturing purposes by the oxidation of sugar, or molasses, by NO_2Ho. This ~~compl~~ process is now almost entirely superceded by another in which sawdust & KHo are use. The KHo cannot completely be superceded by NaHo though this would be much cheaper. The limit is found to be ½ of each. The Sawdust is mixed with the caustic potash & soda, & heated on an iron plate at a temperature

of from 135° to 140° Cent for 6 hours. Sodic & potassic formates are ~~to~~ at first to a great extent produced, but on the temperature being raised to between 170° to 200° this is transformed to oxalate. The fused mixture thus obtained, in which there is a great excess of alkali, is lixiviated, & it is found that the oxalic acid is almost entirely ~~completely transformed into~~ combined with the soda. The potash is separated by crystallization, & the sodic oxalate mixed with lime (milky lime). Insoluble Calcic oxalate is thus formed. This is subjected to the action of dilute SO_2HO_2, filtered through canvas, (by means of causing a vacuum below) to free it from the SO_2CaO & pure oxalic acid results. The potassium & sodium are retransformed to NaHo & KoHo & used again.

<u>Oxalic acid</u> crystallizes in four sided prisms. Is soluble in water & alcohol. It can readily

be sublimed, but in the process partially decomposes. It sublimes at the temperature of boiling water in vacuo. At a greater heat it is transformed into CO_2 & Formic acid, the formic acid also usually splits up, still further into CO & OH_2,

$$\left\{\begin{matrix} COHO \\ COHO \end{matrix}\right. = CO_2 + \left\{\begin{matrix} H \\ COHO \end{matrix}\right.$$

formic acid

$$\left\{\begin{matrix} H \\ COHO \end{matrix}\right. = OH_2 + CO.$$

It may also thus be transformed by any powerful dehydrating agent as SO_2HO_2.

$$\left\{\begin{matrix} COHO \\ COHO \end{matrix}\right. = CO + CO_2 + OH_2$$

This is the best method of producing CO. The two semy molecules of oxatyl have not been seperated.

<u>Heated with excess of caustic potash</u> H is evolved & potassic carbonate formed. If silver oxalate be produced it is found to be explosive, by a slight heat. its explosion gives rise to metallic silver

$$\left\{\begin{matrix} CO\,Ago \\ CO\,Ago \end{matrix}\right. = 2CO_2 + Ag_2$$

Oxalic acid is largely employed by the calico-printer, & also for cleaning leather &c.

Oxalic acid forms 3 series of salts

normal	acid	& superacid which must be regarded as molecular compounds.
$\left\{\begin{matrix}CO\,Ko\\CO\,Ko\end{matrix}\right.$	$\left\{\begin{matrix}CO\,Ho\\CO\,Ko\end{matrix}\right.$	$\left\{\begin{matrix}CO\,Ho\\CO\,Ko\end{matrix}\right.$ $\left\{\begin{matrix}CO\,Ho\\CO\,Ho\end{matrix}\right.$
$\left\{\begin{matrix}CO\\CO\,Bao''\end{matrix}\right.$	$\left\{\begin{matrix}CO\,Ho\\CO\\Bao''\\CO\\CO\,Ho\end{matrix}\right.$	

Except the alkalies, most oxalates are insoluble in water, & all are decomposed on heating to redness.

The Basicity of the acids which are formed from oxalyl, depend on the number of ferny molecules of $\left\{\begin{matrix}CO\,Ho\\CO\,Ho\end{matrix}\right.$, each of which adds unity.

Oxamic acid. If hydrammonic oxalate is heated on an oil bath, oxamic acid results.

$$\left\{\begin{matrix}CO\,(N^{v}H_2O)\\CO\,Ho\end{matrix}\right. = \left\{\begin{matrix}CO(N'''H_2)\\CO\,Ho\end{matrix}\right. + OH_2$$

It is a white crystalline powder soluble in water by boiling in which it is retransformed to hydrammonic oxalate, by the assumption of a molecule of water. By the precise reverse of the above equation. It is a monobasic acid & forms insoluble salts

It is evident that the change can be carried one stage further, & if normal ammonic oxalate be used Oxamide $\left\{\begin{matrix} COAd \\ COAd \end{matrix}\right.$

$$\begin{matrix} CO(N^{v}H_4O) \\ CO(N^{v}H_4O) \end{matrix} = 2OH_2 + \left\{\begin{matrix} CO(N'''H_2) \\ CO(N'''H_2) \end{matrix}\right. \text{oxamide}$$

It is neutral tasteless, insoluable in alcohol & cold water. If heated it gives cyanogen

$$\left\{\begin{matrix} CO(N'''H_2) \\ CO(N'''H_2) \end{matrix}\right. = 2OH_2 + \left\{\begin{matrix} CN''' \\ CN''' \end{matrix}\right.$$

By the action of dilute acids it gives oxalic acid.

Lecture XI.

Thursday Feb 17th

Hydrides of organic radicals. is the second great class of organic bodies. We have already considered the hydride of cyanogen, Hydrocyanic acid? They have been divided into the hydrides of Monad radicals dyad radicals &c, but this is not necessary for so far as is known, these are Identical. Thus vinyl $H-\overset{\overset{CO}{|}}{\underset{\underset{C}{|}}{C}}-H$ is a monad compound radical (two bonds of C latent.) But when it forms its hydride, the two

latent bonds are freed, & we get a dyad or triad hydride. thus $\begin{array}{c} H \\ H-C-H \\ H-C-H \\ H \end{array}$ & this is precisely the same as ethyl hydride (Ethyl $\begin{array}{c} H-C-H \\ H-C-H \\ H \end{array}$ ethyl hydride $\begin{array}{c} H \\ H-C-H \\ H-C-H \\ H \end{array}$) It is also ddentical with ethilic hydride. The Hydrids of the monads dyads &c being identical, it will only be necessary to consider those of the monads. These are divided into two great classes.

I. Hydrides of the positive or basylous radicals.

II. Hydrides of the negative or chlorous radicals.

Class I.

Two series of hydrides belonging to this class are well known.

1 Hydrides of radicals of Methyl series

2 Hydrides of radicals of Phenyl series

1 Hydrides of radicals of Methyl series

Marsh gas C_nH_{2n+2} series

Methods of preparation

$$\underset{\text{Zinc compound of rad}}{Zn(C_nH_{2n+1})_2} + 2OH_2 = \underset{\text{Zincic hydrate}}{ZnHO_2} + \underset{\text{hydride of radical}}{2\left\{\begin{matrix} C_nH_{2n+1} \\ H \end{matrix}\right.}$$

$$\underset{\text{Iodide of monad rad}}{2\left\{\begin{matrix} C_nH_{2n+1} \\ I \end{matrix}\right.} + Zn = ZnI_2 + \underset{\text{dyad radical}}{C_nH_{2n}} + \underset{\text{hydride of monad rad}}{\left\{\begin{matrix} C_nH_{2n+1} \\ H \end{matrix}\right.}$$

The start point of this series is methylic hydride or marsh gas. They may all be prepared by the first process, & in the case of methilic hydride the combination takes place very vigorously with evolution of heat & light. Some of them may be prepared also by special processes as from the iodides, in this reaction however much of the substance splits up &.

For Marsh gas there are several special methods Thus it is formed by the putrefaction of vegetable matter under water, in marshes &c. The water is apparently decomposed & the putrefaction carried on at the expense of its oxygen. & CH_4 & CO_2 formed. This process has taken place to an enormous amount in the coal strata where vegetable matter has so to speak putrified. The CH_4 is often retained in fissures &c at an enormous pressure, & when these are opened by the miner, "blowers" of gas are produced which sometimes give rise to very violent explosions.

Marsh gas is one of the constant products of destructive distillation, & forms from about 40 to 50 per cent of coal gas. A vast number of other hydrides of the series are produced at the same time, indeed with coal gas it is a question if the whole series is not formed. CH_3 however is the only member which is produced by putrefaction. It is the lowest member of the series, & is a gas which has not yet been condensed, as we ascend in the series we come to amylic hydride, & such bodies which are volatile liquids, & when we go still higher to solids as paraffin. They are all distinguished for their great indifference, they are, so to speak the noble metals of organic Chemistry. The word paraffin indeed means small affinity. It was so called because no change was seen to take place when it was treated with acids &c.

Methylic hydride, Marsh gas, light-carburetted hydrogen, fire damp. (CH_4). It found in nature under the circumstances already indicated. It also occurs in large quantities in some peat bogs, especially in Chat Moss between Liverpool & Manchester. There it is uncertain whether it is derived from the fermentation of the peat, or from the underlying coal strata. The bog being impervious retains it, & when a pole is thrust down or a boring made it escapes in great quantities & under great pressure. In one case it burned for many weeks, & was afterwards, till an accident happened from it, used to heat a steam boiler.

It is also evolved in great quantities from the mud volcano of Bulgenac? in the Crimea.

In the Laboratory it may be made conveniently by heating nearly to redness a mixture of Quicklime, sodic acetate & caustic soda. It is never however thus obtained quite pure.

$$\left\{\begin{matrix} CH_3 \\ CONao \end{matrix}\right. + NaHo = CONao_2 + CH_4$$

It may also be obtained as under

$$Zn\,Me_2 + 2\,OH_2 = 2\,MeH + Zn\,HO_2$$

this is of theoretical interest.

It may be obtained entirely from inorganic bodies, by passing CS_2 & SH_2 over red hot copper in a tube

$$CS_2 + SH_2 + 4\,Cu = 4\,CuS + CH_4$$

<u>CH_4</u> is a colourless inodorous gas, not poisonous when inspired. Its specific gravity is ·556? or 8 Cr[illegible]. Being so much lighter than air it tends, in coal mines to accumulate along the roofs of the passages. It is nearly insoluble in water but dissolves in about 1/2 its bulk of alcohol. It burns with a flame of very feeble luminosity & gives OH_2 & its own volume of CO_2. It burns with a more luminous flame in Cl on account of the seperation of solid carbon particles.

It is immaterial, whether coal gas contains

from 40 to 60 per cent of CH_4, & as much CO_2 & H_2 so little does it help the luminosity. If however the gas be burned at a very high temperature, heated to redness before ignition, the CH_4 gives a good light. CH_4 explodes when mixed with not less than 3½ times its volume of air, & not more than 14. When these limits are exceeded the temperature of combustion is not sufficient to raise the surrounding mass to its ignition point. In small quantities it does not explode with great violence, not so much so as $H + O$. On explosion it gives a pressure of from 4 to 5 atmospheres. Two volumes of O are required for its complete combustion.

CH_4 & Cl when mixed & exposed to light combine to form Chloroform, usually with explosion.

When exposed to decomposition by the passage of electric sparks CH_4 gives nearly but not quite twice its volume of H. It gives not quite the theoretical volume on account of the formation of Ethylene.

Ethylic hydride, can only be prepared pure by the first reaction.

A convenient manner is to put Zn, with ethylic Iodide, & water, into a flask & heat. It comes off as a colourless inodorous gas. It is nearly insoluble in OH_2 but somewhat more so in ~~water~~ alcohol. Its specific gravity compared with H is 15. It has not yet been condensed. It yields two volumes of CO_2 when burned. It is not acted on by Cl in the dark but by the action of light gives ethylic Chloride & another gas which has the same formula but is incondensable. It seems therefor to be an isomer, though the constitutional formula would not admit of there being an isomeric form unless C bonds are of different values.

Amylic hydride is the next in the series which has been studied. It is probably the

lightest liquid known, & burns with a very luminous flame.

The higher members of the series are called Paraffin. They occasionally occur native as fossil wax & Ozokerite &c. They are also found in petroleum. Paraffin is manufactured on the large scale from Cannel coal, especially ~~especially~~ from Leesmind Cannel from N. Wales & Boghead from near Edinburgh. When the distillation is carried on at a very low temperature (dull redness) large quantities of paraffin are found in, & extracted from the tar. Which generally contains from 1 to 5 per Cent.

Hydrides of the Radicals of the Methyl series

Methylic Hydride or marsh gas	MeH or CH_4
Ethylic hydride	EtH or C_2H_6
Propylic or tritylic hydrate	PrH or C_3H_8
Butylic hydride or tetratylic hydride	BuH or C_4H_{10} both alcohol above 0°
Amylic or pentylic hydride	AyH or C_5H_{12}
Hexalic or Caproylic hydride	CfH or C_6H_{14}

I soon title me get to the solid paraffins. The highest of the series is

Pentadecatylic hydride $C_{15}H_{32}$ boils at 254°–260°

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Note book
of
Chemical lectures

delivered at the
Royal College of Chemistry
Oxford Street
by
Professor Frankland
1869

George Mercer Dawson.

May picture H with only 1 pt-of attraction Zn^{2} pt & so on

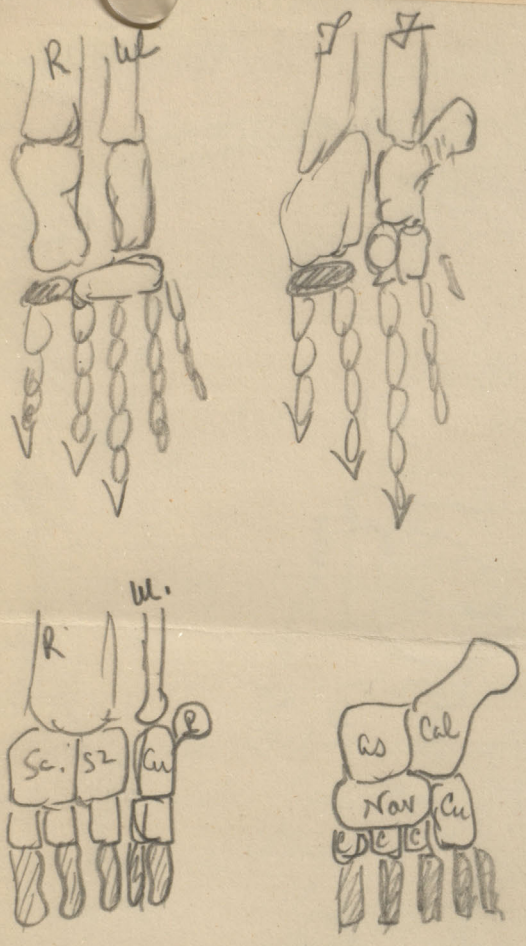
Much clearer form ~~fiction~~ theory call them bonds. may be compared to gravitation. Must have some symbol, most simple a line connecting the symbols. & mind requires to be helped by some mechanical contrivance. Property of fixing a certain number of atoms termed atomicity. Zn = 2 of H + Cl. O ^{IV} C by 4 S by 6. If you place to right or above the symbol of an element a certain number of dashes H' Zn'' B''' C'''' or 4. No bond can remain disunited. Molecule smallest quantity any element that can exist seperately. All therefore polyatomic. most di-atomics N may be pictured thus O=O Cl thus not however of much importance.

Ph Contains 4 atoms in molecule may be represented thus

An element with an even no of bonds may exist as monatomic molecule Zn Cc Hg are found to be thus. not necessary that each element should exist so. Of for instance to atom molecule. Ozone 3 atoms connected.

ozone. 1 bond Monad 2 dyad 3 triad 4 tetrad

For simplicity very desirable to avoid as much as possible atomicity marks. thus Every monad no mark Atomicity marks unnecessary for O. simply to remember O as dyad. Carbon very rarely requires mark, almost



double tubes &c Notochord &c
Visceral arches & Clefts. Limbs absent or present. not more than 2 pair. Endoskel. Hard productions of al Canal as teeth but jaw part of facilities of head. & nothing to do with limbs! Complete vascular system & serous sacs unsuitly viscera. Valvular heart. Hepatic portal system.

...ion, Zn with two
...theory if we call
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elements should exist thus; O for instance

May picture H u

Much clearer from
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of atoms termed ato
S by 6. If you place
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Ph Contains 4 atom

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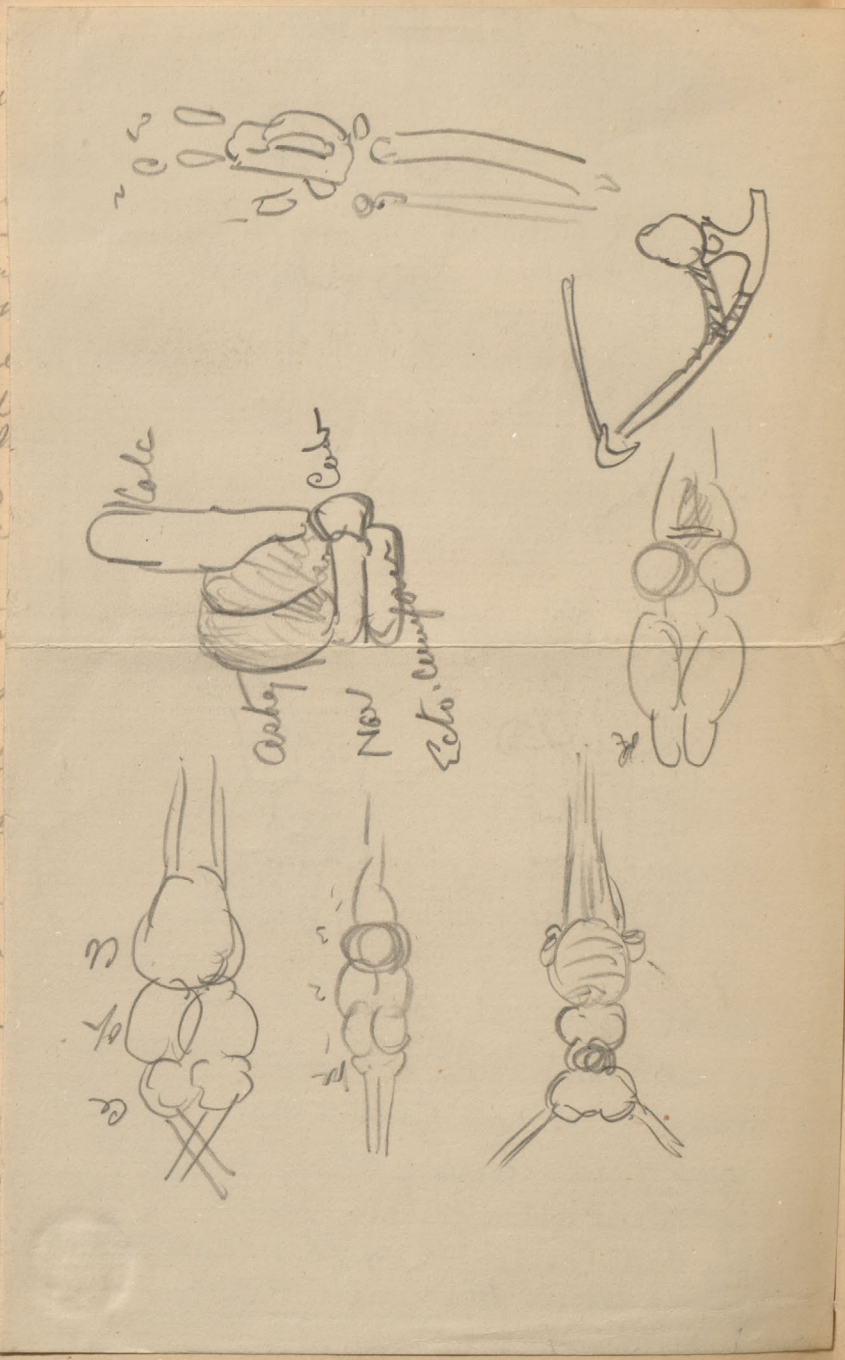
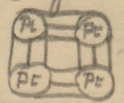


We may picture H with only one point of attraction, Zn with two and so on. It will be much clearer from theory if we call them bonds. It is a force which we may if we like compare to gravitation. We must have some emblem of this force, as the mind requires to be helped by mechanical contrivances; the simplest is a line, connecting the symbols of the elements. (H)— The property of filling a certain number of atoms, which any substance possesses is called its atomicity. Zn = two of H or Cl. C = 4 S = 6. If you place to the right, or above, the symbol of any element a certain number of dashes, as H′, Zn″, B‴, C⁗ or 4 It will represent its atomicity. No bond can remain disunited, or unsatisfied. A molecule is the smallest quantity of any element that can exist separately. All molecules are therefore polyatomic, most of them diatomic. N may be pictured thus (N)≡(N) and Cl thus (Cl)—(Cl); the bonds satisfying each other. It is not however of much importance how we represent this to the mind.

P which contains four atoms in a molecule, may be represented thus  An element with an even number of bonds may exist as a monatomic molecule; Zn Hg are found to be so, it is not however necessary that such elements should exist thus; O for instance

invariably tetrad, never mark except when as dyad. (rare). $Zn''Cl_2$ constitutional formula if printed Zn in thick type. unnecessary to mark Zn as dyad as being combined with Cl_2 it must be so $SO_2(HO)_2$ unnecessary to mark S^6 (hexad) as the nos below show it to be so. $\left\{\begin{matrix} C^4H_3 \\ CH_3 \end{matrix}\right.$ tetrad with 4 bonds in connection

Atomicity not perfectly fixed. N pentad, often triad and sometimes monad. S sometimes tetrad sometimes dyad. When element changes atomicity in 2 or some multiple of 2. dyad S never tryad, next atomicity tetrad, next 6. N 531. May be pictured to the mind. that two of the bonds of an atom satisfying each other. S by union of one pair becomes tetradic by union of two dyadic. Must always have some free bond. Maximum no of bond of elements as absolute atomicity. Latent atom where max no not engaged. Active atomicity no uniting it to any other. Sum of active, and latent always = to absolute. Sulphurus acid 2 bonds latent 4 active = 6 absolute of S

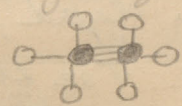
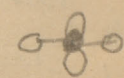
has two bonds, and is a double atom molecule. Ozone is three atoms of O connected it can be represented thus Elements whose atoms have only one bond are called, monads; two dyad, three triad, four tetrad, and soon. For simplicity it is desirable to avoid atomicity marks as much as possible. And by a few simple rules they can be greatly reduced. all monads are not marked. Atomicity marks are unnecessary for O as it occurs so often, you have simply to remember that O is dyad. C very rarely requires mark it almost invariably occurs as a tetrad. It is never marked except when, as is rarely the case, it enters into combination as a dyad.

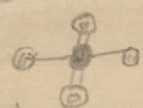
$Zn''Cl_2$ Constitutional formula if Zn printed in thick type. It is unnecessary to mark Zn as a dyad because being combined with Cl_2 it must be so.

$SO_2(HO)_2$ it is not necessary to mark S as a hexad as the numbers below show it to be so.

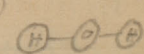
$\left\{\begin{matrix} C^4H_3. \\ C^4H_3. \end{matrix}\right.$ C tetrad with four bonds in connection

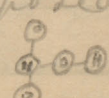
The atomicity of substances is not perfectly fixed N usually a pentad, though often triad and sometimes monad. S as well as being hexad is sometimes tetrad, and sometimes dyad.

Sulph hydrogen Some apparent exceptions element F dyad tetrad' hexad, when comb with Cl gives formula: most simply expressed by $FeCl_3$ but by vapour density Fe_2Cl_6 thus united  , $FeCl_2$ 

FeO_2 Ho_2  Latent atomicity conveniently expressed by roman numerals to left of symbol not however generally necesary, only to remember absolute atomicity, latent always found by deducting active expressed in formula In very rare cases necessary to deviate:

$\begin{cases} CH_2-O-C \\ CH_2-O-C \end{cases}$ stroke on line of formula indicate that symbols after it not united with those before. Not contemplated to use graphic notation generally. Translate all symbolic formulae into graphic.

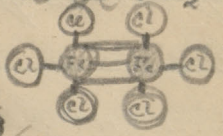
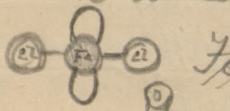
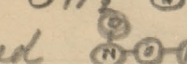
first consider absolute atomicity of elements and then how disposed of. OH_2 

Nitric acid NO_2HO  element with highest atomicity grouping element put 1st

When an element changes its atomicity it does so in two or some multiple of two. Hyat S is never triad, the next atomicity is tetrad, the next hexad; not 5, 3, 1, but 6, 4, 2. This may be pictured to the mind by supposing that two of the bonds of an element satisfy each other. S by the union of one pair becomes tetradic, of two diadic. They cannot however all unite thus there must always be left some free bond or bonds The maximum number of bonds possessed by any element, called its Absolute atomicity, The number of bonds engaged in uniting it to any other, its active atomicity. And part of the atomicity is said to be latent when the maximum number is not thus engaged. It will easily be seen that the sum of the active and latent must always equal the maximum. In Sulphurous acid (SO_2) four of the bonds of S. are active, two latent, sum, six, Absolute atomicity of S. In sulphuretted hydrogen (SH_2) but two of the bonds of S are active. To this rule there are some apparent exceptions. Fe whis is either dyad, tetrad, or hexad, when combined with Cl gives a compound whose formula is most

Symbolic graphic glyptic formulae give no indication of force stored in molecule. CO_2 ⊖⊖⊖ no force CH_4 o-o-o gt force. Compound radicle a compound taking the place of simple subs in many compounds. $a + b = ab$
$a'' + 2b = a''b2$
monad dyad tryad compound rads?
Compound radicle may be either monad dyad &c
A compound ~~atom~~ radicle consists of one or

such an element where there is even no of bonds aught to be able to exist alone, such is the case. Almost infinite no of compound radicle exist. they can be represented by symbols, and thus used for simplicity.
Any polyad element C with 3 of 4 leaves one bond, and constitutes monad radicle take away one more of 4 dyad. &c. In inorganic chem only necessary to assume a few compounds

simply expressed by $FeCl_3$ but by its vapour density it is found really to be Fe_2Cl_6 It may be pictured to the mind thus  $FeCl_2$ thus  FeO_2 thus $FeO_2H_{O_2}$ thus The latent atomicity is conveniently expressed by Roman numerals to the left of the symbol. It is not however generally necessary, as you have only to remember the absolute atomicity, the latent can always be found by deducting the active which is expressed in the formula. It is sometimes necessary to deviate from these rules as in $\left\{\begin{matrix}CH_2-O-C\\CH_2-O-C\end{matrix}\right.$ the stroke on the line of the formula indicates that the symbols after it are not united with those before. It is not contemplated to use the graphic notation generally, but it is a good exercise to translate all symbolic formulas into graphic. To do this, first consider the absolute atomicity, and then how it is disposed of. OH_2  Nitric acid NO_2H is thus grouped . The element with the highest atomicity is called the grouping element and put first in formulæ.

Symbolic, graphic, glyptic, formulæ give no indication of the force stored in any ~~compound~~ molecule.

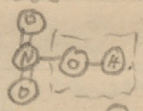
	Molecular formula	atomic formula	abbreviated atomic formula
Hydroxil	$(HO)_2$	HO	Ho but to use
Hydrosulphyl	$(HS)_2$	HS	Hs this formula.
Ammonium	$(NH_4)_2$	NH_4	Am
Ammonoxyl	$(NH_4O)_2$	NH_4O	Amo
Amidogen	$(NH_2)_2$	NH_2	Ad
Potassoxyl	$(KO)_2$	KO	Ko
Zincoxyl	(ZnO_2)	$\overset{O}{\underset{O}{Zn''}}$	Zno''

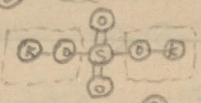
A number to which not necessary to attach names, O in combination with metals with some bonds, free, rarely used.

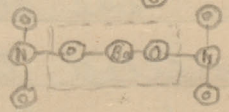
No of dashes after radicle shows no of atoms of O in combination, no dashes after monad radicle

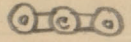
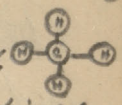
Hydroxil —O—O Zincoxyl —O—Zn—O—

Compound rads in dotted lines

Nitric Acid 

Potassic Sulphate 

Basic Nitrate 

In CO_2  there is no store of force, in CH_4  great force is stored. A compound radical is a group of elements taking the place of simple substances in many compounds. A compound radical may a monad dyad &c just as a simple substance. Any compound radical having an even number of bonds should be able to exist alone, and such is found to be the case. There exist an almost infinite number of compound radicals they can be represented by separate symbols, and this is sometimes done for symplicity. C with three of H leaves one bond and constitutes a monad radical take away one more of H it is a dyad &c. In inorganic chemistry it is only necessary to assume a few compound radicals

Compound radicals necessary to assume in inorgan Chem

	Molecular formula.	Atomic formula.	abbreviated atomic formula.
Hydroxil	$(HO)_2$	HO	Ho
Hydrosulphyl	$(HS)_2$	HS	Hs
Ammonium	$(NH_4)_2$	NH_4	am
Ammonoxyl	$(NH_4O)_2$	NH_4O	amo
Amidogen	$(NH_2)_2$	NH_2	ad

There are a number to which it is not necessary to attach names O in combination with a metal, with some bonds free.

Examples

Potassoxyl	$(KO)_2$	KO	Ko
Zincoxyl	(ZnO_2)	$\left\{\begin{matrix} O \\ Zn \\ O \end{matrix}\right.$	Zno"

Radicals.

An element is a simple radicle and enters into combination in the following manner a, b, c, & d, being monad elements a'' a dyad a''' a triad and a^{IV} a tetrad element.

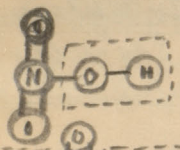
$$a + b = ab$$
$$a'' + 2b = a''b_2$$
$$a''' + 3b = a'''b_3$$

q c q c

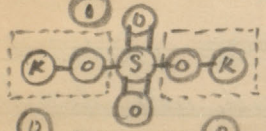
A group of elements replacing a, a'' or a''' in the above equations is a compound radicle

$$(a''b) + b = (a''b)b$$
$$(a'''b)'' + 2b = (a'''b)''b_2$$
$$(a'''bc) + b = (a'''bc)b$$
$$(a^{IV}b)''' + 3b = (a^{IV}b)'''b_3$$
$$(a^{IV}bc)'' + 2b = (a^{IV}bc)''b_2$$
$$(a^{IV}bcd) + b = (a^{IV}bcd)b$$

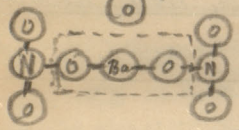
The number of dashes after the symbol of the radical shows the number of atoms of O in combination. Hydroxyl (H)—(O)— monad radical Zincoxyl —(O)—(Zn)—(O)— dyad radical. Examples of compound radicals in combination. (the comp rads in dotted lines.



