

*Sulphuret of Antimony
Metallic Dots*

*Chromate of Iron. Heat with salt potash to form
nitrate of Iron & Chromate Potash*

*Chrom^m discov^d in Siberia in red Lead ore
but thro^g to be red oxide of Lead -*

*A very extensive deposit Chromate of Iron
in Bone Hills near Baltimore. -*

Say nothing abt^t its coloring properties here.

...ive, but more fre
...plur, iron, cobalt,
...It is exceedingly
...tre, a crystalline
...At 356° it sublimes
...in condensing cry
...fusing point has r
...gravity is 5.88.

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170. Chroma
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Chromium is a
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open air.

Krupke
Cotton

Thirty

CHROMIUM.

tive, but more frequently in combination with sulphur, iron, cobalt, and other metals.

It is exceedingly brittle, has a bright metallic lustre, a crystalline structure, and a steel-gray colour. At 356° it sublimes slowly without liquefying, and in condensing crystallizes in rhombohedrons. Its fusing point has not been ascertained. Its specific gravity is 5.88. Its vapour has a strong odour of garlic. It tarnishes by exposure to the air, and when heated in contact with oxygen, is rapidly converted into a white oxide.

169. *Antimonium*.—Antimony was discovered in the 15th century, by Basil Valentine. It is sometimes found native, but its principal ore is the sulphuret, from which it may be obtained, by heating the powdered ore, with half its weight of iron filings, in a covered crucible. Antimony is a brittle metal, of a light bluish gray-colour, having a lamellated structure. It possesses considerable metallic lustre, which tarnishes by exposure to the air. Its specific gravity is 6.7. It fuses at 810°, and may, by very slow cooling, be obtained in crystals, the primitive form of which is a rhombohedron.

name perhaps black
Lead

When heated to a white heat in a covered crucible, and then suddenly exposed to the air, it takes fire and burns with a white light, and with the formation of white vapours that condense into small acicular crystals having a silvery lustre.

170. *Chromium*.—Chrome was discovered in 1797, by Vauquelin. The principal ore of chrome is its combination with iron. It is also found united with lead.

Chromium is a brittle metal, almost infusible, of a yellowish white colour, and a distinct metallic lustre. It is scarcely acted on by the most powerful acids. Its specific gravity is 5. It is also obtained in the form of a black powder, which acquires a metallic lustre by pressure, and takes fire when heated in the open air.

Taken name from black
Kruppa after great variety of
colours of its oxides

form
to Potash

lead ore

Lead

Antimony

171. *Vanadium*.—Vanadium was discovered in 1830, by Sefström in Swedish iron, although its existence as a distinct metal had been announced in 1801, by Del Rio, of Mexico. Vanadium is found combined with iron and with lead. It has generally been obtained from its ore in the form of a heavy black powder, which assumes, under a strong pressure, a lustre like that of graphite, and which takes fire at a red heat. It may also be obtained in a crystalline mass, having a brilliant metallic lustre, and a white colour, and which is so brittle, that it falls to powder upon being moved. It is not oxidised by air or water at common temperatures.

172. *Molybdenum*.—Molybdenum was announced as a distinct metal in 1778, by Scheele, who did not, however, succeed in separating it from its ore. It is usually found combined with sulphur, or with lead.

It is a brittle, grayish white, and almost infusible metal. Its specific gravity is 8.6. When heated in open vessels, it combines with oxygen and forms an acid. *is graphitic like black lead*

173. *Tungstenum*.—Tungsten is so called from the Swedish words, *tung sten*, heavy stone, on account of the density of its ores.

It is a metal of a grayish white colour, having a brilliant lustre. It is nearly as hard as steel, and almost infusible. Its specific gravity is 17.6. It takes fire when heated in the open air.

174.—*Manganeseum*.—Manganese was first obtained in a metallic state by the Swedish chemist, Gahn. It is found combined with oxygen in the form of a black oxide. It is a hard, brittle metal, of a grayish-white colour, and granular structure. Its specific gravity is 8.013. It is exceedingly infusible; tarnishes by exposure to the air; absorbs oxygen rapidly when heated to redness, and slowly decomposes water at common temperatures.

175. *Titanium*.—Titanium was discovered by

Chromate

*Chromate
but the*

*a very
in base
say*

Vanadium a Scandinavian Ditty

from $\mu\alpha\lambda\upsilon\beta\delta\omicron\varsigma$ Lead - is graphite - hence perhaps black
~~after Wolfram~~ Lead

after Wolfram, tho' that is Tungstate
of Iron & Manganese

to be found of origin of its name

From Titan ~~iron~~ son of Atlas & Perce

originally the Latin
word for a compound
of Tin & Silver - but
after 14th Century applied
to Tin alone. -

Stannic in English
Tin works
Stannic Lead &c

From Columbia friend of Allen.

from our own same as Caelus most
ancient of gods - or Urania
The Muse presiding over astronomy.

Klaproth. It is found combined with oxygen in the mineral called rutile, or titanite. It has been obtained in the state of a deep blue-coloured powder, that takes fire in warm air.

Metallic Titanium is also found in minute cubic crystals, in the slag of certain iron works. These crystals have a bright metallic lustre, and the colour of copper. Their specific gravity is 5.3. They scratch rock crystal, and are exceedingly infusible. Exposed to hot air, they become covered with a purple film.

176. *Columbium*.—Columbium was so called by its discoverer, Hatchett, who obtained it in 1801, from a mineral found at New London, in Connecticut. Two years afterwards, Ekeberg obtained it from a Swedish mineral, and called it Tantalum. The identity of the two metals was proved by Wollaston in 1809.

Columbium is obtained in the form of a black powder that is a non-conductor of electricity, but which acquires a metallic lustre and an iron-gray colour, and becomes a conductor by pressure. It takes fire below redness, and burns with a vivid light. Its specific gravity and fusing point are not known.

177. *Uranium*.—Uranium was obtained by Klaproth in 1782, the year in which the planet Uranus was discovered, and received its name from this coincidence. Its properties are imperfectly known. It has been obtained by conducting hydrogen gas over its protoxide heated in a glass tube. The substance thus obtained, which was supposed to be metallic uranium, was crystalline, of a metallic lustre, and a reddish-brown colour. It suffered no change by exposure to air at common temperatures, but when heated, absorbed oxygen, and was reconverted into the protoxide.

178. *Osmium*.—Osmium is found in native platinum, from which it has been obtained in the state

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 in very small quantity
 ore very scarce - little
 quite unobtainable.
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 Urania
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of a black powder, that acquires a metallic lustre by friction. Its specific gravity varies from 7 to 10, according to its mode of preparation. It takes fire when heated in the open air, and is dissolved by fuming nitrous acid. †

179. *Stannum*.—Tin was known to the ancients. It is found combined with oxygen, and is procured from its ore by the aid of heat and charcoal. ‡

Tin has a white colour, and a lustre resembling that of silver, tarnishing very slowly by exposure to the air. It is so soft that it may be cut with an iron knife; it is inelastic and malleable. When bent backwards and forwards it emits a peculiar crackling sound. Its specific gravity is 7.2. At 442° it fuses, and its surface becomes covered with a gray powder. At a white heat it takes fire and burns with a white flame. It may be beaten into leaves of the thickness of the $\frac{1}{1000}$ th of an inch.

180. *Aurum*.—This metal has been known from the remotest antiquity. Gold is found in metallic grains among sand in the beds of rivers, and crystallized in octahedrons and cubes in rocky veins.

