CHEMISTRY

LECTURER

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Language of chemistry

Chemistry is the branch of science which ~~st~~ study the composition, structure and properties of the substance which on undergoing chemical reaction. Such substances are terms as matter.

On the basis of different concept the universe substances can be classified as:

(a) On the basis of definite mass, volume & shape:
Matters are three types:

(i) Solid

Solid are those substance which have its definite mass, volume & shape. They are also hard & rigid in structure. For example: stone, iron, table, book etc.

(ii) Liquid

Liquid are those substances which have its definite mass & volume but donot have its definite shape. It has ability to mobile & flow from higher level to lower level. For example: milk, water, alcohol, cholaform, benzene etc.

(iii) Gas

Gas are those substances which have its definite mass but donot have its definite volume & shape. It can occupie the large shape and can be flow.

(b) On the basis of Chemical composition of matter in further classified as:

(i) Elements

There are pure substances which neither decomposed nor built up by normal, ordinary physical or chemical process. There are 118 elements are already discovered. Out of these 92-elements are naturally exist and remaining are artifical by applying nuclear process.

for example: sodium, potassium, iron, silver, gold, mercury etc.

Elements are further classified as:

(1) metal

These elements are hard and rigid, lustrous, mealable, ductile & be a good conductor of heat & electricity.

Note: substance must be free electron in solid metal and free ions in water need to ~~supl~~ supply electric and heat.

The elements of 80-1. are metals. for example: copper, iron, silver, gold, magnesium etc.

(2) non-metal

These elements are brittle (easily breakable), non-lustrous, non-ductile and bad conductor of heat and electricity. Mostly electronegative (-) elements are non metals.

for example: nitrogen, carbon, oxygen, chlorine etc.

(3) mettaliods

These elements are shows the indermediate character of metal and non-metal are called mettalidds. for example: silicon, Germinium, Arsenic, Molybdenum etc.

(ii) Compound

Compound are the substance which contain two or more elements in definite proportion. for example; in water (H_2O) compound the proportion of Hydrogen and oxygen is 1:8 by its weight.

(iii) Mixture

Those substances which are obtain by mixing two or more elements as well as compounds in indefinite proportion. for example: salt in water, milk, oil in water, salt in sand, alloy, amalgum (metal + Hg).

To assign the language of chemistry easiest to indicate chemical terms following parameters can be used that is:

① Symbol

Symbol can be used in language of chemistry in order to provide shortform of full name of the elements.

In 1833,
Berzelius discover the concept of symbol of a chemical element which where derived from the accepted names of the elements in latin, Greek, English, places of the laboratary, name of the scientist, name of the planet etc. Therefore, symbol is defined as the shortform or abbrevation of full name of the specific elements.

While writing the symbol of the elements the initial letter always written in capital letter, A symbol consist single or more letter from the accepted name of the elements. If content more letters first is written capital and then other one in ~~similar~~ smaller form. For example:

* Symbol derived from latin words like:

Element	Symbol	latin name
Sodium	Na	Natrium
Iron	Fe	Fernum
Copper	Cu	Cuprum
potassium	K	Kalium
Mercury	Hg	Hydragyrum
Silver	Ag	Argentum

* Symbol derived from place or name of the laboratary.

Element	Symbol	Place or laboratory
Californium	Cf	University of California
Americium	Am	America
Polonium	Po	Poland
Berkelium	Bk	University of Berkely

* Symbol derived from name of the scientist.

Element	Name of the scientist	Symbol
Curium	Madam Curie	Cm
Einstenium	Albert Einstein	Es
Fernium	E. fermi	Fm

* Symbol derived from name of the planet

Element	Name of the planet	Symbol
Uranium	Uranus	U
Plutomium	Pluto	Pu

Significance of symbol

Symbol of the elements are only shortform of specific elements but it also represent the atom of the elements. Symbol can have qualitative and quantitative significances.

(a) Qualitative Significance

- It represnt the specific name of the chemical elements.

(b) Quantitative Significance

- It represent the one atom of the element.
- It represent the atomic number of the element.
- It represent the atomic net of the element in amu or gm scale.
- It represent the 6.023×10^{23} (1mole) of the element.

Significance 'Ca"

(a) Qualitative Significance

- The symbol 'ca' indicates Calcium element.

(b) Quantitative Significance

- It is one atom of Ca.
- It's atomic number is 20.
- It's atomic weight is 40 amu or 40 gm.
- It consists 6.023×10^{23} no of Ca.

* Formula :-

When atoms of same or different elements combines to form chemical substances which is called as formula. Chemical formula consist symbol of the element and number of atoms at subscript position.

* Molecular formula

The symbolic representation which indicates the actual numbers of atoms present in molecules or compound is terms as molecular formula. for example :- The molecular formula $C_6H_{12}O_6$ (glucose) represents 6 atoms of carbon, 12 atoms of Hydrogen & 6 atoms of oxygen.

Significance of molecular formula

① Qualitative Significance

- It gives the name of the chemical substance of the formula.
- It tells the name of the elements present in formula.

ⓑ Quantitative Significance

- It indicates one molecules or compound of the substance.
- It gives molecular weight of the substances in amu or gm scale.
- It gives the actual numbers of each of the atoms present in chemical formula.
- It consists 6.023×10^{23} no. of chemical substance.
- It indicates the proportion of each of atom in the substance.

H_2SO_4

ⓐ Qualitative Significance

- The chemical formula of 'H_2SO_4' indicates sulphuric acid.
- The formula consists Hydrogen, Sulphur and oxygen element.

(b) Quantitative Significance

- It is one molecule of H_2SO_4.
- Its molecular weight is 98 amu or 98 gm.
- It consists 2 atom of Hydrogen, 1-atom of sulphur & 4-atom of oxygen.

H:S:O

- The proportion of H_2SO_4 is 1:6:32 by weight.

Valency:-

Valency is the combining capacity of an atom with atoms of other elements which is a whole number an consist only one number except some variable valency of element.

The concept of valency can be defined as:-

Old Concept

According to this concept valency of an element is define as the number of Hydrogen atom or Cl atom or twice the number of oxygen atom with one atom combines to each other. for example:- The compound like $AlCl_3$ (Aluminium trichloride), NH_3 & CO_2 of its valency of Al, N and C is 3, 3 and 4 respectively. This is because the number of hydrogen and chlorine is 3 similarly in CO_2 oxygen atom in 2.

Some hydrocarbon ~~hydrogen~~ compound (ie. compound contain carbon and hydrogen element only) ie methane (CH_4), ethane (C_2H_6), Ethene (C_2H_4), Ethyne (C_2H_2) where the valency of carbon atom is 4, 3, 2 & 1 respectively. But valency is only single valued and the old concept was failed.

Modern concept

To remove the limitation old concept, modern concept was discovered which is based on electronic configuration.

According to this concept valency of element is defined as the number of electron loss, gain or share to get nearest noble gas configuration during the combination of each of atoms of the ~~example~~ elements.

for example : in NaCl compound :

$_{11}Na : 1s^2, 2s^2\ 2p^6, 3s^1 \xrightarrow[1e^-]{loss}$ Valency of Na = 1

$_{17}Cl : 1s^2, 2s^2\ 2p^6, 3s^2\ 3p^5 \xrightarrow[1e^-]{gain}$ Valency of Cl = 1

Variable valency of the elements

There are some elements which contain more than one valency number & such elements are called variable valency of the elements.

Those atoms of the such element when combines with other atoms of the elements to gives different compounds.

for eg:

Elements	Valency	Name of the elements
Iron (Fe)	Fe(II) or Fe^{+2}	Ferrous
Ferrum	Fe(III) or Fe^{+3}	Ferric
Copper(Cu)	Cu (I) or Cu^{+}	Cuprous
Cuprum	Cu (II) or Cu^{+2}	Cupric
Gold (Au)	Au(I) or Au^{+}	Aurous
Aurum	Au(III) or Au^{+3}	Auric

Note: While writing the name of the chemical substance for variable valency of the elements.

- For lower valency of the element, at last 'ous' word can added
- For higher valency of the element, at last 'ic' word can added

for ex.

$FeCl_2$ = Ferrous Chloride
$FeCl_3$ = Ferric Chloride

AuCl = Aurous Chloride
$AuCl_3$ = Auric Chloride
Cu_2SO_4 = Cuprous Sulphate
$CuSO_4$ = Cupric Sulphate

Radicals

Most of the inorganic compound contains two opposite charged unit or part which is termed as radical.

In radicals its contains one element only or more than one different element of atom, which represent single species.

for example: K^+, Na^+, La^+, CO_3^{-2} (Carbonate ion), CN^- (Cynide ion), OH^- (Hydro-oxide ion), NH_4^+ (Ammonium ion) etc

Types of radicals

1. On the basis of charge carries, they are two types:

(a) Electropositive radicals or Basic Radical = Those species which carries the positive charged are called as Electropositive radical. These are also called as Basic radical because during the formation of salt it goes through a base.

for example:

$NaCl \leftarrow NaOH + Cl$

Base

Na^+, K^+, Mg^{+2}, Ca^{+2}, Al^{+3}, Zn^{+2}, NH_4^+ etc

⑥ Electronegative or Acidic radicals:

Those species which carries the negative charged are called as electronegative radicals. These also called as acidic radicals because during the formation of salt it goes through an acid.

for example: OH^-, Cl^-, SO_4^{-2} (sulphute ion), SO_3^- (Sulphite ion), S^{-2} (Sulphide ion), NO_3^- (Nitrate ion), NO_2^- (Nitride ion)

② On the basis of Chemical Constituents are three types:

K^+, O_2^{-2} } ① simple radical

OH^-, CO_3^{-2} } ⑪ Compound radical

$[Fe(CN)_6]^{-3}$ ⑪ Complex radical

① Simple radical

These radical reprensent the single element of one or more atoms and reprensent a single species is called Simple radical.

for ex: K^+, Na^+, O^{-2} (oxide ion), O_2^{-2} (Pero-oxide ion) Hg_2^{+2} (Mercurous ion) etc

② Compound radical:

Those radical which contain two or more ~~simple~~ atoms of different elements, which represent a single species is termed as compound radical.

for ex:

OH^- (Hydroxide ion)
CN^- (Cyanide ion)
NH_4^+ (Ammonium ion)
HCO_3^- (Bicarbonate ion)
SO_4^{-2} (Sulphate ion)
HSO_4^- (Bisulphate ion)
SO_3^{-2} (Sulphite ion)
MnO_4^- (Permanganate ion)
$Cr_2O_7^{-2}$ (Dichronate ion)

③ Complex radical:

Those radical which contain two or more simple and compound radicals which represent the single species is term as complex radical. In complex radical the unit can be enclosed by big bracket "[ ]".

for example:

$[Fe(CN)_6]^{-4}$ = Ferrocyanide ion

$[Fe(CN)_6]^{-3}$ = Ferricyanide ion

* Radicals having 1, 2, 3, 4 or 5 unit positive or negative charged are also called as monovalent, divalent, trivalent or pentavalent respectively.

* Write the Chemical formula:

By the knowledge of radicals chemical formula can be written by combination of acidic and basic radicals with corresponding valencies of each species.

While writting the chemical formula following steps can be involves:

(a) At first, acidic and basic radicals of the species can be written side by side, where basic radical at LHS and acidic radicals at R.H.S.

ex:- $Na^{(+)}$ $CO_3^{(-)}$

+ → Basic
- → acidic

(b) If the radicals are compound or complex, they can be enclosed by small bracket '( )' or big bracket '[ ]' respectively.

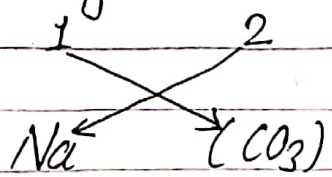
ex:- $Na(CO_3)$

( ) → compound
[ ] → complex

(c) The valency of each species written at the term of the symbolic notation. for ex:-

1	2
Na	(CO_3)

④ The valency of each species shifted to criss-cross or multiply way ie.



The valency of acidic and basic radicals get exchange each other.

finally, If valencys are ~~did~~ divided by common number they can be divided to get chemical formula of the given compound. ~~for~~

for example:

ⓐ Pot nitrate ~~valency~~

valency: 1 1

symbolic notation: $K(NO_3)$

$= K_1(NO_3)_1$

$= KNO_3$

ⓑ Pot nitrite:

valency: 1 2

symbolic notation: $K(NO_2)$

$= K_2(NO_2)_1$

$= K_2NO_2$

(c) Pot. sulphate:

Valency: 1 2

Symbolic notation: $K \quad (SO_4)$

$= K_2(SO_4)_1$

$= K_2SO_4$

(d) Sod. ferrocyanide

Valency: 1 4

Symbolic notation: $Na \quad [Fe(CN)_6]$

$= Na_4[Fe(CN)_6]$

(e) Sod. dichromate

Valency: 1 2

Symbolic notation: $Na \quad (Cr_2O_7)$

$= Na_2Cr_2O_7$

(f) Calcium sulphate

Valency: 2 2

Symbolic notation: $Ca \quad (SO_4)$

$= Ca_2(SO_4)_2$

$= CaSO_4$

Chemical Equation:

With the knowledge of symbol and formula of chemical substances, which reaction, can be express in equation which is called chemical equation.
Chemical equation is the short hand notation of chemical reaction, where chemical changes can be ~~req~~ represent.

for ex: When zinc metal react with hydrochloric acid following chemical changes occur and represent its chemical equation as;

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2 (\uparrow)$$

The chemical substance represent at LHS towards arrow are called reactant which can undergo chemical changes whereas at right handside are called product which can be produce during chemical reaction.
While reading the chemical equation including its term like an arrow (→) means to gives / to produced to yield and positive sign (+) at reactant indicates 'react with' at product side 'in addition to' or 'and'. An arrow pointing towards upward means evolution of gas or downward means precipitate (ppt) of solid substance.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2 (\uparrow)$$

* Imp Essential aspect of chemical equation

For true chemical equation should be follow the essential facts:

(1) A chemical equation should represent which are pratically possible

for ex:
$Cu + 2HCl \longrightarrow CuCl_2 + H_2 (\uparrow)$ [∵ Not possible]

(2) A chemical equation should be balance by using suitable number.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2 (\uparrow)$

(3) In chemical equation elementary gas like H_2, O_2, N_2, Cl_2 etc can be written in molecular state.

for example:
$Mg + 2HCl \longrightarrow MgCl_2 + 2H$ [Not a true equation]
but H_2 [true]

Significance of chemical Equation:

for example: chemical equation

$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2 (\uparrow)$

Significance two ways :

① Qualitative Significance:

- It gives the information about the chemical change during the reaction

ie. when sodium carbonate react with hydrogen chloride to gives sodium chloride, water and carbondioxide gas.

② Quantative Significance:

- It gives the information about the amount or numbers during the reaction.

i) one molecules of Na_2CO_3 react with 2 molecule of HCl to gives two molecules of NaCl, one molecule of H_2O and one molecules of CO_2 gas.

ii) 106 parts by weight of Na_2CO_3 react with 73 parts by weight of HCl to gives 117 parts by weight of NaCl, 18 parts by wt. of H_2O and 44 parts by wt of CO_2 gas.

(iii) one mole of Na_2CO_3 react with two molecules of HCl to gives two mole of NaCl, one mole of H_2O and one mole of CO_2 gas

ie. 22.4 lit of CO_2 gas at NTP

NTP = Normal temprature and pressure

$0C = 273\ K$

$P = 760\ mmHg$

Define Chemical equation. Signifiga the following chemical equation

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2 (\uparrow)$$

By two way we signify the chemical equation.

① Qualitative Significance

- when calcium carbonate react with hydrogen chloride to gives calcium chloride addition to water and carbondioxide gas.

② Quantitative Significamce

- one molecule of $CaCO_3$ react with two molecule of HCl to gives one molecule of $CaCl_2$ addition to one molecule of H_2O and one molecule of CO_2 gas.

- 100 parts by weight of $CaCO_3$ react with 73 parts by weight of HCl to gives 111 parts by weight of $CaCl_2$ addition to 18 parts by weight of H_2O and 44 parts by weight of CO_2 gas.

- one mole of $CaCO_3$ react with two mole of HCl to gives one mole of $CaCl_2$ addition to one mole of H_2O and one mole of CO_2 gas.

Imp

Limitation of chemical Equation:

$$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$$

For a general chemical equation few terms are limited while writing the chemical equation, they are;

① The physical state of the chemical substances.
② The concentration of the starting and producing chemical substances at the end of chemical reaction.
③ The condition requirement to carried out the chemical reaction.
④ The rate of change of chemical reaction on the basis of reacting substances.
⑤ The evolution or absorpation of heat energy during the chemical reaction in terms of exothermic or endothermic process.
⑥ The production of gas or precipitation (ppt.) of solid substances.
⑦ The unidirectional or bidirectional process of the chemical reaction.

* To remove the above limitation for general chemical equations, following steps can be used;

① The physical state of chemical substances can be represent by a notation for the formula as s = solid; l = liquid; g = gas or aq = aqueous

② The concentration of the chemical substance represent by using the words, dil = dilute ; conc = concentrate

③ The condition requirement for the chemical reaction can be indicate above or below the arrow sign by using the parameter like temperature, pressure or catalyst.

~~$N_2(g) + H_2(g) \rightleftharpoons 2NH_3(g) + Heat$~~
~~Fe/MO~~
~~200 - 900 atm~~
~~450 - 500°C~~

$$N_2(g) + H_2(g) \underset{450-500^\circ C}{\overset{Fe/MO}{\underset{200-900 atm}{\rightleftharpoons}}} 2NH_3(g) + Heat$$

④ The rate of changing the reacting substances can be express on the basis of natural of chemical substance and represent as;

$$H_2 + Cl_2 \xrightarrow[(Sunlight)]{h\nu} 2HCl, \quad Rate = 10 \times 10^5 min^{-1}$$

$h\nu$ ($h\nu$ = Frequency)

$\Delta E = h\nu$

⑤ The evolution of heat energy ie exothermic process can be represent by the addition of heat energy along with product whereas absorption of heat ie endothermic process can be represent by subtracting the heat energy from product.

for ex. $N_2 + 3H_2 \rightarrow 2NH_3 + 22.4$ Kcal ie Exothermic process

$2NO + O_2 \longrightarrow 2NO_2 - 44.5$ kcal ie Endothermic process

⑥ The upward arrow (↑) or downward arrow (↓) after the chemical substances represent evolution of gas or precipition of solid substances

Ex:- $AgNO_3 + HCl \longrightarrow AgCl\downarrow + HNO_3$
(white ~~prect~~ precipitate)

Balance Chemical ~~Equation~~ Equation:

The chemical equation in which the number of each atoms in reactant and product be identical is called balanced chemical Eq. The equation can be balance by adding a co-efficient numbers before the symbol and formula of the chemical substance.

The chemical equation can be balanced by following ways;

i) Hit and trial Method
ii) Partial Equation Method
iii) Oxidation number Method

i) Hit and trial method

This method can be used to balance the simple chemical ~~chemical~~ equation where no-one any heard and fast rule can be applied. To balance the equation by this method, substitute any number towards reactant or product side and then trail it unit the equation become balance.

for example: The skeletation (Unbalance) chemical equation as;

$3Fe + 8HNO_3 \longrightarrow Fe_3O_4 + 4H_2O + 8NO_2$

2) partial equation method

This method can be used to balance the complex chemical equations, where the given chemical equation cannot balanced by single step. Due to this equation become partition to probable other steps according to the nature of reacting chemical substances. Therefore, it is called as partial equation method

To balanced the chemical equation it can be based on specified rules. for given reacting substances, like HNO_3, $KMnO_4$, or $K_2Cr_2O_7$ etc which are common oxidising agents.

ex :

* Rules for HNO_3 (Nitric Acid): It involves following steps;

Step 1: Decompesition of HNO_3 according to the concentration.

(conc.) $2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

conc. Nitrogen dioxide Nascent oxygen

$HNO_3 \longrightarrow 2NO + H_2O + 3[O]$

Moderately conc. — Nitric oxide

$2HNO_3 \longrightarrow N_2O + H_2O + 4[O]$

dilute — Nitrous oxide (Laughing Gas)

Step II: Nascent oxygen combine with given metal or non-metal to form corresponding metal oxide or non-metal oxide respectively.

$M + [O] \longrightarrow MO$

(Metal or Non-metal)

Step III: Metallic oxide is basic in character and combines with given acid to form salt and water.

Whereas, Non-metallic oxide is acidic character which combine with water to give corresponding acid.

$\underset{\text{Non-metallic}}{MO + H_2O} \longrightarrow \text{Acid}$

$\underset{\text{Metallic}}{MO + HNO_3} \longrightarrow \text{Salt} + H_2O$

> Step IV: Cancel ~~out~~ cut the unstable ~~~~ intermediate ie nascent oxygen, oxides by multiplying suitable number.

Step II: ~~Added~~ Added all the balance partial equation to get balance equation.

Eg: $Cu + \underset{\text{Conc.}}{HNO_3} \rightarrow Cu(NO_3)_2 + NO_2 + H_2O$

Step I: $2HNO_3 \rightarrow 2NO_2 + H_2O + [O]$

Step II: $Cu + [O] \rightarrow \underset{\text{(Base)}}{CuO}$

Step III: $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$

$Cu + \underset{\text{Conc}}{4HNO_3} \rightarrow Cu(NO_3)_2 + 2NO_2 + 2H_2O$

$Zn + \underset{\text{conc.}}{HNO_3} \rightarrow Zn(NO_3)_2 + NO_2 + H_2O$

Step I- $2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$

Step II- $Zn + [O] \longrightarrow ZnO$

Step III- $ZnO + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O$

Answer: $Zn + 4HNO_3 \xrightarrow{\text{conc.}} Zn(NO_3)_2 + 2NO_2 + 2H_2O$

for non-metal

$C + HNO_3 \xrightarrow{\text{conc.}} H_2CO_3 + H_2O + NO_2$

Step I- $2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$]x2

Step II- $C + 2[O] \longrightarrow CO_2$

Step III- $CO_2 + H_2O \longrightarrow H_2CO_3$

Answer: $C + 4HNO_3 \xrightarrow{\text{conc.}} H_2CO_3 + H_2O + 4NO_2$

$S + HNO_3 \longrightarrow H_2SO_4 + H_2O + NO_2$
conc.

Solution

Step I: $2HNO_3 \longrightarrow 2NO_2 + H_2O + [O]$]x3

Step II: $S + 3[O] \longrightarrow SO_3$

Step III: $SO_3 + H_2O \longrightarrow H_2SO_4$

Answer: $S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$

* for Acidified $KMnO_4$: Pot. permangate :

Rule:

Step I: Decomposition of $KMnO_4$ to its K_2O, MnO & [O]

$2KMnO_4 \longrightarrow K_2O + 2MnO + 5[O]$

Step II: (a) K_2O react with H_2SO_4 to form corresponding salt & water.

(b) MnO react with H_2SO_4 to form Corresponding salt & water

$K_2O + H_2SO_4 \longrightarrow K_2SO_4 + H_2O$

$MnO + H_2SO_4 \longrightarrow MnSO_4 + H_2O$

Step III: Nascent oxygen combines with rest of the third reactant to gives its product.

$$H_2S + [O] \rightarrow H_2O + S$$

Step IV: Cancelled out the unstable intermediate that is ~~nascent~~ [O], K_2O, MnO,.

Step V: Finally added all the steps and get the balance equation.

for eg:

Balance the equation by partial equation method:

$$KMnO_4 + H_2SO_4 + H_2S \rightarrow K_2SO_4 + MnSO_4 + H_2O + S$$

Solution

step I: $2KMnO_4 \rightarrow$ ~~$K_2O + 2MnO + 5[O]$~~

step II: ⓐ ~~K_2O~~ $+ H_2SO_4 \rightarrow K_2SO_4 + H_2O$

ⓑ ~~MnO~~ $+ H_2SO_4 \rightarrow MnSO_4 + H_2O$]x2

step III: $H_2S + [O] \rightarrow H_2O + S$]x5

$$2KMnO_4 + 3H_2SO_4 + 5H_2S \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$$

$KMnO_4 + HCl \longrightarrow KCl + MnCl_2 + H_2O + Cl_2$

Solution:

Step I: $2KMnO_4 \longrightarrow K_2O + 2MnO + 5[O]$

Step II: ⓐ $K_2O + 2HCl \longrightarrow 2KCl + H_2O$

ⓑ $MnO + 2HCl \longrightarrow MnCl_2 + H_2O$] × 2

Step III: $2HCl + [O] \longrightarrow H_2O + Cl_2$] × 5

Answer: $2KMnO_4 + 16HCl \longrightarrow 2KCl + 2MnCl_2 + 8H_2O + 5Cl_2$

* For acidified $K_2Cr_2O_7$: Pot. dichromate

$K_2Cr_2O_7 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

Rules:

Step I: Decomposition of $K_2Cr_2O_7$ into K_2O, Cr_2O_3 & nascent oxygen [O].

$K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + 3[O]$

Step II: K_2O & Cr_2O_3 both are basic in character and combine with given acid to form corresponding salt and water.

$K_2O + H_2SO_4 \longrightarrow K_2SO_4 + H_2O$

$Cr_2O_3 + 3H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 3H_2O$

Step III: Nascent oxygen combines with third reacting substances or given acid to form its product.