Nitric acid Hydroxyl in combination



Potassic sulphate. Potassoxyl in combination



Basic nitrate. Basoxyl in combination.

Monday Oct 18th 1869

A salt is formed by the displacement, more or less completely of the displacable H from an acid. Salts may be classified under three heads, acid, normal, and basic. In many acids all the H is not displacable

An acid salt, is one in which the replacable Hydrogen of the acid is only partially replaced by a metal, or positive compound radical.

Examples

Sulphuric acid, SO_4H_2 Hydric sodic sulphate SO_4HNa

Carbonic acid CO_3H_2 Hydric potassic carbonate CO_3HK

Classified salts under 3 heads.
formed by displacement of displacement more
or less complete of H from acid.
Normal salt where all the H replaced by equiv of
metal (in many acids all the H not displacable.
having same no of bonds) acid salts those in which displacable
H of acid is only partially replaced by a metal, or compound
radicle. Cannot have acid salt of acid which contains
only 1 atom of H. If acid salt formed, acid must contain at
least 2 atoms of H. Basic salts usually only normal salts
of acids of greater basicity. When the no of bonds of the
metal or compound positive radicle contained in a salt
exceeds the no of atoms of replacable H in the acid the compound
usually called a basic salt.

have taken of union of atoms. Atomic union usually attended
by breaking up of 2 molecules, and rearrangement of
atoms. Even the formation of HCl for we have 1 atom
of Cl with 2 molecules and one of H do ($Cl_2 + H_2 = 2HCl$)
In some cases (rare) two molecules combine without breaking
up. ($CO + Cl_2 = COCl_2$). Numerous cases when
different kind of action has to be assumed. Called
molecular in opposition to atomic what molecules

A normal salt is one in which the replacable H of the acid, is all replaced by a metal or positive compound radical.

NO_3H Nitric acid { Sodic nitrate $NO_3\,Na$ / Potassic nitrate $(NO_3)_2\,Ca''$

Sulphuric acid SO_4H_2 { Potassic sulphate $SO_4\,K_2$ / Calcic sulphate $SO_4\,Ca''$

Phosphoric acid PO_4H_3 { Potassic phosphate $PO_4\,K_3$ / Calcic phosphate $(PO_4)_2\,Ca''_3$

When the number of bonds of a metal or positive compound radical contained in a salt, exceeds the number of atoms of replacable Hydrogen, contained in the acid the compound is usually termed a basic salt.

Carbonic acid CO_3H_2 { Malachite $CO_3.H_2\,Cu''_2$ / Blue cupric carbonate $C_2O_8\,H_2\,Cu''_3$

Sulphuric acid SO_4H_2 { Tribasic cupric sulphate $2O_8\,H_4\,Cu''_3$ / Turpeth mineral $2O_6\,H_5Cu''_3$

There cannot be an acid salt of any acid which contains but one atom of H. If an acid salt is formed the acid ~~salt~~ must contain at least two atoms of H. Basic salts are really only normal salts of acids of greater hydricity.

Union of atoms. Atomic union is usually attended by the breaking up of two molecules, and a rearrangement of atoms. Even HCl is thus formed, for we have one molecule of Cl with two atoms and one of H with two atoms ($Cl_2 + H_2 = 2HCl$.) In some rare

combine more loosely, without interpenetration
such is the case with H2O of crystalization.
Common alum thus contains 24 H2O water. Such compounds
reveal in their very appearance this form of combination
both more like mixtures, do not change appearance
colours &c as in true chem compounds

62 metals classified into metals and non metals
or metaloids. Also into + and − elements.
Another and more important founded on atomicity
thus into 6 classes according to atomicity monads dyads.
These again broken up into sections according to
properties, and resemblance

Weights measures and standards.
Decimal system more and more adopted. Used Constituent
used in science almost entirely
Gram as unit of weight. Metre as standard of
measure. Measures of length derived from circumference
of the earth. Divided into four arcs, taken as unit
of measure ten millionth of arc one meter. divided
into 10 parts decimeters, hundredths centimeters. centimeters
into ten parts millimeter. longer measures designated by
Greek prefixes kilometer meter Centimeter. millimeter
most common. Measure of length connected into measures
of capacity by decimeter. cubic decimeter unit of
measure of capacity called litre. contains 1000 cubic

cases two molecules combine without breaking up ($CO + Cl_2 = COCl_2$) There are numerous cases in which a different kind of action has to be assumed Called molecular in opposition to atomic combination where molecules combine more loosely without interpenitration. Such is the case with water of crystalization. Thus common alum contains 24 of water. Such compounds reveal in their very appearance this form of combination, are more like mixtures of their constituent materials do not change appearance colour as is done by true chemical compounds.

The 62 elements are classified into metals, and non metals or metaloids. Also into posative and negative elements. Another and more important classification is founded on atomicity. According to atomicity they are divided into 6 classes; monads, dyads &c These classes are again broken up into sections according to properties, and resemblance.

Weights measures and standards.

The decimal system is now more and more adopted, it is used almost exclusively on the continent, and is now almost the only system used in science. The gramme is taken as the unit of weight, the meter as the standard of measure.

centimeters. do not usually go below this division. Measure of weight cubic centimeter of pure water weight termed a gramme rather more than 15-½ English grains. gramme subdivided into decigramme, centigramme, millegram. For larger unit killogramme, or 1000 grammes rather more than two lbs. Value of any force acting on matter reckoned by meter-killogramme force required to raise a kilo 1 meter, measure like foot lb. Employ centigrade thermometer scales readily converted into each other by these formulas

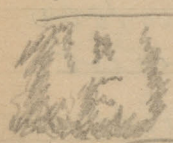
Hydrogen

Occurs in large quantities in nature in combination 1/9 of water, constituent of all vegetable and animal substances. evolved free in small quantities from volcanoes. Always as gas. We know that it exists free

The meter is the ten millionth of a quadrant of the earth's circumference. The meter is divided into tenths, called decimeters, into hundredths called centimeters, and thousandths called millimeters. The longer measures composed of 10 many meters count upwards by the Greek prefixes. The Kilometer meter, centimeter, & millimeter, are the measures most commonly made use of. The liquid measures are converted into measures of capacity by the decimeter, the cubic decimeter being the unit of capacity; it is called a litre. It contains 1000 cubic centimeters, and measurement does not usually go below this. The unit of weight is a cubic centimeter of pure water at °C It is termed a gramme, and equals rather more than 15-1/2 English grains. The gramme is subdivided into decigrammes, centigrammes, and milligrams. For larger unit the Kilogramme consisting of 1000 grammes, is used; it equals rather more than two pounds. The value of any force acting on matter, is reckoned by the meter-kilogramme it is the force required to raise a kilo. one meter. It is rapidly superseding the foot-pound.

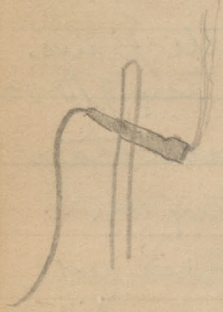
The Centigrade thermometer is now used

in the sun, and stars, perhaps under such great heat as to forbid Combination, even with O
When neg intensely ignited exhibits a peculiar red glow by which readily detected by spectroscope no temperature obtained by chemical means can make H glow. but by electric spark.
Spark nothing more than ignited gas or air. Gives beautiful pinkish red glow. &c.
Showed 6 photographs of eclipse of Aug 7th taken in America. H about 14 times brighter than are



luminosity in red flames as luminous probably as most perfect H vacuum.

Transmit a stream of H through a tube into the air in electric light, ~~the~~ shadows ascending shadows on screen.



for scientific purposes. The corresponding degree of Farenheit, is easely found by this formula.

Cent into Far n° C $\frac{9}{5}$ (n° + 32 F

Far into Cent n° F $\frac{5}{9}$ n° − 32 C

Hydrogen. H Atomic weight 1

Occurs in nature in large quantities, but in a state of combination. It is 1/9 by weight of water, and enters into the constitution of all vegetable and animal substances. H has been proved to exist free in small quantities as one of the gaseous products of volcanoes. It is so far as known always a gas. We know that it exists free in the sun and also in the stars and nebulae.

Perhaps under such great heat as to forbid its combination, even with O. When very intensely heated it exhibits a peculiar pinky-red glow, which is readily detected especially by the spectroscope, as peculiar to H. No heat obtained by chemical means, is sufficient to raise it to incandescence. But by the electric spark we can make it visable. The electric spark is nothing more than the gas or air through which the current passes raised to incandescence

(showed the Electric light in H by means of a strong battery and coil)

It is incandescent H which constitutes the

Tuesday oct 19 1869.

Hoffmans process founded on the volume of one litre at 0°C 760 millimeters pressure. 2 litre weighs ·0896 gramme. as atomic weight of H taken as unity, the weight of any other gas will be as the atomic weight of H to. The atomic weight of O 16 weighs just 16 times as much as a litre of H. This weight has been named the crith. O litre 16 criths. Cl 35·5 & so on. If you wish to ascertain the weight of a litre of any gas body. all that has to be done is to multiply the atomic weight by the crith. H [1|1] Cl [35|35·5]. so with all diatomic. monatomics as Zn, or Hg. ~~only contains~~ half one litre only weighs half [2|n]. P. and as being 4 atom ~~com~~ elements contain twice as much. HCl you have an atom of H weighing 1 crith and one of Cl 35·5 [1|35·5] the sum of these is 36·6 2|36·6 18·25 ·0896

Add together the constituents of of the molecule, and you have the atomic weight?

One of most simple processes of obtaining H by displacing the H from water by means of of a metal by action of positive metal entering into combination with the O and setting free H. Caesium Rb Ka so powerfully positive as to cause heat enough to inflame the H the same but not to so great an extent of Sodium the chemical charge $2OH_2 + Na_2 = 2ONaH + H_2$

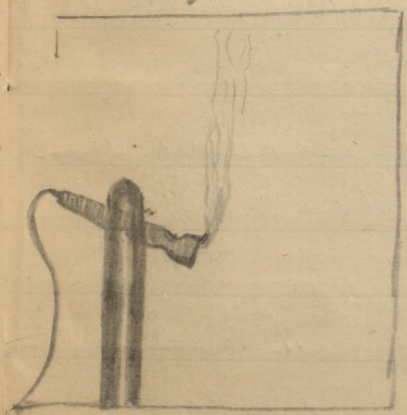
so called red flames seen projecting from the sun in a total eclipse. and which can now be seen at any time by Mr Lockyers apparatus. (showed two photographs of eclipse of 1st of August last, exhibiting them on a screen by the electric light they showed the hydrogen prominences, or projections of the chromosphere very distinctly.)

H is about 14 times lighter than air, but in the red flames, its tenuosity is probably so great as to exceed any most perfect Hydrogen vacuum.

Red flames as seen through a telescope

(showed a slide of the red flames as drawn by Lockyer from telescopic views, and then another taken ten minutes later showing the great change which took place during that time)

(To show that H is much lighter than air a stream of it was forced into the air from a tube in the electric light. The shadow on the screen appeared something like this.



2 3 parts of Na only liberate 1 part of H, but the H occupies a considerable space on account of its lightness

Another process interesting as being a simple mode not well adapted for preparing quantities.

a much better process to substitute a sol of HCl and Zn for K or Na. Gran Zn and HCl. and Aq

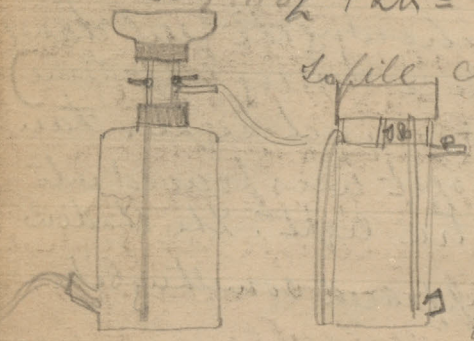
$$2HCl + Na_2 = 2NaCl_2 + H_2,$$

$$2HCl + Zn = ZnCl_2 + H_2$$

Another process more generally used and on the whole preferable. Sulphuric acid cheaper, and contains displaceable H, do not require to have a very positive metal Zn or Fe do

One molecule of acid acts on one of Zn

$$SO_2 H_{O_2} + Zn = SO_2 Zn_{O'} + H_2$$



To fill close lower aperture Gas holder. Another process employed formerly and now often employed technically for preparing quantities. by passing steam through iron filings in red hot tube.

$$Fe_3 + 4OH_2 = {}^{IV}(Fe)^{VIII}O_4 + 4H_2,$$ By acting on Zn by boiling sol of potassic hydrate or dodic do.

$$2OKH + Zn = ZnK_{O_2} + H_2$$

potassic Zinc oxide

H perfectly colourless transparent and tasteless & has no smell. Seen in last lecture that H has

Tuesday Oct 19th 1869.

Hoffmans process for finding the weight of a gass obtainable from a compound &c is founded on the weight of one litre of H at 0°C and, 760 millimeters barometric pressure. Under these circumstances a litre of H weighs .0896 gramme. As H is taken as unity, the weight of an equal volume of any other gas, or element in the gaseous state, will be to H, as its atomic weight to that of H. Thus the atomic weight of O is 16 and a litre of O consequently weighs just 16 times as much as one of H. Cl weighs 35·5 times a litre of H and so on. The weight of a litre of H is called by Hoffman a crith. If you wish to ascertain the weight of a litre of any gaseous bodies, in grammes, all that you have to do, is to multiply its atomic weight by the crith (·0896) This holds true of all diatomic elements as (H [H][H] & Cl [Cl][Cl]) with monatomic elements as Zn [Zn] or Hg [Hg] a litre of course only weighs half of the result thus obtained. P & As being four atom elements, the result must be doubled. In H Cl you have an atom of H weighing one crith, and one of Cl weighing 35·5 [1][35·5] the sum of these is 36·6 the atomic weight of HCl. Add together the atomic weights of the constituents of the molecule, and you get the atomic weight of

a different refractive power than air Spec grav 0691 as compared with air. H usually however taken as unity. much simpler series of gases than air and also as air is only a mixture. Although H has been submitted to 800 to 1000 atmospheres with intense cold. H has never been condensed, condensed almost to = Water, but still remains gaseous. presents difficulty when jar inverted, & otherwise. Weighing H in scale. H perfectly incapable of supporting combustion. And as a rule all gases that burn cannot support combustion. Inexpensable thought not from any poisonous quality. H unites with oxy bodies & ignited with very considerable energy. Being exceedingly light has not the power of transmitting sound much. Sound diminished to about 1/4 in H.

Next element Cl possesses props almost diametrically opposite to H. Neg element. Na Cl contains about 60 parts of Cl. Nearly always met with in combination. Magnesic chloride, and Calcic chloride in sea water. Cl also met with in volcanoes, white smoke from them composed of condensed H Cl.

May be obtained by heat from certain comps

the molecule, from this by multiplication by the atomic you can obtain the absolute weight in grammes of a volume of the substance.

One of the most simple processes for obtaining H is to displace the H from waters by the action of a positive metal, which entering into combination with the O of the water, will set free the H. Caesium Rhubidium & Calcium are metals so powerfully positive, that when brought into contact with OH_2 they not only libirate H but in doing so cause heat sufficient to inflame it. Sodium and Lithium also immediately set free the H of OH_2 but do not generally inflame it.

$$2\,OH_2 + Na_2 = 2\,ONaH + H_2$$

The atomic weight of Na being 23 it takes 23 parts by weight to take the place of one part of H in OH_2 but H being so light even this much occupies considerable space. A much easier process and better adapted for obtaining H in some quantity, though not used on very large scale, is to substitute a solution of HCl, and Zn for Na or K.

$$2\,HCl + Na_2 = 2\,NaCl_H + H_2$$

$$2\,HCl + Zn = Zn\,Cl_2 + H_2$$

Another process applicable on the large scale, and preferable, is to use sulphuric acid, which is cheaper than HCl. It contains displacable H, and does not require a very energetic positive metal, Zn or Fe sufficiently so. One molecule of acid acts on one of Zn

when combined with metals having small positive energy as Gold & Platinum.

$PtCl_4 = 2Cl_2 + Pt$.

If HCl brought into contact with manganese oxide.

$MnO_2 + 4HCl = MnCl_2 + 2OH_2$

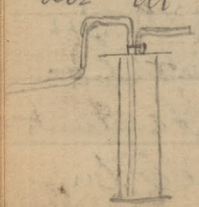
$MnCl_4 = MnCl_2 + Cl_2$ (manganese dioxide)

Better to allow Cl to pass through water to absorb HCl, Must be collected over warm water, as so soluable in cold. Electric current passed through HCl decomposes it into equal volumes of H & Cl. Positive H going to neg pole and vice versa

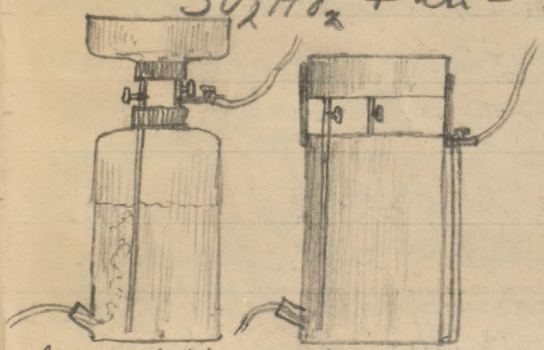
Wednesday Oct 20 1869.

Instead of HCl we may use Sodic chloride by using some substance (SO_2OH) which liberates the Cl. The displacable H of the Sulphuric acid combines with the Cl, and the HCl thus formed with the manganese oxide. $MnO_2 + 2SO_2HO_2 + 2NaCl = SO_2Na_2O_2 + SO_2Mn$" $+ 2OH_2 + Cl_2$.

Better to collect Cl by displacement of atmospheric air in this apparatus. Spec grav 2.45. By colour of Cl you can tell when the jar is filled. Thus collected dry. Properties. Greenish yellow, from it Chlorus. Suffocating and irritating. By no means dangerous in



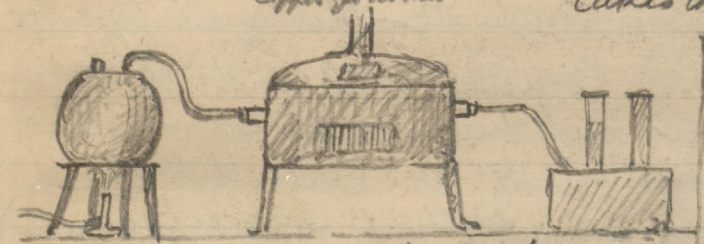
$SO_2H_{O_2} + Zn = SO_2Zn^{II}O + H_2$



Another process much employed formerly, ast often used for preparing H in quantity, though not so pure as from the Zn process. Is by decomposing steam by passing it over red hot Iron finely divided which takes the O from OH_2.

$Fe_3 + 4OH_2 = {}^{IV}(Fe)^{VIII}_{2}O_4 + 4H_2$.

By acting on Zn by a boiling solution of Sodic or Potassic hydrate H can be obtained $2OKH + Zn = Zn K_{O_2}$ (potassic zinc oxyde) $+ H_2$. H is a perfectly colourless transparent, odourless and tasteless gas. We have seen in last lecture that H has a different refractive power from air, by the ex of making the H throw a shadow on a screen with the electric light. Its specific gravity as compared with air as unity is .0691. In specific gravities however H itself is usually taken as unity. we thus get a much simpler series of gravities, and more accurate as air is only a mixture, and subject to slight variations. Although H has been submitted to a pressure of from 660 to 1000 atmospheres together with extreme cold, and has thus been condensed to



Apparatus for preparing H from steam.

more dilute form. Cl 13½ times heavier than air
Exposed to pressure of 6 atmospheres condensed to
a clear liquid. At 15° Cent water absorbs 2 ½ volumes of
Cl. Sol must be kept dark, or light helps it to
decompose the aq. With the exception of H the most
neg element we know, and exercises these properties
at ordinary temps. With highly pos element as
As or Sb at common temps combine with apparent
energy for combination. Sodium also combs at ordinary
temps. Sodic Chloride not being volatile encrusts
the Na and stops action. If Na be melted this
not the case. gives very brilliant combustion,
(with clouds of Na Cl)
Phosph also combines actively with Cl.
Spontaneously with combustion.
all these materials combustable in O or Air.
Combustion of an ordinary taper very different
burns red with great smoke. Coal gas in Cl
also gives great smoke. Incapacity of combining
with C Hydrocarbons. C and Cl do combine, but
never under these circumstances. (by indirect comb CCl_4
Turpentine on rag bursts into flame, only H taken
by Cl. great production of soot. $C_{10}H_{16} + 8Cl =$
$16HCl + 10C$. Another characteristic of Cl its power of
acting on organic subs at ordinary temps, many

almost the specific gravity of water, it has never been condensed into the liquid or solid state. When a jar of H is lit inverted it burns at the mouth of the jar with a quiet flame, when the jar is turned up it burns very rapidly on account of its lightness. The lightness of H can be shown in a scale by ~~inverting a~~ pouring a jar of it up into an inverted bell glass, which it raises. H is perfectly incapable of supporting combustion, and as a rule all combustable gasses are so. It is inespisable simply because it excludes O. H unites with negative bodies in general with very considerable energy. Being so tenuous it does not transmit sound well; sound is diminished to about 1/14 of its loudness in air, in H

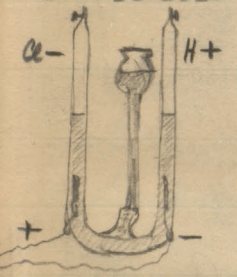
Chlorine. Cl. 35·5.

This element possesses properties almost diametrically opposite to H. It is an electro negative element. It occurs in large quantities, but almost always in combination. NaCl contains about 60 parts of Cl. It is also found abundantly in magnesic and calcic chlorides, which are constituents of sea water. Cl exists uncombined in small quantities in the gas from volcanoes. The white smoke which rises from them has been shown to be condensed HCl Cl may be obtained from its combinations with

organic subs intensely colourish the H taken and replaced by Cl these comps usually nearly colourless (Bleaching) Manve Magenta Indigo logwood. Dyer and Calico printer makes use of this prop bleaches cloth, or bleaches out pattern from dyed cloth. Cl exceedingly poisonous element, especially to lower orders of animals and vegetable. Thus destroys pukeffers, and fermentation Employed as Chloride of lime. Acts also by decomposing Sulph H combines with H and sets free S. Cl unites with every other element. HCl this comp occurs in nature as ante. Vesuvius and Aetna evolve large quantities. Produced by a variety of processes. H & Cl mixed in diff light or sunlight. even most diffused light. Explodes in bright sunlight. Remains unaltered any length of time in dark. Combination by artificial light. Pen O or Carbonic Carbonic disulph and Nitrous Oxide? Comb equally well prod by action of heat. (Mix two gas of Cl and H and ignite) Jet of H burned in Cl burns white, and forms HCl. Best method of obtaining HCl. ~~Sodic Chloride~~ by SO_2OH_2. Gas must be collected over Hg. If wished to obtain the gas dry passed through Concent SO_2HO_2. $SO_2HO_2 + NaCl = SO_2HO$ $NaO + HCl$.

metals & small positive energy as Au. Pt. by heat alone. $PtCl_4 = 2Cl_2 + Pt$. If HCl be brought into contact with Manganic oxide Cl is easily obtained. $MnO_2 + 4HCl = MnCl_4 + 2OH_2$ second stage $MnCl_4 = MnCl_2 + Cl_2$.
manganic chloride

It is better to allow the Cl thus obtained to pass through an intermediate vessel containing water to absorb any HCl. Cl must be collected over warm water, as it is very soluable in cold. Another method of preparing this gas is by the direct decomposition of HCl by the electric current. HCl is thus decomposed into equal volumes of H & Cl. H being the positive element goes to the negative pole, Cl to the positive one.



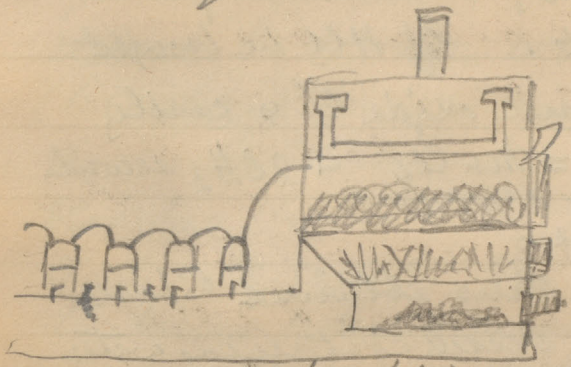
Wednesday Oct. 20 1869

Instead of using HCl in the preparation of Cl we may obtain it from the much cheaper substance Sodic chloride. SO_2HO liberates Cl from this salt when both are mixed with MnO_2. The displacable H of the SO_2HO unites with the Cl of the NaCl and forms HCl which is immediately decomposed by the MnO_2

$MnO_2 + 2SO_2HO_2 + NaCl = SO_2NaO_2 + SO_2MnO'' + 2OH_2 + Cl_2$

It is best to collect Cl by displacement of atmospheric air. Its specific gravity is 2·45· by its colour you can easily tell when the vessel is full. Cl may be thus collected perfectly dry.

On large scale to make acid. two or three tons



of sodic chloride, apparatus cemented and concent SO_2OH_2 now only one exit by earthenware pipe. Net gas wanted but sol. gas absorbed into Ag only tube does not dip into water sufficient energy of absorbtion without. Wolfes bottles. to use as little SO_2OH_2 the reaction sought to be obtained is this $SO_2OH_2 + 2NaCl = SO_2Na_2 + 2HCl$.

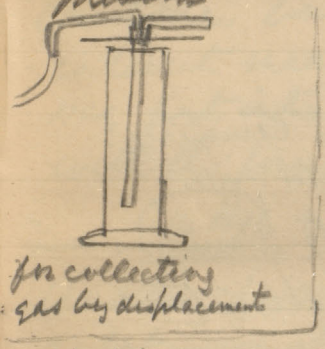
norm sodic sulph

~~One litre~~ of Can be condensed. Lighted taper plunged into HCl immediately extinguished. stream of ~~HCl~~ electric sparks partly decompose HCl, but when some quantity of H & Cl collect they explode, operation becomes again. Very soluble in water. Ag even as ice absorbs HCl. Ice introduced into cylinder of HCl over Hg absorbs HCl and makes Hg rise

40 Tar 480 volumes of HCl absorbed by Ag the specif grav means of testing the strength. Hydrometer In ag specif grav 1. In sol of HCl 1.65 want to know percentage of real acid. found by table carefully constructed. Similar tables constructed for other acids. Acid alkaline & neutral reactions.

Blue litmus red by acid. Red blue by alkali.

The colour of Cl is greenish yellow, from the Greek word Chloros. It is suffocating and irritating to breathe, and a few ounces of the pure gas inhaled, has been known to produce immediate death. It is however by no means dangerous when present in the atmosphere in small quantities. It is 13½ times as heavy as N. When it is exposed to a pressure of four atmospheres, it condenses into a clear green liquid. At 15° Cent water absorbs more than two volumes of Cl. This solution requires to be kept in the dark, as the light causes it to decompose the water, forming HCl with its H and setting free O. With the exception of Fluorine Cl is the most powerfully negative element which we know, and exercises this property at ordinary temperatures. With highly positive elements such as As or Sb it combines at common temperatures with sufficient energy to cause combustion. Na also combines with Cl at ordinary temperatures, but their compound NaCl being nonvolatile. It encrusts the Na and stops the action. If the Na be previously melted and introduced into Cl it combines with very vivid combustion, the production of an intense yellow light, and the evolution of white smoke in clouds, consisting of finely divided NaCl. The combustion



for collecting gas by displacement

Turmeric yellow browned by alkalies. Neutral reaction

Thursday Oct 21

Hydrochloric ac forms salts of Cl with the metals metallic oxides, or hydrates

$$OKH + HCl = KCl + OH_2$$
$$ZnO + 2HCl = ZnCl_2 + OH_2$$

HCl of commerce almost invariably in commerce contaminated by imps. Its yellow colour given by $FeCl_3$, Principal impurities SO_2OH_2 Arsenious acid derived from SO_2OH_2, which is now almost always prepared by the burning of Iron pyrites which contains arsenic, which is converted into arsenious acid. Earthen vessels, or coke towers, contain Iron which is dissolved by the condensing HCl. Readily detected. SO_2OH_2 by Baric chloride. Arsenic by sulph yellow pp with sulphuretted hydrogen Fe by Potassic ferrocyanide. Cl & H present examples of the most simple form of metals monatls forming simple compound HCl.

of an ordinary taper in Cl is very different from that in air. In Cl it burns with a small red flame, and forms great clouds of smoke. Coal gas jet burned in Cl also produces a great deal of smoke. This shows the incapacity of Cl to combine with C only the H burns, setting free the C of the hydrocarbons. C and Cl do however combine, but never under these circumstances, by indirect means CCl_4 can be formed. Turpentine on a rag put into Cl takes fire immediately, and burns with the formation of great smoke.

$$C_{10}H_{16} + 8Cl_2 = 16HCl + 10C.$$

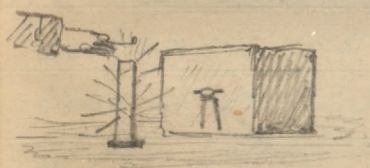
Turpentine

Another characteristic of Cl is its power of acting on organic substances at ordinary temperatures. Many organic substances are intensely coloured from this Cl takes the H and replaces it by Cl, these compounds are usually nearly colourless, and on this depends its property of bleaching. Patterns can thus be bleached out on cloth dyed with vegetable colours. Cl is an exceedingly poisonous element especially to the lower orders of animals and plants it thus destroys the organisms which cause fermentation and putrifaction. It acts also as a disinfectant by decomposing sulphuretted hydrogen It combines with the H and sets free the S. For these purposes it is usually employed as Chloride of Lime. Cl unites with every other element. Vesuvius and Etna evolve large quantities of Cl as HCl in form of white smoke

Oxygen O 16

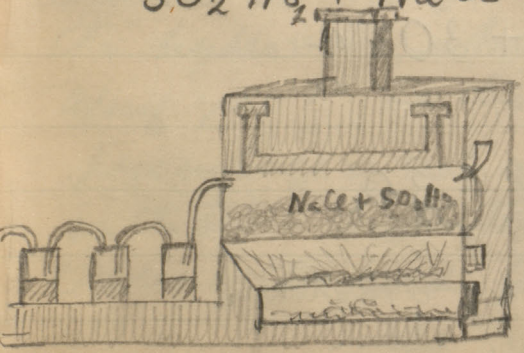
Most abundant element we know 8 out of 9 parts of water about 1/3 of crust of earth. 1/5 of atmosphere. Nearly all in state of combination, but residual portion about 1 2 millionth part of the whole free, of this small portion wanting earth uninhabitable. Exists free in air, from this source chemist obtains supply, but not directly, not known any body to combine with N and leaving the O anything which combines with the N combines with O more readily. Various modes of entrapping the atmospheric O. As by action of mercury which heated nearly to boiling for a long time oxydises, and forms red oxide of Hg. If this be heated but a few degrees higher than temp at which it was formed, when it decomps into Hg & O. Various other bodies similar Manganous Oxyde heated to

HCl is produced by a variety of processes, H & Cl mixed and exposed to diffused daylight, or sunlight combine to form it. They remain for any length of time uncombined in the dark but combine slowly even in the most diffused daylight. In bright sunlight they combine with explosion. The combustion of P_2O_5 or Carbonic disulphide and Nitric oxide? give sufficient light to cause this explosion. A ball filled with the mixed gases enclosed in a box with a plate glass front can thus be safely exploded.