It is the only metal of a yellow colour. Its specific gravity is 19.257. It has a brilliant metallic lustre, which is not tarnished by the longest exposure to air and moisture. In ductility and malleability it surpasses all other substances. A grain of gold may be extended so as to cover 52 square inches, with a thickness not exceeding $\frac{1}{33000}$ of an inch, in which state it appears green by transmitted light. A grain of gold may also be drawn into a wire 550 feet long. Gold is very tenacious, though inferior in this respect to iron, copper, platinum, and silver. When pure it is exceedingly soft and flexible. It fuses at 2016°, and is not oxidated by being kept for months in a state of fusion in an open vessel. By means of the oxyhydrogen blowpipe, or the galvanic battery, it may be set on fire, and burns with a greenish blue flame.

originally the Latin
word for a compound
of Tin & Silver - but
after 4th Century applies
to Tin alone. -

Stanneries in England
Tin works
Stannaria Lanes &c

+ Its peroxide is extremely volatile and has a peculiar pungent odour (a circumstance not common to metallic oxides,) & from which its name is derived 95/17 odour - Is found in very small quantity and therefore very scarce - little known & quite unappreciated.

≠ Is a metal much less generally distributed in the world than many others - Its chief localities being in the S W extremity of England, viz Cornwall and Devonshire and in Malacca Banca Sumatra and certain East India Islands - also, tho' to no great extent in Mexico - No location of it yet discovered in U States. - Is never found native, and its ores have no metallic character except weight.

The metal is called Black & Grain Zinc - The former obtained from Vines & the latter (an oxide) from Steam works.

Gold combines most readily & completely with Mercury forming an amalgam & upon this principle depends the method of getting this metal & metal as also from it over as will be described at p. 178

16 Metals neither acids or alkalis
but heavy melting & gradually oxidized
2nd group or class begins. Platinum

+ but does not as a matter of course accompany
Gold, which is much more generally distributed
than Platinum - for instance Gold is distributed
in a N.E. & W. direction thro' the whole length
of N. America - But not a single deposit of
Platinum has been found in any part of it.

Humboldt in his last work on Asia says that
one Mass weighing 2 1/2 lbs was found near Nijni
Tagilek in the Uralian Mts. Humboldt in
Harper's Family p 353

from Pallas or Minerva

See my specimen in Bottle in plate Stat
14 dwts 9 grs @ 8.75

Gold is readily
181. Platinum
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Gold is readily dissolved by chlorine and fluorine.
 181. *Platinum*.—This metal is found in Brazil, Peru, and the Uralian Mountains. It was discovered by Ulloa, in 1705. Platinum occurs only in a metallic state, in the same localities with gold.

Platinum is a metal of a white colour, which is less pure and brilliant than that of silver. It is, after iridium, the heaviest known substance, having a specific gravity of 21.25. It is a very soft, malleable, and ductile metal, and like iron, admits of being welded at a high temperature. It is a less perfect conductor of heat than several other metals. Like gold it undergoes no change by exposure, for any length of time, to air and moisture, and it is not melted or oxidated in the strongest heat of an air furnace, although it is fused by galvanism and the oxyhydrogen blowpipe. Chlorine is its only solvent.

Platinum is precipitated from its solution in chlorine in the form of a gray metallic powder. This powder possesses the remarkable property of effecting the inflammation of a mixture of hydrogen and oxygen gases. If a current of hydrogen gas be directed upon a small mass of this powder, it renders it red-hot, and soon takes fire. This property is possessed, in a less degree, by the thin leaf, the fine wire, and the filings of platinum, by gold, nickel, and several other metals. When the native platinum is digested in nitro chlorohydric acid, the solution is found to contain chlorides of platinum, palladium, and rhodium, and there is left a black powder which consists of osmium, iridium, and other metals.

182. *Palladium*.—This metal was discovered in 1803, by Wollaston. It exists in small proportions combined with native platinum.

It resembles platinum in colour and lustre, but is much harder and more fusible. It is ductile and malleable; its specific gravity is 11.3 to 11.8. It is unalterable by exposure to air and moisture, and is

one of its salts, and when dissolved in water,

2 colours of its

Krupfer

of German Ullian
 Kupfer nickel,
 copper, because
 it is to be of copper

Gold is readily dissolved by chlorine and fluorine.

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Kupfer nickel,
Kupfer, because
it is to be of copper

oxidized and dissolved, by nitric, sulphuric, and chlorohydric acids.

183. *Rhodium*.—Rhodium was discovered by Wollaston, in 1803. It exists in combination with native platinum.

It is a brittle, extremely hard metal, of a white colour, with a specific gravity of about 11. It is not attacked, when pure, by any of the acids, and requires the strongest heat of a wind furnace for its fusion.

184. *Iridium*.—This metal is found in combination with native platinum. It was discovered along with osmium in 1803, by Tennant. It is so brittle, that it falls to powder when burnished. Its colour is that of platinum, and it is the heaviest and most infusible of all the known metals. Its specific gravity has been recently determined by Dr. Hare to be 21.8. It is acted upon with difficulty by the acids, and when finely divided is oxidated at a red heat.

185. *Nickelium*.—Nickel is found in combination with arsenic and sulphur, and is also a constituent of those masses of native iron, which are supposed to be of meteoric origin.

It is highly ductile and malleable, has a brilliant metallic lustre, and a white colour intermediate between tin and silver. Its specific gravity is 8.279, which rises to 9, when hammered. It is attracted by the magnet and is susceptible of permanent magnetism, but loses this property at 630°. It is fusible with difficulty, and suffers no change by exposure to air and moisture at common temperatures.

186. *Argentum*.—Silver was well known to the ancients. It is found native, and in combination with many other metals, and with sulphur.

It is of a clear white colour, and exceeds all the pure metals in brilliancy. It is very soft, malleable, ductile, and tenacious. It crystallizes in octohedrons, and cubes. It may be beaten into leaves of the thick-

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Platinum
Humboldt
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Робор

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родов a Rose from the colour of some of its salts, and
particularly its chloride when dissolved in Water.
See my specimen in Bottles.

Iris the rainbow, from the variety of colours of its
oxides & solutions.

Specimens in Bottles - Pure & Kupfer
Nickel a term of detraction among German Miners
associated with Kupfer, or Kupfernickel,
meaning good for nothing copper, because
its ore was at first thought to be of copper
& yet it yielded none

X Mercury has the power of completely dissolving even without the assistance of any artificial heat - Gold Silver Copper Tin Lead Zinc & several other metals, in indefinite quantities, producing an Amalgam which go by the name of the metal taken up - No combination however takes place with Iron Steel or Platinum. Upon this, several useful processes depend, which will be described hereafter p. 178

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ness of $\frac{1}{100000}$ th part of an inch, and drawn into a wire thinner than a human hair: a wire $\frac{1}{8}$ th of an inch in diameter will support 270 lbs. Its specific gravity is 10.474. to 10.51. It melts at a full red heat, and by an intense and long continued heat may be made to boil and evaporate away. Melted silver will absorb 22 times its volume of oxygen, with which it parts when becoming solid. In cooling from its fluid state, silver becomes covered with minute granulations in consequence of the escape of the oxygen, which it had absorbed. One or two per cent of copper destroys this property. It does not alter by exposure to air and moisture. In the galvanic circuit and the oxyhydrogen blow pipe, silver burns with vivid scintillations, and a light green flame.