$H_2S + [O] \rightarrow H_2O + S$

Step IV: Cancelled out [O], K_2O, Cr_2O_3 by multiplying the equation with suitable number.

Step V: Finally added all the balance equation to get balance chemical equation.

$K_2Cr_2O_7 + H_2SO_4 + H_2S \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

Soln

Step I: $K_2Cr_2O_7 \longrightarrow$ ~~$K_2O + Cr_2O_3 + 3[O]$~~

Step II: (a) ~~K_2O~~ $+ H_2SO_4 \rightarrow K_2SO_4 + H_2O$

(b) ~~Cr_2O_3~~ $+ 3H_2SO_4 \rightarrow Cr_2(SO_4)_3 + 3H_2O$

Step III: $H_2S + [O] \rightarrow H_2O + S$] x 3

$K_2Cr_2O_7 + 4H_2SO_4 + 3H_2S \rightarrow K_2SO_4 + Cr(SO_4)_3 + 7H_2O + 3S$

$K_2Cr_2O_7 + HCl + H_2S \longrightarrow KCl + CrCl_3 + H_2O + S$

Step I: $K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + 3[O]$

Step II: a) $K_2O + 2HCl \longrightarrow 2KCl + H_2O$

b) $Cr_2O_3 + 6HCl \longrightarrow 2CrCl_3 + 3H_2O$

Step III: $H_2S + [O] \longrightarrow H_2O + S \quad]x3$

$K_2Cr_2O_7 + 8HCl + 3H_2S \longrightarrow 2CrCl_3 + 2KCl + 7H_2O + 3S$

General Chemistry

Atoms is the smallest partical of the element which may or may not be freely exist in nature but they are highly reactive.

Atoms are neutral species and consist three particles that is electrons, protons, neutrons. These particles are called sub-atomic particles. These sub atomic particles can be arrange own its manner where centralies cent circle is called as necutes which includes protons and neutrons particles and positive

in character. Around the neucleus negatively charged electrons revolve in a circle like a solar system. An such arragnment are called atomic structure

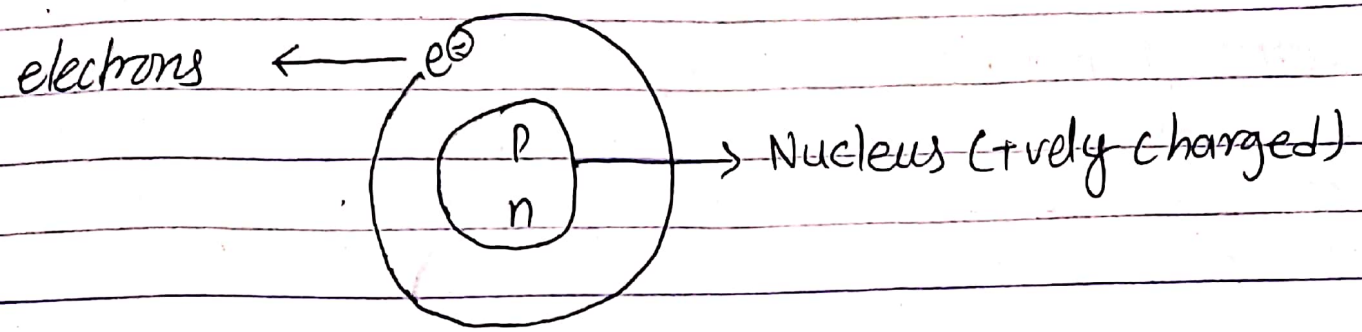


Fig: General Atomic structure

Molecule:-

The molecules are the smallest particles of an element or a compound which is freely exist in nature. They are stable in state which can be obtain by the combination of atomic form of same or different element.

for ex: H_2, HCl etc

Imp

Dalton's atomic theory: (father of atom) {Modern theory of atom}:

In 1813, Dalton first purpose/discovered the internal arragenment of atoms and purpose a theory that is Dalton's atomic theory: It has following Postulates:

@ All the matters are made of up by very small tiny particles which is indivisible and called as atoms.

(b) Atoms are neither created nor be destroyed or transformed be one atom to another.

(c) Atom of the same elements having all its physical or chemical properties be identical.

(d) Atom of the different element having all its properties be different.

(e) Into the compound the relative ratio of the different elements become simple whole number.

The ~~dan~~ Dalton's atomic theory was the success-ful discovery in term of modern atomic theory and followed at the middle of 19th century and modified in some postulates by Sir J.J Thomson, Neils Bohr, Chadwick & Co-worleers. Such modifications are:-

(a) ~~An~~ Atom is no ~~log~~ longer considered to be indivisible: It has beed found that, in atom there are ~~so~~ presence of fundamental particles that is electron, protons, neutron can be ~~parti~~ division when external agency way applied.

(b) Atoms of the same elements have not all properties identical: In term of isotops, which means element having same atomic number but different atomic weight is term as isotopes. for example: The ~~is~~ to isotops

of Hydrogen is protium ($^{1}_{1}H$), Deuterium ($^{2}_{1}H$), tritium ($^{3}_{1}H$) have same elemental state but its properties be differ in terms of atomic weight.

(c) Atom of the different element are not always different in properties.

In termsof isobar there are certain elements having different atomic number but similar atomic weight that is isobar.

for ex: $^{40}_{18}Ar$ $^{40}_{20}Ca$

Argon Calcium

Where, Atomic numbers are different but its atomic mass became identical.

(d) The ratio of each atom in compound become integral but not always simple ratio:

eg: ~~cellulose sugar ($C_{12}H_{22}O_{11}$)~~ The compound like sugar ($C_{12}H_{22}O_{11}$). The ratio of C, H & O - elements are 12:22:11 which is not a simple ratio.

(e) Atom of the one element can change into another element of the atom

for example: The atom of the nitrogen element convert into oxygen atom by nuclear reaction with alpha-particles ($^{4}_{2}He$):

$$^{14}_{7}N + {}^{4}_{2}He \longrightarrow {}^{17}_{8}O + {}^{1}_{1}H$$

α-particle protium

(f) The mass of the atom converted into energy. By using Einstein's equation that is $E = mc^2$, mass and energy can be interconvertable.

* Atomic weight:

Introduction: Atoms are small particles which are not paratically seen even by using powerful micro-scope. Therefore, its weight cannot be weighed by using laboratory equipment due to neglegible in amount.

for example:- The careful calculation shows that. The actual weight of H-atom is 1.67×10^{-23} gm & C-atom is 1.97×10^{-24} gm. which is negolegible in amount.

Therefore, To remove the such difficulty the weight of the atom can be measure with reference to standard weight of standard elements. for such In early development of chemistry, Hydrogen element was taken to be standard element due to lighter and its atomic weight was 1. Therefore, Atomic weight is the number of an element which expressed how many times such element heavier than weight of H-element.

Mathematically,

Atomic weight of an element = $\frac{\text{Wt. of 1 atom of an element}}{\text{Wt. of 1 atom of H-element}}$

Later on O-element was taken as standard.

element because due to highly reactive than H-element.

After, In 1961, IUPAC (International Union of Pure Applied Chemistry) select the new scale to express the new atomic weight by taking C^{12} isotope of Carbon element. This scale of relative weight of an atom is called atomic mass unit & represent as amu.

1 amu is defined as $\frac{1}{12}$ th absolute weight of C^{12} isotope of carbon element.

ie. $1\ amu = \frac{\text{Absolute weight of } C^{12}\text{-ispote of Carbon}}{12}$

Where, $1\ amu = 1.66 \times 10^{-24}\ gm$

Therefore, Atomic weight of an element is defined as average relative weight of an element as comparre with C^{12} isotope of weight of C-atom. ie. 12 amu.

In other word it is the number which express how many times such element be ~~higher~~ heavier than $\frac{1}{12}$ th weight of C^{12} isotopes of carbon.

Mathematically,

Atomic wt of an element = $\frac{\text{Absolute wt of an 1-atom of the element}}{\left(\frac{1}{12} \text{ wt of } C^{12} \text{ isotope of carbon}\right) \text{amu}}$

for Ex: Atomic wt of H-atom is 1.008 amu, magnesium is 24 amu.

Q Define amu? What is the meaning of the atomic weight of mg and O-atom are 24 amu and 16 amu, respectively?

⇒ Amu is the number which express how many times such element be heavier than $\frac{1}{12}$ th weight of C^{12} isotopes of carbon.

It is the number which express 24 times mg is heavier than $\frac{1}{12}$ th weight of C^{12} isotopes of carbon.

Similarly,
It is the number which express 16 times O is heavier than $\frac{1}{12}$ th weight of C^{12} isotopes of carbon.

* Gram atomic weight & No. of gram atomic weights

It is the atomic weight of the element which can be express in gram scale.

for example:

Gram atomic weight of O-atom = 16 gm
Gram atomic weight of N-atom = 14 gm

Imp

Note: The number of gram atom is related to the weight of the atom by the relation:

$$\text{No of gram atom} = \frac{\text{wt. of the element in gram (gm)}}{\text{Gram atomic weight of the element}}$$

---

* How many no ~~fo~~ of gram atom in Oxygen which contain 8 gm?

Given data,

Weight of the O-element = 8 gm
no. of gram atom in oxygen = ?
We know,

$$\text{No. of gram atom in oxygen} = \frac{\text{wt of O-, in gm}}{\text{Gram atomic wt of O}}$$

$$= \frac{8}{16} = \frac{1}{2} = 0.5$$

Imp

* Fractional atomic wt.

The atomic weight of the element is not in whole numbe is termed as fractional atomic weight.

for example: the atomic weight of H-element is 1.008
Cl-element is 35.5 which is fractional atomic weight.

This is because the atomic weight of an element is the average relative weight of its various isotopes present in the nature of its specific abundance(existan ce). As a results its fraction can be appears.

for example: Cl-element exist in 2 isotopes that is ^{35}Cl & ^{37}Cl into 3:1 proportation.

Therefore,

$$\text{At wt of Cl-element} = \frac{35 \times 3 + 37 + 1}{3+1} = 35.5 \text{ amu}$$

V.V.Imp

(*) Determination of atomic wt: By Dulong & Petit's Method:

To calculate the exact atomic weight of solid element by using exact equivalent weight valency no., Dulong & Petit's gave the rule / i.e. Dulong & Petit's law

Which state that, "the product of specific heat and atomic weight of solid elements is approximately equal to 6.4."

Mathematically,

$$\text{At weight} \times \text{Specific heat} = 6.4 \text{ (approx)}$$

The product of atomic weight & specific heat is termed as atomic heat.

To calculate exact atomic weight by using this method following steps can be involves:

i) Calculation of approx atomic weight:

By Using Dulong's & Petit's equation, approx. atomic wt can be calculate as:

$$\text{Approx. atomic wt} = \frac{6.4}{\text{specific heat}}$$

ii) Calculation of exact equivalent weight:

By using the relation.

$$\text{Equivalent wt. of the metal} = \frac{\text{weight of metal taken}}{\text{weight of standard element}} \times \text{Equivalent wt of standard element.}$$

where, standard element is, H=1.008, O=8 & Cl=35.5

iii) Calculation of exact valency number:

Valency can be calculate by using the relation,

$$\text{Valency} = \frac{\text{Approx. atomic wt.}}{\text{Equivalent wt.}}$$

Note: Valency = step ① / step ⑪

Since, Valency is whole number, it converted to nearest whole number if it is fractional

ie. 3.4 ≈ 3 ; 3.6 ≈ 4

Step: IV) Calculation of exact atomic weight:

By using the relation,

Exact atomic wt = Equivalent weight x Valency

Numerical zone:

The chloride of metal is found to be contain 20.2% of the metal. The specific heat of the metal is 0.224. Calculate the exact atomic weight of the metal?

Given,

Wt of metal taken = 20.2 gm

Wt of chlorine = (100 − 20.2) gm

= 79.8 gm

specific heat of the metal = 0.224
Exact atomic weight = ?
We have,

(a) approx atomic weight = $\frac{6.4}{\text{Sp. heat}} = \frac{6.4}{0.224} = 28.57$

(b) Equivalent wt of the metal = $\frac{\text{wt of metal taken}}{\text{wt of Cl}} \times \text{Eq wt of Cl}$

$= \frac{20.2}{79.8} \times 35.5$

$= 8.98$

(c) Valency = $\frac{\text{App. atomic weight}}{\text{Equivalent weight}} = \frac{28.57}{8.98} = 3.18 \approx 3$

(d) exact atomic wt = Eq. wt x Valency
$= 8.98 \times 3$
$= 26.94$

(*) 2.380 gm of a Metal on treatment with dilute acids & ignition to gave 3.022 gm of metal oxide. specific heat of the metal is 0.055. calculate exact atomic wt.?

Given,

wt. of metal taken = 2.380 gm

wt of metal oxide = 3.022 gm

wt of oxygen = (3.022 − 2.380) = 0.642 gm

specific heat of metal = 0.055

Exact atomic wt = ?

We have

a) approx atomic wt $= \frac{6.4}{\text{Sp heat}} = \frac{6.4}{0.055} = 116.36$

b) Equivalent weight of the metal $= \frac{\text{wt of metal}}{\text{wt of O}} \times \text{Eq wt of O}$

$= \frac{2.380}{0.642} \times 8$

$= 29.65$

c) Valency $= \frac{\text{App. atomic wt}}{\text{Eq. wt}} = \frac{116.36}{29.65} = 3.92 \approx 4$

d) Exact atomic wt = Eq. wt × valency

$= 29.65 \times 4$

$= 118.6$

(*) Trivalent of the metal & there is 31.6 % of oxygen in its oxides. Calculate the exact atomic wt of the metal?

Given,

Valency of metal = 3
wt of oxygen = 31.6 gm
wt of metal = 68.4 gm
Exact atomic weight = ?

We have,

(a) Eq. wt = $\frac{68.4}{31.6} \times 8$

= 17.31

(b) Exact atomic wt = Eq. wt x valency
= 17.31 x 3
= 51.94

monovalent

(*) The specific heat of metal is 0.25 & its equivalent weight is 12. Calculate exact atomic weight of the metal.

Given,

specific heat of metal = 0.25
Equivalent weight of metal = 12
exact atomic weight = ?

We have, By using Dulong & Petit's method.

(a) app. atomic wt = $\frac{6.4}{0.25}$ = 25.6

(b) Valency = $\frac{25.6}{12}$ = 2.1 ≈ 2

(c) Exact atomic weight = 12 × 2
= 24

Molecular weight:

Introduction: molecular weight is defined as average relative weight of a molecules of the element or compound to the $\frac{1}{12}$ weight of atom in C^{12} is tope of Carbon.

Mathematically:-

the molecular wt of the molecules = $\frac{\text{Absolute weight of the molecule in elements or compound}}{\frac{1}{12}\text{th weight of an atom in } C^{12}\text{- isotope of carbon}}$

In other word, "The molecular weight is the number which expressed how many times such molecules

is heavier than $\frac{1}{12}$th weight of an atom in C^{12} - isotopes of carbon."

for ex: The molecular weight of oxygen (O_2) is 32 amu & Nitrogen molecules is 28 amu.

Note: "molecular weight of the substance can be calculate by adding each of the atomic weight in each atom"

for ex: The molecular weight of H_2SO_4 compound can be calculate as;

$= 2 \times (H\text{-atom}) + 1 \times (S\text{-atom}) + 4 \times (O\text{-atoms})$
$= 2 \times 1 + 1 \times 32 + 4 \times 16$
$= 98$ amu

VVI

* Avogadro's Hypothesis: [1811] [Amadeo Avogadro's]

In 1811, Amadeo Avogadro's modified the Berzelius hypothesis by introducing the molecules in place of atom and term as avogadro's hypothesis.

Which states that "equal volume of the gases substances contains equal number of molecules, under similar condition of temperature & pressure."

Application of Avogadro's hypothesis:

(a) Determine the atomicity of gases molecules:

Atomicity of gases molecules is define as the number of atoms present in the molecules which can be easily explain with the application of avogadro's hypothesis like homoatomic molecules ie. hydrogen, oxygen, chlorine etc are diatomic. It can be explain as ~~chemical~~ by using the chemical equation;

Hydrogen & Chlorine are diatomic:

This can be explain by the chemical equation as, hydrogen & Chlorine react to give hydrogen chloride.

$$H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$$

1 vol 1 vol 2 vol

Applying Avogadro's hypothesis, where, n Volume = n molecule

1 molecule	1 molecule	2 molecules
$\frac{1}{2}$ molecule	$\frac{1}{2}$ molecule	1 molecule

This shows that; One molecule of hydrogen chloride contain half molecule of hydrogen & Chlorine respectively. Since, Atoms cannot be divides therefore molecules of Hydrogen & Chlorine contains even numbers of each atoms ie 2, 4 or 6 etc. this indicates Hydrogen & Chlorine contain 2 half of the molecules i.e. 2 atoms in each molecules which is diatomic molecules.

Imp

② Determine the relationship between between molecular weight and vapour density (V.D):

The vapour density of a gas is define as the ratio of weight of certain volume of the gas substance to the weight of same volume of Hydrogen gas measure under similar condition of temperature & pressure.

ie. V.D = $\frac{\text{weight of 'V' volume of Certain gas substance}}{\text{weight of 'V' volume of hydrogen gas}}$

Applying Avogadro's hypothesis where 'V' volume = 'n' molecules

V.D = $\frac{\text{Weight of 'n' molecular of gases substances}}{\text{weight of 'n' molecule of hydrogen gas}}$

$= \frac{\text{wt of 1-molecule of gases substance}}{\text{wt of 1-molecule of hydrogen gas}}$

$= \frac{\text{wt of 1-molecule of gases substances}}{2 \times \text{wt of 1-atoms of hydrogen gas}}$

or, $V.D \times 2 = \frac{\text{Wt of 1-molecule of gases substances}}{\text{wt of 1-atoms of hydrogen}}$

According to definition of molecular wt.

We get,

$$\boxed{\text{Molecular wt} = 2 \times \text{V.D}}$$

Therefore, molecular weight is twice to the vapour density of gases substances."

③ Derive the relationship between mass-volume of gass molecules

We know that, Avogadro's hypothesis can give the relationship between mass, volume of gasses molecules at NTP condition ie Normal Temperature & pressure where $T = 273\,k$, $P = 760\ mmHg$.

1CC or 1ml of H_2 gas at NTP is equal to 0.000089 gm ie

1CC of H_2 gas at NTP = 0.000089 gm of H_2

Similarly the volume-mass relation for other gases molecules is, 1CC of gasses substance = V.D x 0.000089 gm of gas [$\because V.D = \frac{mol.wt}{2}$]

ie 1CC of O_2 gas = 16×0.000089 gm of O_2
= 0.001424 of O_2

1cc of N_2 gas = 14×0.000089 gm of N_2
= 0.001246 of N_2

Determination of molecular weight: Victor-Meyer's tube method

Principle: This method is applied to calculate the molecular weight of volatile solid or liquids where known quantity of metal or substances is converted

into vapour and volume of vapour can be measured under lab temperature & pressure. Thus product volume is then converted into NTP volume and wait of such substances can be calculate by multiplying 0.000089 gm with its volume.

The vapour density of the substance can calculate by using the relation

$$V.D = \frac{\text{wt of substance taken in gases}}{\text{wt of } H_2 \text{ gas at NTP}}$$

Where,

Wt of H_2 gas displaced at NTP = Volume ~~of~~ x 0.000089gm at NTP

Then,

Molecular weight = 2 x Vapour density

~~Prod~~ Procedure:-

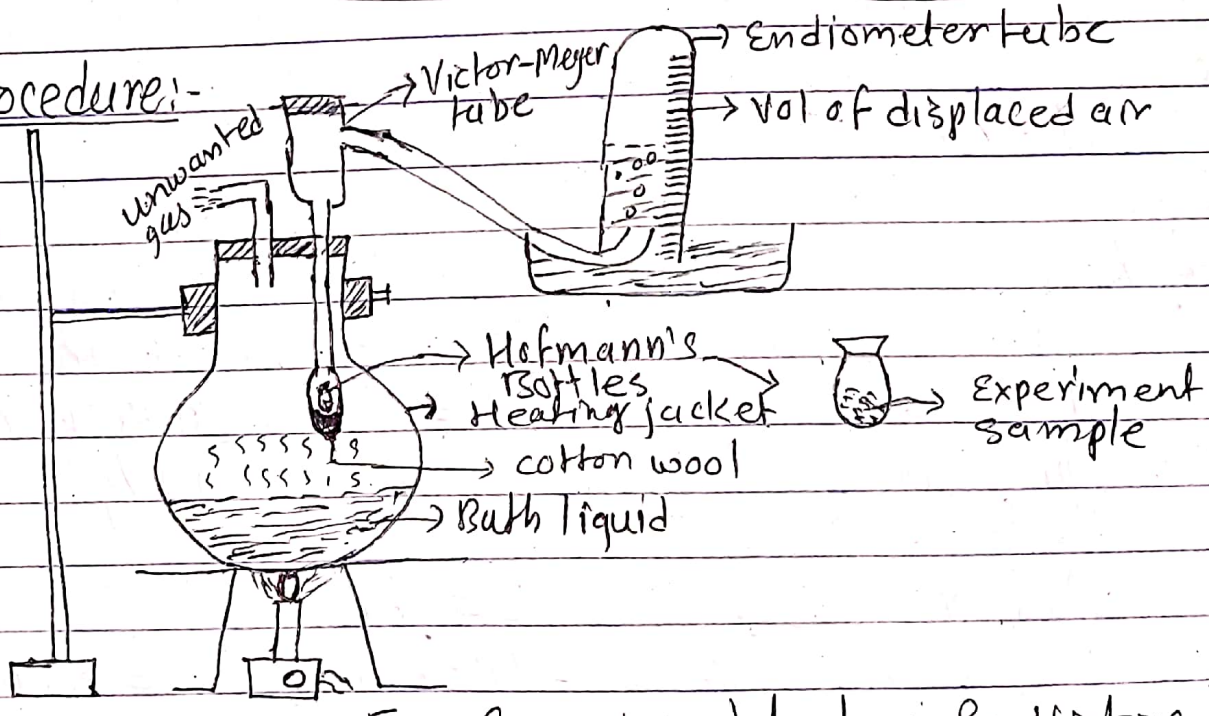


Fig: Experimental setup & Victor-Meyer's tube method

Victor Meyer's tube: Method

The apparatus used in this method is victor's meyer's tube which is funned like shape at upper part and ~~cylind~~ Cylindrical in shape at lower part. At the lower part of this tube a cotton wool can be taken which prevent the breakage of glass where the sample taking Hofmann's bottoles drop inside. By the help of air tight heating jacket containing bath liquids vapourised the experimental sample.

The upper part of tube contain side tube goes through a eudiometer water containing tube. The vapour of gas can displaced some volume. The expirement can be stopped bubbles of gas can prevent to produce. Finally, noted the volume of displaced air lab temperature, atomspheric pressure & aqueous ~~tension~~ tension of water during the process.

~~Imp~~

*Calculation:

Let, weight of the sample taken = w gram
volume of displaced air = V_1 ml or cc
Temperature of water = $T^\circ K$ [$= (0^\circ C + 273) K$]
pressure of moist air = P mm Hg

Aqueous tension at $T^\circ C$ = f mm Hg
∴ Pressure of dry air = $(P - f)$ mm Hg = P_1 mm Hg

By changing the laboratory volume to NTP Volume by using combine gas equations, we have:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Where, 1 = Initial condition
2 = final condition at NTP
where $T_2 = 273K$, $P_2 = 760$ mm Hg, $V_2 = ?$

Therefore, $V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2}$

$$V_2 = \frac{(P - f) \times V_1 \times 273K}{T°K \times 760 \text{ mmHg}}$$

$V_2 = x$ ml (let) at NTP.