The combination is caused equally well by heat. If two cylinders one of H and the other of Cl be mixed together and flame applied a sharp explosion results. The best method of obtaining HCl is by acting on NaCl by SO_2HO_2 The resulting gas must be collected over Hg on account of its solubility in OH_2. If it be wished to obtain it dry, it must be passed over concentrated $SO_2H_2O_2$

$$SO_2H_2O_2 + NaCl = SO_2HO\,NaO + HCl.$$



To make the acid on a large scale two or three tons of NaCl are put into a retort of this sort the apparatus sealed up and SO_2HO introduced by a funnel, heat applied, and the resulting gas led off into a series of Wolfs bottles and absorbed by Aq

temp of full redness 1/3 of the O expelled.
Occurs in nature as Pyrolusite. This
formerly the most convenient mode, now
abandoned.

$$2HgO = 2Hg + O_2$$

$$3MnO_2 = {}^{IV}(Mn_3)^{VIII}O_4 + O_2$$

Manganic tetroxide

Next reaction by far the most important
by which O is produced. that by which the
O is liberated by living plants.

$$CO_2 = C + O_2$$

Carbonic anhydride

All inconvenient for obtaining O for experiment
Better from Potassic Chlorate, which decomposes
into potassic chloride and O.

Atomic $\begin{cases} O\,Cl \\ O \\ O\,K \end{cases} = KCl + 3O$ or

Molecular $2\begin{cases} O\,Cl \\ O \\ O\,K \end{cases} = 2KCl + 3O_2$

first not quite correct as O diatomic and
cannot exist as separate atom

The tubes in the Woljs bottles do not dip below the surface of the water the gas so soluable as to make this unnecessary, and it would be dangerous. To use as little SO_2OH_2 as possible the reaction sought to be obtained is this

$$SO_2OH_2 + 2\,NaCl = SO_2Na_2O_2 \text{ (normal sodic sulphate)} + 2\,HCl$$

HCl can be condensed into a liquid. A lighted taper plunged into HCl immediately becomes extinguished. A stream of electric sparks passed through HCl partially decomposes it, but when the quantity decomposed becomes considerable, the H & Cl recombine with explosion and so on. It is exceedingly soluable in water, which even in the state of ice rapidly absorbs it. A piece of ice introduced into a cylinder of HCl over Hg immediately absorbs the gas and causes the Hg to rise and fill the tube. At 40° Far 480 volumes of HCl are absorbed by water. The specific gravity of this solution is the means employed to ascertain its strength. This is found by means of the hydrometer, which stands in pure water at specif grav 1°. In this solution of HCl at 1·65 the percentage of real acid can be found from this in the table constructed for the purpose. There are also tables of this kind for the other acids.

this process improved by MnO_2 takes no part in reaction but helps on the action - Action may be regarded as consisting of this nature. It possesses affinity for more O Manganic and Permanganic acids - not formed at this temp. but the pull of the force through not strong enough to form these acids, but helps decomp of potassic Chlorate.

Another process suggested as more economical distilling SO_2OH_2 or red hot Pt or bricks

Atomic $SO_2OH_2 = SO_2 + OH_2 + O$ or

Molecular $2SO_2OH_2 = 2SO_2 + 2OH_2 + O_2$

Also by electric spark, but passed through Aq acid with SO_2OH_2 to give it more conductive power

$2OH_2 = O_2 + 2H_2$

2 vols of H, & one of O liberated H going to neg pole.

MnO_2 treated with SO_4H_2 and heated

Thursday Oct 21st.

HCl forms salts of Cl with the metals metallic oxides or hydrates, thus

$$OKH + HCl = KCl + OH_2$$
$$ZnO + 2HCl = ZnCl_2 + OH_2$$

Commercial HCl invariably contaminated with impurities these generally consist of sulphuric acid, Arsenious acid and Ferric Chloride. The Arsenious acid is derived from the SO_2 H_2O used in preparing the HCl, the SO_2 H_2O being almost always prepared by burning Iron pyrites. and this contains As, which is converted into Arsenious acid, which is changed in preparation of HCl into still more volatile Chloride. The carbon vessels (or when HCl is made on a still larger scale) towers lined with coke, used for condensing the acid, contain iron, which dissolves, occurring as $FeCl_3$, and giving the acid its yellow colour. These impurities are readily detected. SO_2 H_2O by Baric Chloride. As by its yellow precipitate with sulphuretted Hydrogen. and Fe by potassic ferrocyanide. Cl + H are an example of the most simple form of combination. Elemental monads. HCl.

forms manganous sulfate and sets free 1/2 of the O.

Molec $2MnO_2 + 2SO_4H_2 = 2SO_2MnO'' + 2OH_2 + O_2$

$2\begin{cases} CrO_2K_0 \\ O \\ CrO_2K_0 \end{cases}$

Steam and chlorine acting at high temps O and Cl nearly equal in oxy quality thus if one sulfid a little can expel the other from combination. HCl and O passed through red hot tube Aq produced. Of Cl, and OH_2 passed through HCl + O

$2OH_2 + 2Cl = 4HCl + 2O$

resulting gases passed through potash to absorb HCl, or free Cl.

O colourless and transparent. no odour or taste. can not be liquified 15·00 or 1600 atmospheres and lowest temps.

Exactly 16 times heavier than H. Slightly

Oxygen. O_2. 16.

O is the most abundant element known to us on the earth. It is 8 out of nine parts of water. about 1/3 of the solid crust of the earth, and 1/5 of the atmosphere. It is nearly all in a state of combination, the free O is mostly in the atmosphere and is about $\frac{1}{2,000,000}$ of the whole. On this depends the habitabilities of the earth. From this source the chemist obtains his supply but not directly, as no substance is known to combine with N and set free O, anything combining with N combines with O more readily.

We may extract O in various ways, as by the oxidation of Hg which heated to near it boiling point for a long time. If this oxide be heated but a few degrees higher, it decomposes into Hg and O. Various other oxides similar. $Mn O_2$ heated to full redness parts with 1/3 of its O. It is found in nature as pyrolusite. This was formerly the most convenient mode of obtaining O but is now abandoned.

$$2 HgO = 2 Hg + O_2$$

$$3 Mn O_2 = {}^{IV}(Mn_3)^{VIII} O_4 + O_2$$

manganic dioxide

The reaction by which O is liberated by living plants is by far the most important.

$$CO_2 = C + O_2$$

Carbon anhydride.

magnetic for equal weights of O and Fe
1 to 2467. effect of total quantity of O in
air considerable = $\frac{1}{25.0}$ # of an inch of iron
over surface. this prop like other magg
subs diminished by elevation of temp.
Change of mag of the O in air by exposure
of one side to the sun, or to radiation of
space. This subject invest by Faraday
Connection proved with diurnal var
of mag needle. 100 cub centimeters
2.99 of O at 15.0 Cent, on this depends
aquatic life. Applied to oxydation of
of their food, and production of force
Combines with all elements but Fl
Powerfully neg element combines with
powerful positives. Cl passed through
a sol of ~~potash~~ soda, and cobaltic oxide
the H in water attracts the Cl the Cobaltic oxide
attracts the O Hcl formed & absorbed by soda

All the reactions however are inconveniant for obtaining O for experimental purposes. It is best obtained from potassic chlorate, which it decomposes into potassic chloride & O

atomic $\left\{\begin{matrix} OCl \\ O \\ OK \end{matrix}\right. = KCl + 3O$ or

Molecular $2\left\{\begin{matrix} OCl \\ O \\ OK \end{matrix}\right. = 2KCl + 3O_2$

the first is not quite correct as O being diatomic element cannot exist as a seperate atom.

This process is improved by the addition of MnO_2 It takes no part in the reaction, but helps it somewhat in this way. It possesses affinity for more O as in Manganic & Permanganic acids. These acids are not formed at so low a temperature as is employed for making the O, but the attractive force of the Mn though not strong enough to form these acids, helps the decomposition of the chlorate. Another process for obtaining O suggested as more economical is by dropping SO_2OH_2 on red hot Pt or bricks it decomposes thus.

atomic $SO_2OH_2 = SO_2 + OH_2 + O$ or

Molecular $2SO_2OH_2 = 2SO_2 + 2OH_2 + O_2$

O can also be obtained by the decomposition of water by the electric spark. This succeeds best when passed through water acidulated with SO_2OH_2 to give it more conductive power. Reaction thus

O set free as cobaltic oxide, not
Capable of combining with the O at the temp
= free O. Bodies which burn in the air
do so much more readily in O N & air
absorbs the heat. Does not like Cl comb
at ordinary temps. Common test for
presence of O splinter of wood reignited.
Comb of P S C; Fe steel wire in jet of
O. O & H mixed explode. Oxhydrogen
balloon. Some substances combine
with O. When some subs spread
out large surface, and placed in piles
to keep in the heat. So with oily cotton
fibres O combs slowly with oils, temps
sometimes enough for combust.
Coal in bulk sometimes does this when contains
much iron pyrites. In Rangoon cable the iron
wire oxydising melted some of the gutta percha.

$2OH_2 = O_2 + 2H_2$

Two volumes of H and one of O are liberated, the H being positive goes to the negative pole.

MnO_2 treated with $SO_2 OH_2$ & heated forms manganous sulphide and gives up one half of its O

Molecular $2MnO_2 + 2SO_2 OH_2 = 2SO_2 Mn'' O_2 + 2OH_2 + O_2$

O obtained also by heating a mixture of potassic bichromate with $SO_2 OH_2$

$$2\begin{cases} Cr_2 O_2 Ko \\ Cr_2 O_2 Ko \end{cases} + 8SO_2 Ho_2 = 2SO_2 K O_2 + 2S_3 O_6 (Cr_2''' O_6)^{VI}$$

potassic sulph. chromic sulph.

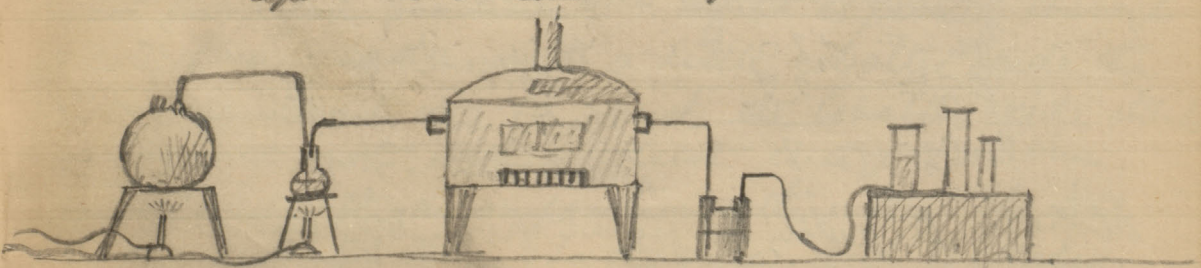
$+ 3O_2 + 8OH_2$

Steam and Cl acting at high temperatures can be decomposed, and yield. O.& Cl are nearly equal in negative energy, thus if one is helped a little it can expel the other from combination. $HCl + O$ passed through a red hot tube give water. If Cl & OH_2 are similarly treated HCl & O result.

$2OH_2 + 4Cl = 4HCl + 2O.$

the resulting gases are passed through potash to absorb HCl & free Cl.

Apparatus used in this process.



Monday 25th Oct

May be supposed that O & C combining rush together, and collision produces heat. Bullet fired against plate. If two bodies elastic much less elevation of temp if perfectly elastic no heat. Lead being soft causes very little rebound hammered becomes hot enough to melt - P. Velocity of body falling by gravity very much less than that of O striking C. 1 lb of H with 8 lbs of O for formation of Aq = that which ensues when 1 falls 22820 feet. When combination takes place alteration of properties. One of most powerful of bodies. If pos in excess comp thus formed still contains some positive energy by more O neutralised, & even invested with neg energy.

Mn & O

Manganous oxide.

Mn = +20
O = −9
MnO = +11

Manganic oxide

Mn = +20
O_2 = −18
MnO_2 = +2 almost absolutely neutral.

Anhydrous Manganic Acid

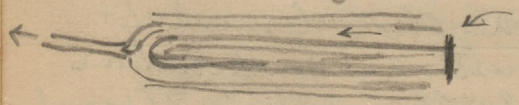
Mn = +20
O_3 = −27
MnO_3 = −7

O assumes two different molecular forms diatomic & triatomic. Ozone triatomic. Properties of this dotropic O widely different from diatomic O

O is a colourless transparent gas and has no smell or taste. It can not be liquified 15·00 to 1600 atmospheres pressure, and lowest temperatures fail to do so. Exactly 16 times heavier than H. It is slightly magnetic. for equal weights of O and Fe, the magnetic property is in the proportion of 1 to 2467. The effect of the total quantity of O in the atmosphere equals that of $\frac{1}{250}$ of an inch of Iron over the surface of the earth. This property as in other magnetic bodies diminishes on the elevation of the temperature. And to the change of magnetism of O in air consequent on rotation of the earth, and presentation of alternate sides to the sun Faraday has traced the diurnal variation of the magnetic needle. 100 cubic centimeters of water absorb 2·99 of O at 15·0 Cent and on this depends aquatic life. From this aquatic animals obtain O to oxidise their food & thus produce force. O is known to combine with all element but F Cl. Being a powerfully negative element it evolves heat sufficient for combustion when it combines with powerful positives. If Cl is passed through a solution of soda, with a little cobaltic oxide, the H of OH_2 attracts the Cl, and the cobaltic oxide attracts the O but not with sufficient energy to combine, merely helps the decomposition of the water. The HCl is immediately taken by the soda, and O escapes. Combustibles in air, burn much better in O, the N of

O transformed into O_3 by the electric spark. Houses struck by lightning peculiar odour perceived due to triatomic O but not known how transformation takes place. 1 in 10,000000 of air probably give perceptible smell. P slowly oxydising in atmospheric air gives O_3

O_3 resembles Cl in exerting its energy at common temperatures it liberates I from potassic Iodide. Iodised starch paper for detecting O_3. Another made by passing electric current through dilute SO_2OH_2 or Chromic acid. portion of the O liberated as O_3. By all these means produced in very small quantity probably not more than 1/10 per cent. Maximum amount produced by weak electric ~~current~~ sparks through dry O. Siemonds apparatus. Induction spark



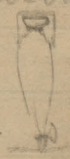
bleaching effect resembling Cl passed through coil of indigo Gaseous. Insol in H_2O acids & alkalies. Oxydises Ag & Hg at ordinary temperatures destroys Caoutchouc. When heated ~~out~~ to 290°

air absorbs part of the heat and hinders combustion. Substances however do not inflame at ordinary temperatures in O as ~~they~~ azote do in Cl. A common test for the presence of O is the rekindling of a splinter of wood. Steel wire burns beautifully in a jet of O passed at first through a spirit lamp flame. O & H mixed explode at red heat and form OH_2 This can be well shown by collodian balloon filled with the mixed gasses and tied with a string dipped in nitre, light the end of this and let it mount to the roof when combination takes place. Spontaneous combustion, such as sometimes takes place in heaps of oily cotton, arises from the large surface of oil exposed to O and heat being kept in. Cargoes of coal sometimes take fire when wet owing to oxidation of contained iron pyrites. The Rangoon cable was nearly destroyed by the heat arising from the oxidation of the casing iron wire, in the ships hold.

Monday Oct 24th 1869.

Heat caused by chemical combination. We may suppose that O & Cl for instance, have an attractive power for each other which causes them to rush together, & that the collision produces heat. Ans impact of bodies produces heat. It has been said that a bullet fired from a rifle against an iron plate causes sufficient heat to fuse part of the lead. This is questioned but it certainly produces great heat. If two bodies striking together are elastic much less heat is produced. Pb being soft and inelastic causes very little rebound

reconverted into O. Diminution of volume when O into Oz. Vice versa. When Oz acts upon S or Hg no diminution of volume takes place, and so Oz liberates its own volume of O. For each vol of Oz. 3 vols of O got form 2 of Oz
Mons Laurin Oil of turpentine. Oz absorbed by turpentine vapour. Nitrous acid same effect on ~~Iodised~~ paper, this formed by electric spark. Same effect prod by ordinary acids as HCl. Test for ozone sometimes fallacious. These actions threw great doubt on existance of Oz in air. But found that it is destroyed by same temp as Oz. and thus proved.
Comps of O & H. OH_2 & ~~OH~~ ooo oooo first always produced by combustion. Comp of Oz found by analysis and synthesis. Decomp of water shown by electric light. Synth first by Cavendish into his eudiometer O & H in proper proportions lit by an electric spark. & Ag results.



Exists in solid liquid & gaseous state.
In large quantities greenish blue. Edges of lakes greenish

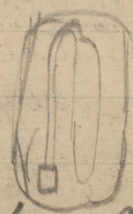
and can easily be hammered hot enough to ignite P. The velocity of any falling body must be much less than that of combining atoms, which can only be compared to planetary motions. The heat generated in the combination of 1 lb of H with 8 of O is equal to that produced by a ton falling 22,320 feet. When chemical combination takes place a complete change of properties is observed in the resulting compound. Thus differs from mechanical mixtures. O is one of the most powerfully electro negative bodies. When it combines with positive substances, but not in sufficient quantity for saturation of positive quality the compound remains positive. When in equal quantity the compound neutral, and if in greater proportion it will have negative qualities. This may be represented thus.

Manganous oxide	Manganic oxide	Anhydrous Manganic acid
$Mn = +20$	$Mn = +20$	$Mn = +20$
$O = -9$	$O_2 = -16$	$O_3 = -27$
$MnO = +11$	$MnO_2 = +2$	$MnO_3 = -7$
positive	almost absolutely neutral	negative.

Ozone O_3

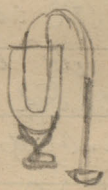
O assumes two different molecular forms diatomic Ordinary O & trialomic Ozone. The properties of this allotropic O are widely different from those of Ordinary O. In fact if we did not know it to be otherwise we might suppose them to be different substances. O is transformed into Ozone by the electric spark, and thus it is that ~~[illegible]~~ when

blue in deep ex parts. Tasteless & odorous. Nearly incompressable like all liquids. Experimenting on compressability, gold globe subjected to powerful pressure a little flattened, but dew on outsid, and also Au weight of expanded. Pressed in an apparatus where equal pressure outside & inside



Ag by application of heat from its freezing points gradually contracts, differs thus from all other liquids

Contracts to ~~X~~ all 4 degrees

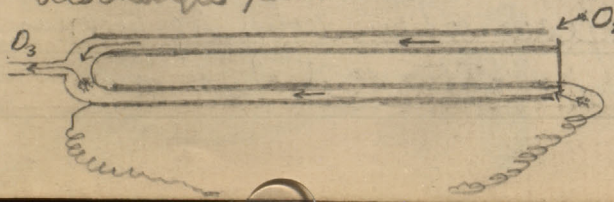


Contraction on application of heat

Tuesday 26th Oct.

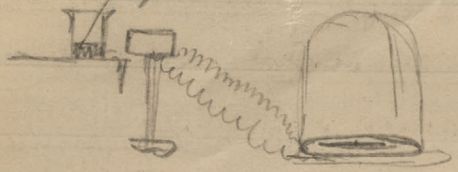
OH_2 51·3 less in a Million. Cooling of Ag by convection Condition under which ground ice forms. Always formed in rippling stream where the whole body is mixed and cooled down. Ice crystalises out, on rough stones sand &c at bottom of stream. Sometimes float stones. Only fresh water possesses this property of expansion. When sea water freezes

a house is struck by lightning the peculiar smell of Ozone is perceived. In this & other instances it is not known how the change takes place. The smell is so penetrating that 1 in 10,000000 of air would probably be perceptable P slowly oxidising in air gives Ozone. Ozone resembles Cl in exerting its negative power at ordinary temperature. It liberates I from Potassic Iodide. ~~and sets free~~ Thus paper dipped in solution of starch and iodide of potassium is used for testing for Ozone. This test however is not infallable as other substances give the same blue colour. Many acids do so as Nitrous and Hydrochloric. Nitrous acid liberated by electric discharge simultaneously with ozone is likely to mislead. HCl from factories &c in air gives fallacious indication. It forms hydriodic acid. When the electric current is passed through water acidulated with SO_2 HO_2 or chromic acid part of the Oxygen is liberated as ozone. By all these methods the quantity produced is very small probably not more than 1/10 of one per cent. The maximum ammount is produced when weak electric discharges are passed through dry O. On this principle Siemonds apparatus is based. It consists of two test tubes one within the other, the outer with its outside covered with tin-foil; the inner with its inside. Between the tubes the dry O passes, and when the foils are put in connexion with a battery, induced electrical discharges pass between all parts of the tubes, through the O



By this means from six to thirty per cent of ozone can be produced.

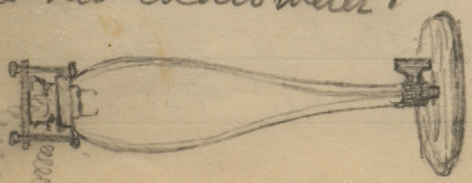
4° point of max density = freezing pt. Specific heat amount of heat given off in cooling through ten degrees as compared to water. Ag has greatest specific heat of any body, next Lithia which has 0.94 sc. Thermal pile. bars of antimony and Bismouth. To show specific heat of Ag 1/2 oz of water at thermo pile deflects needle x 1/2 as of Hg if same specif heat as Ag would reduce the temp to 1/2 (the mean) but having low specif heat takes much less heat to warm it to (Ag 1.0000 Hg 0.0333. about 30 times the weight



. Specif heat of Ag exercises great influence on climate. Small quantity of water heats large quantity of cold air. Thus cold water absorbs a great deal of heat. from this that climate of islands so much more equable than that of Continents (Ag 1000 Air?) Latent heat or heat of fluidity. waters very great. Latent heat that amount which disappears when solid ag becomes liquid. If you take Ice & water and heat no

Ozone has a bleaching effect, and bleaches solution of indigs &c much like Cl. Always gaseous. It is insoluable in water, acids, or Alkalis. It oxydises Ag & Hg at ordinary temperatures, & destroys caoutchouc. When heated to 290° it returns into the state of oxygen. When Ozone acts upon Ag or Hg no diminution of its volume takes place. For ozone liberates its own volume of O. Three volumes of Oxygen are contained in two of Ozone. Ozone is absorbed by oil of turpentine or its vapour and ~~from~~ by taking advantage of this Mons Saurin? showed its relation to O. The uncertainty of the ozone test for some time threw great doubt on its presence in the air, but the power of changing the colour of the Iodised paper was found to be destroyed in the air when heated to 290° and its existance thus proved.

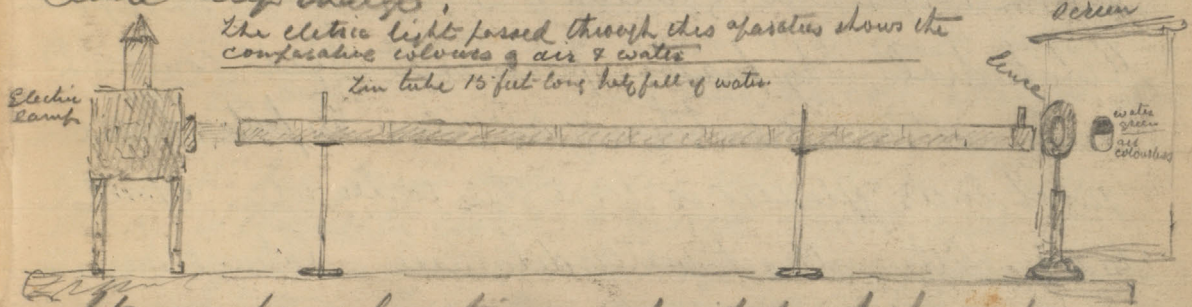
<u>OH_2 water</u>; is the most common compound of O & H there is another however OH. H–O–H H–O–O–H. OH_2 always formed from combustion of H or Hydrocarbons. The composit of water has been determined both by analysis and synthesis. (Showed decomp of Ag from platinum electrodes magnified and thrown by electric light.) The synthesis of water was first accomplished by Cavendish in his eudiometer.



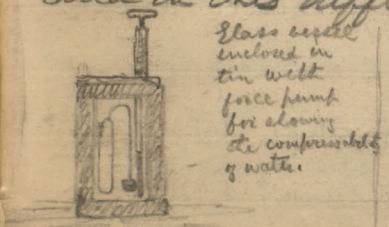
O & H in proper proportions are lit in a strong glass vessel by an electric spark, and the vessel becomes bedewed with water

elevation of temperature till last of ice melted. This heat disappears. It is measured by the amount of heat used to melt a pound of ice, would raise the heat 900 degrees. water used as the scale for other elements. This causes Hg to be difficult to freeze in large quantities. A cubic yd of Hg gives out heat in freezing = to a bushel of coal. Expansion of water in freezing. Not singular in this respect. Shown by enclosing it in iron bottle which efects in freezing mixture. Disintegration of mountains. Coherent action. As a rule solubility of solid increased by heat. Cohesion between the parts of solid weakened more than that of liquid. Solution usually merely physical in some cases (Chemical solution) undergoes change. Phosphoric Chloride. Changes into Phosphoric acid & H Cl. ($PCl_5 + 4OH_2 = PO_4H_3 + 5HCl$. Salts separate almost always pass out in regular geometrical forms. Used to purify and separate substances. First time some of water or other substance enclosed in crystal.

OH_2 exists in the solid, liquid, & gaseous state. In large quantities it is greenish blue, and when very deep indigo. Thus the edges of clear lakes greenish blue & centre deep indigo.



It was for a long time undecided whether water was compressible or not. It has been enclosed in a gold globe and subjected to great pressure, the globe was slightly flattened, and thus the compressibility thought to be proved, but the outside of the globe was found bedewed with moisture, and besides the globe might have been expanded a little. The compressability has been proved however to be about $\frac{1}{1000000}$ of an inch per atmosphere, by a very ingenious arrangement by which the water is subjected to pressure in a glass cylinder drawn out into a capillary tube which is inserted into a cup of Mercury. The cylinder is exposed to equal pressure outside and inside, and error thus avoided by being enclosed in a strong glass vessel of water. Air is pumped down a tube into this and pressure then applied. Water when heated from the freezing point contracts till it arrives at 4° Cent and in this differs from all other liquids. About this temp it expands. This is well shown in an arrangement somewhat like the last which is first put in ice & water, and afterwards in warmer water. (Contraction & expansion shewn by figure tube)



Bodies which crystalise in same shape isomorphous in two systems dimorphous. S cryst in two distinct forms. Cryst also by fusion. S in Carbonic disulphide Octohedral. by fusion prismatic. Cryst combine with various quantities of aq Alum 24 parts. Some substances efflorese or loose their water when exposed to air. Others attract water deliquesse. Calcic & Magnesic Chlorides.

Oct 27th

Some oxides changed into hydrats by aq Sodic potassic basic Calcium Anhydrides, converted into acids. Water of crystallization held in looser combination than other substances in comp, Molecular union. High temperature ~~often~~ ~~evolve~~ evolved in change of anhydrides into acids. Phosphoric anhydride ~~when~~ with a drop of water gives heat enough to light a piece of gun cotton lying on it. Specif grav of ice .9184. Salts or gasses in water expelled when it freezes. Bubbles in ice from this cause, when it freezes rapidly. Artificial ice full of these bubbles. 0° Cent water running from melting ice always this temp. When aq in molecular combination its melting point is altered. Salts (as Alum) contain

Tuesday Oct 26th.

When in large quantities together as in ponds or lakes water cools by convection, the cold stratum on top sinks to the bottom, and replaced by next quantity of water and thus the whole cools down to 4° Cent, below this point the water expands, and thus the cold stratum floats on top, and the state below do not cool any lower. Ground Ice forms only where water, as in a rippling stream is thoroughly cooled & mixed together ~~and~~ then the ice crystalises out, on the rough stones, pebbles, or sand of the ~~sea~~ bottom. & sometimes accumulates in sufficient quantity to float stones &c from the bottom. Only fresh water possesses this property of having its maximum density above its freezing point, when salts are dissolved in it, as in sea water it looses it, and gradually the maximum density falls to 0° Cent. Specific heat, is that amount of heat which any body gives off in cooling through 1° as compared to that given off by water under the same circumstances. Water has the highest known specific heat. The next highest is lithia. The thermal pile for measuring minute quantities of heat is composed of bars of bismouth & antimony soldered together at the ends and so arranged that when put in connection with a magnetic needle, the least heat causes an electric current which deflects the needle. The high specific heat of water can be shown by putting 1/2 lb of boiling water in a beaker before the thermo electric pile, and noticing the degree to which the needle is deflected. Now add 1/2 lb of cold Hg. If x = deflection of the needle with the hot water & Hg had

water as ice, & whenever they crystalise heat is given out. (Sodic sulphate dissolved in aq before thermo pile deviates needle & shows cold of melting of 10 molecals of water contained in that salt.) Supersaturated sol of sodic sulphate show heat in crystalization when atmosphere allowed access. It takes 10 mols of water and combines with them as ice evolving heat. Solidyfication ensues from contact of crystal of the same salt or one of closely allied cryst form. On the congelation of salts depends freezing mixtures.