Silver forms an insoluble compound with chlorine, which thus furnishes a ready test of its presence. It is dissolved freely by nitric acid. *is got from ore same as Gold.*

187. *Hydrargyrum.*—This metal was well known to the ancients. Mercury or quicksilver is found native in small quantities; its principal ore is its combination with sulphur. *not used in chem is by I why? -*

It is distinguished from all other metals by its fluidity at the common temperature. It has a white colour like that of tin, and a brilliant metallic lustre. At -39° or -40° , it becomes solid, and in congealing has a tendency to crystalize in octohedrons. Solid mercury is malleable and ductile; its specific gravity is 15.612, while that of the fluid is 13.568. At 662° it enters into ebullition and evaporates. Mercury is not altered by exposure to air and moisture at common temperatures. It is dissolved by chlorine, and by nitric and sulphuric acids. *hot* — +

188. *Bismuthum.*—Although this metal was known to the ancients, it was confounded by them with tin and lead. Bismuth is found native, and in combination with sulphur, oxygen, and arsenic. — ⊕

It has a reddish-white colour, and considerable

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⊕ called by old
german writers
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metallic lustre. Its structure is highly lamellated, and it crystallizes in octohedrons and cubes. Its specific gravity is 9.8. It is brittle when cold, but may be hammered into plates when warm. At 476° it fuses, and at a red heat sublimes in close vessels, and burns with a bluish white flame in open ones. It conducts heat more slowly than most other metals. When fused it becomes covered with a gray film of oxide, and it is not much altered by exposure to air and moisture at common temperatures.

189. *Plumbum*.—Lead was known to the ancients. It is generally found combined with sulphur, in the ore called galena.

It is of a bluish-gray colour, and a brilliant metallic lustre, which speedily tarnishes by exposure to the air. It is very soft, flexible, and non-elastic, and is ductile, and highly malleable. It is the least tenacious of the ductile metals. Its specific gravity is 11.351. It fuses at 612° , but does not sublime at a white heat. When cooled slowly it forms octohedral crystals. Lead absorbs oxygen quickly at high temperatures, and becomes covered with a film of oxide.

190. *Zincum*.—Although the ancient Greeks and Romans were unacquainted with zinc, they used its ore, calamine, in the manufacture of brass. Zinc has long been known to the Chinese, but the method of extracting it from its ores was not known in Europe till the middle of the eighteenth century. Zinc is found in combination with sulphur in the mineral called blende.

It has a brilliant metallic lustre, a bluish-white colour, and a highly lamellated crystalline structure. Its specific gravity is 7. It is a hard metal, being acted upon with difficulty by the file. At low and high degrees of heat, it is brittle, but between 210° and 300° it is both malleable and ductile. It fuses at 773° , and when slowly cooled, crystallizes in four

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Griffin Morgan of the Eastern Shore of Va
reports that Colver will weld & about
Augth 1841 obtained a patent for this his
invention

will be described hereafter p 178

or six-sided prisms. In close vessels it sublimes unchanged at a white heat, and when heated to a red heat, in a covered crucible, bursts into a flame when the cover is removed, burning with a brilliant white light, and being converted into a white flocculent powder.

Zinc undergoes little change by the action of air and moisture, but is rapidly acted upon by diluted sulphuric acid.

191. *Cadmium*.—Cadmium was discovered by Stromeyer, in 1817. It is found in combination with the ores of zinc.

It resembles tin in colour, lustre, and fusibility, but is harder and more tenacious. It is very ductile and malleable; its specific gravity is 8.604 to 8.694. It is nearly as volatile as mercury, and its vapour condenses in globules of bright metallic lustre. It absorbs oxygen in the open air, and is readily dissolved by nitric acid.

192. *Cuprum*.—Copper has been known from the earliest ages. It is found native and combined with sulphur. It is distinguished from all other metals, except titanium, by its red colour. It has a brilliant metallic lustre; it is ductile, malleable, highly tenacious, hard, elastic, and sonorous. Its specific gravity is 8.895. It fuses at 1996° F. being more fusible than gold, and less so than silver.

It is slowly oxidated by exposure to the air; nitric acid acts upon it with violence. At a high temperature copper takes fire and burns with a rich green flame. It is one of the best conductors of heat known; melted copper volatilizes water so rapidly as to occasion dangerous explosions, when it is poured into vessels containing the smallest portion of moisture. It does not decompose water at any temperature.

193. *Ferrum*.—Iron is the most abundant of all the metals; it is found in native masses of considerable magnitude, which are supposed to be of meteoric

1835 lbs from
Van
Geo Gibbs

1835 lbs from
Van
Geo Gibbs

origin. It is also found in combination with other metals, and with sulphur, and with oxygen, which last are its most abundant ores.

It has a peculiar gray, or bluish-white colour, and a bright metallic lustre, which is much increased by polishing. It is very ductile and malleable, and the most tenacious of all the metals. Its specific gravity is 7.7; its texture is fibrous, and it requires for its fusion the highest temperature of the wind furnace. At common temperatures it is very hard and unyielding, but at a red heat it becomes very soft and pliable, so that two pieces may be incorporated or *welded* together by hammering. It is attracted by the magnet, and may be rendered permanently magnetic. It is rusted or oxidated by exposure to the air and moisture; and is rapidly dissolved by dilute sulphuric acid. Iron is the only metal which takes fire by collision with flint. It becomes hot, and may be heated to a red heat by percussion. It burns with vivid scintillations in oxygen gas, and a bar of iron heated to a full white heat, may be made to burn in the open air by rapidly whirling it round. A circular disc of soft iron, made to revolve in a lathe, will cut the hardest steel, without being itself worn away.

When it is first obtained from its ores in the form of *cast iron*, it contains many impurities, such as carbon, and other metals. Cast iron fuses much more readily than pure iron, and acquires a granular texture in cooling. There are two kinds, the white and the gray; of which the former is exceedingly brittle, and the gray more soft and tenacious. The difference between them appears to be owing to changes dependent upon the rapidity of their cooling; for the former is converted into the latter by being strongly heated and slowly cooled.

When bars of the purest malleable iron are exposed for several days to a full red heat in contact with

how the
will be described hereafter p 178

Stident to prevent sheet rust by ^{slight} ~~slight~~ ^{gilding}

describe Meteoric Stones.

Iron & Nickel

Barrow's Journal p 229

Poling of Limestone

1000 weight 1635 lbs from
Lucca in Yale College
from Geo Gibbs

MINERAL.

combination with oxygen, which

sh-white color, and is much increased in malleability, and its

Its specific gravity is 7.8, and it requires for its fusion

of the wind furnace, very hard and unyielding, very soft and pliable

incorporated or welded together, attracted by the magnet

permanently magnetic, exposure to the air and

oxidized by dilute nitric acid, which takes fire, becomes hot, and may be

ion. It burns with a blue flame, and a bar of iron may be made to burn in it round. A circle in a lathe, will being itself worn

ores in the form of impurities, such as iron, fuses much more easily

as a granular mass, the white and exceedingly brittle, porous. The difference

owing to changes in cooling; for the iron being strongly

iron are exposed in contact with

a rich vein of Cobalt was discovered
at La Motte, Madisonian Co. in
Missouri in March 1844 - It had
been supposed for several years to be
Black oxide of Copper

from Greek word λανθάνω I lurk because it
was long concealed in ores of Cerium

3rd Group has 5 metals - 1st Aluminium
base of earths

Upon the
will be described hereafter p. 178

combined charcoal, the
intermediate
contains 1.3 to 1.75
in ductility and
greatly exceeds it in
ductility. Its texture
is susceptible of the high
than pure, and less s
steel by fusion.