We know,
1cc of displaced air (Hydrogen gas) at NTP = 0.000089 gm of gas

∴ xcc of displaced air at NTP = $x \times 0.000089$ gm
= y gm

Vapour density (VD) = $\frac{\text{Wt of metal taken in gas}}{\text{Wt of displaced air at NTP}}$

$= \frac{w \text{ gm}}{y \text{ gm}}$

$= z \text{ gm (let)}$

Finally,

Molecular weight $= 2 \times V.D$

$= 2 \times z$

$= 2z$

Numerical zone,

0.15 gm of volatile liquid when treated with Vector Meyer's tube apparatus displaced 40.5 cm^3 air collected over a water at 15°C and 746 mm Hg Pressure calculate the molecular weight of ~~vola~~ liquid. (Aqueous tension at 15°C = 13.7 mm Hg)

Given,

wt of volatile liquild = 0.15 gm

volume of the displaced air (V_1) = 40.5 cc

Temperature of water (T_1) = (15°C + 273) K = 288 K

Pressure of the air (P) = 746 mm Hg

Aqueous tension (f_{aq}) = 13.7 mm Hg

Pressure of dry air (P_1) = (746 − 13.7) mm Hg

= 732.3 mm Hg

at NTP

$P_2 = 760$ mmHg

$T_2 = 273$ K

$V_2 = ?$

$$V_2 = \frac{P_1 V_1 T_2}{T_1 \times P_2}$$

$$V_2 = \frac{732.3 \times 40.5 \times 273}{288 \times 760}$$

$$V_2 = \frac{8096674.95}{218880}$$

$V_2 = 36.99$ ml

ICC of displaced air $= 36.99 \times 0.000089$

$= 0.00329211$ ml

Vapour density (VD) $= \frac{\quad}{0.00329211}$

fed In a Victor Meyer's expirement 0.09 gm of liquid displaced on vapourization 28.9 cc of air. collected over the water in 16°C and 753 mmHg pressure. Calculate the vapour density and moleculer ~~of H~~ weight of liquid (Aqueous tension in 16°C = 13.5 mmHg)

Given,

$m = 0.09\,gm$

Volume $(V_1) = 28.9$ cc

Pressure $(P_1) = 753\ mmHg - 13.5\ mmHg = 739.5\ mmHg$

Temperature $(T_1) = $ ~~16°C~~ $(16°C + 273) = 289\ K$

Changing the vol at NTP - volume by using combine gas eqn By the formula,

$$\frac{V_1 P_1}{T_1} = \frac{V_2 P_2}{T_2}$$

$$\frac{28.9 \times 739.5}{289\ (16+273)} = \frac{V_2 \times 760}{273}$$

$$V_2 = \frac{21371.55 \times 273}{289 \times 760}$$

$$V_2 = 26.56\ ml$$

We know

1 cc of displaced air = $26.56 \times 0.00089\,gm$

$= 0.00236\ gm$

Vapour density = $\frac{0.09\ gm}{0.00236\ gm}$

VD = 38.13

Mol. wt = 2 x VD

= 2 x 38.13

= 76.26

The chlorides of metal is found to be contain 20.2%. of the metal. The specific heat of the meted is 0.224. The vapour density of its chloride is 133.4. Calculate exact atomic wt. of the metal & also write molecular formula.

Given,

% of metal = 20.2% = 20.2 gm
% of Cl = 100% − 20.2% = 79.8% = 79.8 gm
Sp. heat = 0.224
Vapour density = 133.4
Molecular weight = 2×133.4 = 266.8
Exact atomic weight = ?
Molecular formula = ?

We have,

App. atomic wt = $\frac{6.4}{\text{sp. heat}} = \frac{6.4}{0.224} = 28.5$

Eq. wt = $\frac{20.2}{79.8} \times 35.5$

$= 8.98$

Valency = $\frac{a}{5} = 3.2 \approx 3$

~~Exact a~~

The molecular formula = MCl_3 (where $x = 3$)

~~Molecular wt (MCl_3) = At. wt of M + 3x atomic wt of Cl~~

=

Ex. atomic wt = Eq. wt x valency

= 8.98 x 3

= 26.94

The oxide of metal is found to be contain 20% of the metal. The spefic heat of the metal is 0.25. The vapour density of its oxide is 130. Calculate exact atomic weight with its formula?

Given, % of metal = 20% = 20 gm

% of oxijgen = 80% = 80 gm

Sp. heat of metal = 0.25

Vapour density = 130

Molecular weight = 130 x 2 = 260

We have,

app. atomic wt = $\frac{6.4}{0.25} = 25.6$

Eq. weight = $\frac{20}{80} \times 8$

= 2

Valency = $\frac{25.6}{2}$ = 12.8 ≈ 13

Exact atomic wt = 25.6 × 13 = ~~327.68~~ 332.8

Mole Concept:

Introduction: The moles indicates the number of particules in terms of atom, molecules, ions or electrons etc. The values of mole is equal to 6.023×10^{23} no & called as Avogadro's number. A mole of the particles which contains the avogadro's number can be express clearly in terms of unit as atom, molecules, ions or electrons. I.e.

i.e. 1 mole of particles = 6.023×10^{23} no. of particles & other.

1 mole of H-atom: 6.023×10^{23} no of H-atom
1 mole of H_2 molecule: 6.023×10^{23} no of H_2 molecules
1 mole of H^+-ions: 6.023×10^{23} no of H^+ ions.

(a) mole and Gram atomic weight

The mole and gram atomic weight of the atom can be related as:

> 1 mole of atom = 6.023×10^{23} no. of such atom = gram atomic weight of the element

Q: Calculate the number of atoms in each of following?
(a) 52 gm of He
(b) 52 mole of He

(a) Solⁿ: We have,

Gram atomic wt He = 6.023×10^{23} no. of He.

4 gm of He = 6.023×1023 no of He

1 gm of He = $\frac{6.023 \times 10^{23}}{4}$ no of He

52 gm of He = $\frac{6.023 \times 10^{23} \times 52}{4}$ no of He.

= 2.4299×10^{24} no of He.

(b) Solⁿ 1 mole of He = 6.023×10^{23}

52 mole of He = $52 \times 6.023 \times 10^{23}$ no of He =

(b) Mole & Gram molecular Weight:

The mole ~~of~~ & gram molecular weight of the substance can be related as:

~~Eaten~~ 1 mole of molecule = 6.023×10^{23} no of such molecule = Gram molecular wt of the molecules.

(Q): Calculate the no of molecules & moles in 1.8 gm of water?

Solⁿ:

Gram molecular Wt of H_2O = 6.023×10^{23} no of H_2O.

18 gm of H_2O = 6.023×10^{23} no of H_2O

1 gm of H_2O = $\frac{6.023 \times 10^{23}}{18}$ no of H_2O

1.8 gm of H_2O = $\frac{6.023 \times 10^{23} \times 1.8}{18\ 10}$ no of H_2O

= 6.023×10^{22} no of H_2O

Q Calculate the ~~mass~~ number of water molecules in one drop of water with its weight 0.05 gm ?

Soln:

Gram molecular weight of H_2O = 6.023×10^{23} no of H_2O

18 gm of H_2O = 6.023×10^{23} no of H_2O

1 gm of H_2O = $\frac{6.023 \times 10^{23}}{18}$ no of H_2O

0.05 gm of H_2O = $\frac{6.023 \times 10^{23} \times 0.05}{18}$

= 1.673×10^{21} no of H_2O

③ Mole & Ionic Compounds:

The compounds like NaCl, $MgCl_2$, $AlCl_3$ etc are ionic compounds which is related to the mole concept as;

> 1 mole of ionic compound = 6.023×10^{23} no of ionic Comp^n
> ($= 6.023 \times 10^{23}$ of +ve ion + 6.023×10^{23} no of -ve ion)
> = Gram formula weight of ionic compound

Q: Calculate the no of Na & Cl- ions in 1 mole of NaCl?

Solⁿ We have,

1 mole of NaCl = 6.023×10^{23} no of Na^+-ion + 6.023×10^{23} no of Cl^--ion

④ Mole & Volume:

1 moles of all gases molecule under NTP condition i.e. T = 273 K & P = 760 mmHg is equal to 22.4 lit of such gas. This volume is called as molar volume. Which is related to the mole concept as;

1 mole of gas = 6.023×10^{23} no of gas = 22.4 lit of gas at NTP = Gram molecular weight of such gases

Q Calculate the weight of ~~2.24~~ 2.24 litre of oxygen at NTP?

Soln

We have,

22.4 litre of O_2 gas at NTP = Gram molecular wt of O_2 gas

22.4 litre of O_2 gas at NTP = 32 gm of O_2 gas

1 litre of O_2 gas at NTP = $\frac{32}{22.4}$ gm of O_2 gas

2.24 litre of O_2 gas at NTP = $\frac{32 \times 2.24}{22.4}$ gm of O_2 gas

= 3.2 gm of O_2 gas

Q: Calculate weight of 10 moles of sugar ($C_{12}H_{22}O_{11}$)

Soln, We have,

1 mole of sugar = Gram molecular weigh of sugar
1 mole of sugar = 342 gm of sugar
10 mole of sugar = 3420 gm of sugar

Q: Calculate the number of molecules present in
a) 1 kg of O_2
b) 1 mol of H_2 at NTP

a)
Soln

~~1000 gm~~

Gram molecular weight of O_2 = 6.023×10^{23} no of O_2

32 gm of O_2 = 6.023×10^{23} no of O_2

1 gm of O_2 = $\frac{6.023 \times 10^{23}}{32}$ no of O_2

1000 gm of O_2 = $\frac{6.023 \times 10^{23} \times 1000}{32}$ no of O_2

1000 gm of O_2 = 1.882×10^{25} no of O_2

22.4 l = 22400 ml

b)

at NTP

22400 ml of H_2 = 6.023×10^{23} no of H_2 [∵ 22.4 l = 22400 ml]

at NTP

1 ml of H_2 = $\frac{6.023 \times 10^{23}}{22400}$ no of H_2

1 ml of H_2 at NTP = 2.688×10^{19} no of H_2

Equivalent Weight:

Introduction:

Equivalent weight of an element is the number which express the how many parts by weight of such element combine or displaced 1.008 parts by wt of H, 8 parts by wt of O or 35.5 parts by wt of Cl elements.

for example:

In Mgo

16 parts by wt of O combine with 24 parts by wt of Mg-element in MgO

8 parts by wt of O combine with 12 parts by wt of Mg element in Mgo

Therefore, The equivalent weight of Mg is 12.

Q Define Equivalent wt of the element? What is the meaning of equivalent wt of Mg is 12?

In $AlCl_3$

3 x 35.5 parts by wt of Cl combine with 27 parts by wt of Al in $AlCl_3$

35.5 parts by wt of Cl combine with 9 parts by wt of Al in $AlCl_3$

In Al_2O_3

3 x 16 parts by wt of O combine with 2 x 27 parts by wt of Al in Al_2O_3

8 parts by wt of O combine with 9 parts by wt of Al in Al_2O_3

* Gram equivalent weight

Equivalent weight of an element is only number and itself has no unit. If equivalent weight of an a element express in gram scale it is termed as Gram equivalent weight.

For ex:

Gram equivalent wt of Mg = 12gm
Gram equivalent wt of Al = 9gm

Also, no of gram equivalent Calculate as,

$$= \frac{\text{wt of the element in gram}}{\text{Equivalent wt of the element in gram}}$$

Variable Equivalent Weight:

The variable equivalent weight of the element is, If the element contain more than one equivalent weight are called as variable equivalent weight.

For example:

In case of FeO & Fe_2O_3, The equivalent weight of Fe is 28 & 18.66 respectively.

Imp:

* Relation between atomic weight, Equivalent weight & Valency:

Let A, E & V are the atomic weight, Equivalent weight & Valency of the element respectively. According to old concept of valency the atoms which can be combines with V-atoms of hydrogen

* Weight of V-atoms of hydrogen = V × 1.008
* V × 1.008 parts by wt of hydrogen combine with A parts by wt of element
* 1.008 parts by wt of hydrogen combine with $\frac{A}{V}$ parts by wt of element
* By the definition of equivalent weight, the number parts by weight of the element combine with 1.008 parts by weight of hydrogen is equivalent weight. Therefore, Equivalent wt (E) = $\frac{\text{Atomic wt (A)}}{\text{Valency (V)}}$

or, Atomic wt (A) = Equivalent weight (E) × Valency (V)

Finally, This is the relation between atomic weight, Equivalent weight & Valency. of

* Determination of Equivalent Weight:

The equivalent weight of the elements determine by following ways:

(a) Hydrogen displacement method
(b) Oxide formation method

(a) Hydrogen displacement method

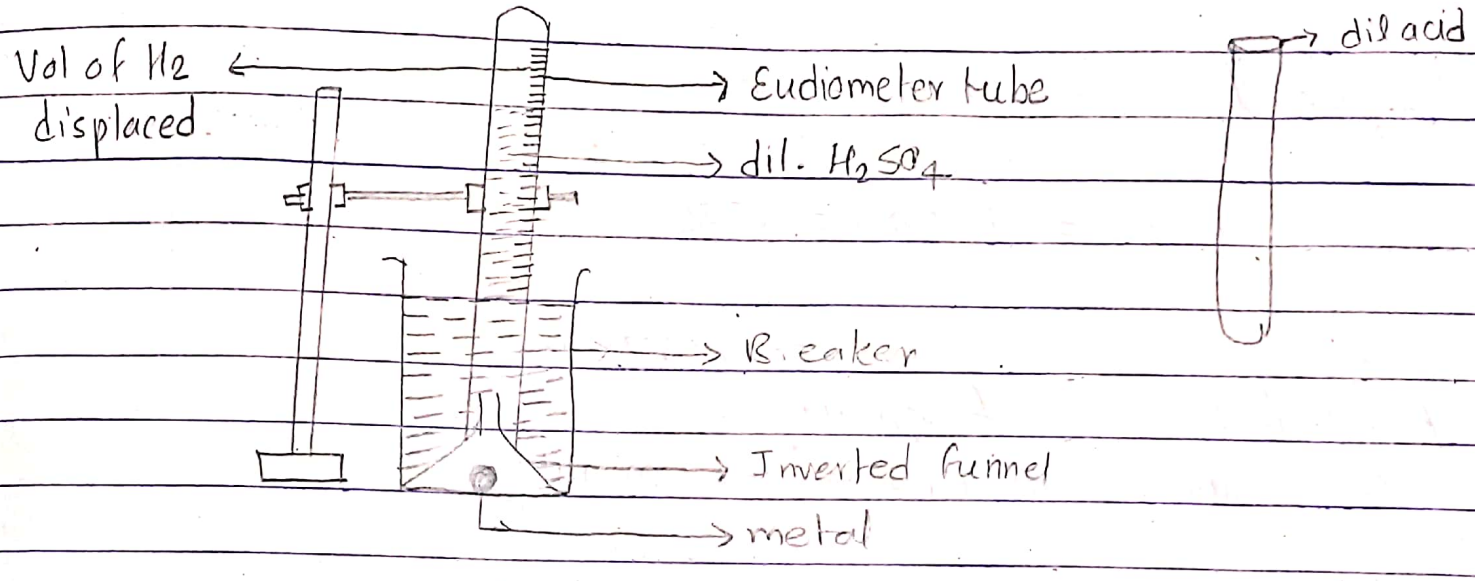
This method is used to determine the equivalent weight of the metals which can displaced hydrogen from dilute acids ie more electro positive than hydrogen like Zn, Mg, Fe, Al etc.

Forexample: $Zn + 2HCl \rightarrow ZnCl_2 + H_2(g)$

In this method, small known weight of metals allowed to react with dilute acids. The volume of H_2 can be measured at NTP-condition as well as calculate its weight. By using the known weight of hydrogen at NTP to known weight of metal taken, equivalent weight of the metal. Calculate by using the relation,

$$\text{Equivalent wt of metal} = \frac{\text{wt of metal taken}}{\text{wt of } H_2 \text{ displaced at NTP}} \times 1.008$$

Procedure:



Hydrogen displacement method

~~Apparatus~~; Procedure:

During the determention of equivalent weight by hydrogen displacement method, ~~==~~ lenenon weight of experimental metal taken at the bottom of breaker. Then, metal is covered by short steam of funnel and water can be filled up to cover the steam of funnel. In Eudiometer tube is dilute acid can be taken and close the up end of tube by thumb and insert inside the stem of funnel. When acid and metal react H_2 gas can be produce and displaced ~~sed~~ certain volume inside the tube. The experiment get stopped till the formation of

bubble of H_2 gas stopped. note the volume of H_2 gas displaced, atmospheric pressure, lab temperature, aqueous tension into the lab.

Calculation:

Wt of the metal taken = w gm
Volume of the hydrogen gas = V_1 cc
temperature = T_1 °C = T_1 K

Atmospheric pressure = P mm Hg
Aqueous tension = f mm Hg
∴ Pressure of dry air (P_1) = (P − f) mm Hg

Change the volume (V_1) into NTP volume by using combine gas equation;

$$\text{i.e.} \quad \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Where; $P_2 = 760$ mm Hg, $T_2 = 273$ k, $V_2 = ?$ } at NTP

Therefore,

$$V_2 = \frac{P_1 V_1 \times T_2}{P_2 \times T_1} \text{ cc}$$

Then, 1cc of H_2 gas at NTP = 0.000089 gm

V_2 cc of H_2 gas at NTP = $V_2 \times 0.000089$ gm

= x gm (say)

Finally,

Equivalent wt of metal = $\frac{\text{wt of metal taken} \times 1.008}{\text{wt of } H_2 \text{ gas displaced at NTP}}$

$\frac{}{(V \times gm)}$

Numerical zones

0.125 gm of reacting metal when dissolve with dilute HCl to give 240 cc of H_2 at 20°C & 755 mm Hg pressure over water. Calculate the equivalent wt of the metal (Given aqueous tension at 20°C = 15mmHg

Soln

We have,

Weight of metal taken = 0.25 gm

Volume of displaced H_2 gas (V_1) = 240 cc or 240ml

Temperature (T_1) = 20°C = (20+273)K = 293 k

Atomspheric pressure = 755 mm Hg

Pressure of moist Air = 15 mm Hg

Pressure of Dry Air (P_1) = (755 - 15) mm Hg

= 740 mm Hg

Change the V_1 - vol to NTP volo by using combine gas equation;

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

where; $P_2 = 760\ mm\ Hg$

$T_2 = 273\ K$

$V_2 = ?$

$$V_2 = \frac{P_1V_1 \times T_2}{P_2 \times T_1}$$

$$= \frac{740 \times 240 \times 273}{760 \times 293}$$

$$V_2 = 217\ gm$$

Then 1 cc of H_2 gas = 0.000089 gm

217 cc of H_2 gas = 217×0.000089 gm

= 0.019 gm

Therefore,

Equivalent weight = $\frac{0.25 \times 1.008}{0.019}$

= 13.26 .

⊛ Oxide formation method:

This method can be used to determine the equivalent weight of metal which is less electro positive than hydrogen & cannot be displaced H_2 gas on react with dilute acids. In this method ~~react~~ known weight of metal is convert into corresponding metal oxide and the weight of metal oxide can be determine on react with atmospheric air. (O_2).

By using the relation equivalent wt of metal oxide calculate as;

$$\text{Equivalent wt of metal} = \frac{\text{wt of metal taken}}{\text{wt of metal oxide} - \text{wt of metal}} \times 8$$

$$= \frac{\text{wt of metal taken}}{\text{wt of oxygen}} \times 8$$

Numerical

0.5 gm of metal when react with air to produce 0.8 gm of metal oxide. Calculate the Equivalent weight of metal.

Given

wt of metal = 0.5 gm
wt of metal oxide = 0.8 gm

Equivalent wt of metal = $\frac{0.5}{0.8-0.5} \times 8$

$= \frac{0.5}{0.3} \times 8$

$= \frac{5}{3} \times 8$

$= 13.33$

Imp

* Equivalent wt of acids, bases & Salts:

@ Equivalent wt of acids:

The equivalent wt of acids is define as the number which expressed 1.008 parts by weight of replaceable hydrogen. It is Calculate by using:

Equivalent wt of acid = $\frac{\text{molecular wt of acid}}{\text{Basicity of acid}}$

where; Basicity of acid is Define as the number of

replaceable hydrogen atom. in the acid.

Calculate the equivalent wt of H_2SO_4, HCl, CH_3COOH (acetic acid)

$H_2SO_4 = 2H^+ + SO_4^{-2}$

Molecular wt of $H_2SO_4 = 98$
Basicity of acid = 2

Therefore, $= 98/2 = 49$

$HCl \rightarrow H^+ + Cl^-$ M wt = 36.5, Eq. wt = 36.5

$CH_3COOH \rightarrow CH_3COO^- + H^+$ Eq. wt = 60

② Equivalent wt of base:

Equivalent wt of base is define as the number of parts by weight of it which completely neutralized 1.008 parts by wt of hydrogen.

Equivalent wt of base calculated by using formula:-

$$\text{Equivalent wt of base} = \frac{\text{Molecular wt of base}}{\text{Acidity of base}}$$

Where, Acidity of base is the number OH group into the base

There also some oxidie containing base, whose acidity number is calculate by using.

$$\text{Acidity of oxide} = \frac{2 \times \text{No of oxygen atom}}{\text{No of metal atom}}$$

for ex: Calculate the equivalent wt of CaO?

Soln Molecular wt of CaO = 56
Equivalent wt = ?

We know,

$$\text{Equivalent wt} = \frac{\text{Molecular wt of CaO}}{\text{Acidity of CaO}}$$

Acidity of $CaO = \frac{2 \times 1}{1} = 2$

Therefore, $= \frac{56}{2} = 28$

Q. Calculate equivalent wt of $Al(OH)_3$

Mol wt of $Al(OH)_3 = 78$

Acidity of $Al(OH)_3 = 3$ $\quad \frac{2 \times 3}{1}$

Eq. wt of $Al(OH)_3 = \frac{78}{3}$

$= 26$

Mol. wt of $Al_2O_3 = 102$

Acidity of $Al_2O_3 = ?$

Acidity of Oxide $= \frac{2 \times 3}{2}$

$= 3$

Equivalent wt of $Al_2O_3 = \frac{102}{3}$

$= 34$

Example

Some bases:

Bases	Acidity of base
(a) $NaOH$, KOH, NH_4OH, K_2O, Na_2O etc.	1 (monoacidic base)
(b) $Ca(OH)_2$, $Mg(OH)_2$, $Zn(OH)_2$, CaO, MgO, ZnO, $Fe(OH)_2$ etc	2 (diacidic base)
(c) $Fe(OH)_3$, $Cr(OH)_3$, $Al(OH)_3$, Fe_2O_3, Cr_2O_3, Al_2O_3 etc	3 (triacidic base)

(3) Equivalent wt of Salt

Equivalent wt of salt is define as the number of parts by wt of it produce when one gram equivalent acid neutralized with base. It is calculate by using;

$$\text{Equivalent wt of Salt} = \frac{\text{Molecular wt of Salt}}{\text{no of metal} \times \text{its valency no}}$$

or,

$$= \frac{\text{Molecular wt of salt}}{\text{total no of cations or anion charged}}$$

for example:- Calculate the equivalent wt of NaCl?

~~Cation~~ Solution,

Molecular wt of NaCl = 58.5
No of Na = 1
Valency of Na = 1
By using formula;

Equivalent wt of NaCl = $\frac{\text{Mol. wt of NaCl}}{\text{No of Na} \times \text{its val}}$

$= \frac{58.5}{1 \times 1}$

$= 58.5$

$= \frac{58.5}{1 \times 1}$

$= 58.5$

(a) $H-\overset{\overset{O}{\|}}{C}-OH$

(b) Fe_2O_3

(c) $MgCl_2$
Molecular wt = 95
no of Mg = 1
Valency = 2
Eq wt. = $\frac{95}{2}$
$= 47.5$

(a) $H-\overset{\overset{O}{\|}}{C}-OH$

~~CH_2O_2~~ CHOOH

Molecular wt = 46
No of metal = 1
its valency = 2
$= \frac{46}{2} = 23$

(b) Fe_2O_3
Molecular wt = 160
no of Fe = 2
its valency = 3

Eq wt = $\frac{160}{2 \times 3}$
$= 26.66$

Oxidation & Reduction process:

The oxidation and reduction process can be used in our daily life like rusting of iron, digestion of food, bleaching of colour, fading of colour matter etc.

- **Concept of oxidation and reduction:**

(a) Classical Concept
(b) Electronic Concept

- **Classical Concept**

According to classical concept, Oxidation is define as a chemical process which involves addition of O or addition of Electronegative specific or Removal of H or Removal of Electropositive specific during the reaction. Where as reduction is define as the process which involves addition of H or addition of Electropositive species or removal of O or removal of Electronegative species.

During such process oxidation can be written as oxidised form and reduction is written as reduced form in any chemical changes.

Removal of O-atom

(a) $CuO + H_2 \longrightarrow Cu + H_2O$

Addition of O-atom

- CuO gets reduced to Cu
- H_2 gets oxidised to H_2O

Removal of H
oxdn

(b) $H_2S + O_2 \longrightarrow H_2O + S$

Redn
Addn of H

- ~~H_2S gets~~

Addn of E.N.S
oxdn

(c) $SnCl_2 + 2HgCl_2 \longrightarrow SnCl_4 + Hg_2Cl_2$

Redn
Addn of E.P.S

(2) Electronic Concept (Modern Concept)

This concept is based on electronic state of the ~~specific~~ where certain charged products are obtained.

According to Electronic concept, oxidation may be define as the chemical process which involves the

loss of electron or increase in electro positive state.

$Mg \longrightarrow Mg^{+2} + 2e^{\ominus}$ (loss of $e^{\ominus}$'s)
$Fe^{+2} \rightarrow Fe^{+3} + e^{\ominus}$ (gain of $e^{\ominus}$'s)

Where as reduction is define as the chemical process involves the gain of electrons or decrease in electro positive state. for example:

$Zn^{+2} + 2e^{\ominus} \rightarrow Zn$
$Fe^{+3} + e^{\ominus} \rightarrow Fe^{+2}$

Imp

⊛ Oxidation & Reduction rxn occur simultaneous ways

According to electronic concept of oxidation and reduction their is a transformation of electrons in the form of loss and gain of electrons. In General chemical equation no one electroons be written This is because if their is oxidation reaction occur by loss of electrons and reduction reaction occur by gains of electron become cancelled to get neutral chemical equation. such combination equation is called as redox chemical reaction, where; Red means Reduction and Ox means oxidation. for example:-

$SnCl_2 + 2HgCl_2 \longrightarrow SnCl_4 + Hg_2Cl_2$
It's Ionic eqn is;

$Sn^{+2} + 2e^- + 2Hg^{+} + 2e^- \longrightarrow Sn^{+4} + 4e^- + Hg_2^{+2} + 2e^-$

Therefore,

$Sn^{+2} \longrightarrow Sn^{+4} + 2e^-$ (oxidation half rxn)

$2Hg^{+2} + 2e^- \longrightarrow Hg_2^{+2}$ (Reduction half rxn)

Redox rxn: $Sn^{+2} + 2Hg^{+2} \longrightarrow Sn^{+4} + Hg_2^{+2}$

Oxidising & Reducing agents:

* Oxidising agent:

A substances which oxidises other but itself get reduces during a chemical reaction is called oxidising agent or oxident. for example: CuO, $KMnO_4$, $K_2Cr_2O_7$, HNO_3, H_2SO_4, KIO_3 (Pot. iodate), SO_3, H_2CO_3 etc.