Ammonic nitrate 1
Water 1
} from 10° to -15°

Ammoniac chloride 5
potassic nitrate 5
Water 16
} from 10° to -12

Sodic sulphate 3
Dilute nitric acid 2
} from 10 to -19

Snow 2
Sodic chloride 1
} -21

Snow 2
Cryst Calcic chloride 3
} from 0° to -45

Snow 3
Potassic hydrate 4
} from 0° to -46

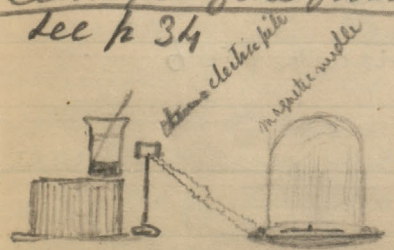
the same specific heat as water 1/2 of Hg would reduce the temperature of the water, and consequently the deflection of the needle to 1/2 × (the mean) but such is not found to be the case, several 1/2 lbs of Hg may be added ~~to~~ and make but a very minute difference. Thus the specific heat of Hg is much lower (water = 1.0000 Hg 0.0333) only about 1/30. The great specific heat of water exercises much influence on climate, as a small bulky warm water will heat a great quantity of air. (Gulf stream) Thus it is that the climate of islands is so much more equable than that of continents. Latent heat or heat of fluidity is the ammount which disappears when a solid becomes a liquid. Water's latent heat is very great. If you heat Ice & water no elevation of temperature is caused till the whole of the ice is liquified. This heat disappears and is used up in changing the ice into water. Latent heat is measured by the ammount required to ~~mine~~ melt a pound of ice; this ammount of heat would raise a lb of water 79°. 79 is therefore the latent heat of water. The large ammount of heat ~~required~~ contained in liquid water, makes it hard to freeze. A cubic yard of water liberates in freezing, heat equal to that produced by the combustion of a barrel of coal. Water expands on freezing, and some other substances do the same. (Shown by enclosing water, in an iron bottle with a screw plug. the whole put into a freezing mixture, and after a little time the bottle bursts with a crack. Ice being found inside) Water acts thus in splitting up rocks &c. High mountains where the temperature always falls to freezing at night, are thus disintegrated, giving rise to avalanches. As a rule the solubility of a solid

Ag at 100 degrees Cent vaporises & boils.
This only at normal pressure of the atmosphere.
Boils in vacuum to 21° Cent. ~~Boiling~~
Shut mates put into vacuum boils. Water
volatilises more or less at all temperatures
A few drops of Ag introduced into barometer vacuum
depresses Hg depends on tension of Ag vapour
heated by steam tension becomes greater
Hg depressed till equal with that in dish
below when tension of vapour = that of air & it
boils. X Formula for correction of gases when
collected moist. Eudiometer. Column of Hg increased

Gas compressed. If aqueous vapour with
gas, the tension of the vapour presses down
the mercury, and gives too great amount
of gas. deduct column of merc in Eudiometer
from length of column in barom at time.
Tables constructed for tension of aqueous vapour
Say ~~temp~~ for tension for temp 9·165 this also
deducted gives true volume of gas. To make this
Covection correct gas must be saturated.

substance in water is increased by heat. By the same degree of temperature the cohesion between the particles of a solid, are loosened more than that between those of the liquid. Solution is usually merely a physical phenomenon. ~~In some cases~~, In some cases, called Chemical solution a change ensues. As Phosphoric Chloride (PCl_5) which changes on solution to Phosphoric & Hydrochloric acids. ($PCl_5 + 4OH_2 = PO\,Ho_2 + 5HCl$.) Salts almost always seperate from solution in regular geometrical forms. This property can be used to purify & seperate them. On the first crystalization the water contained in the crystals may contain some other substance, but after several crystalizations this is got rid of. Bodies which crystalise in the same shape are called isomorphous. Those which crystalise in two systems dimorphous. S crystalises in two distinct forms when from Carbonic disulphide (CS_2) in octohedrons, when from fusion in prisms. Crystaline substances combine with various quantities of water. ($BaCl_2\ 2OH_2$, $2OH_2$) ($S_4O_8Ko_2('Al_2'''O_6)^{VI}$, $24\,OH_2$). Some substances effluesse or loose their water when exposed to air, others deliquesse or attract moisture from the air. Sodic Sulphate, & Carbonate examples of the first. Calcic & Magnesic Chlorides of the second.

See p 34



Volume of gas V as red off. V true volume
height of baiom

V : V' :: 30

1 inch = error of vapour tension 30 − 1 = 29

$V' = \frac{V29}{30}\left(\div 30\right)$ When sun setting or
rising rays pass through about 200 miles of atmosphere
blue green tint of atmosphere may be due to vapour of aq
Specy Grav of aq vap .622. Temperature of water
does not rise beyond boiling point. Absorbed
in converting it into vapour, It would raise a
litre? of aq 536°. A kilo of water by passing
steam through it will increase by certain
amount when raised to 100°. 1 kilo =
.187 $\frac{1.187}{1.100}$ of steam has been condensed in
187
raising the aq to 100°. 1 kilo of steam would raise
5.36 kilo of water through the same temperature;
would raise 1 kilo of steam through 536°.

Tuesday Oct 28th

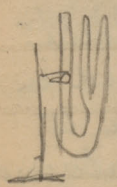
Hydrogen or Hydric peroxide H_2O_2 Great theoretical
interest some practical importance. prepared by passing
Carbonic anhydride through baric peroxide suspended in

Wednesday Oct 24th

OH_2 converts some oxides into hydrates, as OK_2 and BaO into OKH & $Ba\,Ho_2$. ($OK_2 + OH_2 = 2OKH$ + $BaO + OH_2 = Ba\,Ho_2$) The water of crystallization is held more loosely than the other substances, it is only molecularly combined. Anhydrides by OH_2 are converted into acids as $N_2O_5 + OH_2 = 2NO_2Ho$. $SO_3 + OH_2 = SO_2Ho_2$. High temperatures result from this change (P_2O_5) phosphoric anhydride with a little water, gives out heat enough to light gun cotton lying on it. The specific gravity of ice is .9184. Salts or gasses in solution in water, are expelled when it assumes the solid state. The bubbles in ordinary ice arise from this cause. When it freezes rapidly the contained gasses have not time to escape, and consequently the ice becomes full of bubbles. Artificial ice not liked as it is so much so. Water running from melting ice is always at the freezing point 0° Cent. When OH_2 is in molecular combination it melting point is altered. Salts holding water of crystalization really contain it as ice. So when they crystallize heat is given out from the solidification of the water. (Shown by a supersaturated solution of sulphate of soda before thermo-electric pile, when a crystal of SO_2Na_2 is put in the whole solidifies, with evolution of heat as shown by needle. SO_2Na_2 dissolved in water under the same circumstances causes the needle to deflect, & show cold.) 10 molecules of OH_2 are contained in SO_2Na_2 ~~three~~ this combines with it as ice giving out latent heat. In a supersaturated solution solidification

$OH_2 \{^{O}_{O}Ba'' + CO_2 + OH_2 = COBa'' + \{^{OH}_{OH}$. thus can obtain about 5 per cent. Concentrated under air pump, both OH_2 & OH volatilize but SO_2OH_2 only absorbs OH_2. concentrated begins to decompose at 2° but when not so concentrated can be kept for some time without change $2\{^{OH}_{OH} = 2OH_2 + O_2$. decomposed by some metallic oxides as that of Ag &c. Give most important evidence of the composition of O. reaction as follows $(OH)_2 + OAg_2 = OH_2 + Ag + O_2$. every atom of O leaving OH takes an atom of O from OAg_2, and forms molecule of ordinary O. This reaction cannot be explained otherwise. (OAg_2 dropped into test tube with OH gives free O.) somewhat similar properties to Cl like in smell & bleaching properties. (bleaches indigo) Transformed into OH_2 by nascent hydrogen. proves that OH_2 is a compound of a 1½ molecule of OH with an atom of H. $(OH)_2 + H_2 = 2OH_2$. If you add to Zn a dilute SO_2OH_2 the gentle stream of H & then OH added H ceases to be given off. Like Cl liberates I from potassic Iodide. $2KI + \{^{OH}_{OH} = 2OKH + I_2$

Water with SO_2OH_2 and OH decomposed by electricity



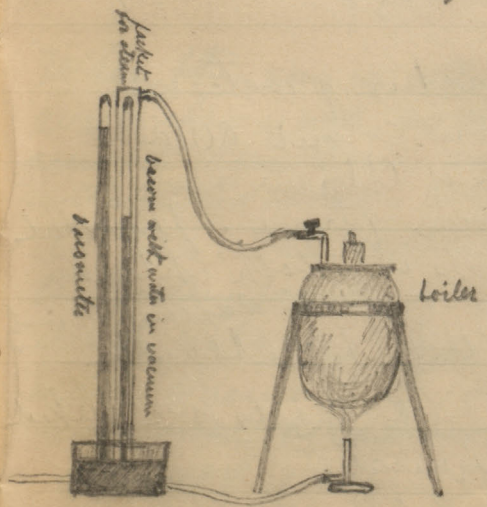
Decomposes plumbic sulphide blumbic sulphide $Pb\,S''$ forms in and dulls paintings transformed by OH to $SO_2Pb O''$. $PbS'' + 4\{^{OH}_{OH} = SO_2PbO'' + 4OH_2$. Pictures thus restored.

ensues on contact with a crystal of the same salt or one of the same, or closely allied crystalline form.
On the heat absorbed cold evolved in the liquefaction of salts depends the power of freezing mixtures.

Examples of freezing mixtures.

Ammoniac nitrate 1 Water 1	Cools from	10° to -15°	Snow 2 Sodic chloride 1	to	— 21
Ammoniac chloride 5 Potassic nitrate 5 Water 10	"	10° " -12°	Snow 2 Crystd calcic chloride 3	from 0° to	45°
Sodic sulphate 3 Dilute nitric acid 2	"	10° " -19°	Snow 3 Potassic hydrate 4	" 0° to pieces Hg	- 46

OH_2 at 100° Cent vaporises with ebullition, or boils. This temperature is constant only at normal pressure of the atmosphere. It can be made to boil in vacuum at 21° Cent. (a beaker of hot water put into under a bell jar & the air exhausted begins to boil again.) OH_2 volatilises more or less at all temperatures a few drops of OH_2 put into the vacuous space above the Hg of a barometer depresses the column. This depends on the tension of the vapour of OH_2. If the barometer tube be encased in a larger one & steam passed between them, the heat increases the tension of the vapour, and the column of Hg is rapidly depressed, till it is on the same level as that contained in the dish below.

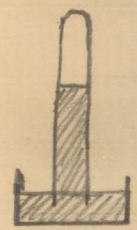


Comps of O and Cl & Cl & OH & O.
none of these bodies produced by direct combination.
consist of 2 atoms of Cl seperated by 1 2 or more atoms of Cl. (Cl)-(O)-(Cl) hypochlorous anhydride O-O-O-O Chloric oxide?
&c Why assume Cl as monad in these comps why not consider as triad Cl OH or pented ClO_2H_O no evidence of polyad character of O outside this series. One atom of Cl always combines with 1 of metal. O in these comps in very unstable equilibrium, and liable to explosion. most of these unimportant. Chloric peroxide by action of SO_3OH_2 on potassic chlorate (reaction) One or two crystals dropped into test tube with SO_2OH_2. fills ~~from~~ with greenish yellow glass. decomposes with explosion at temp of 60° ~~water~~. Specif grav 2.33? Oxydises organic substances with great rapidity. Sugar & potassic chlorate when touched with SO_2OH_2 ignites by formation of this substance.

Hypochlorous acid. by the action of water on hypochlorous anhydride. yellow colour acrid taste, formed also by the action of Chlorine upon Mercuric oxide. present in Chloride of time. powerful oxidising agent converts metals into both chlorides oxides or oxychlorides according to their superior affinity for O or Cl. Formerly thought that hyperchlorides & Chloride of lime formed when Cl passes over slaked lime. If so salt aught to deliquesse

Old $2Cl_2 + 2CaHO_2 = CaCl_2 + CaO''Cl_2 + 2OH_2$
Calc Chloride Calc hypochloride

and consequently the tension of the vapour equals that of the air; and the water boils. The formula for the ~~collect~~ correction of gasses when collected moist, in the endiometer



The first correction is to deduct the length of the column of Hg in the endiometer, from the length of that in the barometer at the time. Next deduct the tension of the aqueous vapour, which pressed down the Hg, & gives to large amount of gas. This is done by a table constructed for any temperature. To be accurate the gas must be saturated with moisture. this done by passing the gas through Hg or wetting the inside of the tube.

When the sun is setting or rising its rays pass through about 200 miles of air, so that the blue-green tint sometimes seen at these times may arise from water vapour present in the atmosphere. The specific gravity of vapour of water is .622. The temperature of water cannot rise beyond the boiling point, as all the heat is absorbed in converting it into vapour. If a Kilo of water be heated by passing steam through it, to 100° it increases in weight a certain amount by condensing the steam. 1 Kilo increases to 1.187 thus .187 of steam has been condensed in raising the water to 100°. Thus the heat which would raise 1 Kilo of steam 5.36° would only raise 1 Kilo of water 5.36°.

more likely. $Ca Ho_2 + Cl_2 = Ca(OCl)Cl + OH_2$
Bleaching powder.

when hypochlorous acid mixed with OAg_2 gives
O organic chloride

$$OAg_2 + \underset{\text{Hypochlorous acid}}{2ClHo} = 2AgCl + OH_2 + O_2$$

Chloric acid

Monday November 1st 1869.

Chloric acid prepared by action of dilute SO_2Ho_2 on Basic Chloride oxidises organic substances, frequently charring them & sometimes igniting. A drop of concentrated acid on paper gently warmed ignites at certain temp with explosion, action once violent. Potassic Chlorate only important salt Calico Printing dying, fireworks & matches. Prepared by action of Cl upon OKH. 5/6 of the material converted into Potassic Chloride which comparatively useless. Better Calcic Chlorate prod and Ca replaced by equal prop of K. Cl passed through Milky lime nearly at boiling point. converts it into Calcic Chlorate &

Thursday Oct 28th

Hydroxil, or hydric peroxide is a substance of great theoretical intent & some practical importance It may be prepared by passing Carbonic anhydride, through basic peroxide, suspended in water.

$$\left\{\begin{matrix}O\\O\end{matrix}\right\}Ba'' + CO_2 + OH_2 = CO Ba\ddot{o} + \left\{\begin{matrix}OH\\OH\end{matrix}\right\}.$$

about 3 per cent can thus be obtained. It may be concentrated under the air pump. Both OH_2 & OH volatalise, but a vessel of $SO_2 Ho_2$ is put in, which absorbs OH_2, and thus OH is obtained in a concentrated form. When in this state it begins to decompose at 210 but when not so consentrated may be kept for some time without change. When it decomposes spontaneously it seperates into OH_2 & O. $2\left\{\begin{matrix}OH\\OH\end{matrix}\right\} = 2OH_2 + \ddot{O}_2$.

It is decomposed by some metallic oxides as OAg_2 & this reaction gives most important evidence as to the constitution of O $(OH)_2 + OAg_2 = OH_2 + Ag + O_2$. thus every atom of O which leaves OH takes an atom of O from OAg_2, and forms a molecule of ordinary O. This reaction cannot otherwise be explained. (OAg_2 dropped into test tube containing OH causes effervessance of O) It smells somewhat like dilute Cl and also somewhat resembles that gas in properties. It bleaches, though not so powerfully as Cl. If in contact with nascent H it combines with it forming OH_2. This reaction proves that OH_2 is a compound of a Hy molecule of $\left\{\begin{matrix}OH\\OH\end{matrix}\right\}$ with an atom of H. $(OH)_2 + H_2 = 2OH_2$. This experiment may be tried by generating some H in the usual way by adding to Zn & dilute $SO_2 OH_2$ and when H is coming off freely, adding some OH; the H immediately ceases to be evolved. It being all absorbed in changing OH into OH_2. Like Ozone it liberates I from potassic Iodide. $2KI + \left\{\begin{matrix}OH\\OH\end{matrix}\right\} = 2OKH + I_2$. If to water acidulated

Chloride.

$$6\,CaHo_2 + 6Cl_2 = \begin{cases} O\,Cl \\ O\,Cao'' \\ O\,Cl \end{cases} + 5\,CaCl_2 + 6H_2$$

if to this evil you add 2 mols of K for each of Ca you get

$$\begin{cases} O\,Cl \\ O\,Cao'' \\ O\,Cl \end{cases} + 2KCl = 2\begin{cases} O\,Cl \\ O\,Ko \end{cases} + CaCl_2$$

no use for Calcic chloride. Used for watering the streets to keep them moist. Not found practically to answer. Dried up & made unpleasant dust. $\begin{cases} O\,Cl \\ O\,Ko \end{cases}$ crystalised out of $CaCl_2$.

Perchloric acid obtained by distilling potassic perchlorate with 3 times of its weight of SO_2Ho_2

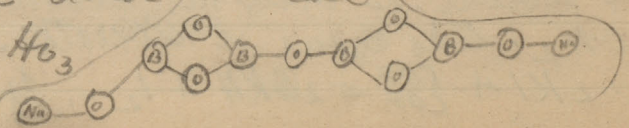
$$2\begin{cases} O\,Cl \\ O\,Ko \end{cases} + SO_2Ho_2 = 2\begin{cases} O\,Cl \\ O\,H \end{cases} + SO_2Ko_2$$

In contact with water forms crystal hydrate

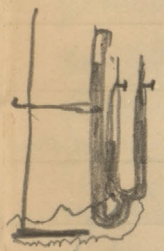
In conformity with plan of taking one element of each series, take **Boron**. Atom weight 11

only found in 1 form of combination with O boric acid / tincal / Boracite.

BHo_3



with SO_2Ho_2 and being decomposed by electricity same OH be added the evolution of H immediately ceases, while that of O goes on. All the nascent H goes to change OH into OH_2. OH has the power of oxidising PbS and changing it into SO_2Pbo''. Paintings dulled by the formation of PbS may thus be restored to nearly their former brilliancy.



$$PbS + 4\left\{\begin{matrix}OH\\OH\end{matrix}\right. = SO_2Pbo'' + 4OH_2.$$

Compounds of O & Cl & O, Cl, & OH.

none of the compounds of O & Cl are formed by direct union of these elements. They all consist of 2 atoms of Cl seperated by one or more atoms of O.

Hypochlorous anhydride Cl–O–Cl Chloric oxide Cl–O–Cl

Chloric acid H–O–O–O–Cl. But why should we assume Cl as a monad in these compounds. why not consider it triad as Cl OH or pentad ClO_2Ho? There is no evidence of the polyad character of Cl outside this series. 1 atom of Cl always combines with but one, of the metals.

Most of these compounds of O & Cl are unimportant.

Chloric peroxide $\left\{\begin{matrix}O\,Cl\\O\\O\\O\,Cl\end{matrix}\right.$ may be obtained by the action of SO_2Ho_2 on potassic chlorate $\left(\left\{\begin{matrix}O\,Cl\\O\,Ko\end{matrix}\right.\right)$.

$$3\left\{\begin{matrix}O\,Cl\\O\,Ko\end{matrix}\right. + 2SO_2Ho_2 = \left\{\begin{matrix}O\,Cl\\O\\O\,Ko\end{matrix}\right. + 2SO_2Ho\,Ko + \left\{\begin{matrix}O\,Cl\\O\\O\\O\,Cl\end{matrix}\right.$$

If a little potassic chlorate & sulphuric acid be heated in a test tube, it soon fills with this gas it is heavy & greenish yellow, & explodes violently at 60° Cent. Specific gravity 2.33? It oxidises

Boron comps. essentially of volcanic origin probably escape observation but for this action. When heated alone stand greatest heat but vapourise with steam formed in volcanoes. Condense, & impregnate waters. In India Tincal & boracite. Boracic acid from Lagoons of Tuscany. China Ceylon South American India, but principally Tuscany. there more than a million lbs made annually. Three conditions amorphous graphatoidal adamantine Boron

Amorph: $B_2O_3 + 3Na_2 = 3ONa_2 + B_2$ or

Generally preferred $2BCl_3 + 3K_2 = 6KCl + B_2$

dark brown or greenish brown powder stains fingers. Dissolves slightly in OH_2. not changed by white heat, but when in contact with air to about 300° burns & forms

Graphatoidal by passing boric chloride by passing boric chloride, over fused aluminium

$Al_2 + 2BCl_3 = Al_2'''Cl_6 + B_2$

Black body cryst in 6 sided tablets

organic substances with great rapidity. When sugar & potassic chlorate are mixed, and touched with a drop of SO_2Ho_2 it ignites from the formation of this gas. When P and $KOCl$ are put at the bottom of a glass, and SO_2Ho_2 added the P burns in this gas as it is evolved.

Hypochlorous acid. ($ClHo$) prepared by the action of water on Hypochlorous anhydride. It has a yellow colour & acid taste. It is also formed by the action of Cl upon $Hg O$. It is a powerful oxidising agent, and converts metals into either Chlorides, oxides, or oxichlorides according to their superior affinity for O or Cl. It is present in Chloride of lime, or bleaching powder. It was formerly thought that hyperchlorid, and Chloride of lime were formed when Cl passes over slaked lime.

$$2Cl_2 + 2CaHo_2 = \underset{\text{calcic Chloride}}{CaCl_2} + \underset{\substack{\text{Calcic} \\ \text{hypochloride}}}{CaO''Cl_2} + 2OH_2$$

If this was the reaction Chloride of lime ought to be deliquescent but such is not the case. It is more likely to be as follows

$$CaHo_2 + Cl_2 = Ca(OCl)Cl + OH_2$$

When Cl Ho is mixed with OAg_2 it forms O & $AgCl$ thus

$$OAg_2 + 2ClHo = Ag Cl + OH_2 + O_2$$

Diamond boron.

$Al_2 + B_2O_3 = Al_2"O_3 + B_2$

Boron is red crystals almost = diamond in hardness, not attacked by acids at any temp fused in OH gives Boric anhydride. (B_2O_3
Boric Fluoride, Bromide, Chloride
Boric anhydride by fusing Boric acid at red heat. when carefully prepared a white glassy mass. Boric acid sometimes called Boracic acid formed in Tuscany. Borax, sodic borate, by acting on a hot saturated borax by HCl = Boric acid + NaCl. White crystal scales Sol also in boiling alcohol. burns with green flame. Used to determine boron, but must be careful not to take Cu as it gives the same colour. Substance suspected should be digested with SO_2 H_2O to liberate boric acid then alcohol added & lit. Excessively feeble acid but can expel CO_2 from its salts. At 100° degrees it loses OH_2 & is converted into

Monday Nov 1st 1869.

Chloric acid may be prepared by the action of chloric sulphuric acid on basic chlorate.

$$\left\{\begin{matrix} O\,Cl \\ O \\ Ba'' \\ O \\ O\,Cl \end{matrix}\right. + SO_2H_{O_2} = 2\left\{\begin{matrix} O\,Cl \\ O\,H_O \end{matrix}\right. + SO_2Ba''$$

Chloric acid oxidises organic substances, sometimes charring them. If a drop of somewhat concentrated $\left\{\begin{matrix} O\,Cl \\ O\,H_O \end{matrix}\right.$ be put upon paper, and gently heated, at a certain temperature it oxidises it so rapidly as to ignite with a flash, & char the paper. Potassic chlorate $\left\{\begin{matrix} O\,Cl \\ O\,K_O \end{matrix}\right.$ is its only important salt. It is used in dyeing, & calico-printing, and also in making fireworks, & matches. It was formerly prepared by the action of Cl upon OKH ~~one fifth~~ 5/6 of the K was however by this process got as Potassic chloride. which is comparatively useless

$$6\,OKH + 3\,Cl_2 = 5\,KCl + \left\{\begin{matrix} O\,Cl \\ O\,K_O \end{matrix}\right. + 3\,OH_2$$

It is better to produce calcic chloride & chlorate by passing Cl through milky lime kept nearly at the boiling point, and then replacing the Ca in the chlorate by an equal proportion of K. Thus only the comparatively useless substance Ca is wasted

$$6\,Ca\,H_{O_2} + 6\,Cl_2 = \left\{\begin{matrix} O\,Cl \\ O \\ Ca'' \\ O \\ O\,Cl \end{matrix}\right. + 5\,CaCl_2 + 6\,OH_2$$

Calcium being diatomic you must add 2 molecules of K for each of Ca.

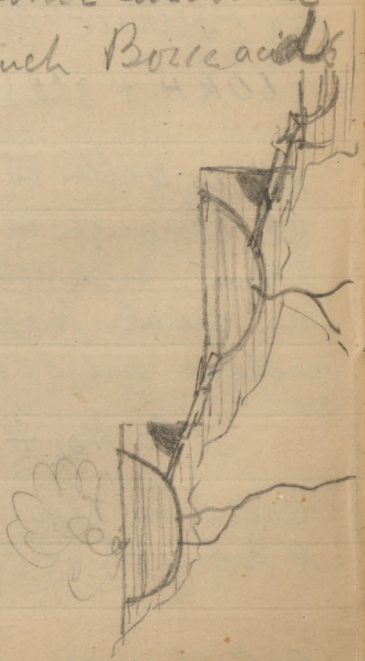
$$\left\{\begin{matrix} O\,Cl \\ O \\ Ca'' \\ O \\ O\,Cl \end{matrix}\right. + 2\,KCl = 2\left\{\begin{matrix} O\,Cl \\ O\,K_O \end{matrix}\right. + CaCl_2$$

As $CaCl_2$ is very soluable it is easy to crystalise $\left\{\begin{matrix} O\,Cl \\ O\,K_O \end{matrix}\right.$ out from it.

Metaboric acid. In the manufacture of Boric acid, which is the first process in making borax advantage is taken of steam vents, led through tanks & condensed, after passing through several basins, it is run into settling tanks where it only contains 1½ per cent of B. Next into evaporating pans heated by volcanic steam in cast pan so concentrated as to crystallise on cooling crust dried in chambers also heated by steam transformed into Borax by adding sodic carbonate. About ½ a ton of sodic carbonate dissolved in water, & then as much Boric acid

Comp of Crude Boric acid

Crust Boric acid	75·6
Calcic sulphate	1·0
Magnesic sulphate	2·6
Ammoniac sulphate	8·5
Sodic sulphate	1·0
Silica	1·2
Ferric sulphate, Alum, Ammonia chloride, Water	9·2



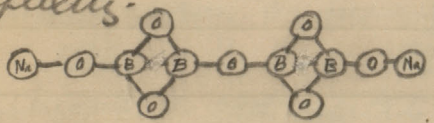
For the $CaCl_2$ produced no use has yet been found. It has been tried dissolved in water to water the streets by way of keeping them moist longer, but the heat in summer dries it up, & the dust containing it is very disagreeable.

Perchloric acid is obtained by distilling O_3ClK with three times its weight of SO_2HHO_2

$$2\begin{Bmatrix} OCl \\ OK_o \end{Bmatrix} + SO_2Ho_2 = 2\begin{Bmatrix} OCl \\ OHo \end{Bmatrix} + SO_2Ko_2$$

Comes over as a thick oily liquid, and forms a crystaline hydrate with OH_2

Boron taken next in conformity with the plan of taking one element of each atomicity 1st. Boron had atomic weight 11. It is only found in nature in one form of combination, with O or OHHo. The three forms in which it occurs are, boric acid BHo_3, Tincal & Boracite. Tincal & Boracite are compounds of great complexity.



All these combounds are essentially of volcanic origin & B would probably escape observation but for this action. When heated alone its compounds stand the greatest heat, but vaporise with steam, & are thus carried up to the surface. The steam condenses & forms waters impregnated with B. B comes from India as Tincal & Boracite, As Boric or boracic acid from Tuscany whence most of the supply is obtained, much more than 1000000 lbs are produced there annually. It

NH_4 evolved & passed through $SO_2 HO_2$ & thus absorbed.

Borax employed chiefly for glazing pottery & in soldering. essential that surfaces should be perfectly clean. borax melts & coats over the surface & thus protects from atmospheric air, also dissolves any oxide previously formed. Blowpipe reactions depends on it power of dissolving metallic oxides & forming salts.

is also found in China Ceylon & South America.
B appears in three allotropic conditions, amorphous, graphatoidal & adamantine or diamond. It may be obtained in the first condition by igniting boric anhydride with sodium. or by passing boric chloride over heated potassium.

$$B_2O_3 + 3Na_2 = 3ONa_2 + B_2 \quad \text{or}$$

$$2BCl_3 + 3K_2 = 6KCl + B_2$$

It is a dark brown or greenish brown powder, which stains the fingers. dissolves slightly in OH_2. burns about 300° in air, but otherwise may be heated to whiteness without change, except becoming slightly more compact. Graphatoidal Boron is obtained by passing boric chloride over fused aluminium.

$$Al_2 + 2BCl_3 = Al_2'''Cl_6 + B_2$$

It is a black substance crystallising in six sided tablets
Diamond boron, by fusing Boric anhydride with Al

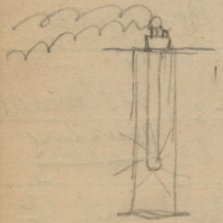
$$Al_2 + B_2O_3 = 'Al_2'''O_3 + B_2$$

Brownish or red crystals which almost equal the diamond in hardness. Not attacked by acids at any temperature. Fused with OKH gives boric anhydride (B_2O_3) B is one of the very few elements which unite directly with N.
There is a basic Chloride (BCl_3) Bromide (BBr_3) & Fluoride (BF_3). Boric anhydride is prepared by ~~heating~~ purging Boric acid at a red heat, when carefully prepared it is a white glassy mass. Borax or sodic borate ($B_4O_5 \cdot Na_2O$) When HCl is added to a hot solution of

Tuesday Nov 2nd

C met with largely in nature but mostly in combination. In atmosphere & waters.