Although cast iron
class of simple elements
exhibit the properties
render it most common
place.

194. Cobaltum.
by a Swedish chemist
name from Kobold
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Cobalt is a brittle
granular and soft
metallic lustre
point of iron, and
slow cooling. Its
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195. Cerium, C
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Very little is kno
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196. Aluminu
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It is obtained
small scales of

powdered charcoal, they are converted into *steel*, a substance intermediate between pure and cast iron. It contains 1.3 to 1.75 per cent of carbon, is far inferior in ductility and malleability to pure iron, but greatly exceeds it in sonorousness, hardness, and elasticity. Its texture is more compact, and it is susceptible of the highest polish. It is more fusible than pure, and less so than cast iron, and forms *cast steel* by fusion.

Although cast iron and steel do not belong to the class of simple elements, yet the modifications they exhibit of the properties of iron are so slight as to render it most convenient to treat of them in this place.

194. *Cobaltum*.—Cobalt was discovered in 1753, by a Swedish chemist, named Brandt. It derives its name from Kobold; an evil spirit—a term applied to its ore by the German miners, before they were acquainted with its value.

Cobalt is a brittle metal, of a reddish-gray colour, a granular and sometimes lamellated structure, and feeble metallic lustre. It fuses below the melting point of iron, and crystalizes in irregular prisms by slow cooling. Its specific gravity is 7.834; it is feebly, but permanently, magnetic; it is slowly oxidized by heat and air, and burns in the oxyhydrogen blowpipe with a rich red or purple flame.

195. *Cerium, Lantanium*.—Cerium, named after the planet *Ceres*, was discovered by Berzelius, in a rare Swedish mineral; and Lantanium has recently been discovered in the same mineral by Mosander. Very little is known of their properties. Cerium has been obtained in minute grains as large as a pin's head, and is a white brittle metal.

196. *Aluminium*.—Aluminium is the metallic base of alumina, one of the most abundant of the earthy oxides. *quite white as pipe clay but green*
It is obtained in the form of a gray powder, or small scales of the lustre and colour of tin. It re-

collected at 1/167

Abundant in Russia
used for killing flies

Spec. in Bottle -

metals, the bases of
in Earthy.

ity of Natolia and

colony tinged with Iron

quires a greater heat than cast iron does, to fuse it. When heated to redness in the open air, in oxygen, or in chlorine gas, it takes fire and burns with a very vivid light. It is malleable and ductile, and is not tarnished by exposure to air and moisture at common temperatures.

197. *Yttrium*.—Yttrium is the metallic base of an earth found at Ytterby, in Sweden, and called from that circumstance Yttria.

Yttrium has been obtained in the form of metallic scales, of a grayish-black colour, and metallic lustre. It is brittle, and burns with splendour when heated to redness in atmospheric air.

198. *Glucinium*.—Glucinium is the metallic base of an earth called glucina, which has hitherto been found only in a few rare minerals, of which the emerald is the best known. Glucinium has been obtained in the form of a grayish-black powder, which acquires a dark metallic lustre by burnishing. It is not oxidised by exposure to air and moisture, but takes fire at a red heat in atmospheric air and in chlorine, and burns with great splendour.

199. *Thorium*.—Thorium is the base of an earth which has been found in a rare Norwegian mineral called thorite. It resembles glucinium in its properties.

200. *Zirconium*.—Zirconium is the base of the earth zirconia. It has been obtained in the form of metallic scales, although little is known of its properties.

201. *Magnesium*.—Magnesium is the base of the alkaline earth magnesia.

It has a brilliant metallic lustre, a white colour like silver, is very malleable, and fuses at a red heat. It is superficially oxidated in a moist atmosphere, but undergoes no change in dry air, or by boiling with water. It inflames spontaneously in chlorine, and burns brilliantly when heated to redness in the open air.

When this
will be described hereafter p 178

Its oxide clay & uses & porcelain at p 167

Abundant, in Russia
used for killing flies
in Bottle -

4th Group
Magnesium 4th Group of 4 metals, the bases of
the Alkaline Earths.
from Magnesia ancient city of Naticolia Asia
also tinged with Iron

x therefore no similitude to Lead as once supposed

The 5th & last group is the base of the Alkalies
11805 a stone

‡ which alkali will be described under vegetable
chemistry see page 225.

See specimen 24 of Smith & Hodgson 1846

x obtained only from Rourning Vegetables or Woods
notwithstanding which its base is a metal -
The nature of this alkali Potassa will be fully
described as well as its mode of preparation
in Vegetable chemistry see page 224

202. *Calcium*.—Calcium is the metallic base of lime, and is a metal of a white colour, whose other properties are unknown.

203. *Strontium*.—Strontium is the metallic base of the earth, strontia; very little is known of its properties.

204. *Barium*.—Barium is the base of the earth baryta.

It is a metal of a dark gray colour, with a lustre inferior to that of cast iron. It sinks rapidly in strong sulphuric acid, and attracts oxygen with avidity from the atmosphere. It rapidly decomposes water, which it causes to effervesce strongly by the disengagement of hydrogen gas. ✕

205. *Lithium*.—Lithium is the metallic base of an alkali, called lithia, which enters into the composition of the mineral *petalite*, and of several varieties of mica. It is a white metal, and little is known of its properties.

206. *Sodium*.—Sodium is the metallic base of the alkali, soda. ✕ Its combination with chlorine is common salt.

Sodium has a strong metallic lustre, and resembles silver in colour. It is so soft and ductile at common temperatures, that it may be moulded into any shape with the fingers. It fuses at 200° , and volatilizes at a red heat. Its specific gravity is .972.

It speedily tarnishes by exposure, and is instantly oxidated by water. When the water is warm, the sodium takes fire in consequence of the heat which is disengaged, and burns vividly.

207. *Potassium*.—Potassium is the metallic base of the common vegetable alkali, potassa. ✕

It was discovered in 1807, by Sir Humphrey Davy, who decomposed potassa by means of a powerful galvanic battery, in the commencement of those celebrated investigations, which led to the discovery of the metallic bases of the other alkalis and earths.

Combustible
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 1808
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 must be 3
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 knowing it by Galv.
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 the external
 he cannot create
 nor can he annihilate
 ted, consequently
 will appear that all
 still must be the same

Potassium is solid at the ordinary temperature. At 70° it is somewhat fluid, and becomes perfectly so, at 150°. At 50° it is soft like wax, and yields to the pressure of the finger. At 32° it becomes brittle. Its texture is crystalline; in colour and lustre it resembles mercury, and its specific gravity is .865. It is opaque, and conducts heat and electricity.

Its affinity for oxygen is so strong, that it rapidly oxidizes in the air, and must therefore be preserved in glass tubes hermetically sealed, or under naphtha, or some other liquid which does not contain oxygen. When heated, in the open air, it takes fire and burns with a purple flame. It decomposes water on the instant of touching it, and so much heat is disengaged, that the potassium takes fire, and burns vividly, at the same time inflaming the hydrogen gas which is disengaged.

When plunged under water, a violent reaction takes place without light, and pure hydrogen gas is evolved.

CHAPTER II. *p. 144 Journey*

OF COMBINATION.

208. The simple substances described in the last chapter, are the elements from which, in virtue of their mutual affinity, are formed all the various compounds in nature.