* Reducing agent:

A substances which reduces other but itself get oxidizes during a chemical reaction is called reducing agent. for example: H_2, C, CO, H_2S, HBr, HI, metals etc.

$$\underset{\text{Red}^n}{4HBr} + \underset{\text{Oxd}^n}{O_2} \longrightarrow 2H_2O + 2Br_2$$

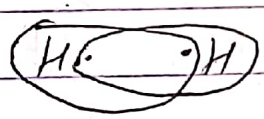
Imp

Oxidation Number (O.N):

The oxidation no of an element is the numbe which expressed the residual charged in an atoms of the elements contains when ionized from molecular state. The oxidation number of element is depends upon the number of electron transfer in each atom in molecules.

- **Rules to count the O.N:**

① When the molecules is homo atomic, like: $H_2, O_2, Cl_2, P_4, S_8, O_3$ etc their is no transfer of electrons occur. ~~Hnce~~ ie

ⓐ In H_2  ⇒ 0

So, there is no net charged separation in each atoms which indicate the oxidation number of such molecules is zero.

② When the electrons share between dissimilar element of the atoms are counted with more electro negative value of the elements.

for example:

In H-F molecule, Fluorine is more electronegative then hydrogen, therefore the shared pair electrons more transferred towards the F atom which is represent as;

where the oxidation number of H-atom is +1 & F-atom is -1 respectively.

Therefore, Oxidation number of atom can have ~~zero~~ zero, positive and negative in terms.

* General rules to Calculate the oxidation Number of an atoms:

There are following rules can be used to calculate the O.N

a) ~~oxidation number~~ The oxidation number of uncombine or homoatomic molecules is zero.

for example: The uncombine element like Cl, Al, Na etc. or homoatomic molecule eO_2, Cl_2, P_4, ~~S~~ S_8 the O.N. is zero.

b) The oxidation number of alkali metal elements ie. Group IA = Li, Na, K, Rb etc. have +1 ① Na.K.li

O.N = Oxidation number

③ The O.N of alkaline earth metals (Group - IIA) elements ie Be, Mg, Ca etc. is +2 in their compounds.

④. The O.N of the ions is equal to the residual charged present on it.
For ex: Al^{+3}, NH_4^+, Mg^{+2}, OH^-, Cl^-, SO_4^{-2}, CO_3^{-2} etc.
the O.N are +3, +1, +2, −1, −1, −2, −2 respectively.

⑤ The ~~oxi~~ O.N of ~~hydrogen~~ hydrogen atom & oxygen atom is +1 & −2 respectively in their compⁿ.

⑥ The O.N of halogen element ie. F^-, Cl^-, Br^-, I^- is −1 in their compounds.

⑦ The algebric sum of ~~oxi~~ O.N in each atom for neutral molecule is equal to zero whereas, for ionic molecule sum equal to its charged numbers.

For Ex. In $KMnO_4$ (neutral molecule), the sum of each atom is equal to zero.
Whereas in SO_4^{-2} (ionic compound), the sum of each atom is equal to −2.

(Q.) Calculate the oxidation number (O.N) of underline or Bold element in the following compounds;

(a) $KMnO_4$

① $KMnO_4$ Solution

Let the Oxidation number of Mn-atom is x. Due to neutral molecule the sum of each atom of O.N is equal to 0.

Therefore,

O.N of 1-k-atom + O.N of 1-Mn-atom + O.N of 4-O-atom = 0

$+1 + x + 4(-2) = 0$

$x - 7 = 0$

$\therefore x = +7$

© $K_2Cr_2O_7$

Let, the O.N of Cr-atom is x. Due to neutral molecule the sum of each atom of O.N is equal to 0.

Therefore,

O.N of 2-K-atom + O.N of 2-Cr-atom + O.N of 7-O-atom = 0

$2(+1) + 2x + 7(-2) = 0$

$2 + 2x - 14 = 0$

$2x - 12 = 0$

$2(x-6) = 0$

$x - 6 = 0$

$x = \pm 6$

Thus, the Oxidation number of Cr is +6.

H_2O_2 (peroxide) $= -1$

KO_2 (superoxide) $= -1/2$

Note:

Compⁿ	Oxidation Number
—O—O— (peroxide)	-1
CO (Carbon monoxide)	0

$[Fe(CN)_6]^{-4}$ -4

$[Fe(CN)_6]^{-3}$ -3

CN^- -1

SO_4^{-2} -2

NH_4^+ $+1$

NO_3

$CaCO_3$

ON of Ca + ON of CO_3 = 0

$x + (-2) = 0$

$x = 2$

$K_4[Fe(CN)_6]$

$4(x) + (-3) = 0$

$4x - 4 = 0$

$x = +1$

$K_3[Fe(CN)_6] = 0$

$3 \times 1 + x + 6(-1) = 0$

$3 + x - 6 = 0$

$x = +3$

NH_4Cl

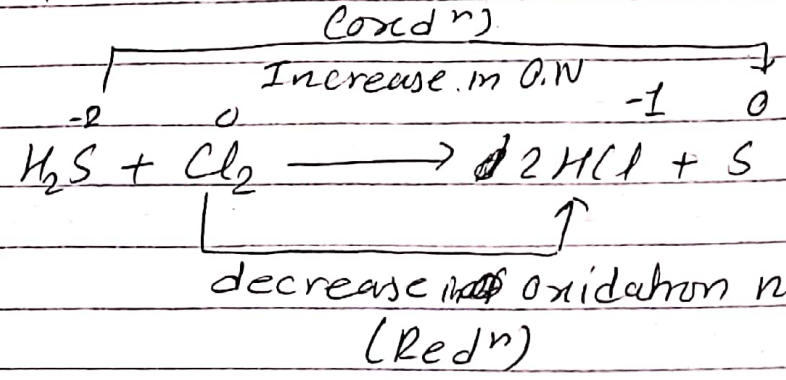
$NH_4^+ + Cl$

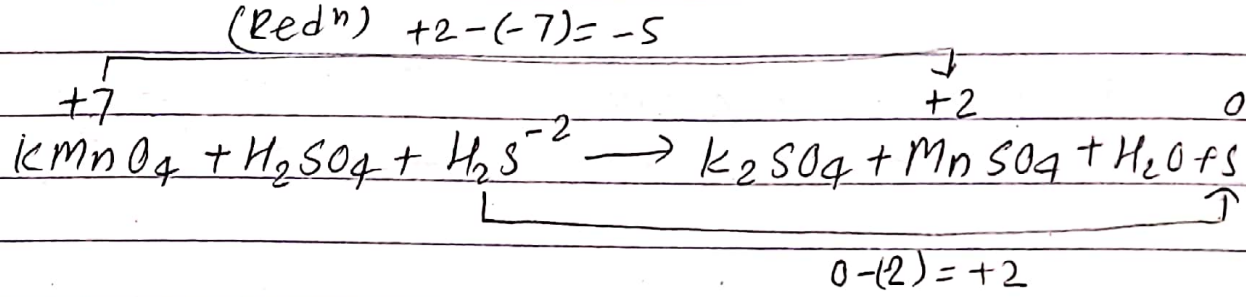
$+1 + x = 0$

$x = -1$

⊛ Oxidation & Reduction in terms of oxidation No:

In terms of O.N the chemical process which involves increase in O.N is called oxidation process whereas decrease in oxdiation number is called as reduction process.





Note: In any Redox chemical equation, there is change can be obtain at two position of each elements which indicates oxidation and reduction process.

VV.Imp

* Balancing of redox reaction: By oxidation number method:

This method for balancing redox chemical reaction is based on the equating the increase in oxidation number in oxidation step and decrease in oxidation number in reduction step should be equal."

It involves following steps:

Step I: Write the skeleton chemical equation with the oxidation number of each element at the top of the symbol.

Step II: Seperate the change in oxidation number & write oxidation and reduction

Step III: Calculate the net change in oxidation number and write the number at bottom of the formula at bracket
If the change in oxidation number of oxidizing & reducing agent are odd in number i.e. 1 & 3, then double it.
Other case become not changeable.

Step IV: Then multiply the increase in O.N of the species with ~~increase~~ decrease in O.N & decrease in O.N of the species with increase in O.N by criss-cross way.

step V: Balance the both side of the element where change in oxidation no. occur.

step VI: Balance the rest of the species which contain mainly non-metal, H & O- elements. For this 1st balance the non-metal then H or O-elements by multiplying a suitable no at H_2O.

Q) Balance the redox reaction by oxidation number methods;

$$KMnO_4 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + MnSO_4 + H_2O + S$$

Step I: $\overset{+1\ +7\ -2}{KMnO_4} + \overset{+1\ +6\ -2}{H_2SO_4} + \overset{+1\ -2}{H_2S} \longrightarrow \overset{+1\ +6\ -2}{K_2SO_4} + \overset{+2\ +6\ -2}{MnSO_4} + \overset{+1\ -2}{H_2O} + \overset{0}{S}$

Decrease in O.N / Reduction

$+7 \rightarrow +2$ Net change $= +2 - (+7) = -5$

Step II: $KMnO_4 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + MnSO_4 + H_2O + S$

$S: 0 \rightarrow +2$ Net change $= 0 - (-2) = +2$

Increase in O.N / oxidation

Step III: $KMnO_4 + H_2S + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + H_2O + S$

(5) (2)

Step IV: $2KMnO_4 + 5H_2S + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$

Hence the equation become balanced.

(Q1) $KMnO_4 + H_2SO_4 + HCl \longrightarrow K_2SO_4 + MnSO_4 + H_2O + Cl_2$

$+1+7-2 \quad +1+6-2 \quad +1-1 \quad +1+6-2 \quad +2+6-2 \quad +1-2 \quad 0$

step I : $KMnO_4 + H_2SO_4 + HCl \rightarrow K_2SO_4 + MnSO_4 + H_2O + Cl_2$

$+7$ Net change $= +2-(+7) = -5 - 1$ (redn) $\rightarrow +2$; 0

step II : $KMnO_4 + H_2SO_4 + HCl \longrightarrow K_2SO_4 + MnSO_4 + H_2O + Cl_2$

(oxdn) $\rightarrow 0$

Net change $= 0-(-1) = +1$

step III : $KMnO_4 + HCl + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2O + Cl_2$

(5) (1)

(10) (2)

step IV : $2KMnO_4 + 10HCl + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5Cl_2$

$2KMnO_4 + 10HCl + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5Cl_2$

(Q) $K_2Cr_2O_7 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

(Q) $KMnO_4 + H_2SO_4 + HI \longrightarrow K_2SO_4 + MnSO_4 + H_2O + I_2$

Redn

N.C = +3-(+6) = -3

I: $K_2Cr_2O_7 + H_2SO_4 + H_2S \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

oxdn: 0-(-2) = +2

Step II: $K_2Cr_2O_7 + H_2S + H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O + S$

(3) (2)

Step III: $K_2Cr_2O_7 + 3H_2S + 4H_2SO_4 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7H_2O + 3S$

Hence balanced

Step I: $KMnO_4 + H_2SO_4 + HI \longrightarrow K_2SO_4 + MnSO_4 + H_2O + I_2$

Redn: +2-(+7) = -5

Step II: $KMnO_4 + H_2SO_4 + HI \longrightarrow K_2SO_4 + MnSO_4 + H_2O + I_2$

0-(-1) = +1

Step III: $KMnO_4 + HI + H_2SO_4 \longrightarrow K_2SO_4 + MnSO_4 + H_2O + I_2$

(5) (1)

(10) (2)

Step IV: $2KMnO_4 + 10HI + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5I_2$

Note:

Due to balance the change in O.N. of Cr-atom it shouldnot be needed to ~~multi~~ multiply net change in O.N.

I: $Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$

II: $Cu + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$

Due to same & different O.N of N-atom, it indicates at L.H.S there should be present of two nitrogen atom for this one HNO_3 should be added at L.H.S.

$Cu + HNO_3 + HNO_3 \longrightarrow Cu(NO_3)_2 + NO + H_2O$

(2) (3)

$3Cu + 2HNO_3 + 6HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

$3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$

I: $\overset{+1\,-2}{H_2S} + \overset{+1\,+5\,-2}{HNO_3} \longrightarrow \overset{+4\,-2}{NO_2} + \overset{+1\,-2}{H_2O} + \overset{0}{S}$

II: $H_2\overset{-2}{S} + H\overset{+5}{N}O_3 \rightarrow \overset{+4}{N}O_2 + H_2O + S$

(−1)

Oxdn (+2)

II: $H_2S + HNO_3 \rightarrow NO_2 + H_2O + S$

(2) (1)

III $H_2S + 2HNO_3 \rightarrow 2NO_2 + 2H_2O + S$

---

* $Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NO_2 + H_2O$
* $Zn + HNO_3 \longrightarrow Zn(NO_3)_2 + NH_4NO_3 + H_2O$

* $\overset{0}{Zn} + \overset{+1\,+5\,-2}{HNO_3} \rightarrow \overset{+2\,+5\,-2}{Zn(NO_3)_2} + \overset{+4\,-2}{NO_2} + \overset{+1\,-2}{H_2O}$

$\overset{0}{Zn} + H\overset{+5}{N}O_3 \rightarrow \overset{+2}{Zn}(\overset{+5}{N}O_3)_2 + \overset{+4}{N}O_2 + H_2O$

Due to same & differentt O.N of N-atom, it indicate at L.H.S there should be present of two nitrogen atom for this HNO_3 should be added at L.H.S.

$2 - 0 = +2$

$\overset{0}{Zn} + H\overset{+5}{N}O_3 + HNO_3 \longrightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{+4}{N}O_2 + H_2O$

$+4 - (+5) = -1$

$Zn + HNO_3 + HNO_3 \rightarrow Zn(NO_3)_2 + NO_2 + H_2O$

(2) (1)

$$Zn + 2HNO_3 + 2HNO_3 \longrightarrow Zn(NO_3)_2 + 2NO_2 + 2H_2O$$

Step I: $\overset{0}{Zn} + \overset{+5}{HNO_3} \longrightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{-3}{NH_4}\overset{+5}{NO_3} + H_2O$

Step II: $\overset{0}{Zn} + \overset{+5}{HNO_3} + HNO_3 \longrightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{-3}{NH_4}NO_3 + H_2O$

Step III: $\overset{0}{Zn} + HNO_3 + HNO_3 \longrightarrow \overset{+2}{Zn}(NO_3)_2 + NH_4NO_3 + H_2O$

(2) (8) (1) (4)

Step IV: $4Zn + HNO_3 + 9HNO_3 \longrightarrow 4Zn(NO_3)_2 + NH_4NO_3 + 3H_2O$

Step I: $\overset{0}{Zn} + \overset{+5\ -2}{HNO_3} \longrightarrow \overset{+2}{Zn}\overset{+5\ -2}{(NO_3)_2} + \overset{+1\ -2}{N_2O} + \overset{+1\ -2}{H_2O}$

$2 - 0 = 2$

Step II: $\overset{0}{Zn} + \overset{+5}{HNO_3} + HNO_3 \rightarrow \overset{+2}{Zn}(NO_3)_2 + \overset{+1}{N_2O} + H_2O$

$+1 + 5 = 6 - 4$

Step III: $Zn + HNO_3 + HNO_3 \rightarrow Zn(NO_3)_2 + N_2O + H_2O$

(2) (4) (1) (2)

Step IV: $4Zn + 2HNO_3 + 8HNO_3 \rightarrow 4Zn(NO_3)_2 + N_2O + 5H_2O$

Calculate the ON

(a) $C_2O_4^{-2}$

$2x + 4(-2) = -2$

$2x - 8 = -2$

$2x = -2 + 8$

$x = \frac{6}{2}$

$x = +3$

(b) $K_2Mn_2O_4$

$2(+1) + 2x + 4(-2) = 0$

$2 + 2x - 8 = 0$

$2x - 6 = 0$

$2x = 6$

$x = +3$

(c) CCl_4

$x + 4(-1) = 0$

$x - 4 = 0$

$x = +4$

Q i $Cr(OH)_3^- + IO_3^- \rightarrow I^- + CrO_4^-$ (Basic medium)

Ionic redox reaction:-

Rule: In ionic redox reaction, electrical charged on both side should be balance by using H^+ - ion in acidic medium or OH^- ion in basic medium.

Finally; H_2O is added at required side to balance the H & O - atom.

Step I: $\overset{+2\ x\ +3}{Cr(OH)_3^-} + \overset{+5\ -2}{IO_3^-} \rightarrow \overset{-1}{I^-} + \overset{+7\ -2}{CrO_4^{-2}}$

(5) (6) -6

Step II: $6\,Cr(OH)_3^- + 4IO_3^- \rightarrow 4I^- + 6CrO_4^{-2}$

Total Charge at L.H.S = $(-6)+(-4) = -10 + 6\,OH^-$

R.H.S = $-4 + (-12) = -16$

Acid, Base and Salt:

Different concept of Acid & base:

- Arrhenius concept
- Bronsted - lowry
- Lewis - concept

-Arrhenius concept:

According to this concept, acid are those substances which gives H^+ - ions in water (aqueous) and base are the substance which gives OH^- ions in water when ionized for example ~~HCl~~ HCl and NaOH are ions as;

$$HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

$$NaOH_{(aq)} \longrightarrow Na^-_{(aq)} + OH^-_{(aq)}$$

Therefore, HCl is arrhenius acid and NaOH is arrhenius base respectively.

Limitations of Arrhenious Concept :

- This concept only applied for water solvent.
- Free H^+ & OH^- ions donot exist in water

H^+ & OH^- ions in water in exist in a complex form as: H_3O^+ (Hydronium ion) and $H_3O_2^-$ as complex ;

ie

$$H^+(aq) \rightarrow H_2O + H^+ \rightleftharpoons H_3O^+ \text{ (Hydronium ion)}$$
$$OH^-(aq) \rightarrow H_2O + OH^- = H_3O_2^- \text{ (Complex)}$$

- There are some bases like NH_3, CaO, MgO etc which donot contain OH group and donot obey the Arrhenious base concept.

(*) Bronstep lowry concept :-

To remove the limitation of Arrhenious concept Bronsted and lowry purposed a concept of acid and base on the basies of proton donar and acceptor.

According to this concept, acids are those substances which donate their protons to other & Base are the substances which accept such protons. Therefore, acids are proton donar and base are proton acceptor

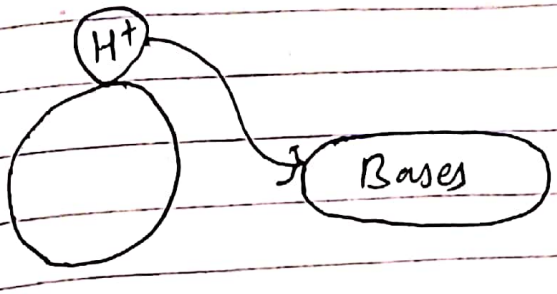


Fig: General concept of acid & Base

For eg

(a) Reaction between NH_3 & HCl

$$H\text{-}Cl + NH_3 \longrightarrow NH_4^+ + Cl^-$$

Acid — base — Ammonium ion

(b) $H_2O + HCl \longrightarrow H_3O^+ + Cl^-$

Base Acid

(*) Lewis Concept

Lewis concept is based upon the electron pair donor & acceptor. Acid are those substance which contain electron deficient centre and can ~~app~~ accept a electron pair whereas base are the substances which are electron rich and can donate a electron pair. For example: A species ~~with~~ which contain electron rich centre like: A ~~is~~ react with electron deficient species B

to gives a complex compound.

lone pair of e⁻s: $:A + B \rightarrow [A \rightarrow B]$

Lewis Base, Lewis Acid

Example:

Lewis Bases ⓐ All the ~~anti~~ anionic species (-ve charged)

OH^-, Cl^-, SO_4^{-2}, CO_3^{-2}, R^- etc.

ⓑ Lone pair of electron containing molecule

$H_2\ddot{O}:$, $\ddot{N}H_3$, $R\ddot{O}H$, $R-\ddot{O}-R$ (Ether) etc.

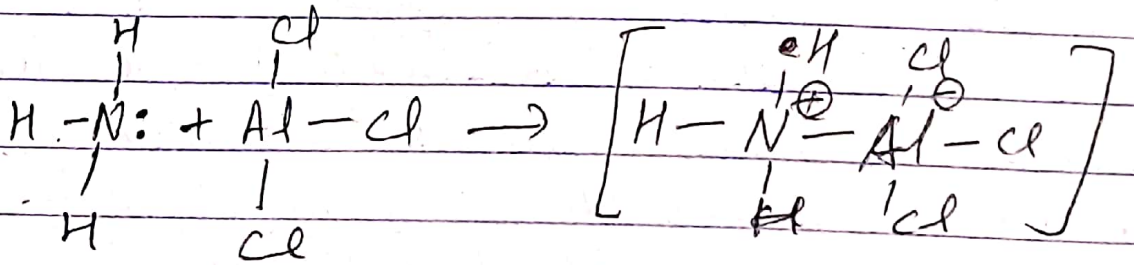
Lewis Acid: ⓐ All the Cationic species (+vely charged)

NH_4^+, $\vec{N}O_2$, H^+, R^+ etc.

ⓑ electron deficient neutral molecule

$AlCl_3$, $FeCl_3$, BF_3, BH_3 etc

For Example: Reaction between NH_3 & $AlCl_3$



Lew. base Lew. Acid Complex

Imp

* Auto-ionization of water : At Amphoteric Substances

$$H_2O + H_2O \longrightarrow H_3O^{+} + OH^-$$

Base Acid

Water is a amphoteric substance which means it acts as acid as while as base during the chemical reaction. When two molecule of water react together they combines to give hydronium ions & Hydroxide ions by accept a proton or loss their proton respectively.

This reaction shows auto ionization of water

Imp

PH- value : Derived from Water molecule:

The pure water can be ionized weakly as;

$$H_2O \rightleftharpoons H^+ + OH^- \quad \text{---} \quad (1)$$

For this equilibrium equation ionization constant (K_c) is;

$$K_c = \frac{[H^+][OH^-]}{[H_2O]} \quad \text{---} \quad (2)$$

where; K_c is ionization constant.

Due to small extent ionization of pure water, the concentrate of water is said to be constant.

$$\text{or } K_c \cdot [H_2O] = [H^+][OH^-]$$

$$\text{or } K_c \cdot k = [H^+][OH^-]$$

$$K_w = [H^+][OH^-] \quad \text{——} \quad (3)$$

Where; K_w is ionic product of water. Where the concentration of H^+ & OH^- ions expressed in mole per litre, experimentally at 25°C it is found ~~to~~ to be 1.0×10^{-14}

Therefore

$$[H^+][OH^-] = 1.0 \times 10^{-14} \quad \text{——} \quad (4)$$

Since, a molecule of water ionized to give same concentration of its H^+ & OH^- ~~ions~~ ions.

$$\text{i.e. } [H^+] = [OH^-]$$

Then,

$$[H^+][H^+] = 1.0 \times 10^{-14}$$

$$[H^+]^2 = 1.0 \times 10^{-14}$$

$$[H^+] = 1.0 \times 10^{-7} \text{ mol/litre}$$

& Similarly

$$[OH^-] = 1.0 \times 10^{-7} \text{ mol/litre}$$

[ ] → concentration

For acidic solution the concentration of H^+ ions is greater than 10^{-7} mol/lit and for basic solution the concentration of H^+ ion is less than 10^{-7} mol/lit

ie $[H^+] < 10^{-7}$ mol/lit Acid solution
$[H^+] \geq 10^{-7}$ mol/lit base solution
$[H^+] = [OH^-] = 10^{-7}$ Neutral solution

pH- value:
It is an number which gives the concentration of H^+-ions present into a solution. It is defined as, the negative logarithm (log) of concentration of H^+- ions into the solution.
Mathematically, it is represent as

$$PH = -\log [H^+]$$

Where, $[H^+]$ = Concentration of H^+-ion in mole per litre.

or, $[H^+] = 10^{-PH}$ ⟶ (Antilog)

The 'p' stands for "negative log of any quantity."

ie $p^x = -\log x$
$p^y = -\log y$

Therefore, p^{OH} is defined as negative logarithm of concentration of hydroxide ion (OH^-) in solution."

ie $p^{OH} = -\log[OH^-]$

Imp

* **Relation between pH & p^{OH}:**

We have,

$pH = -\log[H^+]$

$p^{OH} = -\log[OH^-]$

&

$K_w = [H^+][OH^-]$

At 25°C, $K_w = 1.0 \times 10^{-14}$

Then,

$[H^+][OH^-] = 1.0 \times 10^{-14}$

Taking negative logarithm on both side, we get;

$-\log\{[H^+][OH^-]\} = -\log(1.0 \times 10^{-14})$

or, $-\log[H^+] + \{-\log[OH^-]\} = -(-14)\log 10$ [$\because \log(a.b) = \log a + \log b$, $\log x^b = b\log x$]

HCl NaOH
HNO_3 $Ca(OH)_2$
H_2SO_4

From above eqn,

$pH + pOH = 14$

This the relation between pH and pOH.

