**Valency:-** Valency is combining capacity of an elem

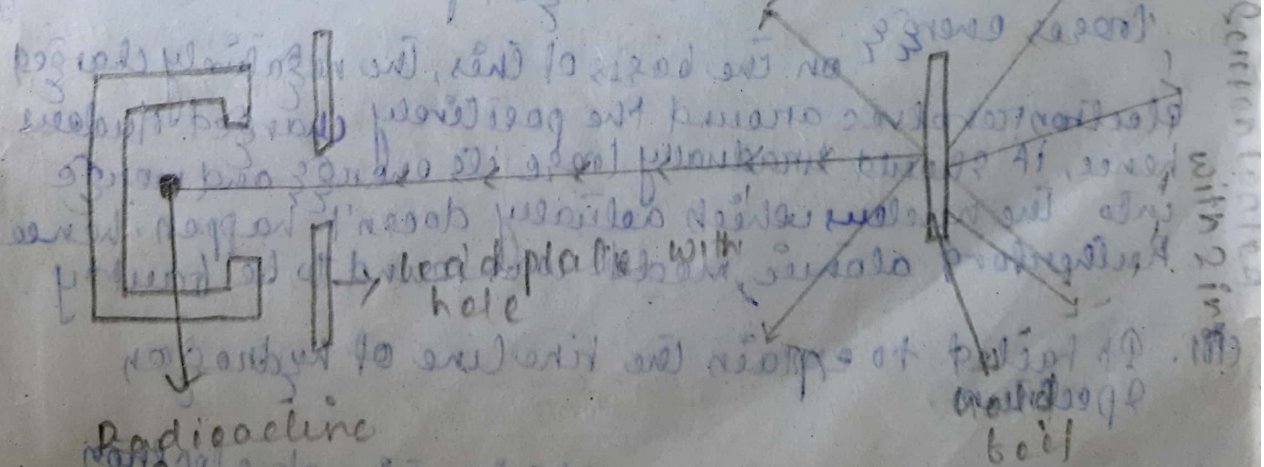
**Radicals:-** A radicals is a group of atom of different elements combined chemically that behave as a single unit with a +ve or -ve charge.

## Fundamental Particles :

| | Electron | Proton | Neutron |
|---|---|---|---|
| (i). | It is discovered by J.J Thomson | It is discovered by Gold Einstein | It is discovered by James Chadwik |
| (ii) | mass of electron = $9.1 \times 10^{-31}$ kg | mass of proton = $1.67 \times 10^{-27}$ kg | mass of neutron = $6.75 \times 10^{-27}$ kg |
| (iii). | Charge of electron = $-1.602 \times 10^{-19}$ C | Charge of proton = $+1.602 \times 10^{-19}$ | Neutra |

⇒ Atomic Number = Nos. of electrons = Nos. of proton
⇒ mass Number = Nos of proton + Nos. of Neutron

* Rutherford Atomic model :-



Rutherford bombarded (struck) thin sheet of gold foil with $\alpha$ particles ($He^{2+}$) which are obtained from a radioactive source. The radioactive source was placed in a lead block. A circular screen coated with Zinc Sulphide was placed on the other side of the foil.

**Observation** :- (i). It was observed that most of the $\alpha$-particles passed straight through the gold foil and caused illumination on the Zinc Sulphide screen

(ii). very few particles deflected at some angles after passing through the gold foil (Zinc Sulphide screen)

(iii). A very few particles retrace their path.

**Conclusion**:-

(i) An atom consist of 2 parts nucleous and extra nuclear part.

(ii) Nucleus is small positively charge particles present at the centre of the atom on which the mass of the atoms depend ~~on mass of nucleus~~.

(iii). The negatively charge electrons are distributed in the extra nuclear part that is the space around the nucleus.

(iv). The electrons revolve around the nucleus in circular path called orbits just like planets which revolve around the sun.

**Drawbacks**:-

(i). According to the classical physicist Clark maxwell when a charge particle moves under the attractive influence of another charged particle it continously looses energy.

on the basis of this, the negatively charged electron revolves around the positively charged Nucleus hence, it should gradually lose its energy and merge into the nucleus which actually doesn't happen. hence Rutherford atomic model was found to be faulty.

(ii). It failed to explain the fine line of hydrogen spectrum.

(iii). It couldn't explain the distribution of electron around the nucleus and they are energies.