209. *Constitution of Bodies.*—A compound substance, so long as it retains the same properties, always consists of the same elements united in the same proportions. This is the essential law of chemical affinity, and is the only certain foundation of the science of Chemistry. † Water, as we have seen, is a compound of oxygen and hydrogen. It is evi-

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water
the

Heat what flows & Rapid Combustion

What Flame

Davy's Lamp

Strontia in Argyleshire
Scotland where 1st found

Light its agency & Colors Barrow

Electricity how Invented? - Heat & Decomposition

Affinity its elective must be 3
double elective 4

combination

only those Davy's apparatus
for producing it by Galv.

+ we may add further to this that however much
the operations of man may change the external
appearance and character of things, he cannot create
or produce any new element, nor can he annihilate
any element that previously existed, consequently
notwithstanding any change, we may rest assured that all
the original elements of a thing are still present & as were

and therefore, with propriety, called their *combining numbers* or their *chemical equivalents*.

211. ~~Law of Multiple Proportions~~.—In many instances, there are several combinations in different proportions of the same elements. Thus there are five compounds of oxygen with nitrogen, and two with iron. In all such cases the proportions of the several elements vary by a very simple law. It commonly happens that one only of the elements is increased in quantity, and this always increases by a simple multiple. Thus in the several compounds of oxygen and nitrogen, that in which there is the least oxygen consists of 8 parts by weight, of oxygen and 14.15 of nitrogen. The second consists of 16, the third of 24, the fourth of 32, and the fifth of 40 parts of oxygen, to the same quantity 14.15 of nitrogen. On the other hand, the first combination of iron with oxygen, contains 28 of iron and 8 of oxygen; and the second $28 \times 2 = 56$ of iron, and $8 \times 3 = 24$ of oxygen. The lowest of these combinations must be conceived to consist of a chemical atom of oxygen, united with one of nitrogen, or of iron; while the others contain 2, 3, 4 or 5 atoms of oxygen united with one of nitrogen, or 3 atoms of oxygen with two of iron.

The views above given of the definite nature of chemical compounds, receive the strongest confirmation from the laws which regulate the union of gases. All the known gases combine either in equal volumes, or in volumes which are in the simple ratio of 1 to 2, 1 to 3, 1 to 4, 2 to 3, 2 to 5, &c., nor can they be made to unite in any intermediate fractional ratio. For example, 50 measures of oxygen unite with 100 measures of hydrogen to form water; 100 measures of nitrogen unite with 50 of oxygen to form protoxide of nitrogen, and with 250, to form nitric acid.

212. *Equivalent Numbers*.—These combining numbers represent not only the composition of these

2 oxides of Lead

of the 1st

1 to 2

1 to 2

as 1 to 5

x

* I prefer calling these
Combining Nos instead
of Equivalent numbers
Representation Nos
because a. v. names

Equivalent Nos refer to the
Substitutes of one thing for another
See list of substitutes p. 215

compounds, but the proportions in which they themselves unite to form more complex combinations. Thus five atoms of oxygen and one of nitrogen form the substance called nitric acid, the combining number of which is the sum of the weights of its elements, that is $5 \times 8 + 14.15 = 54.15$. One atom of oxygen, and one of potassium, form the substance called potassa, the combining number of which is 47.15; and one atom of nitric acid and one of potassa, unite to form the salt called nitrate of potassa, the atomic weight or combining number of which is $54.15 + 47.15 = 101.3$. This law applies to the most complex combinations. The combining or atomic weight of any substance whatever, is the sum of the weights of the simple atoms that compose it; and these numbers, or their multiples, express in all cases, the proportions in which the bodies combine.

213. The lowest combination of oxygen with iron, is in the proportion of 8 to 28, and the next highest, of 12 to 28. If we regard 8 as the weight of an atom of oxygen, 12 must represent an atom and a half, which is manifestly an impossible quantity. It is found likewise, that when this oxide enters into combination, its combining number is 80, and not 40; and we must therefore suppose that it is formed of three atoms of oxygen and two of iron.

214. There is a combination of sulphur and oxygen (the hypo-sulphurous acid) in the proportions of 16.1 to 8, and of which the combining number might be supposed to be 24.1. It is found that this acid unites with a single atom of oxides to form salts, and that its combining number is always 48.2, and not 24.1. It is therefore inferred, that it is a compound of two atoms of each of its elements. These examples prove that the actual combining number of a body cannot be ascertained from mere theory, without ascertaining the fact from experiment.

primitive element

*Wollaston's scale
of them
back
to be 138
gains*

*of 1 1/2 to 1 - tho' the
fraction is avoided
explain this further
by reference to notation
of vulgar fractions 1/2*

2/4 3/6 6/12 all alike

*and as their chemical
was refer to proportions
only & not to any thing
definite, the referre
not may be allowed
like measure.*

215. *Proximate and Ultimate Elements.*—It is easy to determine the proportions of the simple ultimate elements that enter into the composition of a complex body. It is far otherwise when we attempt to ascertain the nature of the proximate elements, as they are termed, of these compounds. What, for example, is the true constitution of the salt called nitrate of potassa? It is formed, as we have seen, by the union of nitric acid with potassa; and we may conceive these to be its proximate elements; or we may imagine the six atoms of oxygen, the atom of nitrogen, and that of potassium which it contains, to be combined in various other ways, so as to render it, theoretically, a substance belonging to an entirely different class. So, likewise, there is a salt which contains six atoms of oxygen, one of nitrogen, and one of lead. Now we may conceive this salt to be the nitrate of the protoxide of lead, ($PbO + NO_5$), or the nitrite of the deutoxide, ($PbO_2 + NO_3$), or it may be, as is now supposed by many, a combination of metallic lead, with a radical consisting of one atom of nitrogen and six of oxygen ($Pb + NO_6$). The speculations into which this uncertainty has led, constitute one of the most subtle and refined investigations in the science, and will be hereafter reverted to.

216. *Isomerism.*—This subject has presented itself to chemists in another aspect. Several substances have been discovered, possessing properties so different from each other, as to create no suspicion of their identity. Yet analysis has proved them to consist of the same ultimate elements united in the same proportions. It might be thought at first sight, that a single fact of this kind would unsettle the science, by destroying the value of sensible properties as a test of identity of composition.

A closer examination shows that it is a natural result of a complex combination. The ultimate elements must be capable of forming various simpler

2 oxides of Lead

of the 1st

* I prefer calling these
 combining Nos instead
 of equivalent numbers
 Representations Nos
 because as the names

Explain what Proximate
& Ultimate Elements

ultimate elements

Two measures parts, second of $1\frac{1}{2}$ to 1. tho' the
fraction is avoided
explain this further
by reference to notation
of vulgar fractions $\frac{1}{2}$
 $\frac{2}{4}$ $\frac{3}{6}$ $\frac{6}{12}$ all alike
and as these chemically
not refer to proportion
only & not to any thing
definite, the symbol
not may be allowed in
later times.

Isomeric
Mrs M & P O S part

X The laws of combination have enabled Wollaston to construct a mathematical scale of chemical equivalents which is of the greatest use to practical Chemists. Explain it ^{as} a scale of equivalents. Humboldt then for brevity proportions.

Decimals always used in Science
Vulgar in commerce

Vulgar may have any Numerator & Denominator has any Numerator but Denominator is always 10 or a multiple of 10 therefore decimal

Numerator is covered 11111111
 $\frac{1}{2}$ is 0.5 but has 10 less and
quarter we must write $\frac{1}{4}$ as 0.25

components
elements
thus, unde
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of each
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218. J
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pounds.