Q a) Calculate the pH of 0.01 M HCl soln?
b) Calculate the pH of 0.01 M NaOH soln?

a) soln

HCl is strong acid & it ionized completely.

$HCl \rightarrow H^+ + Cl^-$

0.01M 0.01 M 0.01M

$\therefore [H^+] = 0.01\,M = 10^{-2}\,M$

We have,

$pH = -\log [H^+]$

$= -\log [10^{-2}]$

$= -(-2) \log 10$ [$\because \log ab = b \log a$]

$= 2$

b) Soln

$NaOH$

$NaOH \longrightarrow Na^+ + OH^-$

$0.01\,M \quad 0.01\,M \quad 0.01\,M$

$[OH^{-2}] = 0.01\,M = 10^{-2}\,M$

We have;

$pOH = -\log [OH]$

$= -\log [10^{-2}]$

$= -(-2) \log 10$

$= 2$

Also,

$pH + pOH = 14$

$pH + 2 = 14$

$pH = 14 - 2$

$pH = 12$

② H_2SO_4

$H_2SO_4 \rightarrow 2H^+ + SO_4^{+}$

0.005M 2×0.005M 0.005M

= 0.01M

$[H^+] = 0.01\,M = 10^{-2}\,M$

We have

$pH = -\log[H^+]$

$= -\log[10^{-2}]$

$= -(-2)\log 10$

$= 2$

③ $Ca(OH)_2$

$Ca(OH)_2 \rightarrow Ca^{+2} + 2OH^-$

0.005M 0.005M 2×0.005M

= 0.01 M

$[OH^-] = 0.01 = 10^{-2}$

We have

$pOH = -\log[OH^-]$

$= -\log[10^{-2}]$

$= -(-2)\log 10$

$= 2$

Also, $pH + pOH = 14$

$pH + 2 = 14$

$pH = 12$

pH-Scale:

The scale on which pH value are represent is called pH-scale. In this scale pH-values can be ranges from 0-14 on the basis of concentration of H^+-ions. This scale can be used to determined the medium of the solution ie acidic, basic and neutral medium

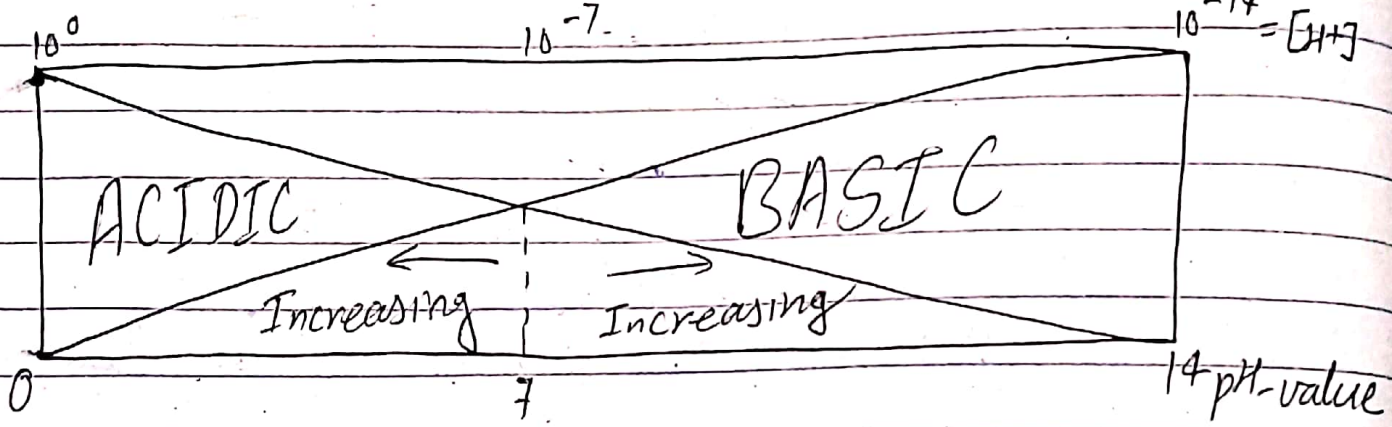


fig: pH-scale

Imp

* Buffer Solution:

Generally, pH of the solution can be changed on small addition of acids or base into the solution. Buffer solution are those which can resist the change on pH value on small addition of acid or base. Buffer solution are 2 types on the basis of their pH-values.

If the pH of buffer solution less than 7 it is called acidic buffer & it can be obtained by mixing weak acid & their salt with strong base.

for Ex: The mixture contain acetic acid (CH_3COOH) & Sodium acetate (CH_3COONa).

If the pH of buffer solution greater than 7, it is called basic buffer & it can be obtained by mixing weak base & ther salt with strong acid.

for Ex: The mixture contain Ammonium hydroxide (NH_4OH) & Ammonium chloride (NH_4Cl)

* Conjugate acid-base pairs:

$$\underset{\text{Acid}}{HA} + \underset{\text{Base}}{B^-} \rightleftharpoons \underset{\text{New acid (conjugate acid)}}{HB} + \underset{\text{New base (conjugate base)}}{A^-}$$

When a acid (HA) react with base (B^-) in Equilibrium reaction to gives new acid (HB) and new base (A^-) which are called as conjugate acid and conjugate base.

The originial acid (HA) & new base (A^-) has a co-relation on the basis of proton donor and acceptor and originial base (B^-) and new acid (HB) also co-related as acid and base concept and such co-relations is called as conjugate acid base pair.

Characteristic of acids:

(a) They have a sour taste.
(b) They are change the following indicator as follows:

Indicator	Acidic medium change in colour
Blue Litmus paper	Red in colour
Methyl orange	Pink
Phenolphthalein	Colourless

(c) The acid can be dissolve must of the metals like Zn, Fe, Al, Mg etc.

(d) Certains metal when react with acid can produce H_2 gas.

$$Zn + \underset{\text{(acid)}}{HCl} \longrightarrow ZnCl_2 + H_2(g)$$

(e) When acid react with base neutralized to gives salt and water.

For eg: $HCl + NaOH \rightarrow NaCl + H_2O$

Acid Base salt

Characteristic of base;

(a) They have a bitter taste.
(b) There solution in water when touch they feels like a soapy.

(c) They change the indicator colour as follows:

Indicator	Basic medium ~~Acidic~~ change in colour
Red litmus	Blue colour
Methyl orange	Yellow
Phenolphthalein	Pink

(d) When they dissolve in some metal salt solution they get precipitate (ppt.).
for eg:

$$BaSO_{4(aq)} + NaOH \rightarrow Ba(OH)_2(\downarrow)$$
white ppt.

$$FeCl_{3(aq)} + 3NaOH \rightarrow Fe(OH)_3\downarrow + 3NaCl$$
Brown ppt

(e) When they react with acid solution to give salt & water.
For eg:

$$KOH + HCl \longrightarrow \cancel{KOH}\ KCl + H_2O$$

Salt & their types:

A salt is produce by partial or complete neutralization of acid by base or vice-versa..

for eg:-

Na_2SO_4 (complete)

$NaHSO_4$ (partial)

KCl, NaCl, $NaNO_3$, $KHSO_4$ etc.

Salt are classified into 3 types:

(a) Normal salt: These salt which are produce by complete neutralization of Acid by base. for eg: NaCl, Na_2SO_4, KCl, $NaNO_3$ etc.

(b) Acidic Salt: These salt which are produce by ~~conc~~ partial displacement acid of their replaceable hydrogen atom by base. for eg:- $NaHSO_4$, $KHSO_4$ etc.

(c) Basic Salt:

These salt which are produced by partial displacement of hydroxyl group (OH) from base by the acid are called as basic salt for eg: $Ca(OH)_2$ i $CaCO_3$, $Pb(OH)_2 . 2PbCO_3$ etc.

Electrolysis:

Electro: Electric current
lysis = Breaking

* Conductor & Non-Conductor:

The substances which can allow the passage of electric current through it is called conductor. Every conductor do not conduct same amount of ~~elec~~ electric current, if the substance can conduct more electric current they are called good conducter whearas lesser amount of electric current are called poor conductor.

The substances which denot allow the flow of electric current through it, it is called non-conductor.

* Types of Conductor:

(a) Metallic Conductor: These conductors are solid in state an ever to conduct electric current due to presence of free electrons. for eg: Iron (Fe), Copper (Cu) Aluminium (Al) etc.

(b) Electrolytic ~~fot~~ Conductors:

These conductors are present in molten or aqueous solution state and able to conduct electric current in presence of free ions. for eg. NaCl in water, HCl in water etc.

* electrolytes:

The substances which is present in molten or aqueous solution state which allow the passage of electric current through transformation of chemical change are called electrolytes.

On the basis of electric current passage electrolytes are 2 types:-

ⓐ Strong electrolytes:

Those electrolytes which are dissolved completely in water are called strong electrolytes.
for eg: HCl, H_2SO_4, HNO_3, $NaOH$, $Ca(OH)_2$, KOH etc.

ⓑ Weak electrolytes:

Those electrolytes which are partially dissolved in water are called weak electrolytes. for eg:- CH_3COOH (Acetic Acid), $HCOOH$ (Formic acid), NH_4OH etc.

Electrolysis:

The term 'Electrolysis' comes from Greek word ie 'Elektro' is equal to 'Electric current' and 'lysis' is equal to breaking. The process of chemical decomposition of electrolytes in molten or solution state can be occur in presence of passage of electric current is called as electrolysis.

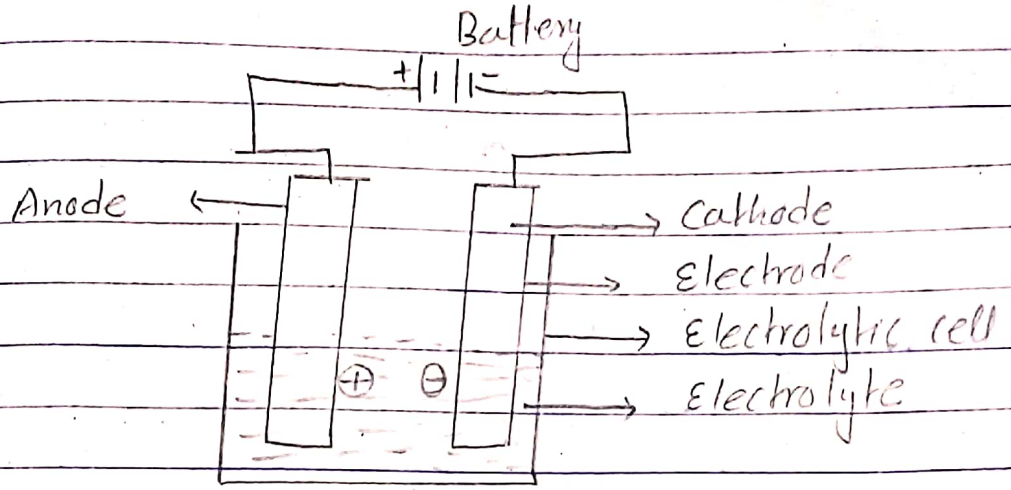


Fig: Electrolysis setup

During electrolysis process aqueous solution of electrolytes are taken into a electrolytic cell. In electrolytes two metallic rods are dipped, the rod which is connected to the positive terminal of battery is called anode electrode and it attract anionic (-ve species and the metallic rod which is connected to the '-' terminal of battery is called cathode and it attract cationic (+ve charge species) from electrolyte solution.

During this transformation chemical reaction can be occure when electric current can be supplied.

For ex: Chemical decomposition of aqueous. HCl during electrolysis process can be represent as,

$$HCl_{(aq)} \xrightarrow{\text{Electric}} \underset{\text{Cation}}{H^+_{(aq)}} + \underset{\text{Anion}}{Cl^-_{(aq)}}$$

At Anode: Oxidation

$Cl^- \rightarrow Cl + e^-$

$Cl + Cl \rightarrow Cl_2(g)$

At Cathode: Reduction

$H^+ + e^- \longrightarrow H$

$H + H \longrightarrow H_2(g)$

Therefore,

$2HCl \xrightarrow{\text{Electric current}} H_2(g) + Cl_2(g)$

Quantitative Aspect of electrolysis:

(a) Faraday's 1st law of electrolysis:

To determine the quantitative aspect of electrolysis to electrolyte faraday's 1st-law was purposed which state that, "The amount of substance deposited or dissolved from electrolytic solution is directly proportional to quantity of electricity pass."

Let 'W' gram of any material deposited or dissolved when 'Q' ~~cot~~ ~~coul~~ coulombs of electricity is passed then;

Mathematically;

$$W \propto Q$$

or $$W \propto It$$

Where, Q = current (I) × time (t)

or $$\boxed{W = ZIt} \quad \text{---} (1)$$

where; z is proportionality constant & called as electro-

chemical equivalent (ECE).

When, I = 1 A & t = 1s then

The above eqn can be;

$$W = z \quad \text{— (2)}$$

Therefore, electrochemical equivalent is also amount of substances deposited when 1A current is pass for 1 sec during electrolysis process

Note:

ECE (z) of electrolyte is related to the faraday constant (1F = 96500 coulombs. electric current by the relation.

$$z = \frac{\text{Equivalent wt. (E)}}{\text{faraday symbol}} = \frac{E}{96500}$$

(Q) Calculate the mass of copper deposited when 2.5 A current pass in copper sulphate solution ($CuSO_4$) for 45 hours [Given atomic wt of

Note: $W = zIt$ | $E = \frac{\text{At wt}}{\text{valency}}$

$z = \frac{E}{F}$

Given,

Current (I) = 2.5 Amp

Time (t) = 1.5 hour = 5400 sec

Weight (w) = ?

We have;

$$W = \frac{E}{F} \times IT$$

Then,

$$\text{Eq. wt} = \frac{\text{Atomic weight}}{\text{Valency}}$$

$$= \frac{63.5}{2}$$

$$= 31.75$$

$$W = \frac{31.75}{96500} \times 2.5 \times 5400$$

$$W = 4.44 \text{ gm}$$

① A current of 10A was pass through a solution of cupper sulphate for 1 hr 20 min and 25 sec. The weight of cupper deposit was 15.5 gm. If the atomic weight of copper 63.5. Calculate valency of IT)

Given,

Atomic weight = 63.5
Faraday constant (F) = 96500
time (t) = 4825 sec
current (I) = 10A
Deposit (W) = 15.5 gm

We have;

$W = ZIT$

$15.5 = Z \times 10 \times 4825$

$Z = 0.00032$

$Z = \frac{E}{F}$

$Z \times F = E$

$0.00032 \times 96400 = E$

$E = 30.84$

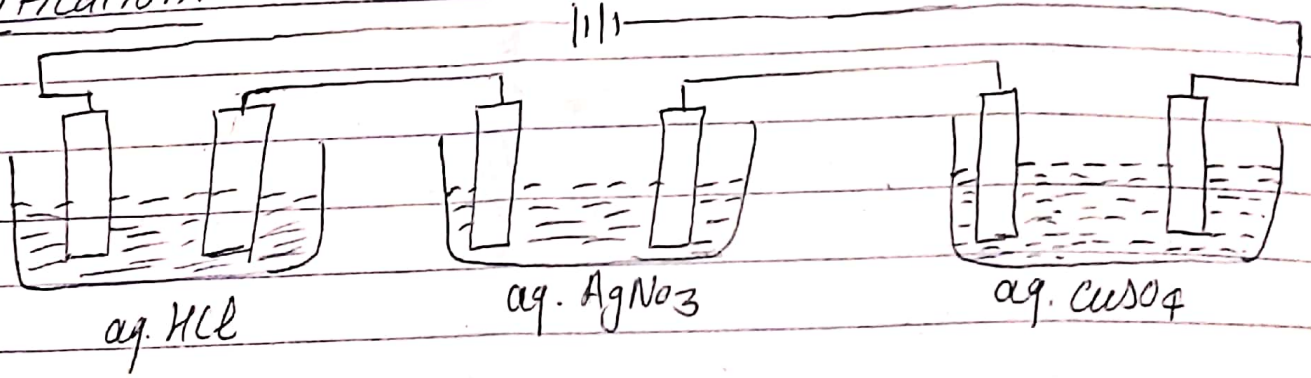
$Eq.wt = \frac{At.wt}{Valency}$

$valency = \frac{63.5}{30.84} = 2.05 \approx 2$

② Faraday's 2nd law of electrolysis:

The faraday's second law of electrolysis is define as, "the amount of substance dissolved or deposited to respective electrodes of different electrolytic solution is directly proportional to their equivalent weight."

Verification:



When the same amount of electric current pass through a number of electrolytic solution like aqueous HCl, aq. $AgNO_3$ and aq. $CuSO_4$ are connected in a series. Then, the mass of different materials deposited at respective electrodes are directly proportional to their equivalent weight.

Mathematically:

Amount of substances deposited (W) = Equivalent weight of substance (E)

Therefore; weight of copper deposited (W_{Cu}) = $\frac{\text{Equivalent wt of Cu } (E_{Cu})}{\text{Equivalent wt of Ag } (E_{Ag})}$

weight of Ag - deposited (W_{Ag})

--(i)

or, $\frac{\text{Wt of } H_2 \text{ evolved } (W_{H_2})}{\text{Wt of Cu-deposit } (W_{Cu})} = \frac{\text{Equivalent wt of } H_2 (E_{H_2})}{\text{Eq wt of Cu } (E_{Cu})}$ ---(11)

Therefore, when the same quantity of electricity is required to deposit 1 equivalent weight of any material during electrolysis is called 1 Faraday electric current.

ie 1F = 96500 Coulombs

Numerical

(Q) An electric current is passed through ~~of~~ 2 three cells of series containing a solution of $CuSO_4$, $AgNO_3$ & KI respectively.

What weight of Cu & Ag would be deposited when 4.99 gm of iodine being liberated? (Given; At. wt of Cu = 63.5, Ag = 108 & I = 127)

Soln let W_{Cu}, W_{Ag} & W_I are amount of Cu, Ag & I_2 - deposited & E_{Cu}, E_{Ag} & E_I are the equivalent wt of such element ~~st~~ respectively.

According to 2nd law of Faraday's

$$\frac{W_{Cu}}{E_{Cu}} = \frac{W_{Ag}}{E_{Ag}} = \frac{W_I}{E_I} \quad \text{---(1)}$$

Then;

$$E_{Cu} = \frac{\text{At. wt of Cu}}{\text{Valency}} = \frac{63.5}{2} = 31.75$$

$$E_{Ag} = \frac{\text{At. wt of Ag}}{\text{Valency}} = \frac{108}{1} = 108$$

&

$$E_I = \frac{\text{At. wt of I}}{\text{Valency}} = \frac{127}{1} = 127$$

Substituted these values in eqn ①

$$\frac{W_{Cu}}{31.75} = \frac{W_{Ag}}{108} = \frac{4.99}{127} \quad \text{— ②}$$

Then. $\frac{W_{Cu}}{31.75} = \frac{4.99}{127}$

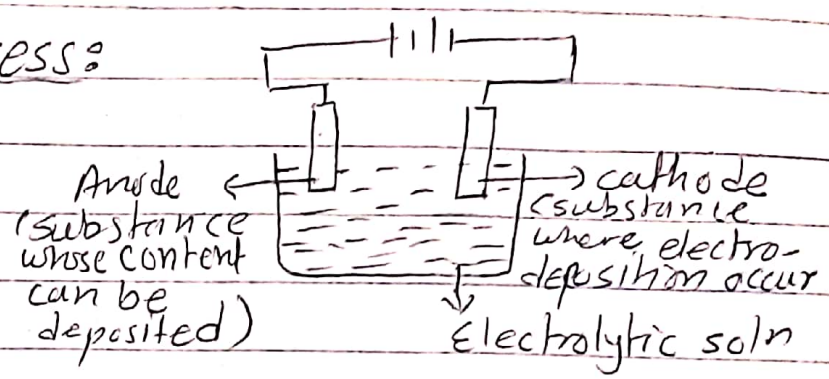
$$W_{Cu} = 1.24 \text{ gm}$$

$$\frac{W_{Ag}}{108} = \frac{4.99}{127}$$

$$W_{Ag} = 4.24 \text{ gm}$$

Application of electrolysis:

ⓐ Electro-platting process:



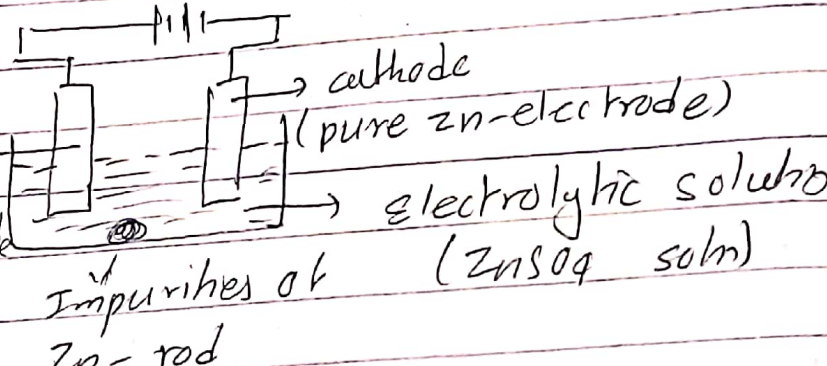
During electroplating process the apparatus can be setup as like in above figure. Where the substances whose containt can be deposit is taken at anode where oxide reaction can be occur and lose their weight ~~when~~ where their aqueous solution can be dipped.

The substances where electro-deposition can occurs taken at cathode where reduction reaction can be occur and increase the weight of the substances. When electric current pass oxidation and reduction reaction can occur ~~simultaneously~~ simultaneously and electro plating process can complete

ⓑ Electrorefining process:

The impure zn-electrode can be purified by this method where impure zn-electrode is connected towards the anode and pure zn-electrode connected towards the cathode. Both the electrode are placed in acidified solution of $ZnSO_4$

When electric current is pass through the solution impure zinc from anode goes into solution and pure zn from solution goes to cathode and get deposit. The impurities of zinc rod can be colleted at the bottom of electrolytic cell.



It involves following reaction(rxn)

$$ZnSO_4 \longrightarrow Zn^{+2} + SO_4^{-2}$$

At anode:

$$Zn \rightarrow Zn^{+} + 2e^{-}$$

$$Zn + SO_4^{-2} \rightarrow ZnSO_4 + 2e^{\ominus}$$

At cathode:

$$Zn^{+2} + 2e^{\ominus} \rightarrow Zn_{(s)}$$

$$ZnSO_4 + 2e^{\ominus} \rightarrow Zn_{(s)} + SO_4^{-2}$$

Qualitative and Quantitave ~~anly~~ analysis:

Solution:

A solution is the homogenous mixing of substance ie. solute & ~~Solvt~~ solute ~~of Solvent~~ which can be ~~used~~ exist in solid, liquid or gasseous state.

For ex: Atmospheric air, ~~alch~~ alcohol in water, salt in water, alloy of metals etc.

Concentration:

It is the amount of solute present in certain volume of solution

Mathmetically,

$$\text{concentration} = \frac{\text{Amount of solute}}{\text{volume of solution}}$$

* If the amount of solute is greater than solvent, The solution is concentrate (conc.).
* If the amount of solute is lesser than solvent, The solution is dilute (dil)

Ways to express the concentration terms: (Strength):

(1) Gram per litre:

The amount of solute in gram dissolve in per litre of solution is termed as concentration in gram per letre.

Mathmatically:

$$\text{Concentration in gram per litre} = \frac{\text{Amount of solute in gram (gm)}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Amount of solute in gm}}{\text{Volume of solution in ml}} \times 1000$$

2. **Normality:-**

It is the number of gram equivalent of solute dissolve in per litre of solution. It is represented by 'N'.

Mathematically,

$$\text{Normality (N)} = \frac{\text{No of gram equivalent of solute}}{\text{volume of solution in litre}}$$

$$\text{Normality (N)} = \frac{\text{wt of solute in gram}}{\text{equivalent wt of solute}} \times \frac{1}{\text{volume of sol}^{n} \text{ in ltr.}}$$

$$\text{Normality (N)} = \frac{\text{wt of solute in gram}}{\text{volume of solution in litre}} \times \frac{1}{\text{Equivalent wt of Solute}}$$

$\therefore$ Normality (N) x Equivalent wt = Concentration in gm/ltr -(i)

If the solution contain 1N, $\frac{N}{10}$ (0.1N) normality of solution is called normal, decinormal solution

3. **Molarity:-**

It is the number of gram-moles of solute dissolve in per litre of solution. It is represented by 'm'.

Mathematically.

$$\text{Molarity (M)} = \frac{\text{No of gram-moles of solute}}{\text{Volume of solution in litre}}$$

$$= \frac{\text{Wt of Solute in gram}}{\text{Molecular wt of solute}} \times \frac{1}{\text{volume of soln in litre}}$$

$$= \frac{\text{Wt of Solute in gram}}{\text{Volume of solution in litre}} \times \frac{1}{\text{molecular wt of solute}}$$

or, Molarity (M) x Molecular wt = concentration in gm/litre
-- ②

If the solution contain 1 M, the solution is called molar solution.