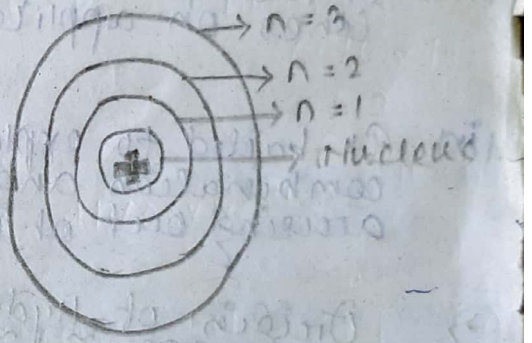
(v) * Bohr's Atomic Model :

Quantum Theory + Rutherford atomic model = Bohr's Atomic model.

(i). Neils Bohr combined Rutherford's atomic model and plank's Quantum theory and put forward a new atomic model. The main postulates of Bohr's Atomic model are :-

(i). Atoms consists of a largely positively charged Nucleus around which the electrons are moving in certain fixed circular orbit called Stationary states.

(ii). Each of the circular orbits is associated with a definite amount of energy and are known as Energy level. The Energy levels are denoted by alphabets K, L, M, N etc.




The energy associated with each energy level is given as

$$E = \frac{-1312}{n^2} \text{ KJ/mol}$$

$n = 1, 2, 3, \cdots$

(iii). Only those orbit are permitted in which the angular momentum of the electron is an integral multiple of $h/2\pi$.

$$h = 6.626 \times 10^{-34} \text{ J.s}$$

Mathmatically, $mvr = nh/2\pi$

where, m = mass of electron
v = velocity of electron
r = radius of orbit
h = planks constant

This is called Principle of Quantization of Angular momentum

(iv) The orbits are non-radiating in nature that is the electron neither looses energy nor gains energy.

whenever, the electron gains energy it comes to excited state and being unstable it will jump back to a higher energy level. while returning back to the ground state it will release energy. The amount of energy absorb or released is given by

$$\Delta E = E_2 + E_1$$

$$\boxed{h\nu = E_2 - E_1}$$

→ Drawbacks of Bohr's Atomic Model :-

(i) it fails to explain the spectra of multiple electron atoms that is atoms having more than one electron.

(ii) It cannot explain the relative intensities of spectral lines

(iii) It failed to explain the splitting of spectral lines on application of magnetic field (Zeeman)

(iv) It failed to explain the cause of chemical combination and shape of molecules arising out of it.

→ Origin of Hydrogen Spectrum :-

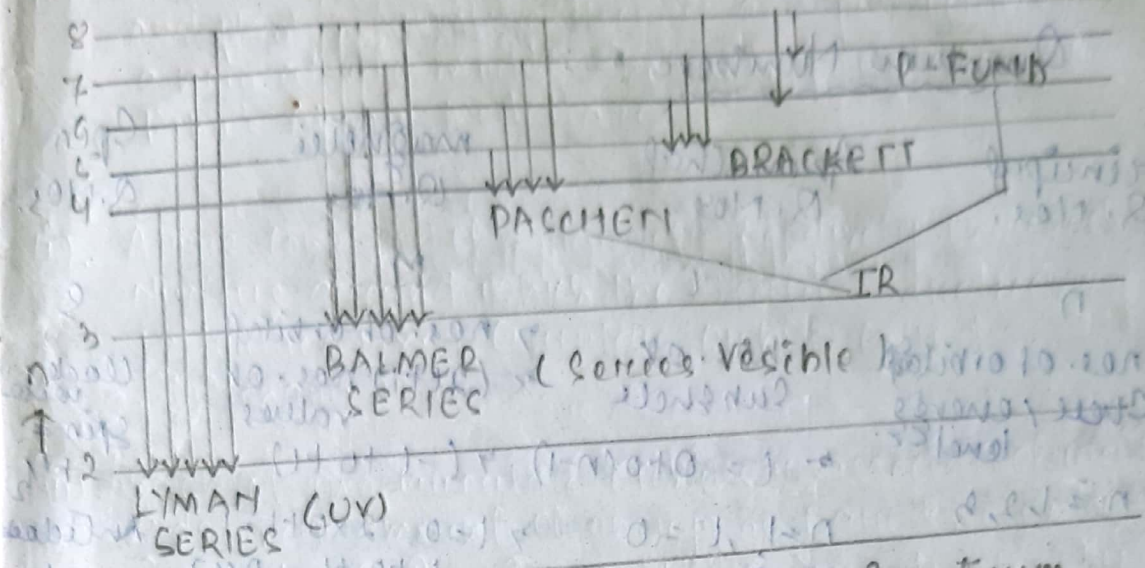
(i) On exposure to some external sources of energy, the atoms get excited and the electron jumps into a higher energy level.