Gregory
184

Gregory
184

Oxygen
Chlorine

Iodine,
Bromine

Fluorine
Nitrogen

Hydroge
Carbon,

Boron,
Silicon,

compounds, which are themselves the proximate elements of the bodies into which they enter, and thus, under an apparent identity, conceal an essential difference of composition. This resemblance is called *Isomerism*, and those bodies are said to be isomeric, the sensible properties of which differ, while their ultimate composition and combining numbers are the same.

217. There is a compound of carbon and hydrogen in their atomic proportions, but which consists undoubtedly of two atoms of each of its elements. This is the olefiant gas of chemists, and its combining number is $6.12 + 1 \times 2 = 14.24$. There is another substance called etherine, entirely distinct in its properties, composed of the same elements in the same proportions; but of which the combining number is found to be 28.48; being composed of four atoms of each of its elements. There are many examples of the *modified isomerism*, of which this is an instance. *The beautiful simplicity of X*

218. *Atomic Weights of the Elements.*—The following table contains the names and atomic weights of the simple elements, and the characters by which they are expressed in designating their various compounds. The numbers are taken from the last edition (1841) of Turner's Chemistry, by Liebig and Gregory.

Explain Devial's fashions

Elements.	Symbols.	At. Num.	Elements.	Symb.	At. N.
Oxygen,	O.	8.	Phosphorus,	P.	15.7
Chlorine,	Cl.	35.42	Selenium,	Se.	39.6
Iodine,	I.	126.3	Tellurium,	Te.	64.2
Bromine,	Br.	78.4	Arsenic,	As.	37.7
Fluorine,	F.	18.68	Antimony,		
Nitrogen,	N.	14.15	(Stibium,) St.		64.6
Hydrogen,	H.	1.	Chrom.	Cr.	28.
Carbon,	C.	6.12	Vanadium,	V.	68.5
Boron,	B.	10.9	Molybdenum,	Mo.	47.7
Silicon,	Si.	22.5			

10*

Notation of Berzelius

*date of Poggendorff
in his Chem. Dicty
with Berzelius - see
J. J. Savan p. 181.*

Elements.	Symbols. At. Numb.	Elements.	Symbols. At. Numb.
Sulphur,	S. 16.1	Tungsten,	W. 99.7
Columbium,	(Tantalum,) Ta. 185.	Zinc,	Zn. 32.3
Uranium,	U. 217.	Cadmium,	Cd. 55.8
Cobalt,	Co. 29.5	Ferrum,	Fe. 28.
Manganese,	Mn. 27.7	Cerium,	Ce. 46.
Titanium,	Ti. 24.3	Aluminium,	Al. 13.7
Stannum,	Sn. 57.9	Yttrium,	Y. 32.2
Aurum,	Au. 199.2	Glucinium,	G. 26.5
Platinum,	Pl. 98.8	Thorium,	Th. 59.6
Argentum,	Ag. 108.	Zirconium,	Zr. 33.7
Palladium,	Pd. 53.3	Magnesium,	Mg. 12.7
Rhodium,	R. 52.2	Calcium,	Ca. 20.5
Osmium,	Os. 99.7	Strontium,	Sr. 43.8
Iridium,	Ir. 98.8	Barium,	Ba. 68.7
Nickel,	Ni. 29.5	Lithium,	L. 6.
Hydrargyrum,	Hg. 202.	Sodium,	(Natrium) Na. 23.3
Bismuth,	Bi. 71.	(Kalium) K. 39.15	
Plumbum,	Pb. 193.6	Potassium,	
Cuprum,	Cu. 31.6	(Kalium.)	

The numbers above given are entitled to as much confidence as the state of experimental science will warrant; although slight differences will arise in calculating the result of different analyses. The only variations which it is important to notice, are, that Berzelius, and other Continental chemists, supposing the same volume of all simple gases to consist of the same number of atoms, regard the atomic weight of hydrogen, nitrogen, chlorine, bromine, iodine, and fluorine, as only half that above stated, and give the atomic constitution of bodies, at double the number of atoms of these elements, which the English chemists assign. Other chemists, from theoretical views, double the atomic numbers of phosphorus, arsenic, and antimony, and halve that of Mercury.

219. *Chemical Symbols.*—There are two methods of using the symbols in the preceding table.

Handwritten note:
 X Here being in atomic theory of B.
 the gas of Dalton, as established by Berzelius
 the number of molecules of substance
 is given at p. 153

Coefficients & Indices or exponents

CHEMICAL SYMBOLS.

The first, or algebraic mode, will be readily understood by a few examples. Thus the several compounds of nitrogen and oxygen are designated by $N+O$, $N+2O$, $N+3O$, $N+4O$, $N+5O$, the figures denoting then umber of atoms. Thus $Fe+O$, and $2 Fe+3O$, denote the protoxide, and sesqui-oxide of iron. The formula, $(N+5O)+(2 Fe+3O)$, denotes the nitrate of the sesqui-oxide of iron, and $(K+O)+2 (S+3O)$, the bisulphate of potassa. The advantages of the algebraic method are its simplicity and exact representation of facts. It is, however, inconveniently long, and Berzelius has introduced several modifications which are recommended by their brevity. He expresses the degree of oxidation by dots placed over the symbol, and the number of atoms of sulphur by commas placed in like manner, and he represents two atoms of base by a dash, through or beneath its symbol. Thus the following algebraic symbols $N+O$, $N+2O$, $N+3O$, $N+4O$, $Fe+S$, $Fe+2S$, $2 Fe+3O$, would be represented by Berzelius thus:

$\overset{\cdot}{N}$, $\overset{\cdot}{N}$, $\overset{\cdot}{N}$, $\overset{\cdot}{N}$, $\overset{\cdot}{Fe}$, $\overset{\cdot}{Fe}$, and $\overset{\cdot}{Fe}$.

220. A more convenient method, which is now becoming general, and which will be adopted in this volume, will be best understood by examples. The symbols are written without any intervening sign, and the number of atoms of each element is designated by figures placed at the foot, and to the right of the proper symbol. Thus NO , NO_2 , NO_3 , NO_4 , NO_5 , $Fe O$, $Fe_2 O_3$, designate the several oxides of nitrogen and iron above mentioned. The proper numeral is prefixed to designate the number of the atoms of these compounds, which unite to form compounds of a secondary order, and the sign of addition, or a simple comma connects the symbols; as $KO+2SO_3$, $KO, 2SO_3$ for the bi-sulphate of potassa.

There are many compounds of a very complex

*When a coefficient has only one figure
then all that follows the symbol
the index only
letter to the right*

Notation of Berzelius

*- date of Poggendorff
in his Chem. Dicty
with Berzelius - see
7th volume p. 181.*

constitution, the occurrence of which as an element of other bodies is so frequent, that a distinct symbol is used to express them. Thus, for instance the composition of Benzole is $C_{14}H_6O_2$, and its symbol is Bz. Water, ammonia, and other compounds, which enter extensively into combination, have also distinct symbols, which will be noticed in the several cases as they occur.

221. *Chemical Nomenclature.*—The rapid advances which the science of chemistry has made within the last sixty years is undoubtedly due, in a great measure, to the nomenclature framed by the illustrious Lavoisier, and his associates, Guyton Morveau, Berthollet, and Fourcroy. It is the most beautiful example of an universal philosophical language, which has ever been presented to the world, and it has greatly aided the diffusion of accurate chemical knowledge, by the perfect precision and self-explaining character of its terms.