Free as diamond graphite, mineral charcoal. Can transform charcoal into graphite & ~~vi~~ but not diamond. Diamond to chemists the least interesting form of C India China earthy crust 3·5·2 supposed to be of veg origin. Octohedral, nonconductor of electricity resists acids alkalies &c & great heat, but in voltaic arc changed into graphite. Scarcely burn in air, heat given off not sufficient to keep it ignition point. If strongly heated may be burnt, but if in O temperature being far greater no nitrogen to take away heat. High refracting power



Graphite chiefly in metamorphic rocks, Cumberland Siberia the Mines in Borrodale worked out Siberia affords chief supply of pure. Soapy feel, & is used for lubrication

this substance boric acid (BHo_3) crystalises out on cooling in white crystaline scales, soluable in alcohol B colours flame green, & this property is used in detecting its presence, care must however be taken not to confound it with the green produced by Cu which it much resembles. The substance suspected to contain B should be drenched with $SO_2 Ho$ to liberate boric acid, then alcohol added & the mixture lit. It is an exceedingly feable acid but can expel CO_2 from its compounds. At 100° Cent it looses OH_2 & is converted into metaboric acid.

In the manufacture of boric acid, which is the first step in the ~~boron~~ process for making borax, advantage is taken of the natural steam vents, which are led through tanks of water & condensed, thus both depositing their boric acid & heating the water. The solution after passing through a series of basins is led into a settling tank, it now contains only 1/2 per Cent of B. It is then led into evaporating pans also heated by steam, and in the last of these is so concentrated as to crystalise on cooling. The crystals are dried in a chamber heated by steam & packed. The acid is transformed into borax by adding sodic carbonate, about 1/2 ton of sodic carbonate is dissolved in water & an equivalent of boric acid added. A quantity of NH_4 is evolved which is

of machinery where ordinary substances not applicable. 2.5 Specif grav cryst in 6 sided plates belonging to rhombohedral may be burnt in O, like diamond. forming CO_2. In impure form used as a pigment. has been used for glazing gunpowder. ~~Charcoal~~ Graphite may be obtained artificially by dissolving C in cast Iron; which cryst out as graphite giving to grey cast-iron its colour. This process takes place in every iron furnace. In crevices where the iron cools slowly in beautiful masses, called cist by the workmen.

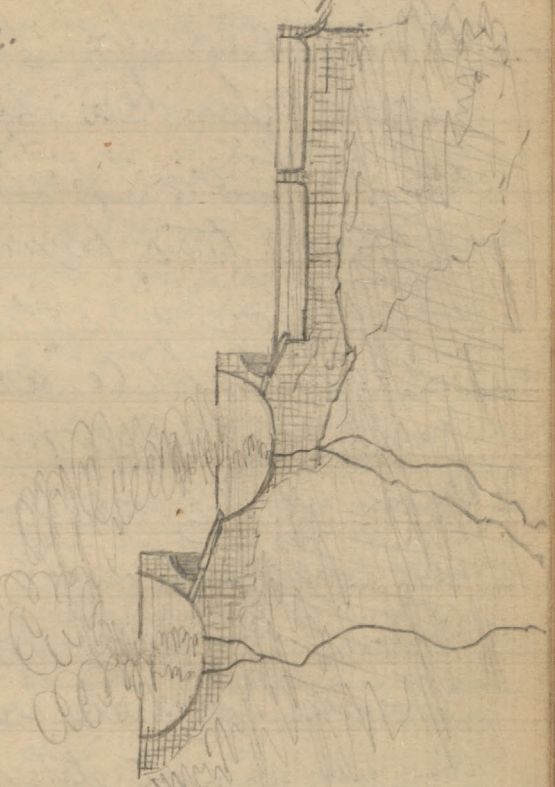
Charcoal. obtained indirectly from the atmosphere, through plant. Solar radiation used, stored up in carbon, set free by burning. Charcoal used almost universally to be prepared by building up & covering with

turf billets of wood
flue in middle H

passed through SO_2 H_2O & thus absorbed & preserved.

Composition of crude Boric acid.

Cryst boric acid	75·6
Calcic sulphate	1·0
Magnesic sulphate	2·0
Ammoniac sulphate	8·5
Sodic sulphate	1·0
Silica	1·2
Ferric sulphide, Alum, Ammoniac chloride, Water	9·2
	98·5



Borax is employed chiefly for glazing pottery & in soldering In soldering it is essential to the union of the two metals as an alloy, that the surfaces should be perfectly clean. Borax melts & protects it from air, & also has the power of dissolving any oxide previously present. The blowpipe reactions depend on this power of dissolving metallic oxides & forming salts with them.

Tuesday Nov 2nd

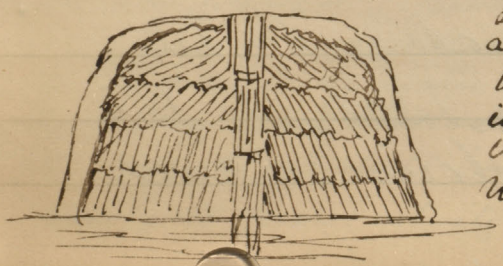
C is met with largely in nature but mostly in combination It occurs in the atmosphere & many waters. It is found pure as the diamond, graphite, & mineral charcoal. Diamond & charcoal can be converted into graphite. But the diamond has not yet been produced by artificial means. Diamonds come principally from India China & Brazil. They are found enveloped in an earthy crust; and are supposed to be

burns & heats ~~char~~ the wood. Mostly superceded by putting the wood in large iron cylinders heated from below, closed all but an aperture for vol products. Obtain two liquids wood tar sinks to the bottom of water & another containing a considerable ammount of acetic acid. temperature easily regulated. lower the temp more readily ignited gunpowder. High temp more charcoal. 13 to 26 per cent of charcoal obtained. Dog wood poplar willow best for gunpowder. Charcoal conducts heat very slowly. oxydisable in very minute state of division. not fusable. absorbs large quantities of gasses especially those sol in water. when recently ignited NH3 over Hg. Deoderises Sulph Hydrogen

and thus putrifying substances. probable that it is combined with condensed O in the pores. This action according to Dr Stenhouse one of surface attraction.

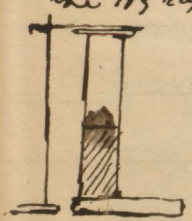
of vegetable origin. The specific gravity of diamond is 3·52 It crystallises in the octohedral system, is a non conductor of electricity, has a very high refractive power, & resists the action of acids, alkalies, & great heat, when out of contact with air. But in the intense heat of the voltaic arc it swells up & changes into graphite. Diamond will scarcely burn in air, as much of the heat given off is absorbed by the N of the air & also in converting the CO_2 into vapour that the temperature soon falls below the ignition point. If however the diamond is ignited in O it continues to burn. (best put in a little trough of Pt foil, and heated by a current of electricity.) Graphite chiefly found in metamorphic rocks. It was worked out in Borrodall, where the best lead for pencils was obtained but it is now worked out. Siberia now affords the chief supply of pure graphite, Graphite has a soapy feel & is used for lubricating machinery where the temperature is too high for oil &c. The specific gravity is 2·5. It crystalizes in six sided plates, belonging to the rhombohedral system. Graphite may also be burnt in O, & forms CO_2 like diamond. In the impure form it is used as a pigment, and has been used for glazing gunpowder. Graphite may be obtained artificially by dissolving charcoal in cast Iron; on cooling it crystalises out as graphite, & it is this which gives to grey cast iron its peculiar colour. This process takes place in every iron furnace, & in the cinders where the iron cools slowly it is sometimes found in beautiful masses. It is called kish by the workmen.

Charcoal is obtained indirectly from the atmosphere thro' the action of plants. The force of solar radiation is stored up in the formation of carbon & liberated again by burning. The old method of preparing charcoal, & one still often employed consists of making a pile of wood, & allowing the combustion to go on slowly under turf &c The heat is obtained mostly from the H contained in wood ($C_{12}H_{10}O_{10}$). This mode is much improved on by putting the wood



Other substances in very fine state possess the same property. Platinum sponge obtained by igniting Chloride of Pt and Am. Ignites H & ignites it by by bringing it so close to O that chemical union commences & makes great heat. Several varieties of Char met with in Commerce. Bone charcoal, from bones in Iron cylinders. Consists of C mixed with large quantity of Calcic phosphate & some Calcic Carbonate. Scarcely possesses any prop of absorbing nox gasses. Acts however on substances in sol in aq differs thus from Charc. 3/4 to 5/6 of organic matter removed by passage through fresh Bone black. when old ceases to act. Action of Common charc everlasting By heating to redness made good again. Takes when quite fresh nearly all the CO Ca from aq. Decolorises, used

in iron cylinders heated from below, & closed all but one aperture to let the volatile products escape. Two liquids distill off, Tar which sink to the bottom naptha & water. There is a considerable ammount of acetic acid. In this way the temperature is easily regulated. When the charcoal is made at low temperatures it ignites easily, & in this form is used for making gunpowder. At high temperatures more charcoal is obtained but it is harder to ignite. 15 to 26 percent of charcoal can be obtained from wood. Dog-wood, poplar, willow, & such woods are used for making charcoal for gunpowder. Charcoal is a bad conductor of heat. It is oxidisable in the air at ordinary temperatures when in a very minute state of division. It is infusable. Charcoal especially when made from hard wood absorbs large quantities of gas, especially those which are soluable in water. It exhibits this property best when recently ignited. (If a few pieces of charcoal be put up into NH_3 over Hg the Hg rapidly fills the vessel by the absorbtion of the gas). It possesses



the property of deodorising SH_2 & thus prevents effluvium & sweetens putrifying substances. It is possible that the SH_2 is combined with condensed O in the pores. The action according to Dr Stenhouse is one of surface attraction. Other substances in a very fine state of division possess the same property. Platinum sponge, which is obtained by igniting the Chloride of platinum & ammonium; ignites a current of NH_3 bringing it so close to O contained in its pores as to cause combination which causes sufficient heat for the ignition of the current of H. Several varieties of Charcoal are met with in commerce Bone charcoal is obtained from bones heated in iron cylinders It consists of C mixed with a large quantity of calcic phosphate & some calcic carbonate. It scarcely possesses any property of absorbing gases. It acts powerfully however on substances in solution in water. 3/4 to 5/6 of the organic matter present in water is removed by passing it through a layer of Bone charcoal. After having been used some time it ceases to act, but by heating to redness can be restored to nearly its former activity. Common charcoal seems to keep its

especially in manufacture of sugar.
Whether it acts in the supposed manner of wood charc generally supposed to be oxydised in fuse in same manner.

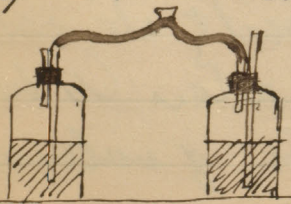
	On Carbon	On ash
Blood charred with potassic carbonate	5·0	20
" " " Chalk	18	"
" " " Calcic phosphate	12	10
Glue " " Potassic carbonate	36	15·5
	34	13·5
Whalebone " " "	4	3·3
Lamp Black " " "	15·2	10·6
" " with potassic carbonate	2·1	1·9
Oil charred with calcic phosphate		
Bone charcoal	1	1

Not all are inherent in animal charcoal. Ash in wood charc fuses & coats over charcoal, supposed. If provision be made for removing this siliceous ash, by potassic or sodic carbonate, & washing the charc then becomes endowed with most of decolorisation. Bone charc only one obtainable in physical condition suitable for sugar refiner. C occasional dyad & tetrad. Dyad $C^{II}O$. Tetrad $C^{IV}H_4$ marsh gas.
Carbonic anhydride only obtainable from the air by indirect processes. Lime water. Mortar absorbs CO_2 & changes into CO_3Ca 4/10000 of its volume of CO_2 in air.

property of absorbing gasses unchanged. Bone charcoal takes when quite fresh nearly all the CO Caö from water but soon looses this property. It decolorises, & is used for purifying sugars & syrups. Whether it acts in the same way as wood charcoal does with gasses is not known. The decolorising power is not alone inherent in animal charcoal. The ash in wood charcoal fuses & coats over the charcoal (supposed) If provision be made for removing this siliceous ash by potassic or sodic carbonate which is afterwards dissolved away, the charcoal becomes possessed of the power of decolorising. Bone charcoal is however the only one yet obtainable in a physical condition suitable for the sugar refines use. Carbon is both Dyad & Tetrad, as in $C''O$ & $C^{IV}H_4$ (marsh gas).

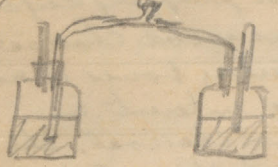
Decolorising power of various animal charcoals	On indigo	on syrup
Blood charred with potassic carbonate	60	20
" " " Chalk	18	11
" " " Calcic phosphate	12	10
Glue " " potassic carbonate	36	15.5
White of egg " " " "	34	15.5
Lamp black	4	3.3
" " With potassic carbonate	15.2	10.6
Oil charred with calcic phosphate	2.1	1.9
Bone charcoal	1	1

Carbonic anhydride, is only obtainable from the air by indirect processes. Lime water absorbs it and changes into calcic carbonate. Mortar gradually absorbs CO_2 & changes into CO Caö. The atmosphere contains 4 volumes of CO_2 in 10,000. This is produced by the processes of combustion, respiration, fermentation putrifaction, & is also evolved in large quantities as a product of volcanic action.



apparatus for proving the presence of CO_2 in respired air.

Produced by combustion respiration putrifaction, volcanoes &c



Boxwood Charcoal at 12° & 722 mm

	absorbs of
ammonia	90
HCl	85
O	9.25
H	1.25
N	6.5
CO	9.42
CO_2	35
with H	5.5

Chiefly met with as calcic & magnesic Carbonate but derived from white marble, by action of $SO_2 HO_2$ or HCl

$CO\,CaO'' + 2\,HCl = CO_2 + OH_2 + Ca\,Cl_2$

2 volume of water dissolves 1 vol of CO_2 this is good for all pressures under two atmosphere twice as much, & so on. On CO_2 depend the power of effervescing drinks. Soda water ~~&c~~ under pressure of 2 3 or 4 ~~or~~ atmospheres. About 1/2 as much more than air Sp gravity 1.525. Pungent sour acid taste.

CO_2 contains exactly its own volume of O when C burnt no diminution of volume

Wednesday Oct 3rd

CO_2 is chiefly met with in nature as calcic & magnesic carbonates ($COCaO''$. $COMgO''$) It is best obtained from marble by dlute HCl, or SO_2HO_2.

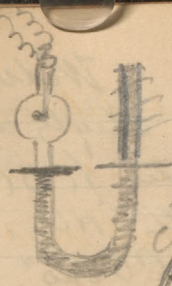
$$COCaO'' + 2HCl = CO_2 + OH_2 + CaCl.$$

One volume of water absorbs one volume of CO_2 at all pressures. The solvent power of the water increasing exactly in proportion to the condensation of the CO_2. On this depends the property of effervescent drinks, water impregnated with CO_2 under 2 3 or 4 atmospheres, & quickly bottled. The specific gravity of CO_2 is compared to 1.525. It has a pungent odour & acid taste. It contains exactly its own volume of O, thus when CO_2 is burnt there is no diminution of volume; & no increase of volume takes place when C is absorbed by O. I shown by burning C in O contained in a bent tube open at one & closed at the other end. A bulb on the closed end in which the C is ignited by an electric current. The height of the Hg remains the same after as before the experiment. The weight of a litre of CO_2 is 22 thus

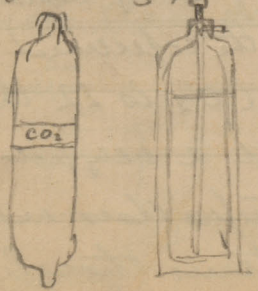
$$\begin{array}{r} O_2 = 32 \\ C = 12 \\ \hline 2 \,|\, 44 \\ 22 \end{array}$$

CO_2 is not a very powerful acid & therefore does not redden litmus strongly

$O_2 = 32$
$C = 12$
$2 \overline{)44}$
22 weight of a litre of CO_2


absorbtion of the C by the O without change of bulk

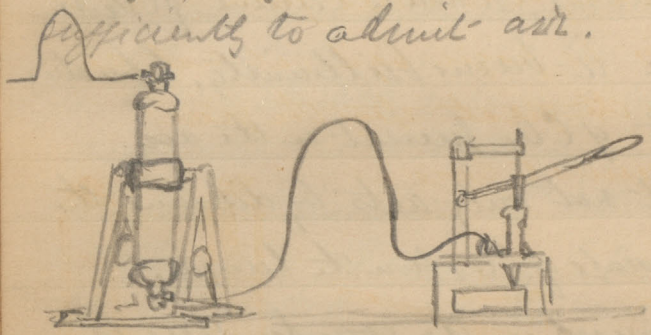
Change of colour in Alkanet rot more easily visable than that of litmus which is but very slightly coloured by CO_2. Certain substances are capable of burning in CO_2 & can withdraw its O & seperating its carbon. K & Na. K put in a tube & a stream of CO_2 passed through & then the K heated past its melting point it takes fire & burns brilliantly. 10 per cent of CO_2 rapidly destroys life. CO_2 in the atmosphere .1 in London. Only near the mound & decomposing action of plant where this small ammount is found increases as you ascend. / seems to depend on the percentage of CO_2 compared with O in air if O be proportionately increased no ill effects. Liquifiable. has its solidifying point above its boiling point. Sodic dicarbonate & dilute SO_4H_2

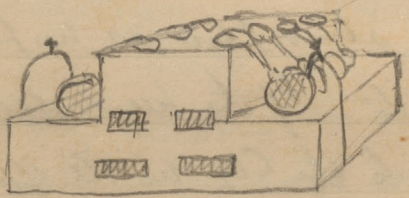


Liquified exerts a pressure of 30 atmospheres at 0° 60 atmos at the ordinary temps.
temp of solid CO_2 -77° Cent.
Ether added -120°

Certain substances are capable of burning in CO_2, those which have a very strong affinity for O as Na & K. If K be put in a bulb blown in a tube & heated beyond its fusing point by a flame, while a current of CO_2 is passed through the tube it burns brilliantly, liberating free carbon. 10 per cent of CO_2 present in the air rapidly destroys life. It not only acts by diluting the O but prevents the free escape of CO_2 from the lungs. Near the surface of the ground in the country there is .04 of CO_2 in London .1. The proportion of CO_2 increases as you ascend higher in the atmosphere as no plants are there present to decompose it. If the per-centage of O be increased in proportion to the CO_2 no ill effects are perceivable. It can be liquified & solidified. The apparatus employed for this purpose must be very strong as it exerts a pressure of more than thirty atmospheres at 0° Cent & 60 at ordinary temperatures. The temperature of solid CO_2 is −77° Cent & of the solid when mixed with ether −120° Cent. Mercury can easily be frozen by CO_2 & ether, and often in that state may be beaten out by hammering. If a piece of frozen Hg

property of extinguishing fire used technically.
In extinguishing fires in coal mines &c
In — coal mine fire extinguished in 8 weeks
& by spray of CO_2 cooled down in three weeks more sufficiently to admit air.



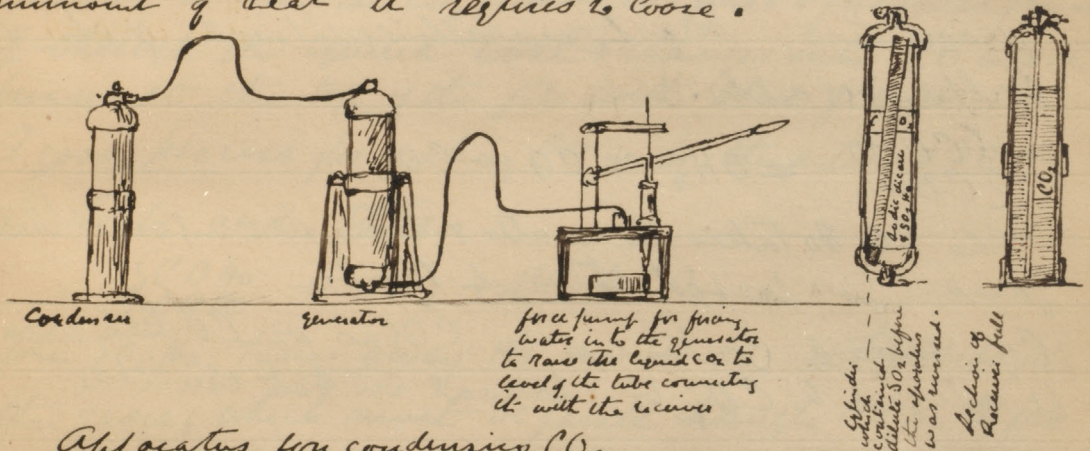


apparatus for producing NO_2 HO_2

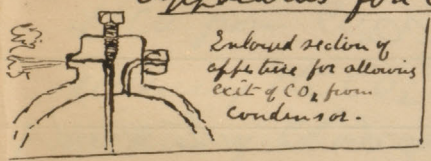
1500
900
3

CO formed with when substances burnt when supply of O limited. Coal gas contains from 5 to 6 percent of CO. Also formed in destructive distillation of wood. When CO_2 in contact

be put in a wire cage suspended in water, it rapidly melts and falls to the bottom, and icicles are found attached to the wire. If solid CO_2 be put into a retort a large quantity of CO_2 may be collected from it as it vaporises. Water may also be frozen by it but not so easily as Hg on account of ~~its great specific~~ the great amount of heat it requires to vaporise.



Apparatus for condensing CO_2



Sodic dicarbonate & Sulphuric acid are used for the production of CO_2 in the solid state in an apparatus represented above.

Thursday Nov 4th.

CO is formed when carbon & substances containing carbon, are burnt where the supply of O is limited.

Coal gas usually contains more than five per cent of CO. It is also formed in the destructive distillation of wood. When CO_2 is heated in contact with

with Graitic carbon. CO_2 being first formed passes through the upper part of the fire changes to CO & burns on top.

$$CO_2 + C = 2CO$$

CO_2 passed through a red hot tube full of charcoal gives CO with CO_2 but good for making large quantities. Most generally employed oxalic & sulphuric acids.

$$\left.\begin{matrix}COHo \\ COHo\end{matrix}\right\} = OH_2 + CO + CO_2$$

The SO_2Ho takes the water & thus decomposes the gases. Gas passed through NaHo

CO_2 ~~reduced~~ contained in $COCaO_2$ or CO BaO may be reduced to CO by charcoal in hot crucible

$$4CO_2 + Fe_3 = {}^{IV}(Fe_3)^{VIII}O_4 + 4CO.$$

From formic acid with SO_2Ho

Potassic ferrocyanide with 4 times its weight in a very large flask. This plan of Fownes probably the best way.

$$Fe''C_6N_6K_4 + 6\underset{\text{present in materials.}}{OH_2} + 6\,SO_2Ho_2 = 6CO +$$

$$2\,SO_2Ko_2 + SO_2Fe'' + 3\,SO_2(NH_4O)_2$$

ignited Carbon (Charcoal) the CO_2 dissolves another atom of C & then becomes CO. If & through a tube heated to bright redness, & containing fragments of Charcoal CO_2 be passed, it may be lit at the other end, as CO & by burning is reconverted into CO_2, thus

$$CO_2 + C = 2CO \qquad 2CO + 2O = 2CO_2$$

Thus it is that the CO_2 formed in fires & furnaces passing up through the ignited coal & changes into CO which burns at the top of the fire with blue flame.

A good process for making CO is by the action of SO_2Ho_2 on Oxalic acid, thus

$$\left.\begin{matrix} CO\,Ho \\ CO\,Ho \end{matrix}\right\} = OH_2 + CO + CO_2$$

The SO_2Ho_2 takes away H_2 & O as OH_2 & thus sets free the gases; which must be passed through NaHo to free the CO from CO_2. CO may also be obtained by reducing the CO_2 contained in $CO\,Ca''$ or $CO\,Ba''$ by means of Charcoal in hot crucibles. thus

~~$+ CO_2$~~ $+ CO\,Ca'' + C = CaO + 2CO$

Also by passing CO_2 over red hot iron.

$$4CO_2 + Fe_3 = {}^{IV}(Fe_3)^{VIII}O_4 + 4CO.$$

Perhaps one of the best ways is that discovered by by Fownes in which potassic ferrocyanide is

Colourless transparent. Specif gravity the same as N. 9? Incondensable slightly lighter than air. Neutral. Explainable & non supporter of combustion. Burns with blue flame

$$CO + O = CO_2$$

Does not effect lime water. Absorbed by cuprous chloride used quantatively. Far more deleterious to animal life than CO_2. 29 g CO_2 ——— probably more than CO_2 CO det in smothering by burning charcoal. Unites with chlorine which on account of light being necessary for its production is called phosgene gas ($COCl_2$)

Pentad element Nitrogen

Chiefly in atmospheric air, and mostly free. Combined in animal & vegetable substances in alkaloids. Debited in tubular. Obtained by abstracting O from air. P continues its combustion till every trace of O removed. Phosphoric anhydride dissolves in the water.

Many metallic elements also suitable as Cu in fine condition. Heated to redness & air passed over it. O absorbed. Also by

decomposed by nine times its weight of SO_2Ho_2 in a nearly large flask.

$$Fe''C_6N_6K_4 + 6OH_2 + 6SO_2Ho_2 = 6CO + 2SO_2Ko_2$$
(present in materials)
$$+ SO_2Fe'' + 3SO_2(NH_4O)_2.$$

CO is a colourless transparent gas. Its specific gravity is the same as that of N .9713. It cannot be liquified. is slightly ~~heavier~~ lighter than air. Inflamable & a non supporter of combustion. It burns with a characteristic blue flame. It does not render lime water turbid. It is absorbed by cuprous chloride, which is used quantitatively in determining the volume of CO in mixed gases. It is far more detetterious to animal life than CO_2 & it is probably mostly owing to its effects when deaths are caused by burning charcoal in confined rooms as when mixed largely with CO_2 it escapes combustion. It unites to form $COCl_2$ with Cl. This compound is a gas, & on account of light being necessary for its production has been called Phosgene gas.

Nitrogen N° 14

Nitrogen mostly pre, in nature, & chiefly in the atmosphere. It is found combined in animal & vegetable substances, notably in the alkaloids. Its presence has been detected in the Nebulae & it probably exists in the fixed stars. It is most conveniently obtained by abstracting O from air. Most substances will not

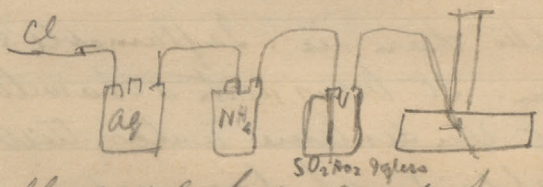
boiling ammonic nitrite, when it decomposes

$N''O(N^{v}H_2O) = N_2 + 2OH_2$

Sodic nitrite & ammonic chloride = N

$NH_4Cl + NONao = NaCl + N_2 + 2OH_2$

By decomposing NH_4Ho with chlorine.



if allowed to go on when excess of ammonia gone. Ammonic chloride produced. most dangerous

Colourless transparent odourless .9713 Spec grav 100 vols of ag only absorbe 1½ of N Thus water contains more O than air.

Incombustable, cannot support combustion under ordinary circumstances. Combustable in O when raised to ignition point which is very high can be raised to it by electric spark. Electric spark passed in air. Rate of production of comps of O & N greatly increased in compressed air Does not fortunately combine with explosive limit produced not sufficient to raise

been long enough to do this thoroughly but go out when the O becomes very dilute. P however continues its combustion till every trace of O has been consumed. The compound produced (Phosphoric anhydride) also dissolves very readily in water. Many metallic elements may also be used for abstracting O, thus if Cu in fine state of division be heated to redness & air passed over it only N is evolved. Also by heating ammonic nitrite when it decomposes. thus

$$N^{III}O(N^{V}H_2O) = N_2 + 2OH_2$$

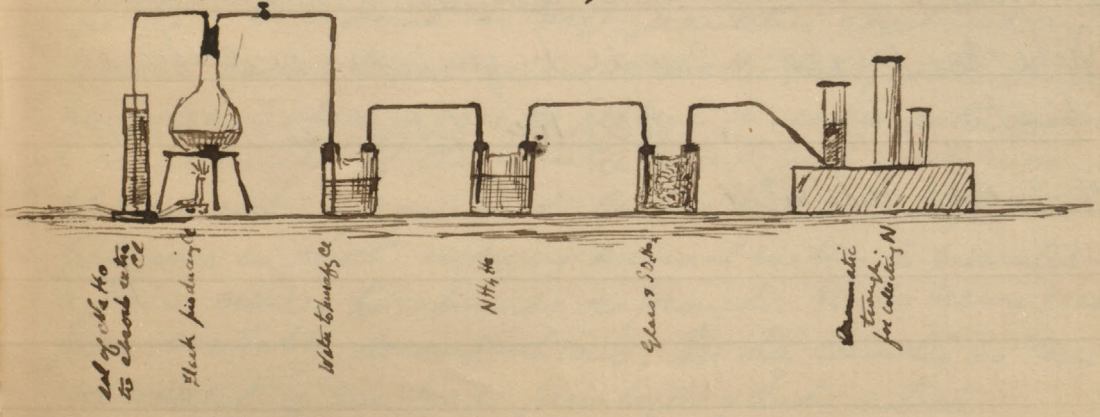
or ammoniac ~~chloride~~ nitrate with sodic & potassic nitrate

$$NH_4Cl + NONaO = NaCl + N_2 + 2OH_2$$

N may also be obtained by decomposing NH_3 Ho with Cl.

$$8NH_3 + 3Cl_2 = 6NH_4Cl + N_2$$

The process must not be carried too far as when the ammonia is all decomposed, ammonic nitrite begins to be produced; it is the most dangerous explosive substance known: the apparatus used is as below.