Note:

Relation between Normality and Molarity:

We have;

Normality (N) x Equivalent wt = Concentration in gm/litre
-- ①

Molarity (M) x Molecular wt = Concentration in gm/litre
-- ②

From eqn ① and ② we write,

Normality (N) x Equivalent wt = Molarity (M) x Molecular Wt.

Q: Convert 1N H_2SO_4 into H_2SO_4 into Molarity concentration?

$$1N \times 49 = M(?) \times 98$$

$$M = \frac{49}{98} = \frac{1}{2} = 0.5\,M$$

⊛ 0.5M H_2SO_4 into normality?

$$N(?) \times 49 = 0.5 \times 98 \times 2$$

$$N = 1\,N$$

④ Molality:-

It is the number of gram-moles of solute dissolved in per kilogram (kg) of the solvent. It is represent by 'm'.

Mathematically:

$$\text{Molality (m)} = \frac{\text{No of gram-moles of solute}}{\text{wt of solvent in kilogram (kg)}}$$

$$= \frac{\text{wt of solute in gram}}{\text{molecular wt of solute}} \times \frac{1}{\text{wt of solvent in kg}}$$

If the solution contain 1 m ~~molality~~ ~~molality~~ ~~is called~~ the solution is called molal solution.

⑤ Mole fraction:

Mole fraction of solute is the ratio of number of moles of solute present in total moles of solution.

Let, 'n' is the number of mole of solute & 'N' is the no of mole of solvent :-

Therefore, Total mole of solution = $n+N$

Mole fraction of solute = $\frac{n}{n+N}$

&

Mole fraction of solvent = $\frac{N}{n+N}$

⑥ Wt. percent of Solute:

The amount of substances in gm dissolve in 100 gm $(\frac{w}{w})$ or 100 ml $(\frac{w}{v})$ of its solution is known as wt. percent of solute. It can be express in 2 ways.

ie $(\frac{W}{w})\% = \frac{\text{wt of solute in gram}}{\text{wt of solution in gram}} \times 100\%$

$(\frac{W}{v})\% = \frac{\text{wt of solute in gm}}{\text{wt of solution in ml}} \times 100\%$

⑦ What is the meaning of 4% NaOH Sol^n ?

→ It means 100 ml of solution contain 4 gm NaOH by $(\frac{w}{v})\%$ concept or 100 gm of solution contain 4 gm NaOH by $(\frac{w}{w})\%$ concept.

Numerical:

What is the normality in 4% NaOH soln?

Soln - 4% NaOH soln means 100 ml of solution contain 4 gram of NaOH

"""""" 1000 ml of solution contain 40 gram of NaOH

Therefore, concentration in gram per lit = 40 gm/lit

or

$$= \frac{\text{Amount of NaOH in gram}}{\text{Volume of soln in litre}}$$

$$= \frac{40 \text{ gm}}{1 \text{ litre}} = 40 \text{ gm/litre}$$

Then,

$$\text{Normality (N)} = \frac{\text{conc}^n \text{ in gm/litre}}{\text{Equivalent wt of NaOH}} = \frac{40}{40} = 1N$$

Standard Solution:

The solution whose concentration is known is called standard solution. They are 2 types:

(i) Primary standard solution
(ii) Secondary Standard solution

~~Prim~~ Those substances whose standard solution can be prepared by directly dissolving known weight of the substance in definite volume of solvent are known as primary standard substances. And their solution are known as primary standard solution. To be primary standard substance it should be follows;

(a) It should be easily available in lab in pure and dry state.

(b) It's compositon donot change during long period of storage.

(c) They should be readily solube in water.

(d) It should not change the state of matter in air or vaccum.

(e) It should not be hygroscopic on contact with skin.

For ex:

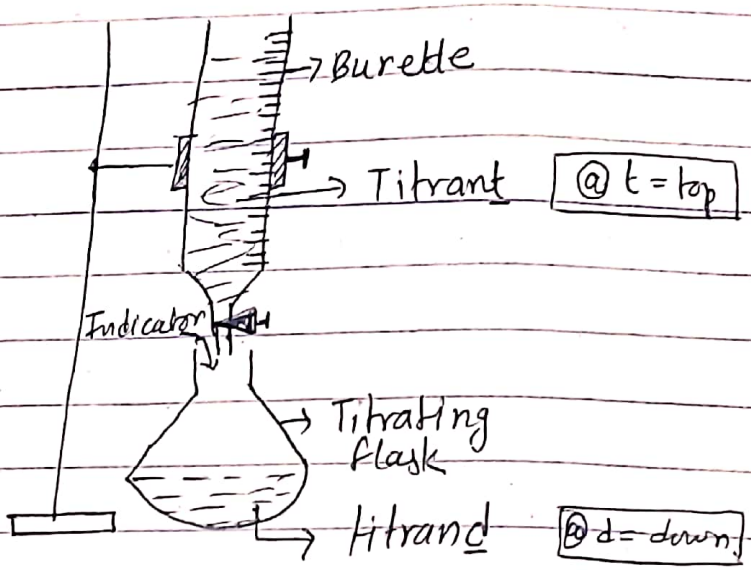
Substances like anhydrous, Na_2CO_3, Succinic acid, NaCl, Silver nitrate etc. are primary standard substances.

The substances which do not fullfill above requirenment or solution cannot be prepared by direct weighing are called as Secondary standard substances of their solution.

* Unknown Solution:

Those solution whose strength cannot known is called ~~the~~ unknown solution.

* Titration process:



The process which is used to determine the concentration unknown solution with known concentration of solution. is called titration process. This is the example of volumetric analysis in Quantitative aspect.

In volumetric analysis or titration two solution are react in titrating flask. One of them is taken in burette which is called titrant and other is taken in titrating flask which is called titrand. With the help of indicator complication of reaction can be indicate by visualizating change in color of indicator.

* Indicator:

Indicator are the reagent which is used in titration to indicate the completion of chemical reaction by changing color of solution. Such point where the color just change is endpoint.

The common acid base indicators are litmus, solution or paper, methyl orange, phenolphthalein etc.

* End point:

In volumetric analysis definite volume of solution is taken in small titrating flask with the help of pipette. A drop of indicator is added then another solution is carefully added through a burette drop by drop. At the completion of reaction color of solution is changed at certain point which is called endpoint.

* Normality Equation:

The titration process is based upon the law of chemical equivalence of two reagents. According to this, the normality equation can be represent as;

$$N_1 \times V_1 = N_2 V_2$$

Where; N_1 = Normality of acid
V_1 = Vol. of acid
N_2 = Normality of base
V_2 = Vol of base

Note:

Normality of the solution is based upon the law of chemical equivalence which states that, the product of strength & volume of one reagent equivalent to another reagent.

i.e- 10ml of 1N HCl = 10ml of 1N NaOH
10 ml of 1N HCl = 5ml of 5N NaOH
10 ml of 1N HCl = 20ml of 0.5N NaOH

Numerical:

Q: 20ml of 2N HCl is mixed with 24ml of 1.5N NaOH is resulting solution acidic or basic or neutral? Calculate the strength of resulting solution?

Solution

20ml of 2N HCl = 40ml of 1N HCl
24ml of 1.5N NaOH = 36ml of 1N NaOH
4ml of resulting Soln = 4ml of 1N HCl

According Normality eqn.

$$N_1V_1 = N_2V_2$$

$$N_1 \times 44 = 1 \times 4$$

$$N_1 = \frac{1}{11} N$$

$$N_1 = 0.0101\ N$$

Hence, the resulting soln is acidic

(Q) 18 ml of $\frac{N}{2}$ HCl, 10.3ml of 2N HCl and 16.4ml of $\frac{N}{10}$ HCl, are mixed together. Calculate the strength of mixture in normality and gm/litre.

18 ml of 0.5N HCl = 9ml of 1N HCl
10.3 ml of 2N HCl = 20.6 ml of 1N HCl
16.4ml of 0.1N HCl = 1.64 ml of 1N HCl
44.7ml of resulting soln = 31.24ml of 1N HCl

Normality eqn

$N_1V_1 = N_2V_2$

$N_1 \times 44.7 = 1 \times 31.24$

$N_1 = \frac{31.24}{44.7}$

$N_1 = 0.69\ N$

Concentration in gm/litre = Normality × Equivalent wt
= 0.69 × 36.5
= 25.18 gm/litre

* Amount of substance required to prepared desired concentration of soln.

When 'W gm' of substance is required to prepared N-normality of solution in 'V ml', following relation can be used:

$$\text{Weight}(w) = \frac{\text{Normality}(N) \times \text{Equivalent wt}(E) \times \text{Volume}(V)}{1000}$$

$$W = \frac{N \times E \times V}{1000}$$

For eg:
The required amount of anhydrous Na_2CO_3 of decinormal (1/10) in 500 ml is;

$$W = \frac{0.1 \times 53 \times 500}{1000 \times 2}$$

$$= 2.65 \text{ gm}$$

(Q) Calculate the amount of Na_2CO_3 required to prepare decinormal solution of it in 250 ml is;

$$W = \frac{0.1 \times 53 \times 250}{1000} \times \frac{1}{4}$$

$$= 1.325 \text{ gm}$$

Fixed Numerical

(*) Calculate the molecular wt. of dibasic acid, 0.45 gm of which is required to 200 ml of $\frac{N}{20}$ Sod. hydroxide Solution for neutralization?

Soln Given,

Basicity of acid = 2 (dibasic)
Weight of Substance (W) = 0.45 gm
Volume of Solution (V) = 200 ml
Normality of solution (N) = $\frac{N}{20}$ = 0.05 N
Molecular wt = ?

We have,

$$W = \frac{N E V}{1000}$$

$$0.45 = \frac{0.05 \times E \times 200}{1000}$$

$$\frac{4.5}{0.05 \times 2} = E$$

$$E = 45$$

Equivalent wt of acid = $\frac{\text{Mole. wt}}{\text{Basicity}}$

$$45 = \frac{\text{Mole. wt}}{2}$$

$$\therefore \text{Mol. wt} = 90$$

⊛ If 0.29 gm of metal is dissolve with 0.1 N (f=0.98) Sulphuric acid in 250 ml. Calculate the Equivalent weight of metal?

Given,

Weight of the substances = 0.29 gm

Note: Normality factor (f) =

It is the ratio of weight taken to the weight to be taken. ie

$$\text{Normality factor (f)} = \frac{\text{wt. taken}}{\text{wt to be taken}}$$

When it is difficult to weight out exactly like 1.325 gm of Na_2CO_3, ~~with~~ we generally weight a quantity which is near about the required weight like:- 1.320 gm or 1.330 gm.

To find out the exact normality of prepared solution it is related to the;

Exact Normality = Normality (N) x Normality factor (f)

Exact Normality = 0.1 x 0.98 = 0.098 N

Volume (v) = 250 ml

We have;

$$W = \frac{NEV}{1000}$$

$$0.29 = \frac{0.098 \times E \times 250}{1000\ 4}$$

$$E = \frac{0.29 \times 4}{0.098}$$

$$E = 11.83$$

Periodic Table:

Introduction:

The table in which the known elements can be arrange on the basis of their physical & chemical properties where identical properties of the element arrange in similar colourmns & different properties are arrange in seperated columbs.

Mendeleev's Periodic Table:

The first periodic table was constructed by Dmetri Mendeleev's on the basis of physical & chemical properties of the element according to his law i.e.

Mendeleev's periodic law:

Which states that, "The physical & chemical properties of the element are periodic function of their increasing atomic weight.

On the basis of this law Mendeleev's construct the periodic table which Consists:

@ Nine Verticle columns & called as group & represent by letter I to VIII & zero groups. Group I to VIII it on further sub-divided into A & B. Group VIII consist three sets of element & zero group contain inert gas elements.

(b) Seven horizontal rows & called as period & represent by number 1 to 7.

	I A	I B	II A	II B	III A	III B	IV A	IV B	V A	V B	VI A	VI B	VII A	VII B	VIII	0
Period-1	H															He
Period-2	Li		Be		B		C		N		O		F			Ne
Period-3	Na		Mg		Al		Si		P		S		Cl			Ar
Period-4	K	Cu	Ca	Zn	Sc		Ti		V		Cr		Mn		Fe Co Ni	Kr
Period-5																
Period-6																
Period-7																

Use of Mendeleev's periodic table

- Easy to Study of element: With the help of ~~me~~ Mendeleev's periodic table it is simplifying the study of specific element and their compounds easily.

- Prediction of new elements: In Medeleev's periodic table their was many vacant place where present and predict the newly discovered element according to their atomic weight & properities. They can be placed on such vacant space.

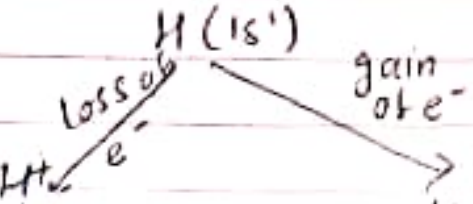
- Correction of doubtful atomic weight: Some doubtful atomic weight can be corrected with the help of periodic table. The equivalent weight of Be is 9.5 & by taking their valancy 2 or 3 Here atomic weight are 9 or 13.5 respectively If 13.5 is their atomic wt they must be place mbetween C & N but in periodic They be lies in between Li & B which corrected then the achuall atomic weight is 9.

Defect of Mendeleev's Periodic table: Limitation:

① Position of hydrogen:

Hydrogen element in periodic table is placed in group I(A) which is resembles to alkali metals and Halogen elements group VII (A) on the basis of lose ~~of~~ or gain of one electron.

ie



Alkali metal I(A)

$Li \rightarrow Li^+$

$Na \rightarrow Na^+$

$K = K^+$

Halogen VII(A)

$F \rightarrow F^-$

$Cl \rightarrow Cl^-$

$Br \rightarrow Br^-$

Therefore, position of hydrogen is uncleared.

(b) Position of Isotopes:

Mendeleev's periodic table is based on the atomic weight of the element but the isotopes of element are placed in same position in the table which do not follow the Mendeleev's periodic law.

(c) Anamalous pair of elements:

Some element having haigher atomic weight placed in first then lower atomic weight of the element for example:- Argon element (atomic weight=40) comes first than K (atomic weight = 39)

(d) Position of lanthanides & Actinides elements:

The 14-elements i.e. $_{58}Ce$ to $_{71}Lu$ are called lanthanide

The 14-elements i.e. $_{90}Th$ to $_{103}Lr$ are called Achnides. Which cannot be seperate out at proper position in Mendeleev's periodic table.

Modern Periodic table:

To remove the defect of Meendeleev's periodic table of the elements on the basis of their physical and chemical properties can be arrange with increasing their atomic number in place of atomic weight. On the basis of Modern periodic law.

"Which stutes that;" the physical & chemical properties of the elements are periodic function of their increasing atomic number."

* Long form of periodic table: On the basis of modern periodic law long form of period table can be construct, which have following features:

① All the elements have been arrange with increasing their atomic number.

② Elements with similar electron configuration have same properties and placed in single column and different properties of the elements placed in sperate column in periodic table. Therefore, in merdern period table it consists;
(a) Seven horizontal rows called periods.
(b) Eighteen Vertical columns called as groups.

Period:

In modern periodic table, there are a horizontal rows from left to right are called periods. Period of the element having similar valence shell. These period can be represented by a number from 1 to 7.

② Period - 1: The first period belongs to filling of electrons from 1st energy shell (i.e. n=1) which includes one 1s - orbital. It ~~no~~ means two electrons or two elements can be present.

(b) Period-2:

The second period belongs to filling of electrons from 2nd-energy shell (i.e n=2), which includes four orbitals (i.e. one 2s & three 2p-orbitals). It means eight electrons or eight elements can be present.

(c) Period-3:

The third period belongs to the filling of electrons from 3rd energy shell (i.e n=3), which includes nine orbital (i.e. one 3s, three 3p & five 3d-orbitals) but 3d orbital can be filled of after the highest fourth-energy orbital 4s and therefore, it doesnot includes in 3rd energy shell. It means only Eight electrons or Eight elements can be present.

(4) Period-4:

The fourth period belongs to fillings of electrons from 4th energy shell (i.e n=4), which includes nine orbitals (ie one 4s, five 3d and three four p orbital. It means 18 electron or 18 elements can be present.

(5) Period-5:

The fifth period belongs to fillings of electrons from 5th energy shell (i.e n=5), which includes nine orbital (ie five 5, five 4d & three 5p). It means 18 electron or 18 elements can be present.

⑥ period - 6:-

The sixth period belongs to filling of electrons from 6th energy shell (i.e n=6), which includes ~~(i.e 16 or~~ 16 orbitals (ie. one 6s, Seven 4f, five 5d & three 6p orbitals.) In this period, the filling up 4f orbital can be start which includes the series of elements ~~to~~ from Cerium ($_{58}Ce$) to Lutetium ($_{71}Lu$) are called as lanthanide series. In this period, 32 electrons or 32 elements can be present.

⑦ period-7:-

The seventh-period belongs to filling of electrons from seventh energy shell (i.e n=7), which includes 16 orbitals (ie one 7s, Seven 5f, three 5d & three 7p ~~orbital or bital~~ orbital) In this period the electron can be filled up in 5f orbitals which includes a series elements from Thorium ($_{90}Th$) to Lawrencium ($_{103}Lw$) are called actinides series. But, in this period 19 ~~#t 94~~ electrons are present.

Groups:

In periodic table there are 18 ~~group~~ vertical columns are present which are called groups. The groups are represent by the number 1 to 18.

~~Group~~ Group 1 (IA), Group 2 (IIA) are called Alkali ~~metal~~ metal, Alkaline earth metals respectively.

Division of block in periodic table:

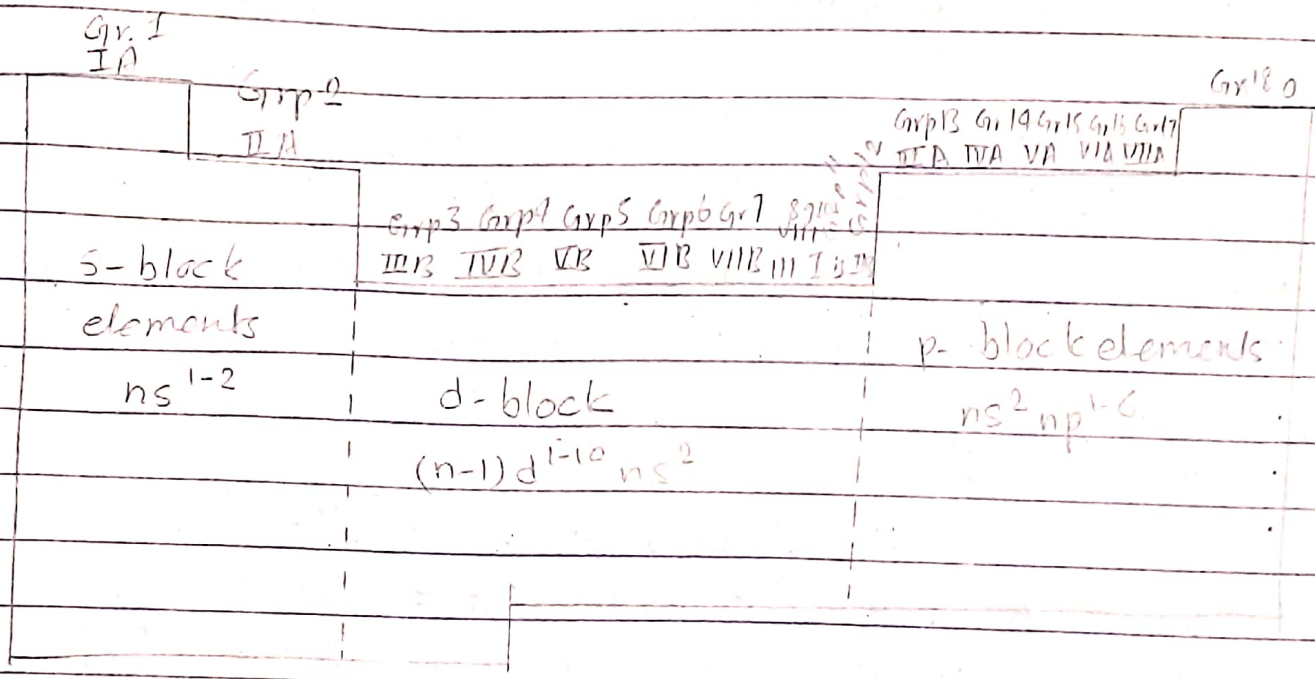


Fig: Block of the elements in periodic table

The long form of modern periodic table can be divided into 4 blocks ie s, p, d, f on the basis of the last electron (valency electron) can be enter into a s, p, d, f subshell.

ⓐ S-block elements:

The elements in which the last electrons can enter the 's' subshell are called s-block elements. This block is lies in left hand side (LHS) in periodic table and consists Grp 1 (IA) and Grp 2 (IIA) elements The general valence shell electronic configuration is ie. ns^{1-2}.

The characteristic of s-block elements are:-

ⓐ They are soft metals
ⓑ They are highly electropositive in nature.
ⓒ They have +1 & +2 oxidation number.
ⓓ They are highly reactive and can forms ionic compounds
ⓔ These elements have low ionic energy.

ⓑ p-block element:

The elements in which the last electrons can enter the 'p' subshell ~~are called~~ & it lies in right hand side in periodic table. This block includes Grp 13 (IIIA), 14 (IVA), 15 (VA), 16 (VIA), 17 (VIIA), 18 (0). Its general valency shell electronic configuration is ns^2p^{1-6}.

The characterstic of p-block elements are:-

ⓐ They are non-metallic in character.
ⓑ They are highly electronegative in nature
ⓒ The oxidation number of these block element are variable
ⓓ They can form ionic & covalent compounds.

③ d-block elements:

The elements in which the last electron can enter to d-subshell of their penultimate (n-1) energy shell is called as d-block elements. This block of element can be lies in between s and p-block. The general valence shell electronic configuration is; $(n-1)^{0}d^{1-10}ns^{2}$, These element are also called as transitional series of elements.

The characteristic of d-block elements are:

ⓐ They are metals & hard with having higher melting point

ⓑ They have variable oxidation numbers and valencies.

ⓒ They can form ionic as well as covalent compound.

ⓓ Mostly they have catalytic properties.

④ f-block elements:

The elements in which the last electron can enter into a f-subshell of their antipenultimate (n-2) energy level are called f-block elements. It can be lies at the bottom of the periodic table, which includes two series of elements ie lanthanides & actinides series of elements. The general valence shell electronic configuration of the element is;

$(n-2)f^{1-14}\ (n-1)^{0-1}\ ns^{2}$.

The characteristic of these block of elements are:

① They are metals with high melting point and densities.

(ii) Most of the actinides element are highly radioactive elements like Uranium (U).

(iii) They can formed coloured compounds.

Ionization Energy (I.E):

It is the amount of energy required to ~~rules~~ released loosely held electrons. from their valence shell is called ionization energy.

ie. $X_{(g)} + I.E \longrightarrow X_{(g)}^{\oplus} + e^{\ominus}$

Gaseous element — Cation

$Na \longrightarrow Na^{+} + e^{-}$

(2,8,1) (2,8)

$Al \longrightarrow Al^{+3} + 3e^{\ominus}$

(2,8,3) (2,8)

Ionization energy can gives ~~Paper~~ important properties of element in which way the neutral gases atom change to their positive ion.

* Variation of I.E in ~~pta~~ periodic table:

Imp

(a) Variation across the period:

The value of ionization energy can be increase with increases in their atomic number ~~ator~~ across the period. This is due to

(a) atomic size can be decrease with increase their nuclear charge.

(b) Progressive addition of electrons into a same energy shell.

Thus, due to ~~change~~ continuous decrease in size of the atom and increasing their nuclear charge. The ionization energy can be increase.

a) In group:

The value of ionization energy decrease regularly with increasing the atomic number along the group in periodic table this due to addition of extra energy shell around the nucleus and weaker the attraction of electron as a result the valence electron can easily release.

i.e.

Period → ie. increase

Group ↓ ie. decrease

(*) Electron Affinity (E.A):

It is the amount of energy released when gases atom can accept an electron to form anion species.

ie

$$X_{(g)} + e^{\ominus} \longrightarrow \underset{\text{anion}}{X_{(g)}} + E.A$$

~~Ho~~ ~~Defect of Electron~~

The magnitude of electron affinity can measure the how long the atom can hold the additional electron.

⊛ Variation of Electron Affinity in ~~pero~~ periodic table.

a) In period:

The value of electrons affinity can be increase with increasing atomic number of an atom in a period. This is due to decreasing their atomic size and increasing the nuclear charge as a result an additional electron easily accepted an atom.

The halogen series of each of the period can be increase their electron affinity values due to their ~~electron~~ anionic form they are ~~result~~ most stable.

⊛ In group:-

The value of electron affinity into a group in periodic table get decrease due to increasing their size and nuclear charge. where; the additional electron cannot be attract easily.