Even in those cases in which the sagacious framers of this language fell into theoretical errors, from the imperfect state of chemical science in their day, the principles which guided them, furnish us with the means of rectifying their errors and supplying their defects.

222. The following is a sketch of the nomenclature at present in use.

The bi-elementary compounds are arranged in genera named from the electro-negative element, by adding to it the termination *ide* or *uret*. Thus the compounds of oxygen, chlorine, bromine, iodine and fluorine, are called oxides, chlorides, bromides, iodides, and fluorides, and the compounds of carbon, sulphur, phosphorus, hydrogen, are called carburets, sulphurets, phosphurets, and hydrogurets.

As the same substances unite in more than one proportion, the various compounds are designated by terms explanatory of their composition. A com-

in 1787

Lavoisier
Morveau

all names are derived from the electro-negative element
 The names must be expressive of nature
 The names of the elements are given
 The names of the compounds are given

Linnaeus had previously adopted the
same system in regard to Plants - Notation of Bergelius
and Cuvier has since done
in the same thing in respect to

Zoology, but several of our
Sciences stand desperately in
need of such a revision -
more than Mineralogy -

- ditto of Poggendorff
in his chem. Dicty
with Bergelius - see
7th Decem 181.

a Universal Language is a
great desideratum & a felt for
so many terms of Science being
divided from the Latin & Greek
Name is the only example at
present known

perties contain no oxygen, and others which form neutral salts have not a sour taste and do not redden vegetable blues. It has therefore become necessary to extend the meaning of the term acid, and to include in the class all those electro-negative compounds which combine with the electro-positive compounds of the same genus, and form crystalline compounds analogous to the salts.

The simple electro-negative elements, oxygen, chlorine, iodine, bromine, fluorine, sulphur, and selenium, combine with the elements which are electro-positive in relation to them, forming compounds which are either electro-negative or electro-positive. The former constitute, as has been said, the class of acids.

Instead therefore of oxygen being, as Lavoisier supposed, the sole principle of acidification, we have oxygen acids, chlorine acids, iodine acids, &c., each constituting a separate genus of acids. It was early discovered that the same substance formed more than one acid, as, for example, there are two acids of sulphur, two of nitrogen, and two of phosphorus. In order to distinguish these from each other, Lavoisier designated that acid which contains the smallest quantity of oxygen, by adding to the name of the base the termination *ous*, and the other by the termination *ic*, as sulphurous, nitrous, phosphorous, sulphuric, nitric and phosphoric acids. Acids have since been discovered intermediate between the above, or of still lower degrees of oxygenation. These acids have been designated by prefixing the term *hypo* to the name of the acid following them in the series of oxygenation. Thus hypo-nitrous, and hypo-nitric acids, contain less oxygen than the nitrous, and nitric acids, and immediately precede them in the series of oxygenation.

225. While it was supposed that oxygen was the sole acidifier, the above nomenclature was sufficient

Bengalic acid
1811

oxy acids chloric
Indic Bonnic

ous ic

hypo acid

Fluic Bonic

for all the cases that could occur. But as there are other acidifiers than oxygen, each forming acids with the same base, it has become necessary to designate the acidifying principle. Hydrogen, for example, forms acids with chlorine, iodine, bromine, sulphur, &c., which are designated by the terms chloro-hydric, iodo-hydric, bromo-hydric, and sulpho-hydric acids. Carbon is another example of this, as it is acidified both by oxygen and sulphur. The two acids are therefore to be called the oxy-carbonic and the sulpho-carbonic acids; but inasmuch as the oxygen acids are the most numerous and abundant, and as long use has familiarized us to their name, we seldom prefix to them the term *oxy*, but always understand an oxygen acid to be spoken of when the name of the base only is given.

226. *Bases*.—The electro-positive bi-elementary compounds are classed together under the name of bases, and possess the common property of forming salts by combining with, and neutralizing the acids of the same genus; that is to say, the electro-positive oxides, and sulphurets, combine with electro-negative oxides, and sulphurets, forming oxygen, and sulphur salts.

227. *Salts*.—Chlorine, iodine, bromine and fluorine, combine with the metals, and these binary compounds are genuine salts. Berzelius distinguishes them by the name of *haloid salts*. The bearing of this fact upon the true theory of the oxygen salts will be hereafter noticed. At present it will suffice to give the Lavoisierian view of their constitution.

As Lavoisier knew of but one class of acids, he was acquainted with but one class of salts, and in framing his nomenclature did not provide for the designation of any but oxy-salts.

Each distinct acid forms and gives its name to a peculiar genus of salts. The salts formed by the acids whose names terminate in *ous* are designated

oxy acid

The base is therefore the thing called acid

As sea salts for all haloids are binary

oxy

and

ous

by the termination *ite*. Thus the salts formed by the sulphurous, phosphorous, nitrous, and arsenious acids, are called sulphites, phosphites, nitrites, and arsenites of the several bases; as the sulphite of iron, copper, &c. The salts formed by the acids whose names terminate in *ic*, are designated by the termination *ate*; thus the salts formed by the sulphuric, carbonic, nitric and arsenic acids are termed the sulphates, carbonates, nitrates, and arseniates of their several bases, as the sulphate of iron, copper, &c.

228. The number of atoms in the electro-negative element of a salt is designated by the Latin numerals. Thus the terms bi, ter, and sesqui sulphate of iron, denote a combination of 2, 3, and $1\frac{1}{2}$ atoms of sulphuric acid, with an atom of oxide of iron. As many of the metals form more than one compound with electro-negative elements, and thus furnish more than one saline base, it is necessary to designate these in the nomenclature of the salts. This can generally be done with great accuracy by using the terms proto, deuto, and per, to designate the first, second, and highest combinations of the metals, with an electro-negative element. Thus the proto-sulphate of iron, and the per-sulphate of iron, denote the combination of sulphuric acid with the protoxide, and per-oxide of iron; and the bi-proto-sulphate, and the bi-per-sulphate of iron denote the combination of two atoms of the acid with an atom of the respective bases.

229. When we wish to designate the class to which a salt belongs, we must prefix the name of the class; thus, for example, the oxy-sulphate of iron denotes a salt in which the teroxide of sulphur (sulphuric acid) is combined with the protoxide of iron.

A sulphur salt is, in the same manner, the combination of an electro-negative sulphuret, with an electro-positive one. The bi-sulphuret of carbon, and

Bougainville acid
Belle

cc
Salts
ite
ate

(acidity)

break
Name
for base

oxy acids chloric
Iodic Bromic
ous &c

Hydrocyanic

Fluoric

explained below p 71.
anode or entering
cathode, going out.

at anode the negative
& at cathode the posit
Electric accumulates

Here we meet with the first
instance of Sir H Davys division
of all the elements into Electro
Pos, & Electro Neg states as
before referred to

the per-sulphuret of arsenic, are sulphur acids, whose correct names are sulpho-carbonic, and sulph-arsenic acids, and their combinations with electro-positive sulphurets, are the sulpho-carbonates and sulph-arseniates.

230. *Electrolytic Decomposition.*—It is observed that when any compound substance whatever is decomposed in the voltaic circuit, one of its elements is separated at the positive, and the other at the negative electrode. It is therefore inferred, that all substances that enter into combination are in opposite electrical states, one of them being negative and the other positive. The laws which regulate the chemical action of the voltaic battery, are therefore calculated to throw much light on the nature of chemical forces.