(ii) Excited state is unstable and electron returns to the lower energy level by emitting energy in the form of light of a particular frequency. This leads to hydrogen spectrum

(iii) If the electron returns to the first energy level. the lines obtained occur in UV region is called Lyman Series

(iv) If the electron returns to second energy level the lines obtained occur in visible region called Balmer Series.

(v). If the electron returns to 3rd, 4th and 5th energy level, the lines obtained occur in Infrared region called Paschen, Bracket and Pfund band.




Series of lines of Hydrogen Spectrum

**Isotopes**

(i) These are the atoms of same elements having same atomic number but different mass number.

(ii) Ex:- $_{1}^{1}H$, $_{1}^{2}H$, $_{1}^{3}H$

**Isotone**

These are the atoms of different elements having same nos. of neutrons and different atomic nos.

Ex:- $_{32}^{76}Ge$, $_{33}^{77}As$

**Isobar**

These are the atoms of different element having same mass number but different atomic number.

Ex:- $_{18}^{40}Ar$, $_{20}^{40}Ca$

*. **Bohr's Bury Scheme :-**

(i) Bohr and Bury gave the following rules for the distribution of electrons in different orbits -

(ii) The maximum nos. of electrons that can be present in an orbit is equal to $2n^2$, where n is the nos. of orbit.

$n = 1$ K shell :- $2 \times (1)^2 = 2$.

$n = 2$ L shell :- $2 \times (2)^2 = 8$.

$n = 3$ M shell :- $2 \times (3)^2 = 18$.

(iii). The Outermost orbit of an element cannot contain more than eight electrons and the penultimate orbit (orbit immediately before the outermost orbit) cannot contain more than 18 electrons.

## Quantum Numbers :-

| Principal Q. No. | Azimuthal Q. No. | magnetic Q. No. | Spin Q. No. |
|---|---|---|---|
| n | l | m | s |
| → nos. of orbital & shell / energy level | → nos. of subshell | → nos. of orbital<br>→ (2l+1) nos. of values | Clockwise spin = $+1/2$ |
| → n = 1, 2, 3 | → l = 0 to (n-1) | → (-l to +l) | Anticlockwise = $-1/2$ |
| n = 1, l = 0 | → l = 0, 2×0+1 = 1 | -l to +l = 0 (s) | |
| n = 2, l = 0, 1 | l = 0, 1, 2×1+1 = 3 | -1, 0, +1 ($P_x$, $P_y$, $P_z$) | |
| n = 3, l = 0, 1, 2 | | | |
| n = 4, l = 0, 1, 2, 3 | | | |
| (s) (p) (d) (f) | l = 2 = 2×2+1 = 5 orbital | | |
| | -2, -1, 0, 1, 2 | | |
| | $d_{xy}$, $d_{yz}$, $d_{zx}$, $d_{x^2y^2}$, ~~$d_{x^2y^2}$~~ $d_{z^2}$ | | |

## Electronic Configuration :-

(i). Aufbau Principle
(ii). Pauli's Exclusion Principle
(iii). Hund's rule of maximum multiplicity.

### (i). Aufbau Principle :-

→ According to this principle, electrons are filled in various orbitals in order of their increasing energies.

→ The energy of different orbitals can be compared from their (n+l) value. The orbital with higher

(n+l) value will have higher energy.

For example :

$n = 1, \; l = 0 \rightarrow 1s$

$n = 2, \; l = 0, 1 \rightarrow 2s, 2p$
(s) (p)

$n = 3, \; l = 0, 1, 2 \rightarrow 3s, 3p, 3d$
(s) (p) (d)

| | 2s | 2p |
|---|---|---|
| n = | 2 | 2 |
| l = | 0 | 1 |
| (n+l) = | 2 | 3 |

→ If the (n+l) value of two orbitals are same, then the orbital with lower n value will have lower energy.

| | 3p | 4s |
|---|---|---|
| n = | 3 | 4 |
| l = | 1 | 0 |
| (n+l) = | 4 | 4 |

We give preference to n value. So,

3p < 4s.

(ii) Pauli's exclusion principle :-

→ According to this principle, no two electrons can have all the four quantum numbers same.

→ An orbital can have maximum two electrons with opposite spins.