Surrounding N to combustion point
N neutral. Titanium Tantalum & Tungsten
burn in current of N. Extensive series of Comps
with O & Ho. Most important NO_2Ho. Pere
pented. Found in large quantities in nature
when animal organic matter perhaps NO_2Ho produced
when a base present it combines. When manure
spread on ground drainage gives nitrates.
N Leaves oxidising animal matter in presence
of base nitric comps found. Never from
vegetable decomps. Excrement of sea birds
form layers of sodic nitrate. Drainage of indian
villages. Nitre in french walls. obtained by
lixiviation of mortar of old walls in good districts
of Paris. Russia Denmark Norway & Sweden
nitre tax levied. made by farmers in nitre
beds — — —. NO_2Ho prod from Potassic
& sodic nitrates

N is colourless, odourless & transparent. Its specific gravity is .9713. 100 volumes of water only absorb 1½ of N & thus it is that the gases dissolved in water contain more O in proportion & less N than air. N is incombustible & cannot under ordinary circumstances support combustion. It is combustable however in O when raised to its igniting point which is very high. It cannot be raised sufficiently by any ordinary flame, but by the electric spark it can be made to enter into combination & compounds of O & N are produced. The rate of production increases very much when if the gases or air be condensed. NO do not fortunately even under these circumstances combine with explosion, which is fortunate as otherwise by a flash of lightning the whole atmosphere would be liable to explode. The temperature generated by the combustion of a part is not sufficient to raise the surrounding portions to the ignition point.

Titanium Tantalum & Tungsten burn in a current of N. & N forms an extensive series of compounds with O & H. The most important of these is NO_2Ho. N is here dental. It is found in large quantities combined with various bases. When animal matter putrifies NO_2Ho is produced, & when a base is present it enters into combination & is preserved. If the drainage from a field where manure is spread out, is examined Nitric acid will be found. Wherever in short oxidising animal matter is presented with a base nitric compounds are formed. NO_2Ho never results from vegetable decompositions. In dry climates as Peru the excrement of sea birds forms layers of Sodic nitrate

Monday Nov 8th.

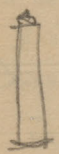
Comps of N & O formed by putrefaction of animal matters. NO_2Ho prep from nat nitrate Na or K, Na cheapest. carried on in series of retorts by the action of SO_2, Na nitrate with = weight gives colourless prod of NO_2Ho with half its weight redist prod of

$$2NO_2Ko + SO_2Ho_2 = \underset{\text{hydric potassic sulph}}{SO_2HoKo} + NO_2Ho$$

In commercial manufacture 2nd process used though some lost, more economical.

1 mol of NO_2Ho consists of a 1/2 mol of Nitroxyl or nitric peroxide with 1/2 mol of Hydroxil

May be proved by actual experimental synthesis



colourless limpid fuming, & powerfully corosive. Specif grav of pure 1.52 never rises to this in commerce. freezes at −40°

Oxydises almost all metals (except gold Pt &) and they combine with the undecomp NO_2Ho nitrates decomp into Oxides by red heat. NO_2Ho combines Molecularly ~~with~~ or perhaps

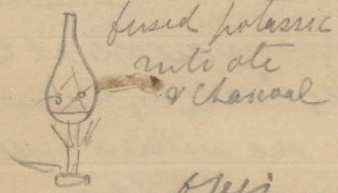
The natives in India also collect it in the vicinity of their villages. The drainage of which spreading out on the hot ground putrefies, & after rain sodic nitrate efflorescs out. It was collected from the mortar at the bases of old walls in Paris, during some of the French wars, where it was produced in somewhat the same way. When the NO_2Ho is combined with Ca it is replaced by K. In Russia, Denmark Norway & Sweden a nitre tax is levied farmers are obliged to make a certain quantity annually. They do so by means of heaps of manure &c, & lime, these are watered with urine and after some months a considerable quantity of nitrate of lime is obtained, which is changed to nitre by displacement of the Ca by K.

Monday Novr 8th

Compounds of N & O are formed by the putrefaction of animal matters. NO_2Ho is prepared from its natural compounds with K or Na. (NO_2Ko, NO_2Nao) NO_2Nao is the cheapest, and so is generally used for this purpose. The NO_2Ho is liberated by the action of SO_2HO_2. Equal weights of NO_2Nao & SO_2Ho_2 give the largest quantity of acid, and also give it without colour. NO_2Nao with half its weight of SO_2Ho_2 gives a reddish acid, from the decomposition of part of the nitric acid. But on account of the saving of SO_2Ho_2 is the process usually employed.

$$2NO_2Ko + SO_2Ho_2 = \underset{\text{hydric potassic sulphate.}}{SO_2HoKo} + No_2Ho$$

chemically, with water in three props
Only NO_2Ho has been satisfactorily isolated
NO_2Ho mono NO_2Ho_3 dibasic NO_2Ho_5 - tribasic
Nitrates all readily sol in aq, & yield O
readily to combustables. NO_2Ho liable to
contain HCl & SO_2Ho_2



Chloride of Na in native salt.
Small quant of SO_2Ho_2 distills
over. Detected by Baric chloride & Ag nitrate
If the NO_2Ho be distilled & the 1st part distilled
over thrown away (HCl) & the rest distilled
at a low temp, & not all distilled over (SO_2Ho_2)
strength by hygrometer. Employed as solvent for
the metals, etching on copper, also largely for
nitro-benzol manufacture from coal tar
necessary in making analine colours, also
for gun cotton, much largest part of
NO_2Ho employed in last 2. 3 vols of HCl
& 1 of NO_2Ho gives Aqua regia. gentle
heat applied copious gas evolved nitrous
oxy chloride, ~~Chlorinitric gas~~ N triad. $O=N-Cl$

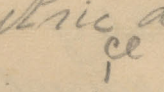
$$NO_2Ho + 3HCl = NOCl + 2OH_2 + Cl_2$$

One molecule of NO_2Ho consists of 1/2 molecule of Hydroxil combined with 1/2 molecule of nitroxyl or nitric peroxide. This may be proved by actual experimental synthesis (If vapour of $\left\{\begin{matrix}NO_2\\NO_2\end{matrix}\right.$ be agitated with $\left\{\begin{matrix}OH\\OH\end{matrix}\right.$ nitric acid results) $\left\{\begin{matrix}NO_2\\NO_2\end{matrix}\right. + \left\{\begin{matrix}OH\\OH\end{matrix}\right. = 2\ NO_2Ho$. Nitric acid is colourless, limpid, fuming & powerfully corrosive. The specif grav of the pure acid is 1·52 but it never rises so high as this in commercial samples. It freezes at -40° It oxidises all metals (except a few, as Pt Au &c) & when oxidised they combine with the undecomposed NO_2Ho and form nitrates. These are again decomposed into oxides at a red heat. NO_2Ho combines molecularly or perhaps chemically, with water, in three proportions.

NO_2Ho monobasic NO_2Ho_3 dibasic & NO_2Ho_5 tribasic. Of these hypothetical acids known only by their compounds only NO_2Ho has been isolated & satisfactorily. All nitrates are readily soluable in water & yield O easily to combustables.

NO_2Ho is liable to contain as impurities traces of SO_2Ho_2 & HCl the first derived from splashing in the retort during manufacture or the distillation of minute quantities over with the NO_2Ho. The second from the action of the SO_2Ho_2 on Sodic Chloride always present in the NO_2Nao. They may be detected by diluting the acid & testing with Basic Chloride & Argentic Nitrate. The NO_2Ho may be purified by distilling at a low Temperature & rejecting the first & last products of the distillation.

Nitric dioxy ~~nitric~~ tetrachloride, Chloronitrogen



forms mol y monad radicals
deep lemon coloured gas
condensable to red liquid

$2NO_2Ho + 6HCl = N_2^{IV}O_2Cl_4 + 4OH_2 + Cl$

most Cl acts per se these reactions attacks the gold.
Nascent H. $NO_2Ho + H$ no action + nascent H converts into ammonia. Nitric anhydride obtained by passing dry Cl at 90° passed over argentic nitrate. when process begins temp lowered to 60°

$4NO_2Ag_2O + 2Cl_2 = 4AgCl + 2N_2O_5 + O_2$

with water $N_2O_5 + OH_2 = 2NO_2Ho$

Nitrous anhydride by starch & nitric acid liquifiable. blue liquid red vapour. N_2O_3

$8NO_2Ho + 2Ag_2 = 4NO_2Ag + N_2O_3 + 3OH_2$

$NOHo$ Nitrous acid both oxydising & reducing agent, can yield O to bodies having strong affinity, take it from those having weak.

$NOHo + O = NO_2Ho$ thus bleaches potass. permang

Sodic nitrite + Indigo in SO_2Ho_2 liberates nitrous acid which yields ~~nitric~~ O & oxydises Indigo

The strength of NO_2Ho is like other acids determined by the hygrometer, a table constructed for the purpose. In the arts it is employed as a solvent for the metals, for etching on copper, & also largely in the manufacture of nitro-benzol from coal tar, for analine colours, & in the production of gun cotton.

Aqua Regia. is composed of 3 volumes of HCl & one of NO_2Ho If a gentle heat is applied to the mixture a copious evolution of gas takes place. This consists principally of Chloronitrous gas or Nitrous oxychloride ($NOCl$) Chloronitric gas or nitric deuto-tetrachloride ($N_2^{IV}O_2Cl_4$). & free Cl.

$$NO_2Ho + 3HCl = NOCl + 2OH_2 + Cl_2 \qquad O=N-Cl$$

$$2NO_2Ho + 6HCl = N_2^{IV}O_2Cl_4 + 4OH_2 + Cl_2 \qquad O=\overset{Cl}{\underset{Cl}{N}}-\overset{Cl}{\underset{Cl}{N}}=O$$

The last forms a molecule of a monad compound radicle. It is a deep lemon coloured gas condensable into a red liquid. It is the nascent Cl which is set free in these reactions which attacks the gold. The power of combination in the nascent state is very curious, thus; NO_2Ho with ordinary H results in no action, but with nascent H is converted into Ammonia.

Nitric anhydride is obtained by passing a current of dry Cl over dry NO_2Ago at 90° (when the process commences the temperature should be lowered to 60°)

$$4NO_2Ago + 2Cl_2 = 4AgCl + 2N_2O_5 + O_2$$

By the action of water N_2O_5 is converted into NO_2Ho.

$$N_2O_5 + OH_2 = 2NO_2Ho.$$

Nitrous anhydride. Is obtained from NO_2Ho by heating it with starch, or arsenious acid; or by the action of NO_2Ho on Ag

also liberates O & liberats I from K iodide ~~absent~~ immediately, most delicate test for nitrites when with nitrates. Starch & drop of $SO_2 Ho_2$.

Nitric peroxide. Having no H cannot be an acid. brown red liquid, red vapours like that of nitrous anhydride. best prep by action of NO_2Ho on As

$$As_2 + 20\,NO_2Ho = As_2O_2\,Ho_{10} + 5\cdot OH_2 + 10\,'N_2''O_2$$

Nitric oxide

$$3Cu + 8\,NO_2Ho = 3\left\{\begin{matrix}NO_2\\ Cu\\ NO_2\end{matrix}\right\}'' + 'N_2''O_2 + 4OH_2$$

Gaseous volume O_2, composition anomalous If we take NO as comp of mol breaks through the rule of Perissads being always perissads This lights by $\left\{\begin{matrix}NO\\ NO\end{matrix}\right.$ but this breaks through the rule of vols being the same always. Gives vol twice as great as other comps. Colourless transparent invisible gas. transforms into nitric peroxide nitrous anhydride. & c Specy grav very slightly greater than air uncondensable. Only dissolves its red fumes with O. behaves remarkably to combustion

$$6NO_2Ho + 2As_2 = 4NO_2 As_2O + N_2O_3 + 3OH_2$$

$$\underset{\text{arsenious acid}}{As_2O_3} + 2NO_2Ho = \underset{\text{arsenic acid.}}{As_2O_5} + N_2O_3 + OH_2$$

N_2O_3 is liquifiable. The liquid is greenish-blue, and has a red vapour.

Nitrous acid ($NOHo$) acts both as an oxidising and reducing agent. It can yield O to bodies having a strong affinity for it, or take it away from those which have not a strong affinity for it. It bleaches potassic permanganate by abstraction of O, thus; $NOHo + O = NO_2Ho$. It yields O and bleaches a solution of indigo in SO_2Ho_2 by oxidising it. It acts by liberating O displaces I from KI, immediately. This is the most delicate test for nitrites when with Nitrates. If starch + a drop of SO_2Ho_2 be added to the solution, & then a drop of KI. Blue colouration immediately takes place if nitrites are present

Nitric peroxide, $\left(\begin{matrix}NO_2\\NO_2\end{matrix}\right)$ having no H cannot be an acid It is best prepared from NO_2Ho & Sn.

$$Sn_5 + 20NO_2Ho = Sn_5O_5Ho_{10} + 5OH_2 + 10\,'N_2^{IV}O_4$$

It is a brown-red liquid with a red vapour like that of Nitrous anhydride.

Nitric oxide, prepared by the action of NO_2Ho on Copper.

$$3Cu + 8NO_2Ho = 3\left\{\begin{matrix}NO_2\\Cu\\NO_2\end{matrix}\right. + {}'N_2''O_2 + 4OH_2$$

Either the gaseous volume or, the composition of this gas is anomalous. If we take NO as the composition of the molecule it breaks through the rule which requires densities to be always fractions. If we take $\left\{\begin{matrix}NO\\NO\end{matrix}\right.$ to make this right, it makes the combining volume twice too much.

It is a colourless, transparent, invisable, gas. It changes into nitric peroxide, nitrous anhydride &c on contact with

incombustable, but supports combustion of substances with high temp of combust as P by being decomposed into N & O. CS_2 gives sufficient heat, and burns with one of the brightest lights we know, rich in actinic rays. Agitated in jar with nitric oxide vapours explode on lighting & give the light.

Tuesday 9th ~~Oct~~.

Nitrous oxide ON_2 absorbed by water unless warm about 2/3 its vol. At 40 Far 5-0 atmospheres condenses into clear liquid, like CO_2 its freezing above its boiling point. If however under pressure, boiling point may be raised above its freezing. Must be pumped into a strong reciever. Under such high pressure Oxydisis so highly as to burn the Fe of apparatus & greatest cold known -140° Cent prod by dissolving solid nitrous oxide in CS_2? Laughing gas substances which give heat enough decomp the gas burn in mixed gasses. P. S. & ordinary taper

ric or O, with copious evolution of red fumes. Its specific gravity is slightly greater than that of air. It has not been condensed. Its red fumes with O are very characteristic. It behaves remarkably toward combustables. It is itself incombustable, but supports the combustion of substances which evolve a great heat in the act of combustion, (as P) by being decomposed into N_2O. If a jar of N_2O_2 be filled with vapours of CS_2 by agitating a small quantity of that substance in it. When let the combined gases deflagrate, with the production of the brightest known artificial light. It is especially rich in actinic rays. The gases may be burned slowly by surrounding a jet emitting N_2O_2 by a cup containing burning CS_2

Thursday Nov. 9th 1869

Nitrous oxide, or laughing gas (ON_2) is prepared by the action of dilute NO_2Ho on Zn, or by heating ammonia nitrate

$$NO_2(N^{V}H_4O) = 2OH_2 + ON_2$$

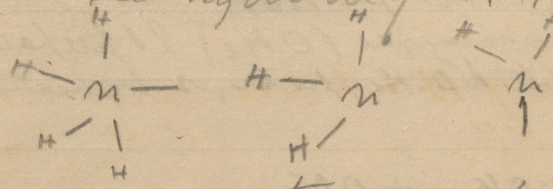
Cold water absorbs about 1/3 of its volume of this gas so that it is necessary to collect it over warm water. At 40° Far & 50 atmospheres it condenses into a clear liquid, which like liquid CO_2 has its freezing above its boiling point. If however under pressure its boiling point may be raised, till above its freezing (in the same way that the boiling point of water rises by increase of ~~temperature~~ pressure) To be condensed it must be pumped into a strong receiver. The operation is dangerous, as when so compressed its oxidising

Optic nerve cannot dist between very bright 1 & 100 often offers =. Test no red fumes when mixed with —)

Nitrogen & H.

$(N^{v}H_4)_2$ NH_3 $(N^{m}H_2)_2$

1st ammonium comp rad not known monad isolated. 3rd also hypothetical rad Amidogen. Comp monad rad, or perhaps in some comps triad rad. Ammonia may be the hydride of NH_2



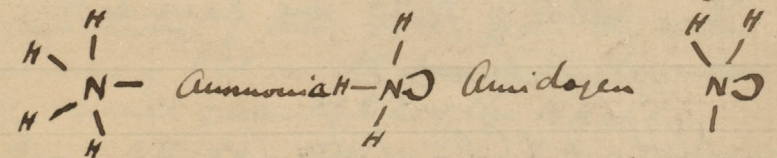
Animals transform food into urea, with putrid substances transformed into Ammonic carb. Sewage of London rich in CO amo. putrefaction of animal matters. NH_3 in air Destruct distillation of nitrogenised organic substances. NH_3 Gas making. ammonic ammoniacal liquor carb & chloride, from bones in bone chaic Also from destruct dist of wood.

power is so great that it often attacks the oil used in lubricating the apparatus, & after having consumed it attacks the iron which burns readily in it & so may cause the apparatus to explode. The greatest cold known is produced by dissolving solid N_2O in CS_2 by this means a temperature of $-140°$ Cent has been produced. P, S, & other substances which generate heat enough to decompose the gas burn in the mixture of N_2 & O which is produced. An ordinary taper does not produce a sufficiently high temperature & so almost immediately is put out. The optic nerve cannot distinguish between the degrees of light when it is very bright so much so that 1 often appears equal to 100 degrees of brightness, & the lime light appears to equal the electric. No red fumes are produced when ON_2 is mixed with O

Three Compounds of N & H are usually distinguished

$(NH_4)_2$ Ammonium. NH_3 ammonia $(N'''H_2)_2$ Amidogen.

Ammonium is a monad compound radical, which has not been isolated. Amidogen is also a hypothetical monad radical, or perhaps in some compounds a triad. Ammonia may be considered as the hydride of amidogen.



The sources of Ammonia are the decomposition of animal & vegetable nitrogenised substances, & animal excreta. Animals transform food into urea, by

Camels dung burnt & Cl_2Am &c. Gas & bone liquors give greatest supply. Slaked lime added boiled & NH_3 given off. passed into SO_2H_2 or HCl (concentrated) crystals deposit on cooling. Most commonly prepared ammonic chloride.

Crude crystals placed in a hemispherical vessel & volatalised. Small quant of ferric chloride from excess HCl or decomp of small quant's of Cl_2Am. NH_3 obtained by action of lime.

$$NH_4Cl + CaO = CaCl_2 + 2NH_3 + OH_2$$

NH_3 must be dissolved over Hg. Much lighter than air specif grav 5.779, 3 vols of H & 1 of N condensed to 2 vols. Will not combine directly. But when decomp occupies double original vol. Water absorbs 780 times its vol. In salts of NH_3 we have either ammonium or ammonoxyl.

$$NH_3 + HCl = NH_4Cl$$

$$N'''H_3 + N^{v}O_2H_0 = N^{v}O_2(N^{v}H_4O)$$

contact with putrid substances in the urine, this is very soon changed into Ammonic carbonate. The sewers of London when tested at the outlet of the sewers is found, even in the short time occupied in its passage, to contain large quantities of CO_2 Amo. The commercial source of Ammonia is the destructive distillation of animal and vegetable nitrogenised substances. Especially coal & bones, the coal being subjected to distillation in the production of gas & the bones for animal charcoal. The ammoniacal liquor from gas works contains the ammonia as carbonate & chloride. The ammoniacal liquors from gas & bones, are first treated with slaked lime, then boiled, when NH_3 is given off. This is passed into $SO_2 HO_2$ or HCl (concentrated) & forms compound with them. HCl is generally used. The solutions become so concentrated that crystals of NH_4Cl deposit on cooling. These are purified by putting them in a hemispherical vessel, which is covered with another of like shape. Heat is applied to the lower, & the NH_4Cl is sublimed pure into the upper hemisphere.

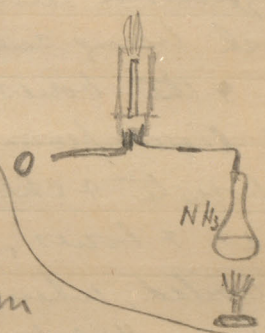
The salt is usually contaminated by small quantities of ~~HH~~ $Fe Cl_3$ from the action of excess of HCl on the iron, & the decomposition of small quantities of the NH_4Cl.

From NH_4Cl NH_3 may of course be obtained by the action of CaO. $2NH_4Cl + CaO = CaCl_2 + 2NH_3 + 2H_2$

NH_3 must be collected over mercury as it is soluble in water. It is not much more than 1/2 as heavy as air

Condenses into liquid at 6 atmos.
Cooling on evap of NH_4Ho used for cooling
freezing. French process of freezing water.
In ether process 1 of coal 2 of ice
By NH_4Ho process 1 from 8 to 10 of ice.
Slightly inflam. does not support combust
burns in O

$$NH_3 + {}_3O = NO_2Ho$$



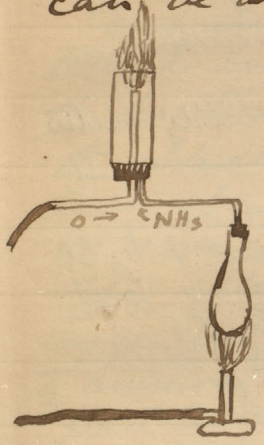
NH_4 ~~Ho~~ amalgum of & Hg

$$Hg_n Na_n + {}_mNH_4Cl = Hg_n(N^vH_4)_m$$

Sodium amalgum in ammoniac chloride.
30 grams of amalgum contain about 1 of Na
Decomp ~~$2H_4Cl + 3Cl_2 = N'''Cl_3 + 4HCl$~~

$$2Hg_n(N^vH_4)_m = 2_nHg + 2mNH_3 + {}_mH_2$$

In the production of NH_3, 3 volumes of N_2 one of N combine to form two volumes of NH_3. It will not support combustion directly but when kindled in O. In an apparatus of this kind this combustion can be well shown. When decomposed by the electric spark NH_3 is seen to accurately double its previous volume. Water absorbs more than 700 times its bulk of NH_3. In the salts formed by NH_3 we have either ammonium or ammonoxyl. Thus



$NH_3 + HCl = NH_4Cl$ Ammonium

$N'''H_3 + N^{V}O_2Ho = N^{V}O_2(N^{V}H_4O)$ ammonoxyl.

NH_3 condenses into a clear liquid at 6 atmospheres of pressure. The cooling caused by the vaporisation of NH_3 is used for freezing water. Two strong vessels one containing a cavity for water are connected, the cavity is filled with water, and the vessel with it cooled in water; on heating the other vessel the NH_3 distills over, & on placing the vessel previously heated in cold water, the NH_3 evaporates into the water so rapidly as to cause cold sufficient to freeze the water ~~absorbed~~ contained in the cavity. By the other process 1 ton of coal gave 2 of ice. By this process 1 ton gives 10 or 12 of ice. NH_3 slightly inflamable, does not support combustion, burns in O.

Amalgam of NH_4 & Hg. Produced by replacing the Na in a sodium amalgam by NH_4. 90 grams of amalgam should contain about 1 of Na. This is put into ammonic chloride. $Hg_n Na_n + m NH_4Cl = Hg_n(N^{V}H_4)_m$. Ammonium amalgam decomposes into $2 Hg_n(N^{V}H_4)_m = 2_n Hg + 2_m NH_3 + m H_2$

Wednesday

Burning of NH_3 reversed

Additional comps of N. usually termed Iodide of N, & Chloride of N. But at any rate Iodide contains N H & I. (NHI_3) derived from ammonia. Formula of N,H_3Cl comp usually written NCl_3. may be $NHCl_2$, or NH_2Cl. Prep variously but best by electrolysing ammonic Chloride. At positive pole Cl evolved in contact with NH_2Cl & forms ~~ammonia~~ nitrous Chloride. raised up to the surface by bubbles of undecomposed Cl. Layer of suspension when in contact explodes. I treated with ammonia = NHI_3. Better to dissolve I in strong aqua regia & then suddenly add excess of ammonia.

$3NH_3 + 2I_2 = NHI_2 + 2NH_4I$. Makes a clean hole when exploded on a plate.

Atmosphere consists of gases vapours & even liquid & solid substances. These present even at greatest heights. Shown by a ray of powerful light. Spores & germs. Urine, muscle, albumen, milk. Permanent as gold if shielded from germs. Proved by Pasteur. Burning of Sodium & diffusion of Soda. Atmosphere as generally stated exists to height of 45. Meteors prove its existence in rare state much higher, more than 100 miles. Indeed

Wednesday Novr. 10th.

The Burning of NH_3 in O. is better shown by introducing the NH_3 by the middle tube, & O by the large surrounding one. (The reverse of yesterdays experiment)

Compounds of N with I & Cl are known, usually termed Iodide & Chloride of Nitrogen, respectively. The Composition of the iodide is, however NH_3I_2. That of the Chloride has not been accurately ascertained on account of its very dangerous explosive character, it is usually written NCl_3, but may be $NHCl_2$, or NH_2Cl.

The Chloride of nitrogen may be prepared in various ways, but with least risk by electrolyzing a solution of ammoniac chloride. Cl being negative is evolved at the positive pole, & there in contact with ammonic chloride (NH_4Cl) nitrous chloride is produced. It does not accumulate in dangerous quantity but is floated up to the surface, on bubbles of ~~undecomposed~~ uncombined Cl. A thin layer of turpentine floats on the surface of the liquid, & immediately on coming in contact with this the NCl_3 explodes.

NH_3I_2 which is also a very explosive substance is prepared by the action of ammonia water, on I. It may however be better prepared by dissolving I in aqua regia, & precipitating it suddenly by an excess of NH_4Ho.

$$3NH_3 + 2I_2 = NH_3I_2 + 2NH_4I$$

It explodes with the slightest touch, & so rapidly as to make a clean hole, without cracks, when exploded on a plate.

probable that it exists in tenuous state through all space. — Comet showed defined line in front of tail, not so behind. 3 miles 1/2 of the atmosphere is below you. If all same density would occupy 5 miles. 15 lbs to square inch 27 million tons on each square mile. Weighing. 4 essential constituents. N.O. water, & CO_2

100 vols of average air contain

O	20.61
N	77.95
CO_2	.04 in London .11
Aqueous vap	1.40 aqueous vap & CO_2 variable.
Nitric acid, ammonia, marsh gas	traces.

Two principal constit's O & N. prop. tolerably uniform. Analyses chiefly by Bunsen & ~~Ra~~ Raignault. CO_2 removed & aqueous vapour. Process of explosion with H exceedingly accurate, when non combustable substances ~~abs~~ only present, any hydrocarbon gives fallacious result. To avoid error should be sure that no CO or CO_2 remain after explosion. Potassic pyrogallate absorbs O. first add strong sol of OKH & then ~~potassic~~ pyrogallic acid. Agitate for 1/2 a minute to a minute. Volume then read off taking care that the volume is equal inside & outside tube.

Moisture in air best determined by finding at what temp it is saturated

...ies of gases and vapours, & liquid
...gen & ...always present in greater or less
...own by a ray of powerful
...i. Many of the solid substances
...ierms, of putrefactive & fermentative
... shielded from these the
...go to decay, are as permanent
...urine, milk, flesh, albumen &c
... without change merely by
...ries &c by making it pass, before
...e substances, through long
...are diffused through the
...anner. [The diffusion of light
... by burning a fragment of
...er. The soda caused by
... instantly diffused through
...presence may be shown
...al places; their flames take
...a]
...ere as generally stated is 45
...ion of meteors prove it to exist
..., they have been measured
... above the surface of the earth
...it exists in a very tenuous
... Comets moving through
... their tail sharply defined,
...llows diminishes gradually
...ossable to tell exactly when it
...ee miles 1/2 of the atmosphere
...ount of the condensation by
...t air. The pressure of the
...to the square inch, or 27,000,000
... The atmosphere consists
...ents. N, O, DH_2 & CO_2

4. Misc. water. Hydrol.
Some theory in connection
Nitrogen.

5 N & O compounds
Theory & Laws in connection

6 Ammonia. Amidogen
comp. Rads.
~~atmosphere. phys &c.~~

7 Carbon & CO_2 & CO?

8 Carbon comps. gas.
flame & Combust.

atmos phys &c.

probable that it exists ...
all space. — Comet ...
front of tail, not so ...
the atmosphere is below ...
would occupy 5 miles.

27. million tons on each ...
4 essential constitue...
100 vols of average air con...

O	20·61
N	77·95
CO_2	·04
aqueous vap	1·40
Nitric acid, ammonia, marsh gas	traces.

& aqueous vapour. Pr...
exceedingly accurate, whe...
~~abs~~ only present, any hy...
result. To avoid error ...
CO & CO_2 remain after ...

hyrogallate absorbs O. ...
of OKH & then ~~potass~~ ...
for 1/2 a minute to ...
then read off Tok...
equal inside & out...
moisture in a...
finding at wh...

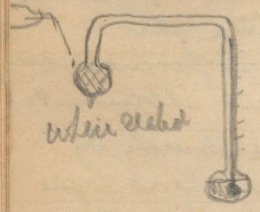
Oxygen	206·1
Nitrogen	779·5
Aq. Vap.	14·0
Carbonic anhydride	·4
Nitric acid. Ammonia Carb. Hydrogen	traces.