231. It has been ascertained by Dr. Faraday, that no substance that is a non-conductor of electricity is either capable of exciting electrical currents in the battery, or susceptible of electro-chemical decomposition; or, in other words, this cannot take place unless an electrical current is transmitted through the substance.

As the solidity of a body prevents that mobility of its particles which is necessary to its decomposition, and as no electrical current can pass in the voltaic circuit without decomposition, it is evident that the exciting body in a circuit must be in a fluid state. Accordingly it is found that ice will not conduct the electric current and is not susceptible of decomposition, and the observation holds true of all other solids that are capable of exciting the voltaic battery in their liquid state.

232. Faraday further ascertained that of all the various combinations of any two elements, one only is susceptible of electro-chemical decomposition, and that this in all cases consists of an equal number of atoms of each element. Bodies susceptible of elec-

For
see
the
same

My water
ity may occur
see 2 things
I believe of metals
Faraday at 230 & 231
the same

tro-chemical decomposition are called *electrolytes*, which are therefore in all cases *binary compounds*. To *electrolyse* a body, is to decompose it by the direct action of electricity; the name being compounded of $\eta\lambda\epsilon\kappa\tau\epsilon\gamma\omicron\nu$, and $\lambda\upsilon\omega$, to loose.

233. The elements of an electrolyte are called *ions*, from $\iota\omicron\nu$, going. Anions are those ions which appear at the anode, and *cations* those which appear at the cathode.

It is ascertained that *most*, and it is probable that *all*, of the simple elements are ions. Owing to the difficulty of obtaining liquid electrolytic compounds of nitrogen, carbon, phosphorus, boron, silicon, and aluminium, these elements have not yet been proved to be *ions*.

An ion is not necessarily a simple body, for any compound substance forming a binary compound with another becomes an ion. Those neutral salts, for example, which contain an atom of acid and an atom of alkali, are all electrolytes, and their elements ions, although none of the acids are themselves electrolytes.

234. Many substances not electrolytes are themselves decomposed by what is called the secondary action of the battery. The elements of the decomposed electrolyte being set free, are presented in their nascent form to the adjacent bodies, a circumstance peculiarly favourable to chemical action. Nitric acid is thus decomposed by the hydrogen of the water which is set free; and nitrous acid and water are formed. In many cases the electrode itself is attacked, as when zinc, for example, is used, it is oxidated by the nascent oxygen of the water.

In experiments with the voltaic battery this secondary action of the pile must be carefully separated from its primary and direct action. The former adds nothing to the quantity or intensity of the electrical currents set in motion by the latter.

explained b^y m^o p^r 71.
anode or entering
cathode, going out

at anode the negative
at cathode the posit
elect^r accumulates

refer this to Shady

235. *The Volta Electrometer.*—It has been clearly ascertained by Faraday, that these currents are an exact measure of the quantity of the electrolytic action of the pile. By using electrodes of platinum and pure zinc, he obtained a battery in which there was no chemical decomposition, except that which was owing to electrolytic action, and he was thus enabled to ascertain its exact amount. By conducting the electrical currents thus produced through a vessel of water, and collecting the gases resulting from its decomposition, he proved that the quantity of water decomposed by the electrical current was precisely equal to that, the decomposition of which, in each cell of the battery, set the current in motion. He also discovered that the same current may be made to perform any number of decompositions, and was thus enabled to submit various compounds at the same time to the action of the same current, and proved that the quantities thus decomposed were always in the exact ratio of their atomic weight. The current which decomposed 9 grains of water ($\text{HO}=9$), also decomposed 230 grains of iodide of lead (1 iodine= $126.3+1$ lead= 103.6) and 143.42 grains of chloride of silver (1 chlorine= $35.42+1$ silver= 108); that is to say, the electricity evolved by the electrolytic decomposition of an atom of water is exactly sufficient to decompose an atom of any other electrolyte. By the aid of a simple instrument called the *volta electrometer*, which consists of platinum electrodes inserted in a graduated glass tube, in which the gases evolved by the decomposition of water are collected, he obtained a measure of the quantity of electricity that had passed through the voltaic circuit in a given interval of time. We are thus furnished with a means of measuring electricity by its chemical agencies, as accurately as we measure the relative degrees of heat by the thermometer.

ity may exist
in 2 Shady
I believe apparatus
to prove

236. *Identity of Chemical and Electrical Forces.*

—It appears probable that when a compound is decomposed by electricity, the positive electricity of the current combines with the negative electricity of the negative element, and the negative electricity of the current with the positive electricity of the positive element. The forces which held the two elements together are thus neutralized, and the inference seems irresistible that they must be the antagonist forces, or, in other words, the opposite electricities of those by which they are thus counteracted. If, therefore, the elements that form compound bodies are held together by electrical forces, and are separated when these forces are neutralized by an equal quantity of the opposite electricity, it is evident that the same quantity of electricity must be the agent in holding together an atom of any binary compound whatever, for an atom of such compound is always decomposed by the quantity of electricity that is evolved in the electrolytic decomposition of an atom of any other binary compound.

237. *Causes of the efficacy of the Battery.*—As no electricity can pass in the voltaic circuit, except what is due to electrolytic action, it follows that the quantity circulated in a battery, is no greater than that evolved by the weakest cell of the battery, and that this is no more than would be evolved by a single pair of similar plates. However powerful the other cells may be, all the electricity evolved by them, beyond what its own chemical action transmits, is arrested by the weaker cell. The superior efficiency of the compound battery appears to be owing to an increase in the *intensity* or energy of propulsion, and not in the quantity of the electrical current.

238. *Chemical affinity elective.*—The chief character by which chemical affinity is distinguished from other kinds of attraction, is that which procured for it one of its earliest names, *viz. elective affinity.*

If lime and magnesia be placed in contact with

explained both in 71.
anode or entering
cathode, going out

at anode the negative
& at cathode the posit
Electricity accumulates

In fact Davy asserted, and all facts
seem to bear out the assertion
that chemical affinity is but a
consequence of elect. attraction
or repulsion

This Material to be understood

Bergman - In Flowers see p. 154

affinity may exist
between 2 things,
but I believe affinity
presumes at least 3 to
be present

List of Chemicals

Nitric acid
Sulphuric acid
Nitrate of Ammonia
Sulph. Ether
Lapis Calaminaris
Pyroligneous Acid, rough & refined
Thiophane Sulphuris
Fibrous of Zinc
Yellow Mesoprot in scales
Sugar of Lead
Ethiops mineral
Pure Mercury
Corrosive sublimate
Blue Vitriol
Crown Marsh
Brown Oxide of Copper
Sodium
Boron in Brown powder
Boric acid in scales
Glass of Borax
Chromic Acid & Vanadium
Metallic Molybda.
Iodide of Potash in
Scales of Tin
Iron
Tin

63 Silliman House
Epitome

Aurum Musivum
Carb. of or pure Bayta
Platinum foil fine
wire and granules
Gums Mastic
Copal
Blume
Sassafras
Guttae
Lycopodium

Paragoric Elixer
Oxy mel Squills
dry Squills
Sweet Spitz Nitre
Tincture Kino
Elixer of Nitric
Antimonial wine
Blue pill
Sicclitz Mixture
Sulp. Ether
Lapis Calaminas
Spum Mastie
Cobal
Gleni
Saudarack
Guttae
Seed Sac
Pyrogis's acid rough
do. — refined
Tinctal or crude Borax
Nitric Acid
Framing D.
Muriatic D.
Nepas Sulphur's
Polishing Patts
Flor
juice Ke
Whe