Atomic structure:

⊛ Orbit & Orbitals:

Orbit:

The selected circular path where dectrons can be revolved around the nucleus is called orbit. It can be represent by K, L, M & N shell or 1st, 2nd, 3rd or 4th energy shell of the

orbit. The number of electrons at a particular orbit is based upon the $2n^2$ rule. where; n = 1, 2, 3, 4--- etc energy shell.

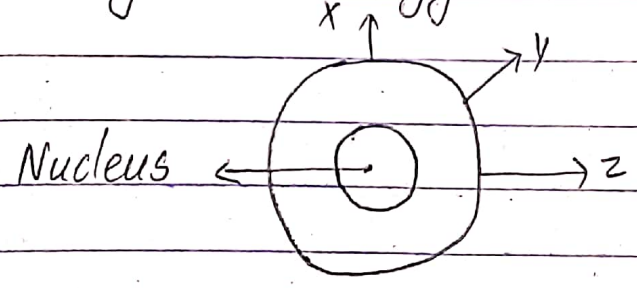
Energy shell	No of electrons	Name of shell
1	$2 \times 1^2 = 2$	K
2	$2 \times 2^2 = 8$	L
3	$2 \times 3^2 = 18$	M
4	$2 \times 4^2 = 32$	N

- ~~Orbit~~ Orbitals:

The region around the nucleus by 3-dimensional (3D) space where probability of finding the electron become maximum in an atom. It be represented by s, p, d and f orbital & their shapes are different on the basis of their types:

① S-orbital:

It is ~~sl~~ spherical in shape & size will be increase with increasing their energy shell ie. 1s < 2s < 3s < 4s -- etc.



S-orbital

② P-orbital:

It is dumb bell in shape & having two lobes in their structure P-orbital are three types ie P_x, P_y, P_z, where the electron density be lies in X, Y, Z axis respectively.

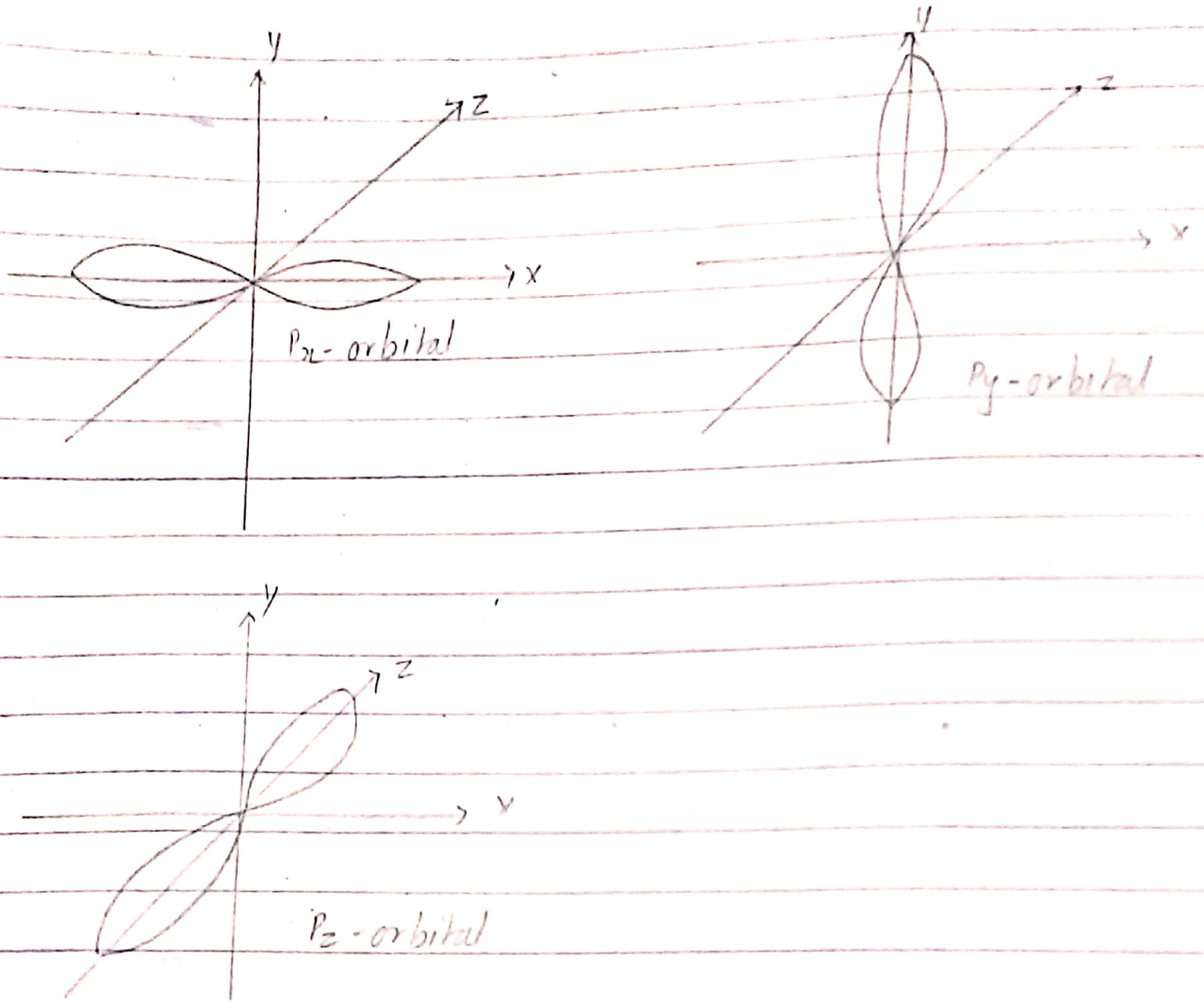


Fig: Types of p-orbital

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⊛ **Quantum Number (Q.N):**

It is the number which an specific the position and energy of an electrons in an atom. Quantum number are 4 types:

ⓐ Principle Quantum no (n)
ⓑ Azimuthal Quantum no (l)
ⓒ Magnetic Quantum no (m)
ⓓ Spin Quantum no (s)

Principal Quantum no (n):

This quantum number is represent by 'n' & specific the energy level of the electrons present and also measure the average distance of the electrons from nucleus in an atom.
For Ex: 2s orbital of their n=2.

Azimuthal Quantum no (l):

This quantum number is represent by 'l' & ~~spef~~ specific the different energy shell of the atoms. Its values depends upon the principle quantum no & range from 0 to n-1 which express s, p, d, f energy shell.

For Ex:

n	l = 0 to (n-1)
1	0 (1s)
2	0 (2s)
	1 (2p)
3	0 (3s)
	1 (3p)
	2 (3d)

Magnetic Quantum no (m):

This quantum number is represent by 'm' & ~~spect~~ indicate the different orientation of sub-shell. Its value depends upon the azimuthal quantum no. (l) & its range is ±l (ie. +l to -l).

Azimuthal quantum no (l)	Magnetic quantum no. (m) m = ±l.
0 (s)	0 } 1-orbital
1 (p)	±1 ($+1_{p_x}, 0_{p_y}, -1_{p_z}$) } 3 orbital

2 (d)	± 2 (+2, +1, 0, −1, −2) 5-orbital d_{xy} d_{yz} d_{xz} $d_{x^2-y^2}$ d_{z2}

④ Spin Quantum Number (s): This quantum number is represent by 's' & indicates the spin of electrons ie. clockwise or upward (↑) & anti-clockwise or downward (↓) It have 2-values ie $+\frac{1}{2}$ (upward) & $-\frac{1}{2}$ (downward)

{Q}: Write the name of the orbital with following queantum no

ⓐ $n=3, l=2,$

Soln

Here, the principle queantum no (n) = 3 indicates the 3 energy shell & Azimuthal quantum no (l) = 2 indicates the d-orbital therefore, the name of the orbital - 3d

ⓑ $n=3, l=1, m=0$

Soln,

Here the principle quantum no (n) = 3 indicates the 3 energy shell & Azimuthal quantum no (l) = 1 indicates the p-orbital & Magnetic quantum number (m) = y. Therefore, the name of the orbital - $3p_y$

⊛ Electronic Configuration:

The electronic configuration of an atom is the filling of available electrons into an orbital with increasing energy levels.

While writing the electronic configuration of an atom in the principal quantum no (n) is written before the symbol of orbital.

$$_{n}1s^{\overset{\text{superscript position}}{\textcircled{1}}}_{0}$$

The no at the right hand side of superscript position of orbital indicates the total numbers of electrons i.e.

$$1s^{1}$$ ← No of electron

1 → Principle quantum no. ; s → name of the orbital (s-orbital)

* Rules of electronic configuration:

① Pauli's exclusion rule:

According to this rule no two electrons in an atom can have all four quantum numbers are same.

This rule can explain the any available orbitals contain only two electrons with opposite spin ie (↑↓)

For example: The electronic configuration of Helium element and their quantum number are: $1s^2$

	n	l	m	s
electron 1	1	0	0	$+\frac{1}{2}$
electron 2	1	0	0	$-\frac{1}{2}$

(b) Hunde's rule:

According to this rule, "The pairing of electrons will be start to same energy level of the orbitals ie p, d or f; till all are singly occupied."

For example: The ~~ex~~ electronic configuration of oxygen is

$_8O: 1s^2, 2s^2 2p^4$

1s 2s 2p

1↿⇂ 1↿⇂ 1↿ 1↿ ☐ (Wrong)

But

1s 2s 2p

1↿⇂ 1↿⇂ 1↿ 1 1 (correct)

$_7N: 1s^2, 2s^2 2p^3$

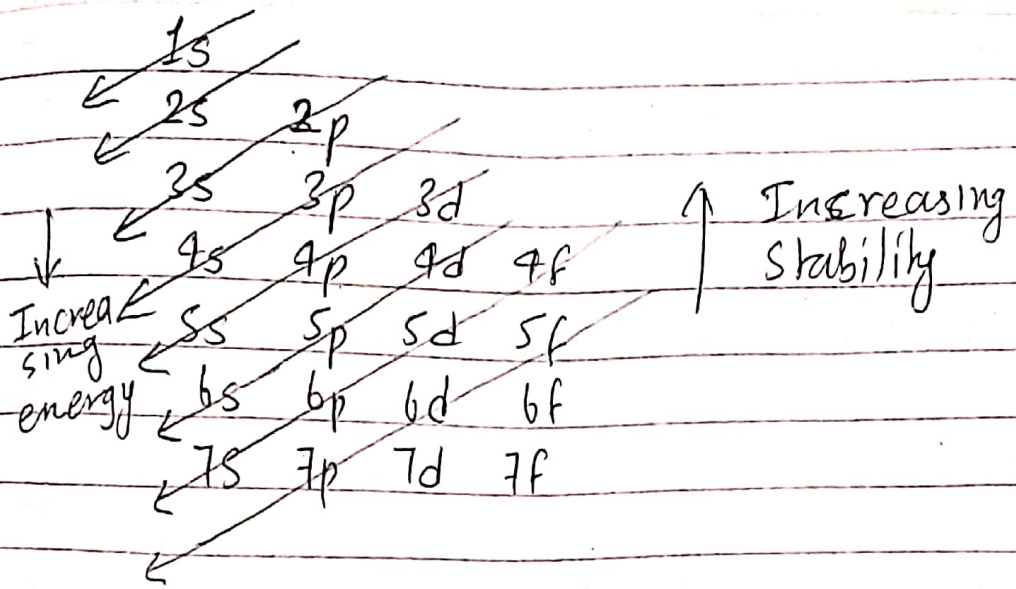
1s 2s 2p

1↿ 1↿ 1 1 1

(c) Aufbau's rule:

According to this rule, "The electrons in an atoms can be build up by filling the available orbitals with increasing their energy level."

The increasing sequence of available orbitals are:-



Note: ~~atomic~~

* Atomic number

Atomic no. = Total no of protons = Total no of electrons

Atomic wt = Mass number:

Mass number = Sum of the nucleus no

= No of protons + No of Neutrons

Q: An atom has 24 electrons & its mass no is 52. Find out

i) Total no of neutrons

ii) Total no of s-electrons

iii) Total no of p-electron

iv) Total no of unpair-electrons

By assign their electronic configuration

24Cr: $1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^2, 3d^4$ (Expected)

$1s^2, 2s^2 2p^6, 3s^2 3p^6, 4s^1, 3d^5$ (Actual EC)

29Cu: $1s^2, 2s^2 2p^6, 3s^2 3p^6, \longrightarrow 4s^2, 3d^9$ (Expected)

$\longrightarrow 4s^1, 3d^{10}$ (Actual EC)

ii) 7
iii) 12
iv) 6

Arrangement of electrons, protons, & Neutrons in an atom:

ⓐ Thomson's atomic Model:

After the discovery of electrons and protons the scientist started to think for arrangment of it. For this purpose J.J Thomson was started to arrange & his model was called as Thomson atomic model.

In his atomic model, the negatively charged electrons and positively charged protons were embedded into a single sphere on the concept of atoms were electronically neutral.

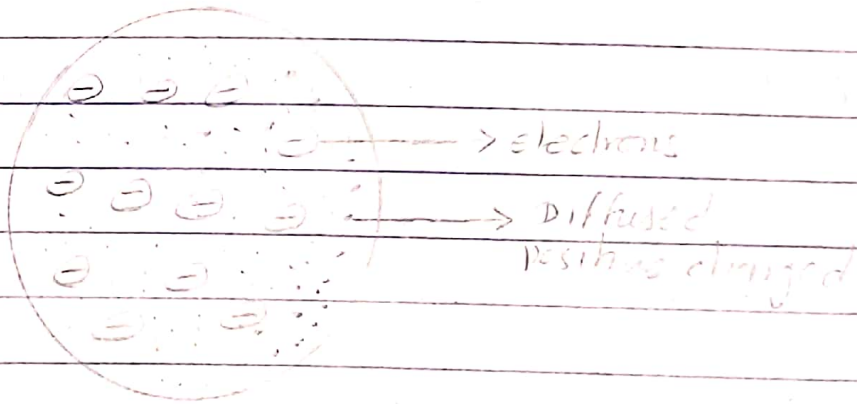


Fig: Thomson's atomic model

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② Rutherford's atomic Model: Scattering Experiment:

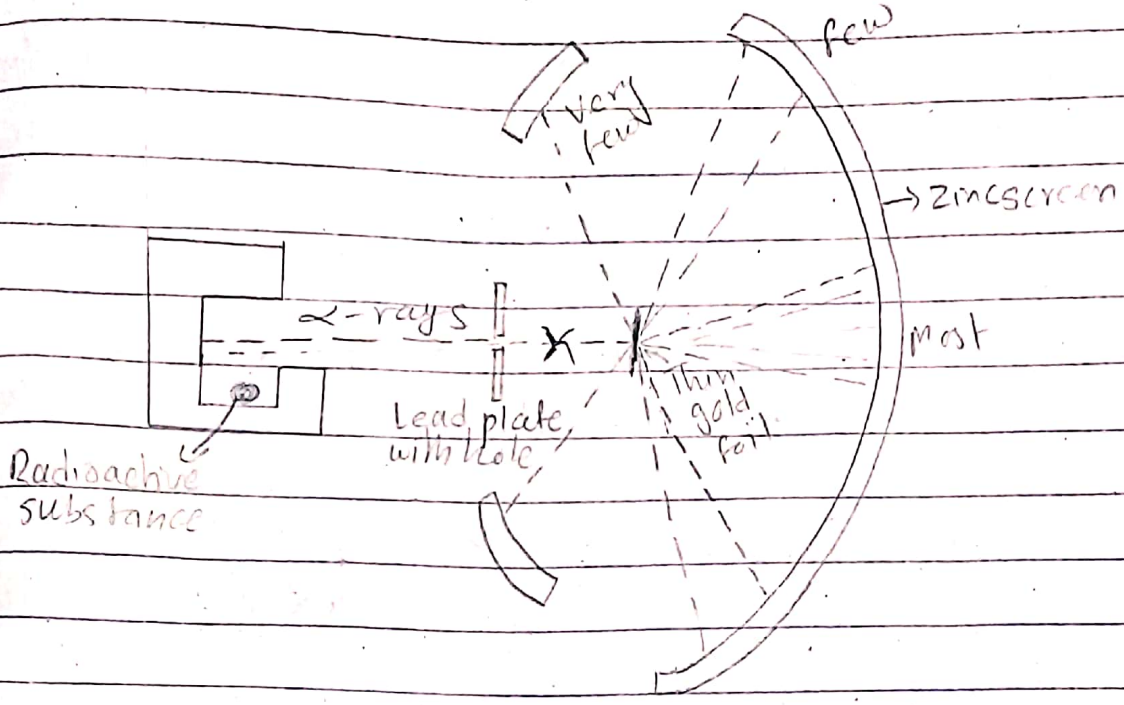


Fig: Rutherford's Scattering experiments

To understand the arrange of electrons & proton in an each atom, Rutherford and his co-workers performed a series of experiment that is Ruther Ford's scattering process.

They bombared α-particles emitted from radioactive substance on a ~~pice~~ piece of thin gold foil.

In this experiment, a piece of radioactive substance is placed into a lead block and produce a narrow beam of α-rays and which can be pass into a thin gold foil. ~~In~~ During this ~~α~~ α-rays after scattering into a movable ZnS screen and produce flash of light in different portion. And ~~deter~~ which determine the

deflected angle.

~~Rutherford's~~ From this experiment following observation are obtained,

ⓐ Most of the α-rays can passed through gold foil without deflection, it means in an atom there is large empty space in their structure.

ⓑ Few of α-rays can be deflected by some angles, it means at the center of the atom positively charged particles are present.

ⓒ Very few of α-rays can be deflected large angle or even return to 180°, it means the particles directly collide with positively mass particles.

Thus, from above absorbed Rutherford purpose ~~a~~, atomic model ie Rutherford's atomic model.

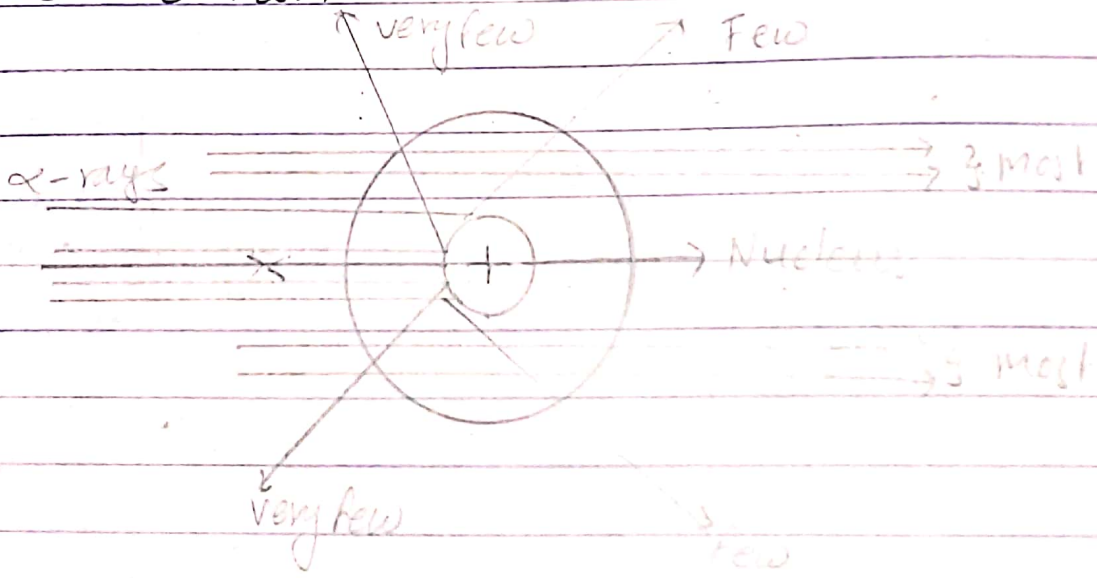


Fig: Rutherfords atomic Model

~~B~~

Limitation:-

① It does not explain the stability of an atom.

© Bohr's Atomic Model:

In 1913, Neils Bohr modified the Rutherford atomic model and purposed Bohr's ~~atom~~ atomic model it consists following postulates;

① An atom consist of positively charged particles which is called nucleus & it revolve the electrons. An An electron in an atom can revolve a selected circular path which is orbit. It is represent by K, L, M, N shell or, 1, 2, 3, 4 - energy shall or ~~path~~ ~~which it called~~ orbit or.

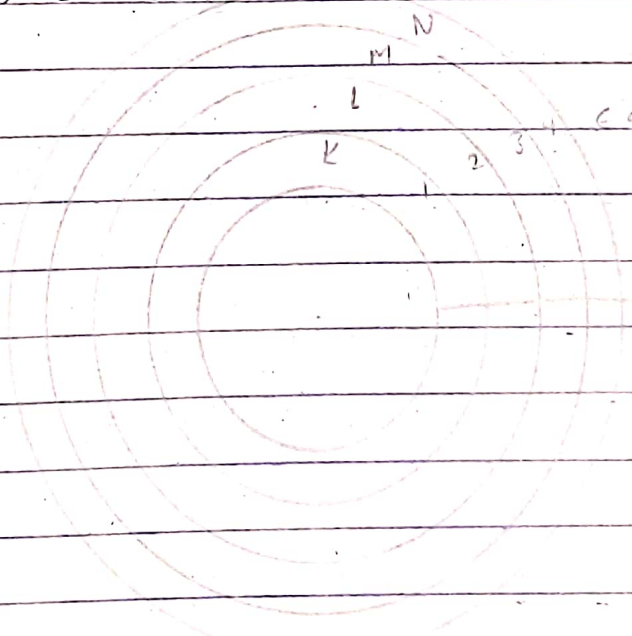
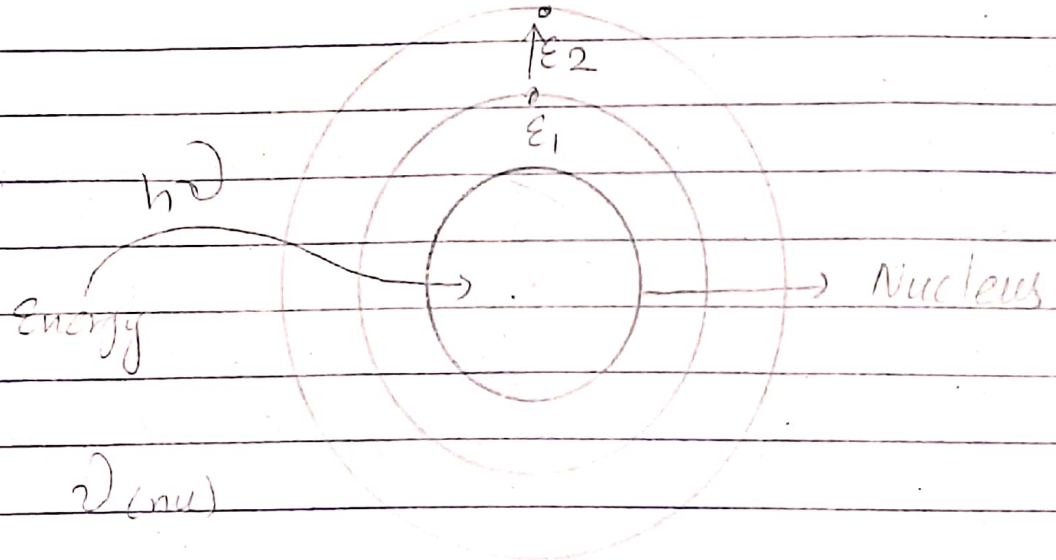


Fig. Atomic Model

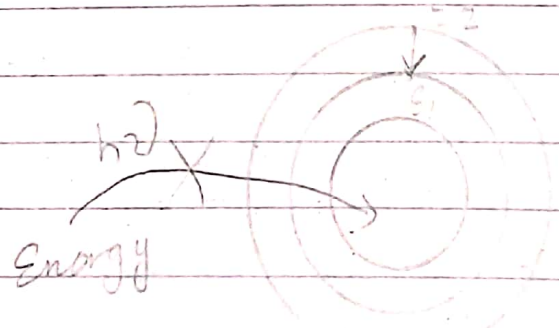
(b) as long as electrons in an atom can be represent in particular orbit. During this it doesnot lose or gain energy & electrons remain constant. This explain the stability of an atom.

(c) When an energy is suspended to an atom, electrons jump to higher energy state. As soon as when the source of energy cut off electron back to their original energy levels.



$\Delta E = E_2 - E_1$

(Absorption of energy)



$\Delta E = E_2 - E_1$ (release of energy)

Electronic theory of Valency & Chemical Bonding:

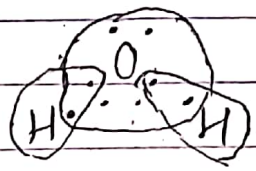
Imp * **Lewis or Electron dots structure:**

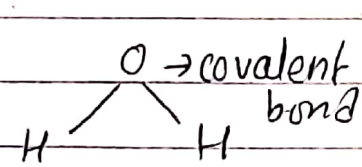
The valence electrons (i.e. electrons present in outermost shell) in an atom can be represent by 'dots' in their structure is called as lewis or electron dots structure.

For Ex: Na-element ⇒ $1s^2, 2s^2 2p^6, 3s^1$
(inner shell / core shell) — (valency shell / outermost shell)

ie. $\dot{N}a$

Mg-element ⇒ $1s^2, 2s^2, 2p^6, 3s^2$
ie $\ddot{M}g$

H_2O → Water ⇒ 

≡ 

> **Note:**
> With the help of Lewis structure we predict the valency of each of the element.