All other constituents then with the exception of OON taken collectively only make up say 15 volumes in 1000 of air. The atmosphere has a very homogenious character & it would hardly be supposed at first-sight that it is

The Atmosphere consists of gases and vapours, & liquid & solid substances are always present in greater or less quantity. These may be shown by a ray of powerful light such as solar, or electric. Many of the solid substances present consist of spores & germs, of putrefactive & fermentative plants, of low organization. If shielded from these the substances most liable to go to decay, are as permanent as gold. Pasteur has kept urine, milk, flesh, albumen &c for years in contact with air, without change merely by freeing the air from germs spores &c by making it pass, before coming in contact with the substances, through long bent tubes. Such spores are diffused through the atmosphere in a wonderful manner. [The diffusion of light substances may be shown by burning a fragment of sodium on a wet filter paper. The soda caused by this combustion is almost instantly diffused through every part of the room. Its presence may be shown by Bunsens placed in several places; their flames take the yellow colour due to Na]

The height of the atmosphere as generally stated is 45 miles. But the combustion of meteors proves it to exist at a much greater height; they have been measured at more than 100 miles above the surface of the earth. It is indeed probable that it exists in a very tenuous state through all space. Comets moving through space have the side of their tail sharply defined, while the other which follows diminishes gradually in brightness till it is impossible to tell exactly when it ceases. At a height of three miles 1/2 of the atmosphere is below you; this is on account of the condensation by pressure of superincumbent air. The pressure of the atmosphere is about 15 lbs to the square inch, or 27,000,000 tons on each square mile. The atmosphere consists essentially of four ingredients. N, O, OH_2 & CO_2

& then by tables of vapour density. If twice as much vapour, double pressure. Daniels hygrometer. Filled with ether. Thermom read off when on outside of bulb bedewed.



In actual experiment watch till dew disappears again, then reread, mean of both readings taken.

Thermom = 50° Fr = 10° Cent, pressure of aqueous vapour at that temp = 9.165 mm. If barom at 760 mm average height

$$\begin{array}{r} 9.165 \\ \hline 750.835 \end{array}$$

tension of aq vap / volume of vap (volume of air.)

volumes directly prop to weight. Volume by crith. Mode of determining CO_2 by passing a stream of air through OKH bulbs, and weighing.

NO_2Ho formed by electric flash & aurora? Constit only mechanically mixed because mere solvent action of aq seperates the N & O. Might have formula N_2O & orgical mixture posesses the same props

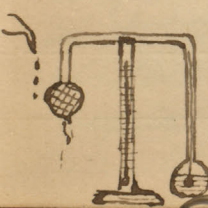
H_2 & CO_2 occur in traceable quantities, N, & O, are almost uniform everywhere.

Average composition of 100 vols of air	
O	20·61
N	77·95
CO_2	·04
aqueous vapour	1·40
NO_2Ho. NH_4Ho marsh gas	traces.

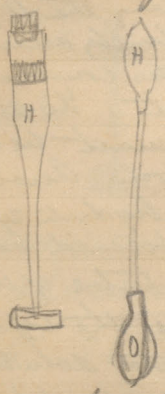
in London the CO_2 rises to ·11

Regnault & Bunsen have paid great attention to the analysis of air. You first remove the CO_2 & aqueous vapour. The process of exploding the O of air with H is exceedingly accurate, providing that no combustable gases are present. To avoid all error you must be sure that no CO or CO_2 is present after the explosion. Another very good process is to absorb the O by potassic hydrate mixed with pyrogallic acid, the Potassic pyrogallate formed has a very great affinity for O. It is performed in a tube of this kind, placed in a cylinder of water before & after the experiment to equalize the temperature & pressure. The ~~tube~~ solution of OKH is first introduced, into the bent part of the tube, then the pyrogallic acid. The aperture is then tightly closed by the thumb, & the tube strongly agitated for ½ a minute or a minute When replaced in the water & the thumb withdrawn the water rushes up, and shows the contraction due to the absorption of the O. The ammount of aqueous vapour present in the air is best determined by finding at what point it is saturated, & then deducing the ammount from tables for vapour density. If twice the quantity of vapour twice the pressure will be caused by it. The point of saturation, or dew point may be found by Daniels Hygrometer, in which by the distillation of ether from one bulb to another, ~~cold sufficient to~~ the temperature is gradually lowered, till dew deposits when the thermometer contained in the tube is read off.

Best way is to read the thermometer when dew forms, & then to watch till it disappears again, & read again. The mean between these two readings is often taken. Suppose the temperature was 50° Fah (10° Cent) The pressure of aqueous vapour at that

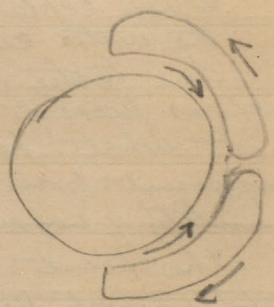


Law of diffusion. thus atmosphere kept light.
When the gases of very different specific grav
diff takes place very rapidly, the
same if the gases have very different
densities. Currents in atmosphere.
Expansion. Solar rays scarcely at
all raise the temp of air, but heat
surface of earth. Changed into dark
rays of heat which are readily absorbed, esp'ly
by the CO_2 & aq vap. Trade winds.



Diffusion of gases

	Density	square root of density	$\frac{1}{\sqrt{\text{density}}}$	Velocity of diffusion
H	0.06926	0.2632	3.7984	3.88
CH_4	0.5539	0.7476	1.3375	1.344
CO_2	1.52301	1.2565	0.8087	0.812.



Calc if no O restored by plants, some
thousands of years before chemist could
detect difference

temperature 9·165 mm if then the barometer stands at 760 mm which is the average height, ~~760 − 9·165 =~~ ~~750·835~~ 760 − 9·165 tension of aq vapour (or volume of vapour) = 750·835 volume of dry air in 760, or the pressure of the dry air when seperated from that of the contained vapour. The volume of vapour is always directly proportionate to the ~~weight~~ pressure)

The CO_2 present in air may be determined by passing it through a series of bulbs with potash, weighed previous to and after the experiment. The small quantities of NO_2Ho are formed by the electric flash, & also perhaps by the aurora. The constituents of air are only mechanically mixed, as the mere solvent power of water seperates the N & O, the solution containing more O in proportion. Besides, an artificial mechanical mixture possesses exactly the same properties.

The vap of aq present in air may be shown by a conical tin vessel containing ice, condensing water, which is collected as it drops.

Thursday Novr. 11th

The law of **diffusion** of gases among each other is. The rate of diffusion is inversely as the square root of the density. By this property the atmosphere is mixed & kept uniform in composition. The more the density of two gasses differ, the more rapidly diffusion takes place between them. The same holds good if they have very different properties.

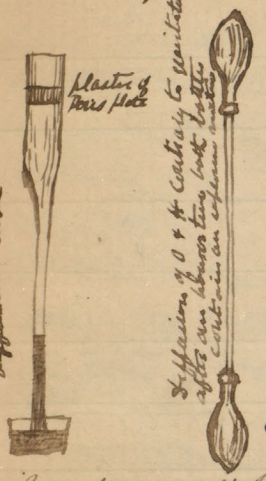
The atmosphere is scarcely if at all heated by the passage through it of the solar rays, but these falling on the surface of the earth heat it, & are again given out in the form of dark rays of heat, which are readily absorbed by the atmosphere, and especially by the aqueous vapour, & CO_2 which it contains, by this means currents are established, & a perpetual interchange of air

Trade winds do not blow north & south, Revolution of earth. At Equator 1000 mils an hour & poles 0 air does not at once acquire this velocity in these lats out of regular trade winds, sometimes upper, sometimes lower current. CO_2 absorbed by plants & O liberated. N & CO_2 also lib. In plants nutritive process 12/150 ·040 000 tons of CO_2 given daily by London. N diminishes the rate & intensity of combustion. Been stated that combustion would not be affected by removal of N, as O would occupy ~~the~~ exactly the same space same quantity in a cubic foot. N also reduces evaporation. the boiling point would be so much lowered.

N renders the existence of animal life possible. Its additional presence enables ag to absorb sufficient quantity of O, Diffuses light & prolongs twilight, refraction diminished to about 1/3 if N absent.

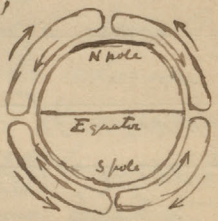
Combustion said to take place whenever chemical action sufficient to raise substance to visable redness. Combustibles & supporters of combustion not proper distinction. If the atmosphere N would be completely removed. A burns in O. as in coal gas.

kept up between the equatorial & polar regions. Giving rise to the trade winds. These do not blow exactly north & south, however, as the air coming from the poles, with no velocity of rotation to the equator, where the velocity is about 1000 miles an hour, does not at once acquire this velocity,



Diffusion of Gases

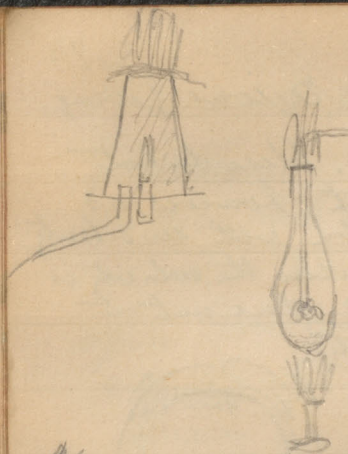
	Density	Square root of density	Velocity	Velocity of diffusion
H	0·06726	0·1632	3·7494	3·83
CH_4	0·5559	0·7476	1·3378	1·344
CO_2	1·52901	1·2365	0·8057	0·812



In places like this country which are out of the regular trade winds, sometimes ~~the~~ the upper & sometimes the lower current impinges on the surface.

CO_2 is absorbed from the atmosphere by plants, & O liberated, but this is not their only function, as they also give out CO_2 & N though in smaller quantity. They thus help to keep the atmospheric pure, from CO_2 which is constantly given out by combustion & respiration. Their action however is very small compared to the size of the atmosphere, as it has been calculated that if they ceased to restore O to the air, it would be some thousands of years, before a chemist could detect any diffrance in the CO_2. In plants the restorative process predominates over the destructive, or combustive. In animals the opposite obtains. It has been calculated that about 150,000,000 tons of CO_2 are given off by London every day.

The N in the atmosphere serves various purposes. It diminishes the rate and intensity of combustion. It has been stated that the removal of N would not affect the rate of combustion, as the O alone, when relieved of the pressure due to the N would occupy exactly the same space, as the atmosphere did, before, & consequently there would be the same



C = C = S

S burns in O. O in vapour of S.

Igniting point - temp at which substances combine. Zinc ethyl burns, and therefore is raised to that point at ordinary temperature of air. CS_2 lit by warm glass rod.

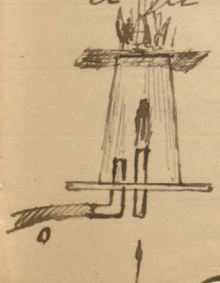
Spark from flint & steel lights H. marsh gas does not light. Coal gas almost always, cannel gas does not light as there is less H. Davy's Lamp not at safe in strong currents of Marsh gas. not at all safe in Coal gas. affords no protection in mixture of H & O. Coal gas with less than 7 or more than 14 of air will not burn. point of combustion lower than ignition point.?

Heat of combustion may be considered from total amount, (absolute thermal effect) & intensity. Absolute thermal effect by foot lbs, or amount of water raised through a certain amount of °.

A known quantity of fuel put under a boiler with a known amount of water. a certain amount of steam evaporated. A little instrument invented by Mr Thompson the quantity of water & fuel so arranged, fuel burned completely, under the water.

quantity of O in each cubic foot of air. This is not the case however, for though the proportion of O remains the same there is no N present to lower the temperature of the burning body, by abstracting heat from it. This may be proved by introducing the proper proportion of O without any N into a bell glass over the air pump, when P is burned in this it gives light almost as intense as that due to ~~[illegible]~~ O of ordinary density. The N in the atmosphere also reduces the rate of evaporation, If the pressure due to N were removed the boiling point of water would be greatly lowered, & evaporation would take place with extreme rapidity. It is the pressure due to N which renders marine life possible, without this pressure, water would not dissolve sufficient air to support such animals & plants. It also diffuses the suns light, & prolongs twilight. The refraction of the heavenly bodies, would would be reduced to about 1/5 if the N was absent.

Combustion is said to take place whenever chemical action is sufficiently intense to raise substances to visable redness. Substances usually divided into Combustibles & supporters of combustion. This is not however a proper distinction, and merely depends upon circumstances: If the atmosphere had been H it would have been completely reversed. A jet of O may be burned in H: a jet of air in coal gas, in apparatus of this construction



Sulphur burns brilliantly in O, O may be burned in vapour of S. [a flask containing a little S heated by a bunsen, & a glass tube connected with O bag introduced, when it burns brilliantly]

Effected by mixing the fuel with 3 parts of potassic chlorate & 1 of potassic nitrate. 30 grains of fuel taken very finely ground & mixed with the oxysalts. Put lightly into a coffee tube, it burns like a slow match, & burns completely, brought without wetting beneath the water by putting a piece of cotton wick steeped with potassic nitrate, & dried. Put into a sort of diving bell of copper, with a stop cock, at lower end a number of small holes to allow escaping gas to bubble in small bits through the water. Take temp of water.

Better that the deflagration should take place with some rapidity. Complete. Moved up & down several times

Temp at first	13° Cent	
at close	21° Cent	
allowance for glass &	8	
copper usually 10 per cent.	9	
this amount lost by	5·172	
apparatus	14·4	
loss	1·44	
	15·84	weight of water displaced by the water at the boiling point.

Between 10 & twelve parts of mixture to 1 of fuel.

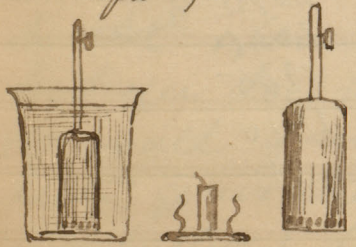
The igniting point is the temperature at which substances combine. Zinc ethyl burns, & therefore is raised to that point at the ordinary temperature of the air. CS_2 may be ignited by a glass rod hot too hot to be born by the hand. A spark from flint & steel lights marsh gas, its point of combustion is so low. Coal gas contains more of than, that produced from cannel and lights by strong sparks from flint & steel (especially a steel mill) the cannel gas does not do so, and the two may be almost certainly distinguished. It is marsh gas which is present in coal pits, and against which the safety lamp is meant to guard. This lamp however is not safe in currents of marsh gas, as the flame constantly impinging on the gauze, may raise it to the temperature necessary for the ignition of that gas. It is not at all safe in coal gas, and affords no protection whatever in a mixture of O & H; This igniting point being so low. Coal gas will not ignite when mixed with less than 7 or more than 14 parts of air. The heat of combustion is often lower than the ignition point. This is the reason that when air has got into the gas pipes, and you try to light the gas, it at first only burns round the light applied. The extra heat supplied by this flame, being sufficient to keep the mixture at the ignition point in its vicinity.

Heat of Combustion, may be considered from two points, either with regard to the total amount generated (absolute thermal effect); or to its intensity. The absolute thermal effect, may be measured by pounds, by the raising of a certain ammount of water, through a certain number of degrees; or by the evaporation of a

Absolute thermal effect of combustables

Hydrogen	4·46	Alcohol	·86
Olefiant gas	1·52	Good coal	·77
Olive oil	1·22	Dry wood	·46
Ether	1·02	Airdry wood	·35
Carbon	1·00	Peat	·36.
Charcoal	·96		

certain quantity of water, which before the beginning of the experiment is raised to the boiling point. The boiling is maintained by a certain weight of fuel, & the difference in the weight of the water, gives the thermal power of the fuel. Such experiments however are extremely difficult, and a little instrument invented by Mr Thompson gives very accurate results with little trouble. It is so arranged that a known weight of fuel is consumed under a known weight of water, which absorbs the heat caused by the combustion & the differences of the ~~~~ temperature of the water gives the number of degrees, which the ammount of fuel employed is capable of raising it through. The fuel is intimately mixed with a compound of 3 parts of potassic chlorate & 1 of potassic nitrate, in the proportion of 10 or twelve parts of the mixture to 1 of the fuel, (which must be very finely ground) This is then tightly put into a copper tube fitted ~~with~~ on a stand, with springs. The tube is then pinned with a piece of cotton then dipped in nitre & dried. The tube thus prepared is then covered with a sort of diving bell of copper, (which is retained in its place by the springs) fitted with a tube & stopcock above, and a series of small holes below to permit the exit of the gases which are formed. The temperature of the water is carefully taken at the commencement of the experiment



It is better that the deflagration should take place with some rapidity. When the combustion is complete the stop-cock at the top of the bell is opened to allow the water access to the inside, the copper apparatus is moved up & down several times to equalize the temperature of the water, & the

C unity of Total thermal effect. Coal gas
olefiant gas being a compound of C & H gives mean between, C & H unity eliminates a small quantity of heat, so that 1 lb of C & comb with H does not give so great thermal effect. Depends upon the ammount of energy with which substances with O.

Pyrometric effect, very different. If 1 lb of one substance gives out as much heat as 1 lb of another, likely that heat by latter twice as intense. Also depends upon specific heats of products of combustion. Depends upon absolute thermal effect & nature or quality of substances produced. Outside range of mercurial thermometer, temperatures doubtful.

	in O	in Air
Carbon	9813° Cent	2456
olive oil	6024	2122
olefiant-gas	5793	2090
Ether	5484	2040
CH_4	4800	1945
alcohol	4521	1910
Hydrogen	3148	1611

Assuming that Carbon at once oxydized & mixed with no more air than necessary

temperature is then again found by the thermometer. An allowance depending on the instrument used, is made for the heat absorbed by the apparatus &c this is usually about 10 per cent.

Temperature of water at first	13° Cent
" " " " Close	21° Cent
Difference of temperature	8°

Dif Reduced to degrees of Fahrenheit by multiplying by 9 & dividing by 5 = 14·4 . 14·4 + 1·44, (tenth allowed for loss) = 15·84. The weight of water evaporated, compared to the fuel employed. water supposed to be at hard leaf pt at beginning of experiment The weight of fuel to be tested, usually 30 grains.

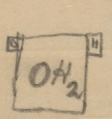
Absolute thermal effect of combustables.

Hydrogen	4·46	Alcohol	·86
Olifiant gas	1·52	Good Coal	·77
Olive oil	1·22	Dry wood	·46
Ether	1·02	Air dry wood	·35
Carbon	1·00	Peat	·36
Charcoal	·96		

Monday Nov. 15th 1869.

C is taken in the above table as unity. H has much greater heating power than C, & Olifiant gas being a compound of C & H gives a mean between its constituents. The chemical union of C & H eliminates a small quantity of heat so that 1 pound of C when burned, united with hydrogen does not give out so much heat as it would if uncombined. The amount of heat generated by the union of two substances (combustion) depends upon the force of their

position of C & H reversed in this table.
C 3 times as great pyrometric a H
1 & gives 9 parts of water, while one part
of C generates only 3 2/3 parts of CO_2. Also
gains by great difference of specific heats. Steam
takes 4 times as much heat as CO_2.
Numbers in table only calculated. Bunsen has
shown & following. When O & H exploded do
not at once all combine, dissociation.
takes place.



steam heated to bright redness &
reduced always to standard temp &
pressure, gives at that heat greater vol per-
manent (dissociation) H & O. On first
combustion of O & H whole does not
combine, the heat generated by first combin-
ation radiates off. The same with Carbon
partly changes at first to CO. These principles
in fuel. When you want intense heat
take anthracite & fuel without H chosen.
Coal now used for smelting iron by latest
Platform heat from which you start. If
from redness you gain 1000° Farenheit
this being the limit of visible redness.

affinity for O. **Pyrometric effect** is very different from the total thermal effect of substances. If one pound of any substance gives out only as much heat as is given out in the oxidation of half a pound of another substance. It is likely that the intensity of the former substance will only be half as great as the latter's. It also however depends much upon the specific heats of the products of combination. Thus

	Pyrometric effect in O	in air
Carbon	9873° Cent	2456° Cent
Alive oil	6024	2122
Olefiant gas	5793	9090
Ether	5484	2040
CH_4	4800	1945
Alcahol	4521	1910
Hydrogen	3148	1611

It is assumed that substances at once oxydise, and are not mixed with any more O than necessary for combustion.

C has 3 times the pyrometric effect of H. As H gives 9 parts of water, while C only gives 3½ parts of CO_2. The specific heat of steam is also much greater than that of CO_2. It takes 4 times as much heat to raise it to the same temperature. These reasons account for the inversion of the relative positions of C & H in this table as compared with the last.

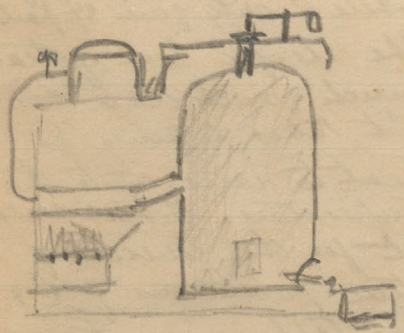
The numbers in this table are only calculated, & Bunsen has shown that, at least, that of H is fallacious. When O & H combine they do not all, at once combine. This arises from what is called dissociation.

When ~~O & H are heated~~ steam is heated to bright redness, & its volume taken, (always reduced to the standard temperature & pressure. It is found that it gains in bulk by the liberation (Dissociation) of some free H & O. It may be represented thus.

When O & H are in combination cannot take place through the whole mass at once

Heat of combustion of H in O.

Sulphur. produced by volcanoes Acid Iceland by comb of Sulphuretted H & Sulphurous acid?
Iron pyrites FeS_2, Copper pyrites. Also with lead a plumbic sulphide. Gypsum Calcic sulphate. Prepared by three processes From native S & compounds. Native at Solfatare & Napels. Marseilles



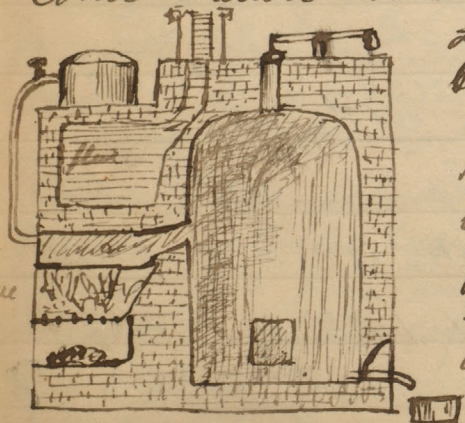
On third day S begins to form liquid layer on floor. If flowers of S wished must be discontinued after 2nd day. Can be carried on for 7 days otherwise, without discolouring the S. run into wooden moulds.

Process usually employed at Marseilles

From ferric sulp & Cupric sulph. mostly in Saxony & Bohemia. Made into large pile about 8 feet high, & two or three hundred long brush, placed at bottom lit & combustion continued by S in minerals employed S condenses in little wells

as the combustion of a part raises the temperature of the remainder so high, that they do not unite until it falls somewhat by radiation & absorbtion by OH_2 vapor. The same occurs with C & it is partly at first changed only into CO. The Pyrometric principles are illustrated by the choice of fuels. If an intense heat is wanted coke, anthracite, or charcoal is used as these contain no H. If only great total thermal effect is required, coal, or wood is employed. Coal is now however used for smelting iron (where an intense heat is required) by using the hot blast. Thus by raising the "platform" of heat from which you start, to redness you gain about 1000° F which is the temperature of visible redness

Sulphur is produced by volcanoes, by the action of sulfurous acid on sulphuretted hydrogen both simultaniously evolved. It also occurs in large quantities in Iron & Copper pyrites [FeS_2, $(FeCu)S_2$] & in combination with Ca as $SO_2 HO_2$ in Gypsum.



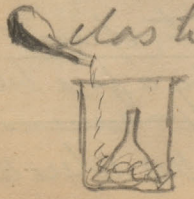
Large quantities of S are obtained in Sicily & Solfatara near Naples from native S. This is melted out from the rocky & earthy materials with which it is found, in a large vessel over a furnace, & when melted allowed to run by a pipe into a retort, open at the end, and heated by a fire below the open end of the retort communicates with a large brick chamber where the

900 tons of copper pyrites gives 100 to 13 v of S by this process. Alkali waste, oxy=sulphate of calcium. discryption deferred till alkali manufacture. Flowers of S. Roll S. & in medicine milk of S. obtained from Calcic persulphide, (which is obtained by boiling S with lime.) HCl or SO_2Ho_2 decompose this comp. 1 of S forms SH_2 & one of S precipitated. When SO_2Ho_2 Calcic sulfate is also pp'tated.

$$CaS_2 + {}_2HCl = CaCl_2 + SH_2 + S$$

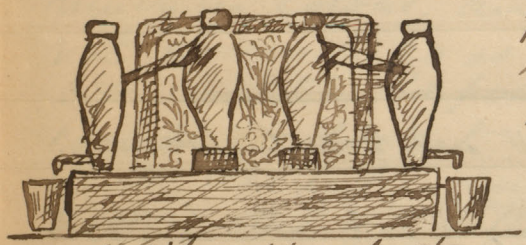
Bad conductor of heat. Non conductor of electricity, becomming negatively electric by wool or silk. When melted first limpid, & afterwards thick. by further heat again becomes limpid but not so much so as at first. Colour deepens all the time.

Allotropic Conditions. If S in 2nd state or 3rd be put into water & cooled quite elastic. Specif grav of 1.95 of amorp S

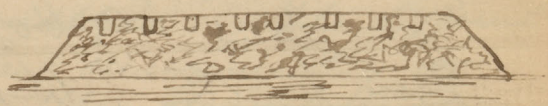


If this S be slowly cooled, prismatic crystals formed, afterwards becomming opaque by breaking ?

S is at first condensed as flowers of S on the walls, but after the process has been carried on for two days, the heat becomes so great, that the S melts & forms a layer on the floor. The process cannot be continued for more than about 7 days, as the heat then becomes so great as to discolour the S. The S is run off the floor by a tap & cast into moulds made of wood.
The process generally employed at Marseilles, and when the S is mixed with a large quantity of earthy matter, is different from the above, & carried on in an apparatus of this kind. In Saxony & Bohemia S is obtained in the roasting of Iron & Copper pyrites, preparatory to reducing them metals. The broken ore is placed in large piles, about 8 feet high, & perhaps 200 or 300 feet long. Brush is placed below

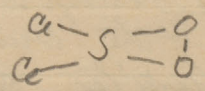


and lit. The heat of the burning brush soon induces combustion of the pyrites, and this being carried on with limited access of air; The combustion of part of the S volatilizes the rest, which is condensed in little wells excavated over the top of the pile, and made fluid-tight at the bottom.
9000 tons of Copper pyrites thus treated give from 100 to 130 tons of S. A large quantity of S is also obtained from the "Alkali waste" from alkali work. (The process will be described when the works treated of)



up into Octohedrons. Flowers of S. treated with CS_2 part dissolves easily & part refuses to dissolve.
Depend on different arrangement of atoms of molecule. Also represent different force found by getting change of temperature when S changes its condition. Heat absorbed in change of Octohedral S to plastic. when heated in test tube temp constant for some time.

Tuesday.

S 3 fold atomicity VI IV & II. 2 most common & when in this state an analogue of O in comps with neg elements.  evidence of Hexad atomicity not so good as that for other conditions always basyloos with dead elements. S sometimes employed in the manufacture of $SO_2 HO_2$. especially when pure $SO_2 HO_2$ wanted. As present in Iron pyrites, this generally used. S used for matches, gunpowder, & for destroying blight mildew &c on plants.

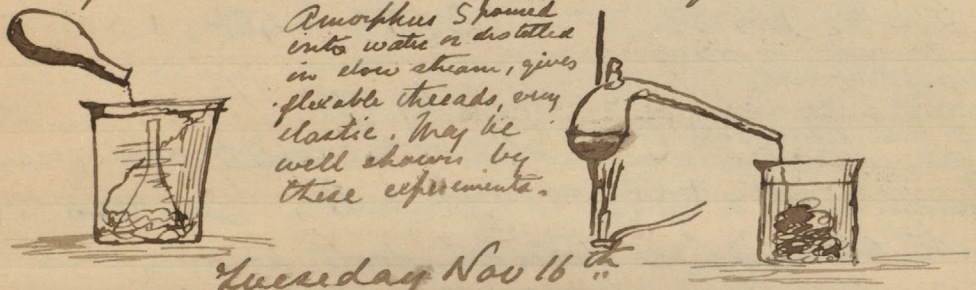
S usually appears in three forms. Flowers of sulphur, Roll sulphur, & milk of sulphur. To prepare milk of S (mostly used in medicine) Bisulphide of Calcium is first made, by boiling lime with S. From this deep yellow liquid ~~fr~~ half the S is precipitated & half escapes as SH_2 on the addition of HCl (or $SO_2 HO_2$)

$$CaS_2 + 2HCl = CaCl_2 + SH_2 + S.$$

S is a bad conductor of heat, a non conductor of electricity, ~~and~~ but becomes negatively electric with wool or silk. When melted S is at first limpid, & yellow, afterwards becomes thick & pasty, & much darker, and on further application of heat deepens much in colour, and again becomes limpid, though not so much so as at first. If S in its 2nd or 3rd condition be poured into water & thus suddenly cooled, it does not harden, but remains soft & elastic like Indian-rubber. This is one of the allotropic forms of S, called the amorphous. If this S be slowly cooled instead of being poured into water, it first forms into prismatic cristals (another allotropic form) & these soon become opaque by breaking up into minute octohedrons (normal form) When flowers of S are treated with CS_2 part dissolves very readily & part refuses to dissolve, This form of S is therefore partly octohedral & partly amorphus. The different states of S represent different arrangement of the atoms of the molecule of S. They also represent different amounts of force. This is found by observing that S raises or lowers its temperature on

SH_2 analogue of water, evolved naturally from volcanoes, & fumaroles in their vicinity. Hepatic waters contain it. Met with in water charged with organic matters & sulphates. Decaying matter has so great affinity for O as to change sulphates into sulphites, these decomposed by CO_2.
Obtained by direct union of its elements, but almost impossible to combine the whole of the S vapour & Hydrogen, on account of dissociation. Best prepared from metallic sulphide & SO_2HO_2 or other strong acid. Generally some free H when thus produced caused by excess of iron in sulphide. Absolutely pure SH_2 prep from Antimonious sulphide. May be collected over water, especially if warmed. or Hg. Liquefiable at 50° F at pressure of 15 atmospheres. Can be frozen to substance. Every organic comp containing S has a most offensive odour. Decomposed at an intense white heat. Combustable, but not a supporter of combustion. When burns in limited quantity of air S liberated, H burns before S. H into water S sulphurous acid.

changing its condition. Heat is absorbed in the form of Octohedral S into plastic. When gradually heated in a test tube it undergoes this change, & the temperature remains constant for some time.