Example :-

(iii). Hund's rule of maximum multiplicity :-

→ According to this rule, no pairing of electrons takes place in P, d and f subshell in P, until each degenerate orbitals or contains one electron. (The orbitals having same energy are called degenerate orbitals).

| Elements | Electronic configurations |
|---|---|
| $_1H$ | $1s^1$ |
| $_2He$ | $1s^2$ |
| $_3Li$ | $1s^2 2s^1$ |
| $_4Be$ | $1s^2 2s^2$ |
| $_5B$ | $1s^2 2s^2 2p_x^1 2p_y^0 2p_z^0$ |
| $_6C$ | $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$ |
| $_7N$ | $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$. |
| $_8O$ | $1s^2 2s^2 2p_x^2 2p_y^1 2p_z^1$. |
| $_9F$ | $1s^2 2s^2 2p_x^2 2p_y^2 2p_z^1$. |
| $_{10}Ne$ | $1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2$. (Noble gas / Inert gas) |
| $_{11}Na$ | $1s^2 2s^2 2p^6 3s^1$. |
| $_{12}Mg$ | $1s^2 2s^2 2p^6 3s^2$. |
| $_{13}Al$ | $1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^0 3p_z^0$. |
| $_{14}Si$ | $1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^0$. |
| $_{15}P$ | $1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^1$. |
| $_{16}S$ | $1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1 3p_z^1$, |
| $_{17}Cl$ | $1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^1$. |
| $_{18}Ar$ | $1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^2$. (Inert gas) |

$_{19}K = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1$.
$[Ar]^{18}$

$_{20}Ca = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2$.

$_{21}Sc = [Ar]^{18}\ 4s^2\ 3d^1$.

$_{22}Ti = [Ar]^{18}\ 4s^2\ 3d^2$.

$_{23}V = [Ar]^{18}\ 4s^2\ 3d^3$.

$_{24}Cr = [Ar]^{18}\ 4s^1\ 3d^5$ (electron can't easily jump. So, it $4s^1$ and $3d^5$. Nor. it will $4s^2\ 3d^4$.)

$_{25}Mn = [Ar]^{18}\ 4s^2\ 3d^5$.

$_{26}Fe = [Ar]^{18}\ 4s^2\ 3d^6$.

$_{27}Co = [Ar]^{18}\ 4s^2\ 3d^7$.

$_{28}Ni = [Ar]^{18}\ 4s^2\ 3d^8$

$_{29}Cu = [Ar]^{18}\ 4s^1\ 3d^{10}$

$_{30}Zn = [Ar]^{18}\ 4s^2\ 3d^{10}$.

Q. why do ~~chromium~~ $_{24}Cr$ and $_{29}Cu$ exhibit Anomalous electronic configuration?

Ans:- The expected electronic configuration of $_{24}Cr$ and $_{29}Cu$ is -

(i) $_{24}Cr \rightarrow [Ar]^{18}\ 4s^2\ 3d^4$.

$_{29}Cu \rightarrow [Ar]^{18}\ 4s^1\ 3d^9$.

but the actual electronic configuration is

$_{24}Cr \rightarrow [Ar]^{18}\ 4s^1\ 3d^5$.

$_{29}Cu \rightarrow [Ar]^{18}\ 4s^1\ 3d^{10}$.

This is because the exactly half filled ($3d^5$) and exactly fully filled ($3d^{10}$) configurations are highly stable.

## Chapter :- 2 Chemical Bonding :-

A chemical bond is defined as a force of attraction which holds together the constituent atoms in a molecule.

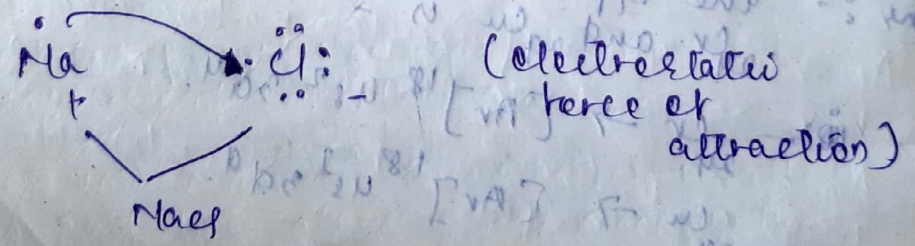
Chemical bonding have 3 types :-

(i). Electrovalent bond / Ionic bond.
(ii). Covalent bond.
(iii). Coordinative bond.

### (i). Electrovalent Bond :-

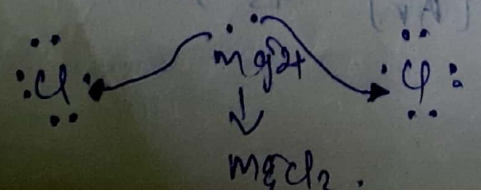
The chemical bond formed by transfer of one or more electrons from one atom to another is called Electrovalent Bond. for example: NaCl.

Na :- 2, 8, 1.
Cl :- 2, 8, 7.