Octet rule:

Atoms except noble gas donot have 8 electrons in their valence shell. Therefore, Every atoms of the element can be acquire stable electronic configuration of their nearest noble gas element. During this atoms of

various element can undergoing chemical combination where their ~~out~~ outermost shell get 8 electrons except Hydrogen element is called octet rule.

Electronic theory of Valency: Postulates:

(a) The capacity of an atom to take part in their chemical combination is determine by their number of valence electrons.

(b) Atom with 8 electrons in their outermost shell are most stable and ~~their~~ therefore other atom of the element try to get such stable configuration, as a result chemical combination takes place.

(c) During chemical combination, an atom of the element exist their electronic configuration to nearest nobel gas element by loss, gain or shared of electrons.

(d) The number of electrons lost, gain or shared during chemical combination is called Valency of the element.

(e) The attrative force which hold the various element together is called as chemical bonding.

~~Dept~~ Depending upon their mode of formation their are 3 types of ~~bond~~ bonds are present:

① Electrovalent or Ionic Bond
② Covalent Bond
③ Coordinate Covalent Bond

① Electrovalent or Ionic Bond:

This type of bond generally present in inorganic compound where a complete transfer of one or more valence electrons from one atom to other atom can occur During this they produce opposite charged ions i.e. positive & negative ions which be hold by ~~usung~~ strong electrostatic force of attraction called as Ionic bond.

This type of bond can be exist between metal and non-metal elements, where metal loss their electrons to form positive species & non-metal gain electrons to form negative species, to get a stable electron's configuration of nearest noble gas elements.

For example:

ⓐ NaCl:

Na (2,8,1) — loss of e⁻ → Na^+ (2,8)

Cl (2,8,7) — Gain of 1e⁻ → Cl^- (2,8,8)

→ NaCl (attraction)

During the formation of NaCl, ~~Sodium~~ Na-atom losse their valence electron to get the nearest noble gas element Ne-atom electronic configuration & Cl-atom gain one electron to get nearest noble gas Ar-atom electronic configuration. During this Na-atom convert into Na^+ ion and Cl^--atom into Cl^--ion. Such oppostly charged ion attracts strongly by their ionic bond to form a NaCl compound.

(b) $MgCl_2$:

Mg $\xrightarrow{\text{loss}}$ Mg^{+2}
(2,8,2)

$2Cl$ $\xrightarrow{\text{gain}}$ $2Cl^-$
(2,8,7)

$\rightarrow MgCl_2$

Properties of ionic compounds:

Ionic bond containing inorganic compounds are called ionic compounds. They having following properties:

(a) Physical state:

Ionic compounds are usually exist in crystalline solid in state which have well-defined geometries & shape. This is due to strong electrostatic force of attraction.

(b) Electrical Conductivity:

Ionic compound donot conduct electric current in solid state but in molten state or solution state they are good conductor. This is due to presence of free ions.

(c) Solubility:

To be soluble the substances they should be follow the rule "like dissolves like". Ionic compounds are soluble in water and other polar solvent but insoluble in non-polar solvent like benzene, ether etc

(d) Boiling & Melting point:

Due to stronger electrostatic force of attraction between each compound. Ionic Compounds have high melting & boiling point.

② Covalent Bond:

The chemical Bonding which is formed by mutual sharing of electron pair between to similar or dissimilar atoms are called covalent bond. The atoms involves to formed a bond can contribute equal electrons and such electrons which is responsible to formed chemical bond are called bond pair of electrons

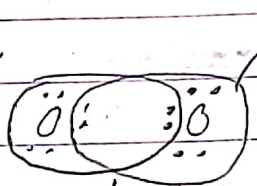
The covalent bond in a molecules can be represent by a line (–) between each atoms
for example:

H_2 molecule:

⇒ H – H

↳ one pair of
bond pair of electrons

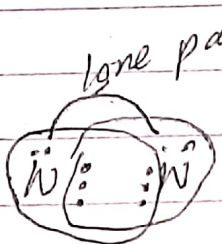
O_2 molecule:



⇒ O = O

↳ two pair of
bond pair of electrons

N_2 molecule



⇒ N ≡ N

↳ Three pair of
bond pair of electrons

When the atoms share one, two or three electrons pairs the bond formed is single, double or triple covalent bond respectively.

Properties of Covalent bonded Compounds:

(a) Physical state:

The intermolecular force of attraction for covalent compounds are usually weak. Therefore, they can exist in liquid or gaseous state. However, few compounds are also exist in solid state like sugar, urea etc.

(b) Electrical Conductivity:-

Covalent compounds are donot contain free ion in fused state or solution state. Therefore, They are bad conductor of electricity.

(c) Solubility:

Covalent compounds are insoluble in water and polar ~~solvent~~ solvent but ~~solu~~ soluble in unpolar solvent like; ether, chloroform, benzene etc.

(d) Boiling & melting point:

They attractive ~~be~~ force between their molecules are generally weak. As a result, leaser amount of energy is needed to breakup their intermolecular association ie have low & melting & boiling & point

⑥ Directional Nature:

Covalent compounds are directional in character which includes a line (—) and they are rigid in state.

⑨ Write the difference between ionic and covalent compounds?

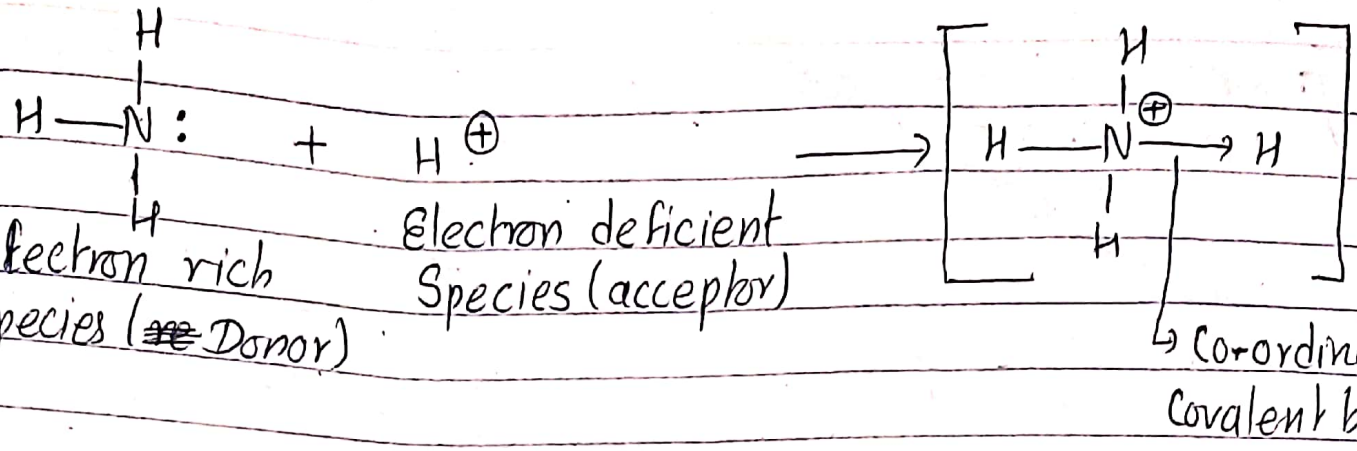
③ Co-ordinate covalent Bond:

It is a special types of co-valent bond where an electron pair shared between two atoms from only one atom during the formation of bond is called co-ordinate covalent bond & formed compⁿ are called co-ordinate compounds.

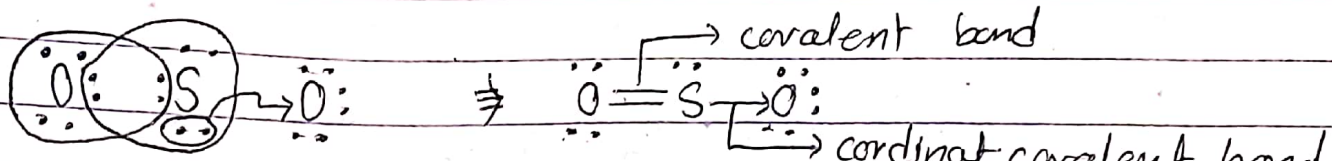
A co-ordinate covalent bond formed between two atoms, where one atom contain their unused electrons in octet state & other atom contain electron deficient with at least one electron pair. The atom ~~that~~ which contribute their electron pair called as donor & other atom which accept an electrons called as acceptor. It be represent by an arrow towards donor to acceptor (→).

For example:

* Formation of Ammonium ion ($\overset{+}{N}H_4$):

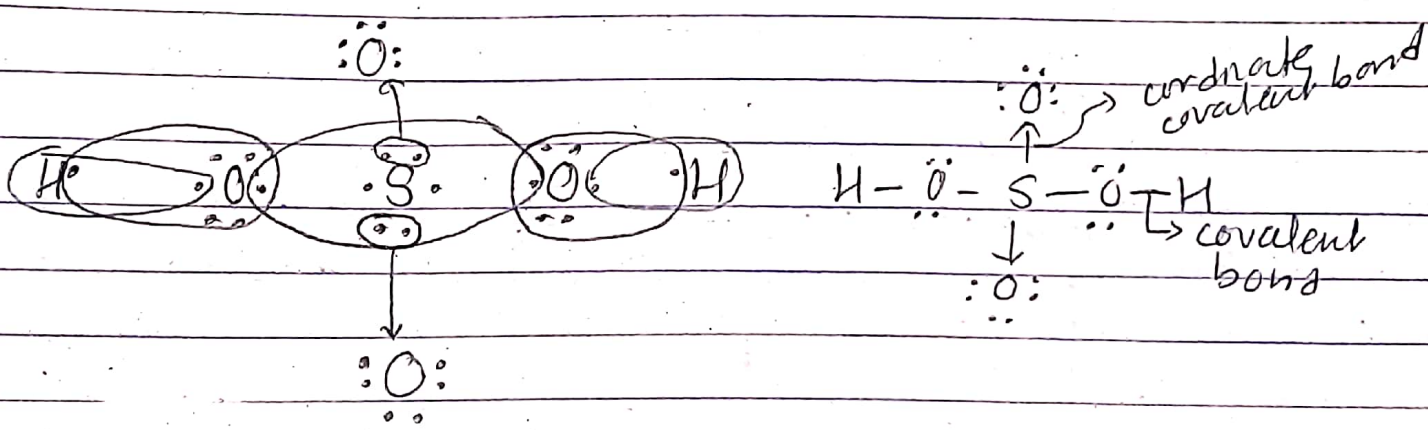


* Formation of Sulphur dioxide : SO2 :



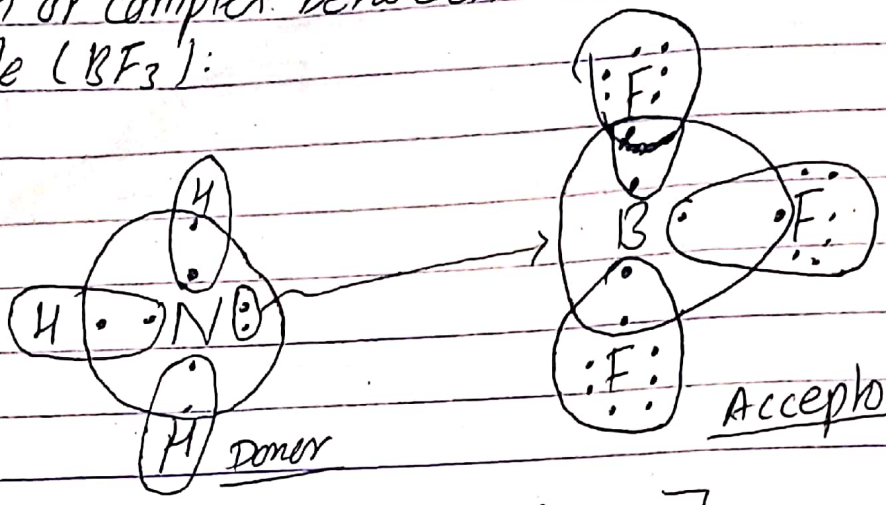
Lewis structure

* Formation of Sulphuric acid : H2SO4 :



Lewis structure

⊛ Formation of complex between ammonia (NH_3) & boron trifluoride (BF_3):



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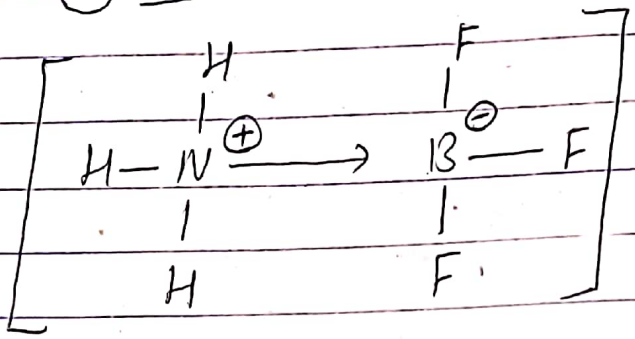
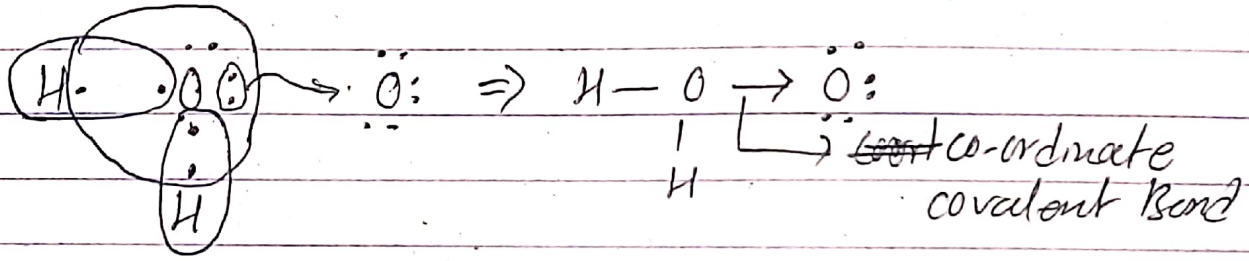


Complex

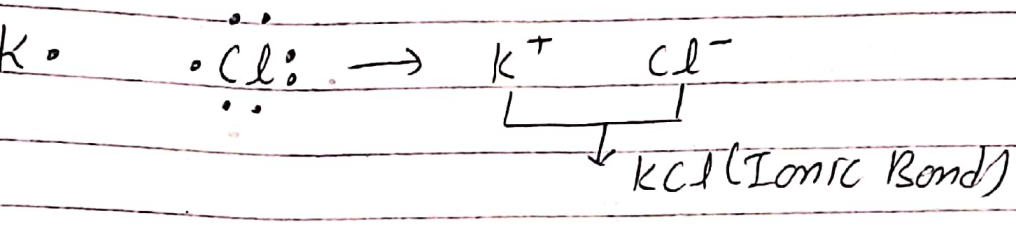
⊛ Formation of Hydrogen peroxide : H_2O_2 :



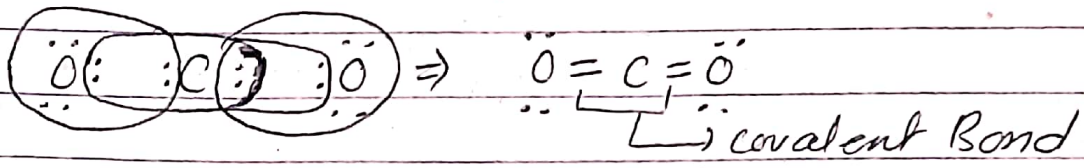
Lewis structure

(*) Name the types of bond involved in following compounds.

(a) KCl



(b) Carbon dioxide (CO_2):



General properties of Co-ordinate Covalent Compounds.

(a) Physical ~~Properties~~ state:

These compounds are exist in liquid and gaseous state.

(b) Electrical Conductivity:

Coordinate compounds are semi-ionic nature due to presence of certain charge and therefore, there are poor conductor of electricity.

(c) Solubility:-
These compounds are sparingly soluble in water but readily soluble in organic solvents. This is due to semi-ionic nature of compounds.

(d) Boiling & melting points:
The boiling and melting points are comparatively higher than covalent compound but lower than ionic compound. i.e. they belongs to intermediate between them.

(e) Directional Character:
The co-ordinate covalent bonds are rigid and directional which be represent by an arrow from donor to acceptor.

(*) Explain the formation of compound MgO and $MgCl_2$ of their ionic bond

(a) MgO :

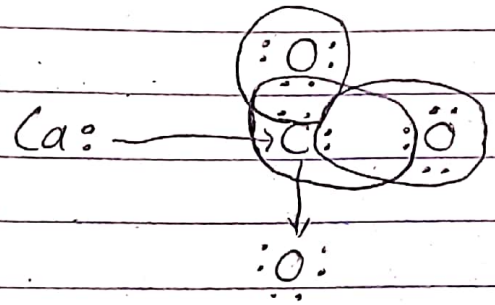
Mg : $\xrightarrow{\text{loss of } 2e^{\ominus}\text{'s}}$ Mg^{+2}
(2,8,2) (2,8)

:O: $\xrightarrow{\text{gain of } 2e^{\ominus}\text{'s}}$ O^{-2}
(2,6) (2,8)

Attraction → MgO → Ionic bond

(*) $CaCO_3$

Ca : $\xrightarrow{\text{loss of } 2e^{\ominus}\text{'s}}$ Ca^{+2}



$\Rightarrow$ Ca^{+2} $[O=C(=O)-O^{\ominus}]$ — $CaCO_3$ → Ionic bond

→ coordinate covalent

=O → covalent bond

$^{\ominus}$
oxide
ion

Corrosion:

Definition:

The spontaneous destruction of metal due to intraction with environment is called corrosion. Corrosion takes place on the surface of exposed metal. For eg. rusting of iron, oxidation of metals (like silver, Aluminium) ~~on~~ on connect with environment.

Classification of Corrosion:-

On the basis of nature and factor affecting the corrosion are different types:

(a) Chemical corrosion:

Such corrosion can be carried in presence of chemical reagent. for example:- when highly reactive metals combines with dilute mineral acids it get decomposed or completely destroyed.

$$Mg + \text{dil } H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$$

(b) Bio-chemical corrosion:

This corrosion can be carried out by the action of microorganisms like:- Bacteria, virus, fungi, Algae etc. for example: The soil composition can be ~~deer~~ change by the interaction with impure water and organic matters which contain different micro-organism

© Electrochemical corrosion:

This corrosion can be produce by electrolysis process where some metallic rod (electrolytes) dipped into a their corresponding solution. For example; Electroplating of ~~for~~ iron by gold.

Rusting of ~~fo~~ iron :-

The ~~formed~~ formation of brown powdery materials at the surface of iron due to interaction with moist air is called rusting of iron. The rust in iron can be exist in hydrated ferric oxide ($Fe_2O_3 . xH_2O$) in state.

Theory of rusting:

Rust can be obtain by following theory :-

ⓐ Electrochemical theory:

According to this theory, "the rust can be produced by their electrolysis process due to presence of impurities of applied electrodes i.e. anode & cathode

At anode: Oxidation

$Fe - 2e^{\ominus} \longrightarrow Fe^{+2}$

Ferrous ion

At cathode: Reduction rxn

$H_2O + \frac{1}{2}O_2 + 2e^{\ominus} \rightarrow 2OH^{\ominus}$

Hydroxide ion

Thus, formed Fe^{+2} & $2OH^-$ ions combined to formed ferrous hydroxide $\{Fe(OH)_2\}$

$$Fe^{+2} + 2OH^- \rightarrow Fe(OH)_2$$
Ferrous hydroxide

The ferrous hydroxide get oxidize with water molecules to form ferric hydroxide $\{Fe(OH)_3\}$.

$$4Fe(OH_2) + 2H_2O + \tfrac{1}{2}O_2 \longrightarrow 4Fe(OH)_3$$
Ferric hydroxide.

At last $Fe(OH)_3$ change to their hydrated formed i.e. $Fe_2O_3 \cdot 3H_2O$ which is rust.

(*) Corrosion protection:

(a) By surface Coating:

Corrosion of metal can be prevented by coating their surface any of the following ways:-

(1) By applying oils, grease, paint, vaslive on the surface of metal.

(2) By coating a thin layer of metal which donot corroded like:- iron can be coated by gold, zinc, nikel etc.

(b) By connecting metal to a more electropositive metals

A metal can be protected with corrosion by connecting it with more electro positive metal which are not corroded for ex: Iron can be prevent by using zinc, copper can be prevent by using nickle metal etc.

Electrochemical series:

The sequencial arrangement of different electrodes in order to increase their standard electrode potential is called electrochemical series. The standard electropotential E° (25°C & 1atm pressure condition) have positive, negative & zero values for various electrodes.

Table: Standard electrode potential for different electrodes are;

Electrodes	E° (Volts)	
		Increasing order
Zn^{+2}/Zn	-0.74	
Fe^{+2}/Fe	-0.46	
$2H^+/H_2$	0.00	
Cu^+/Cu	+0.34	
Ag^+/Ag	0.0.80	

Application of Electrochemical series:

ⓐ Calculation of standard cell potential ($E°_{cell}$):

The standard cell potential for a particular cell can be obtain by using the ~~formula~~ relation;

$$E°_{cell} = E°_{cathode} - E°_{anode}$$

where; $E°_{cathode}$ and $E°_{anode}$ are standard electrode potential for cathode and anode electrode respectively.

ⓑ Prediction of anode and Cathode electrodes:

The electrodes with negative electrode potential show the lesser tendency towards reduction then the reduction tendency of H^+ ions which means lesser electrode potential value of the electrode can acts as anode whereas electrode potential with positive value show the greater tendency towards reduction an acts as cathode electrodes.

ⓒ Prediction of evolution of H_2 gas or not react with dil mineral acids:

Those electrode which are more electropositive then hydrogen can liberate hydrogen gas on react with dilute mineral acids otherwise other metal do not.

Chemical reaction:

It is the process where chemical substances get changes to other forms. The chemical reaction can be express in their chemical equation, where reactant change to their product.

Types of chemical reaction:

(a) Combination or addition reaction:

When a compound is formed by direct combination of reacting constituents & the process is called combine or addition reaction.

for ex: Combination of Hydrogen and Chlorine in presence of sunlight to form HCl.

$$H_2 + Cl_2 \xrightarrow[\text{Sunlight}]{h\nu} 2HCl$$

ii) Mg metal when burn in oxide to form MgO.

$$Mg + O_2 \xrightarrow[(air)]{\Delta} 2MgO$$

Magnesium oxide (white powder)

(b) Decomposition rxn:

The chemical reaction in which certain substances get breakup into their constituents is called decomposition reaction. It is carried out by the application of heat, light, electricity etc.

For example:

* Thermal decoposition Calcium carbonate in CaO & CO_2 gas

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2(g)\uparrow$$

* Electrolysis of water to their O_2 & H_2

$$2H_2O \xrightarrow{\text{Electricity}} 2H_2(g) + O_2(g)$$

(c) Displacement reaction:

The chemical reaction in which one of the elemental constituents can displaced by other elements & such reaction are called displacement reaction.

For example

* Mg metal displaced H-atom from dilute acid.

$$Mg + \underset{\text{dil}}{2HCl} \longrightarrow MgCl_2 + H_2(g)$$

(d) Neutralization reaction:

The reaction of an acid with a base in which their characteristics properties can destroyed or neutralized to the formation of salt and water are called neutralization reaction.

For Ex:

(*) Reaction between HCl acid & NaOH base to form their corresponding salt and water

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

(*) Calcium oxide (lime) on react with sulphuric acid H_2SO_4 to form calcium sulphate & water

$$\underset{\text{(lime)}}{CaO} + \underset{\text{(dil)}}{H_2SO_4} \longrightarrow \underset{\text{(salt)}}{CaSO_4} + H_2O$$

(e) Polymerization reaction:

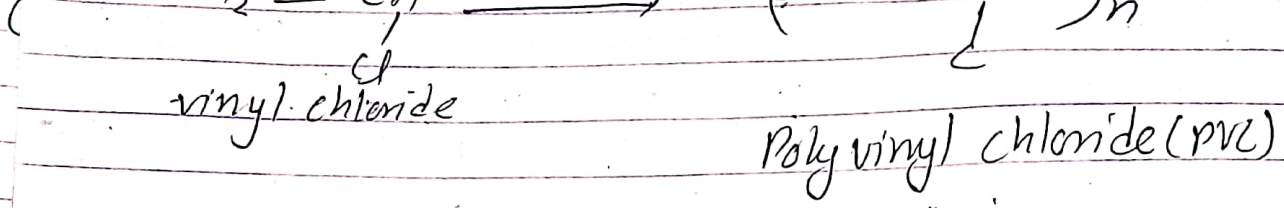
The process of combination of more number of simple molecules ie monomers to form their single complex molecule. ie polymer is called polymerization reaction.

for Ex

(a) formation of polythene, bakelite, PVC, rubber, teflon etc.

$$n\,CH_2=CH_2 \xrightarrow{\text{Polymerized}} \left(CH_2-CH_2\right)_n$$

Ethene (Monomer) → Polyethene (polymer)


$n CH_2 = CH$
Cl
vinyl chloride
$\rightarrow$
$+CH_2 - CH+_n$
Cl
Poly vinyl chloride (PVC)