Tuesday Nov 16th "

S has a three fold atomicity being either VI, IV or II. II is the most common, in fact it is always thus when in combination with negative- (or basylous) elements. When diad it is an analogue of O in compounds with negative elements. Thus SH_2 & S_2H_2 are exactly similar to OH_2 & O_2H_2. The evidence of the hexadic condition is not so convincing as that for the diadic & tetradic, but assuming it simplifies a great many compounds. S is sometimes employed in the manufacture of SO_2H_2. especially when this acid is wanted quite pure, as As, is always present in that made from pyrites. S is also used for matches, gunpowder, & in filling plants, as hops, & the vine, from blights, or fungoid growths, to which they are subject, & to which S proves fatal.

Sulphuretted Hydrogen is the sulphur analogue of water. It is evolved from volcanoes & fumaroles in

SH_2 explodes with O. when equal vols of sulphuretted H & sulphurous acid mixed 1/2 S liberated.

$5 \cdot SH_2 + 5 \cdot SO_2 = S_5 \cdot O_6 H_2 + 4OH_2 + 5 \cdot S$

poisonous. bird killed by air 1/15-00 to air hampered from SH_2 by a variety of processes.

Cl $SH_2 + Cl_2 = 2HCl + S$. SO_2 also used acts as above. Ferric hydrate removes SH_2 from air, and gives it up again when exposed to air. Used almost universally to free coal gas from SH_2 Fe_2S_2? exposed to current of air. (Ferric hydrate on tow plunged into mixture of SH_2 & O causes explosion from heat prod by this action. Pp 'tates metals. *

S_2H_2 Hydrosulphyl. by polysulphite of lime, and HCl. Decomposed by alkalies, but remains in acid sol as an oily fluid. Decomposed the same substances whic decompose Hydroxil. Manganic peroxide. Argentic oxide? Comps of Cl & S unimportant.

Sulphurous anhydride SO_2 prod by fuel which contains iron pyrites. & in large quant by roasting of copper ores. Only comp formed when S is burned in air or O. Prod most

their vicinity. It is also present in those waters called hepatic. It is met with in water, (as of rivers) charged with organic matters & sulphates. The decaying matter has a sufficiently strong affinity for O to change the sulphates into sulphites, & these are decomposed with evolution of SH_2 by the CO_2 present in the water. SH_2 may be formed by the direct union of its elements. But it is almost impossible to combine the whole of the S vapor & H on account of dissociation. For practical purposes it is best prepared by the action of some strong acid on a metallic sulphide. When prepared from Ferric sulphide there is always some free H evolved from the excess of Fe in the sulphide. It may be prepared pure from Antimonious sulphide, by the action of HCl. It may be collected over water especially if warmed, or over Hg. It may be liquified at 15°F under a pressure of 15 atmospheres. & can be frozen to a clear substance like ice. It has an offensive odour, especially in small quantities, or when evolved from FeS. It is decomposed at an intense white heat into its constituent elements. It is Combustable, but does not support combustion. When burned with limited access of air S is deposited partly because O has more affinity for H than S, and partly by the action of the Sulphurous acid formed on the remaining SH_2. [The formation of Sulphurous acid (SO_2) when SH_2 is burned shown by holding a rod dipped in NH_4 Ho over a jet of burning SH_2. (copious white fumes of Ammonia sulphide evolved)

conveniently by action of SO_2HO_2 on Cu or Hg, or Fe is not wanted pure.

$$2SO_2HO_2 + Cu = SO_2 + SO_2CuO'' + 2OH_2$$

Most cheaply prepared & CO_2 does not for most processes hurt

$$2SO_2HO_2 + C = 2SO_2 + CO_2 + 2OH_2$$

Cheapest by combustion of S with MnO_2 in closed retort

$$S_2 + MnO_2 = SO_2 + MnS''$$

twice as heavy as atmospheric air. When S burnt in O no ~~diminut~~ expansion of volume. $\boxed{\begin{matrix}O & & O\\ 16 & 32 & 16\end{matrix}} = 64 \div 2 = 32$ criths.

Liquifies at 45°F under 2 atmospheres. Does not burn or support combustion. & reddens damp litmus paper.

Sulphurous anhydride
Sulphurous acid
Sulphuric anhydride
Sulphuric acid

SH_2 explodes violently when mixed with O & ignited. When equal volumes of SH_2 & SO_2 are mixed half the S is liberated; thus,

$$5\,SH_2 + 5\,SO_2 = S_5O_6H_2 + 4\,OH_2 + 5S.$$

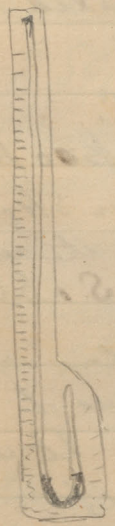
SH_2 is very poisonous, a bird being killed by 1/1500 part of it in air. Air can be purified from SH_2 by several processes. Cl when mixed with the air effectually does so; thus $SH_2 + Cl_2 = 2HCl + S$, SO_2 may also be used, and acts as shown before. Ferric hydrate removes SH_2 from air, and gives it up again when exposed to a current of pure air. It is now almost universally used to free coal gas from SH_2. [Ferric hydrate on tow, plunged into a mixture of SH_2 & O causes an explosion by the heat produced by this action.] SH_2 very useful as a precipitant for the metals in analysis.

Hydrosulphyl $|S_2H_2|$ if formed as a thick yellow oily liquid, sinking to the bottom, when Disulphide of Lime, is poured into dilute HCl. It is decomposed by alkalies, & thus is not formed when ~~cold~~ HCl is poured into Bisulphide of Lime, but is decomposed, & S precipitated (as ante) It is permanent in acid solutions.

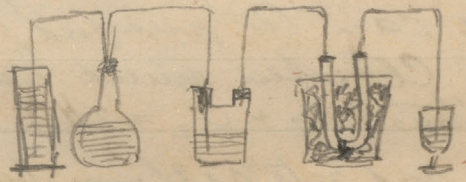
It is decomposed by the same substances which decompose Hydroxil, (as Manganic peroxide) with evolution of SH_2. Compounds of Cl & S unimportant.

Sulphurous anhydride. SO_2. Produced by the combustion of fuel which contains pyrites, as most coals. Also in the roasting of copper ores,

SO_2 liquified at 14 F. pressure of liquefaction of gasses to measure very low temperatures?



By inclining tube after liquefaction it again pails into gas.



Water at ordinary temp absorbs 33 vols of SO_2. Water boiled again given up unchanged by water. But must not suppose that it remains unchanged in the water. $SO_2 + OH_2 = SOHO_2$. Not changed by passing through red hot tubes. Decomp at redness by copper which takes both elements. Also by potassium & sodium. Forms a large series of salts with bases. Possesses powerful bleaching powers. Used for bleaching especially silk & wool. Cl not well adapted for bleaching except vegetable substances. SO_2 does not destroy colouring matters seems to enter into combination, and may be restored by acid of superior affinity. as SO_2HO_2. Cl altogether chances the colouring matter by replacing H by Cl or O. Bleaching by vapours of burning sulphur.

Mumical to low forms of life.

Liquified & poured into water, freezes it by boiling off.

and whenever S is burned in O. It is produced most conveniantly by the action of SO_2HO_2 on Cu ~~or~~ Hg, (or Fe if not wanted pure)

$$2SO_2HO_2 + Cu = SO_2 + SO_2CuO'' + 2OH_2.$$

It is ~~most~~ cheaply prepared by the action of SO_2HO_2 on C, & the CO_2 also produced does ~~f~~ not for most purposes hurt.

$$2SO_2HO_2 + C = 2SO_2 + CO_2 + 2OH_2$$

It is most cheaply prepared by the combustion of S with MnO_2 in closed retorts

$$S_2 + MnO_2 = SO_2 + MnS''$$

SO_2 is twice as heavy as atmospheric air. When S is burned in O no expansion of volume takes place. The sulphur is absorbed. It ~~must be~~ may be represented thus

S	32
O 16	O 16

$= 64 \div 2 = 32$ Criths

SO_2 Liquefies at 45°F under 2 atmospheres. It does not burn or support combustion, & reddens damp litmus paper.

Wednesday Novr. 17th

SO_2 liquified with only the ordinary pressure of the atmosphere at 14 Far. The liquefaction of SO_2 & the ammount of pressure required may be well shown by enclosing some SO_2 in a long tube recurved at the end, into which mercury equal to several atmospheres may be placed. It is liquified at ordinary temperatures at about 2 atmospheres

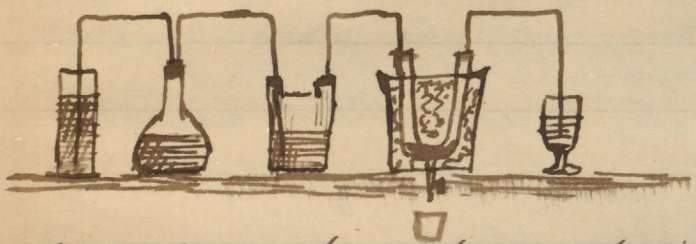
Sulphuric anhydride. Spongy platinum Cupric oxide & other similar substances. Cause $SO_2 HO_2$ to combine with an other atom of O. Sulphurous anhydride & O passed through red hot tube full of spongy Pt combine & form SO_3. This forms white cloud in air from formation with moisture of $SO_2 HO_2$. Proposed for the formation $SO_2 HO_2$ on Commercial scale sometimes spongy Pt but the action of the spongy Pt becomes feeble by clogging with dust. P in large earthenware retorts. Proposed to use porous siliceous materials, as Cupric oxide But operation proceeds with much less success. Abandoned. $SO_2 + O = SO_3$. Another process, more frequently used. Nordhausen $SO_2 HO_2$

$SO_2 HO$ Impossible to take a salt of this acid.
O"
$SO_2 HO$ Sodium, or potassium.

$$\begin{matrix} SO_2 NaO \\ | \\ SO_2 NaO \end{matrix} = SO_2 NaO_2 + SO_3.$$

Phosphoric anhydride, put into $SO_2 HO_2$ abstracts Water, and forms Meta phosphoric

By pouring in mercury the SO_2 may be liquified, & afterwards be made to boil off again into gas by inclining the tube, & thus shortening the length of the column of Hg. Water at ordinary temperatures absorbs about 33 times its volume of this gas. SO_2 may also be liquified by passing it through a U shaped tube embedded in a freezing mixture. The SO_2 collects as a liquid at the bottom of the U tube & may be drawn off by a tap.



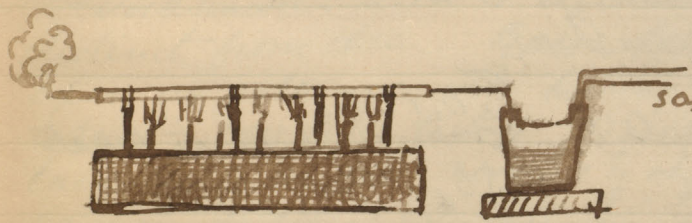
When water holding SO_2 in solution is boiled it gives it off again unchanged, but it must not be supposed from this that it dissolves in the water unchanged, as when in that condition it takes H & becomes an acid; thus, $SO_2 + OH_2 = SOH_2O_2$. SO_2 is not changed when passed through a red hot tube. It is however decomposed at a red heat by Copper, which takes both the elements. It is also decomposed by Potassium & Sodium. SO_2 forms a large series of salts with the bases. It possesses powerful bleaching properties, and is used more especially in the bleaching of wool & silk, Cl is not so well adapted for bleaching such substances as these, for its bleaching power is strongest with vegetable substances. SO_2 does not however destroy the colouring matter in the same manner as Cl. It seems only to enter into combination with them, and they may be restored by the action of an

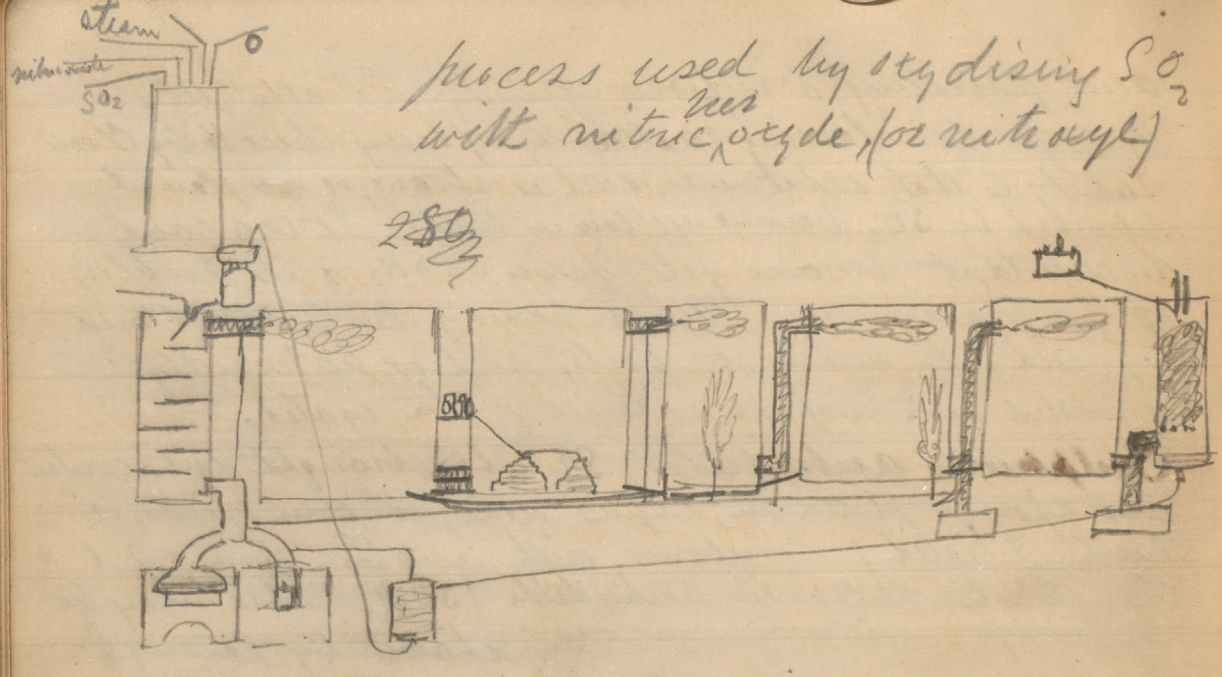
acid. SO_3 may be distilled off.
Cryst fibrous mass. Perfectly dry does not redden litmus paper, and is not an acid.
Forms several hydrates. Nordhausen Eichenhal as distinct. boil in form 3.

SO_2HO_2 melts at 10.6° Cent may be cooled below this without freezing
SO_3HO_4 melts at 9. boils at 207°
SHO_6 ~~melts at~~ boils at 193°
Basic salts may be looked upon as salts of acids having greater bacisity than usual.
SO_3 Chiefly used as absorbtion of Olefiant gas, and organics called Olifines.
SO_2HO_2 most important comp of S & O
Discovered by Basil Valentine in 14th Cent.
Forms as it were a key to compound otherwise locked up. Prod from SO_3 by variety of processes. Also prod by oxidising SO_2 If " By exposing sol of SO_2 to air, in fact very difficult to keep SO_2. Sulphites rapidly turns into sulphates. One of most interesting processes where SO_3 combined directly with OH

acid possessing a superior affinity. Cl altogether destroys the colouring matters by replacing their H by Cl or O. Thus it is that substances, such as straw, or ~~so~~ flannel bleached by SO_2 become yellow in time. It is a good disinfectant because of its action on SH_2, & its hostility to low forms of life. When some of the liquified acid is poured into water it boils, and is so rapidly converted into vapour as to freeze the water.

Sulphuric anhydride. SO_2 when brought into contact with spongy platinum, cupric oxide, or even bricks, or earth, & heated; combines with another atom of O & changes into sulphuric anhydride [SO_3]. This may be shown by passing a mixture of dry SO_2 & O over spongy platinum contained in a red hot tube. The formation of SO_3 is made evident by a white cloud at the end of the tube. This cloud is on account of the formation of minute globules of $SO_2 Ho_2$ by the SO_3 attracting moisture from the air & combining with it. A modification of this process where spongy platinum was contained in large earthenware vessels & SO_2 introduced. If the process could be made to work well $SO_2 Ho_2$ could be produced more cheaply. But it was found that after some weeks the platinum clogged by the introduction of particles of inorganic dust & could not again be made serviceable without redissolving in aqua-regia & this was too expensive. Cupric oxide &c were then tried but not found to work well, and the process was finally abandoned.





process used by oxydising SO_2 with nitric oxyde (or nitrous)

$2SO_2$

Wednesday

$$2SO_2 + N_2O_4 + O = \begin{cases} SO_2(NO_2) \\ O \\ SO_2(NO_2) \end{cases}$$ white crystl comp.

In practice this comp not formed unless too much little steam;

$$\begin{matrix} SO_2(NO_2) \\ O \\ SO_2(NO_2) \end{matrix} + 2OH_2 = 2SO_2H_2O + N_2O_3$$

nitrous anhydride

$$3N_2O_3 + OH_2 = 2NO_2HO_4 + 2N_2O_2$$

nitric oxide

which immediately absorbs O & process begins again

Another process more usually employed for making SO_3 By heating nordhausen sulphuric acid, or one of its salts. It can also be easily prepared by depriving ordinary SO_2Ho_2 of its water by phosphoric anhydride. If the mixture be then distilled SO_3 volatilizes And cools as a white crystalline fibrous mass. Which must be sealed up from air if wanted to be kept. It possesses no acid properties when dry, & does not redden litmus paper. It forms several hydrates

$SOHo_4$	melts at 16°Cent	boils at
SHo_4	melts at 9°	boils at 207°
SHo_6	melts at	boils at 193°

Nordhausen acid is excluded from this list as being distinct from them. Basic salts may be looked upon as salts of acids having greater basicity than usual. (see above list) SO_3 is chiefly used in the laboratory as an absorber of oliffiant gas, & organic compounds called oliants, in analysis.

Sulphuric acid SO_2Ho_2 is the most important compound of S & O. It was discovered by Basil Valentine in the fourteenth century. It forms as it were a key to to many compounds which would otherwise be locked up for manufacturing purposes. It may be produced from SO_2 by various processes By exposing a solution of SO_2 aq to air it rapidly oxidises into SO_2Ho_2. It is in fact very difficult to keep a solution of SO_2. Sulphites also rapidly turn into sulphates. One of the most interesting processes is where SO_2 is directly combined with Ho_2

Heat of burning S or pyrites sometimes employed for generating the steam. (coal generally used in this country. For burning ~~abo~~ pyrites a kiln about 6 feet high and 4 or 5 feet broad. (square) Gaelssac tower.

acid which collects allowed to attain a specific gravity of 1·6 not more or it absorbs nitrogen drawn into leaden pans which are either evaporated by heat from below. or by reverberatory furnace. bottom heat soon destroys pans. ~~by~~ surface heat carries off more acid. evaporated to 1·75. Acid thus produced, (especially when from surface pans) known as brown acid ($SOHo_4$) cannot be further concent in Lead pans. must be carried on either in glass or Pt 1·815 (SO_2Ho_2) this improperly called rectified acid.

Platinum still costs from 4 to 6 thousand pounds, but found most ~~convenient~~ economical in the end

Thursday Nov. 18th.

When SO_2 & nitric peroxide are mixed without steam, a white crystalline feathery compound forms, which when acted upon by steam, decomposes with effervescence, into Sulphuric acid & nitrous anhydride. In the manufacture of SO_2Ho_2 this compound is never formed, unless the process is going on improperly, from want of sufficient steam. The nitric oxide formed immediately changes back into peroxide (N_2O_4) & oxidises fresh quantities of SO_2. And so on. The reaction is as follows.

$$2\,SO_2 + N_2O_4 + O = \begin{cases} SO_2(NO_2) \\ O \\ SO_2(NO_2) \end{cases}$$ this then

by the action of steam changes thus $\begin{matrix} SO_2(NO_2) \\ O \\ SO_2(NO_2) \end{matrix} + 2\,OH_2 =$

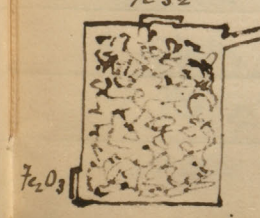
$2\,SO_2Ho_2 + N_2O_3$ and then the nitric anhydride

nitrous anhydride.

thus $3\,N_2O_3 + OH_2 = 2\,NO_2Ho + N_2O_2$. which

nitric oxide

immediately absorbs O and the process begins again. The SO_2 is usually obtained by burning iron pyrites, or poor copper pyrites in a square



SO_2 kiln, something like this, about about 6 feet high & 4 or 5 broad. The combustion once started is carried on by the pyrites alone. The heat of the

1 lb of S thus gives 3 lbs of SO_2Ho_2 of spec grav. .03 lb of sodic nitrate. Contains traces of nitric anhydride, lead, & Cl. Cl from use of sodic or potassic nitrate containg traces of sodic or potassic chloride.

$$SO_2(NH_4O)_2 + N_2O_2? = SO_2Ho_2 + 3OH_2 + N_2$$

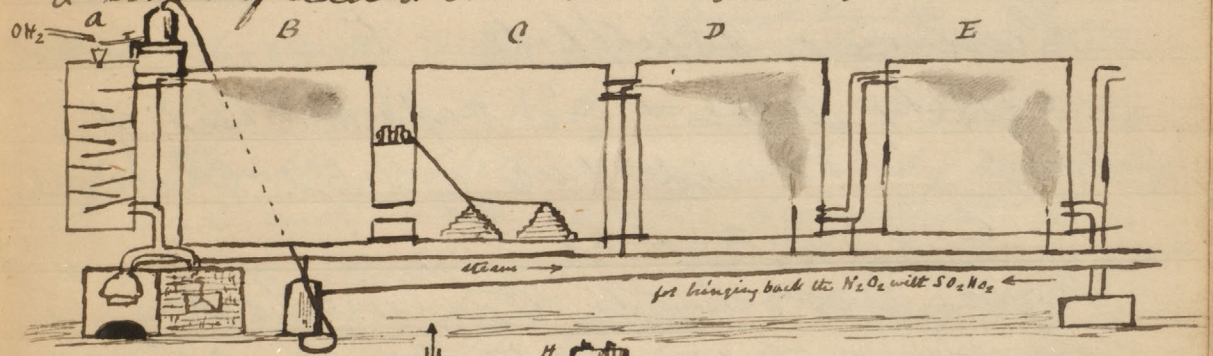
nitrous anhydride

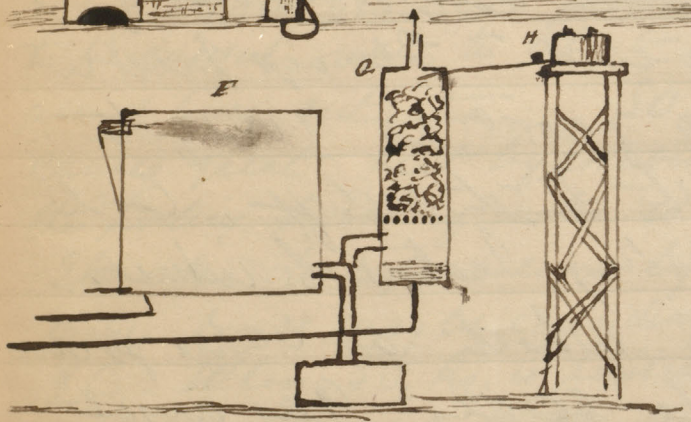
Cl cannot be ~~thus~~ got rid of by any practical process. only may be kept out by using pure NO_2Ho as already described.

SO_2 & Ag mixed in water gives great heat. Destroys sugar by its affinity for OH_2. Strength may be ascertained by tables of spec grav. but better by decomposing it ~~53 = 49~~ with a known weight of Carbonate of soda 5.3 of this denotes 4.2 of the dibasic SO_2Ho_2. Used in making salt Cake, Superphosphate of lime. Ammonic Sulphate.

Remaing comps of S with O & Ho are unimportant.

burning pyrites is sometimes used to heat the water, & produce the steam required in the process. But is is better to employ Coal, as the vapour of SO_2 corrodes the boiler. The manufacture of SO_2HO_2 is carried on in a series of leaden chambers as below.





a tower in which the strong SO_2 Rich (N₂O₂ in solution) is deprived of N_2O_2 by the net SO_2 & steam.
B first chamber.
C Chamber with cascades (Porcelain) down which NO_2HO is made to drip. To supply oxydiser for SO_2

D & E and F chambers in which the conversion of SO_2 into SO_2HO_2 takes place. (E & F have cooling boxes)
G coke tower through which concentrated SO_2HO_2 is allowed to percolate & absorbed the N_2O_2 which passes up through it. The product is lead back to a tank above a.
H tank of concentrated SO_2HO_2

1 lb of S thus, gives 3 of SO_2HO_2 & .03 lbs of sodic nitrate are employed in oxidising it

Selenium & Tellurium, resemble S very closely, and go through the same atomicities. Tellurium in gold found in Transylvania.

Carbonic disulphide. Carbon does not readily burn in S vapour. But if S vap be passed over ignited charcoal.

$$C + S_2 = CS_2$$

much less volatile than corresponding oxygen compound. Always prod in manufacture of coal gas & one of the most difficult to get rid off. Coal (with iron pyrites) heated to redness: looses some S which as vapor forms CS_2 with the coal. Gas ought not to contain more than 1 in 100 cubic feet.

Colourless liquid high refracting power insol in water. Highly inflam miscible with alcohol & ether. Is analogous of CO_2.

Commercial SO_2Ho_2 Contains traces of nitrous anhydride, lead, & Cl. The Cl arises from the use of sodic or potassic nitrate, containing Chlorides of these metals, which is invariably the case with the crude salts. The nitrous anhydride may be removed by the action of ~~nitrous anhydride~~ ammonic sulphate. Thus,

$$SO_2(NH_4O)_2 + N_2O_3 = SO_2Ho_2 + 3OH_2 + N_4$$

The Plumbic sulphate may be got rid of by diluting the acid with water & either decanting the pure acid off or, distilling it. The Cl cannot be got rid of by any practical process. The only way is to be careful not to let it get in. By the use of pure nitrates. SO_2Ho_2 mixed with OH_2 causes great heat by combining with. even above the boiling point of water is sometimes attained. It also decomposes sugar by its great affinity for water. Sugar may be considered a compound of OH_2 & C. When SO_2Ho_2 is poured into a strong solution of sugar, it abstracts the OH_2 & the sugar remains as a black frothy mass of C. The strength of SO_2Ho_2 may either be ascertained by taking its specific gravity & calculating it by proper tables, or, more accurately by saturating it with a known weight of $CONa_2O$", and thus calculating its acid power. 5.3 of $CONa_2O$ denote 49 of the dibasic Sulphuric acid (SO_2Ho_2).

Bromine. present in sea water in water of certain brine spring in bittern. In waters of dead sea. also in small quant in molluscs. Manufactured from bittern, from salt works in Germany and Austria. Concen and Magnesic Salts cryst out. Then treated by ~~brom~~ Cl & sodic Br decomposed into NaCl. Br may be distilled over but forms comp with C Thus found better to dissolve it in ether. This sol drawn off and treated with with NaHO or OKH, combines & ether decanted off. Bromate & Bromide bromates decomposed by heating to redness Then heated with MnO_2 & SO_2HO_2 & free Br obtained.

Ac OH_2 hot or cold

acids

alkalis

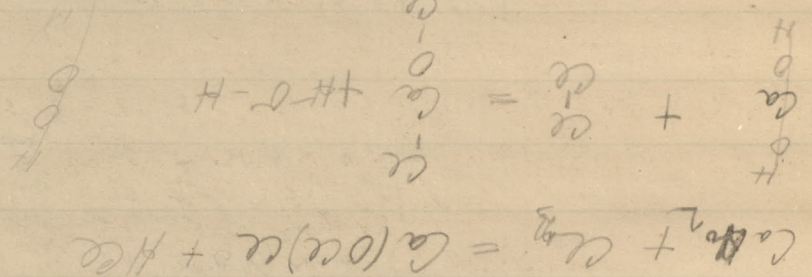
Alcohol

To convert Cent into Farh $\frac{9}{5}$ n° + 32 F

Farh n°F = $\frac{5}{9}$ (n° − 32) C

Molecular combination

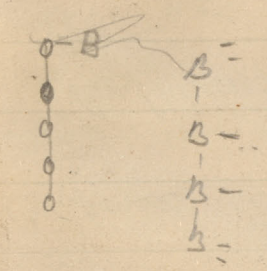
Iodic chloride dissolved at 10°C NaCl $2OH_2$

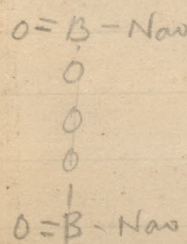


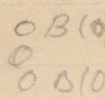
Basic salts

Carbonic acid CO_3H_2 { Malachite $CO_3.H_2Cu''_2$; Blue cupric carbonate $C_2O_8H_2Cu''_3$

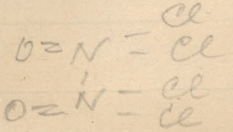
Sulphuric acid SO_4H_2 { Tribasic cupric sulfate $SO_8H_4Cu''_3$; Emplectite mineral $SO_6H_5{}''_3$







$NO_2Ho \quad NH_3$

$NO_2Ho + 8H = NH_4Ho + 2OH_2$

$N_2O_2Cl_4$