(ii). $MgCl_2$.

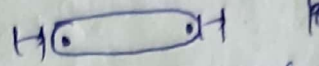
Mg :- 2, 8, 2.
Cl :- 2, 8, 7.



(ii). **Covalent Bond** :- It is the chemical bond formed by mutual sharing of electrons between two atoms. The shared pair of electrons belong to both the participating atoms.

example :- $H_2$

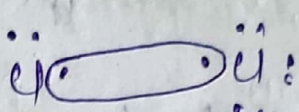
$_1H = 1$



H - H (single covalent bond)

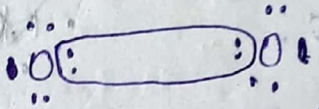
$Cl_2$

$_{17}Cl = 2, 8, 7$



Cl - Cl (single covalent bond)

O = 2, 6

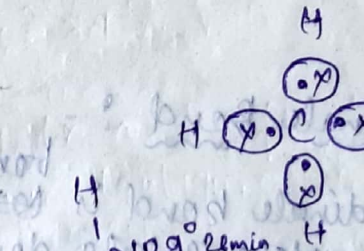


O = O (double covalent bond)

$CH_4$ (Methane).

$_6C \Rightarrow 2, 4$

$_1H \Rightarrow 1$



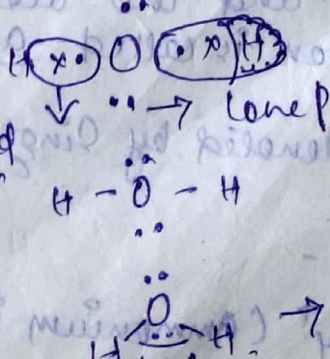
→ Tetrahedral Structure

$109° 28$ min.

$H_2O$

$_8O \Rightarrow 2, 6$

$_1H = 1$



Bond Pair → Lone pair of electrons

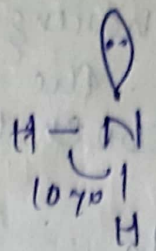
→ V-Shaped Structure or Bent Structure

Ammonia

$NH_3$

$_7N - 2, 5$

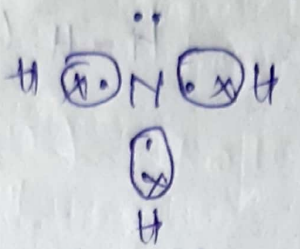
$_1H - 1$



$H - \underset{\text{lone pair}}{N} - H$

$H$

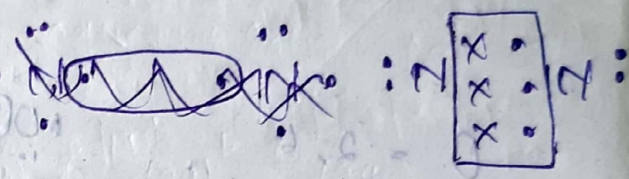
→ Pyramidal Structure



Nitrogen molecule

$N_2$

$_7N - 2, 5$



$_7N - 1s^2\ 2s^2\ 2p_x^1\ 2p_y^1\ 2p_z^1$ $\quad :N \equiv N:$

↓

Triple Covalent Bond.

(iii). Coordinate Bond :-

→ A coordinate bond is ~~called~~ formed when an atom with complete octate donate its pair of electron to another atom.

→ The donated pair of electrons is counted for the stability of both the atoms

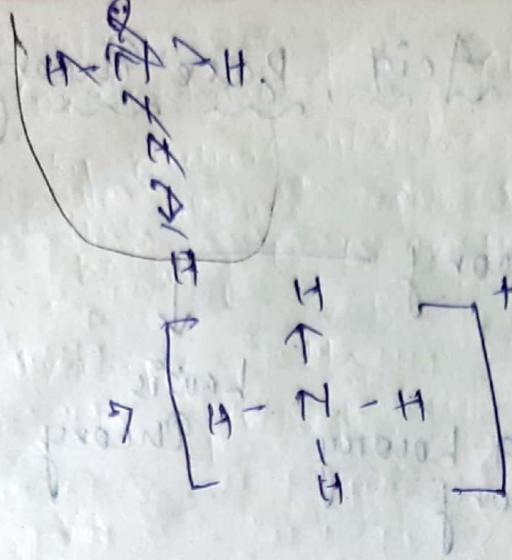
→ The atom which donates the electron is called Donor and the atom which accepts the electron is called acceptor.

→ It is denoted by single headed arrow (→).

Example :-

$NH_4^+$ (Ammonium ion).

$NH_3$ $\quad H^+$



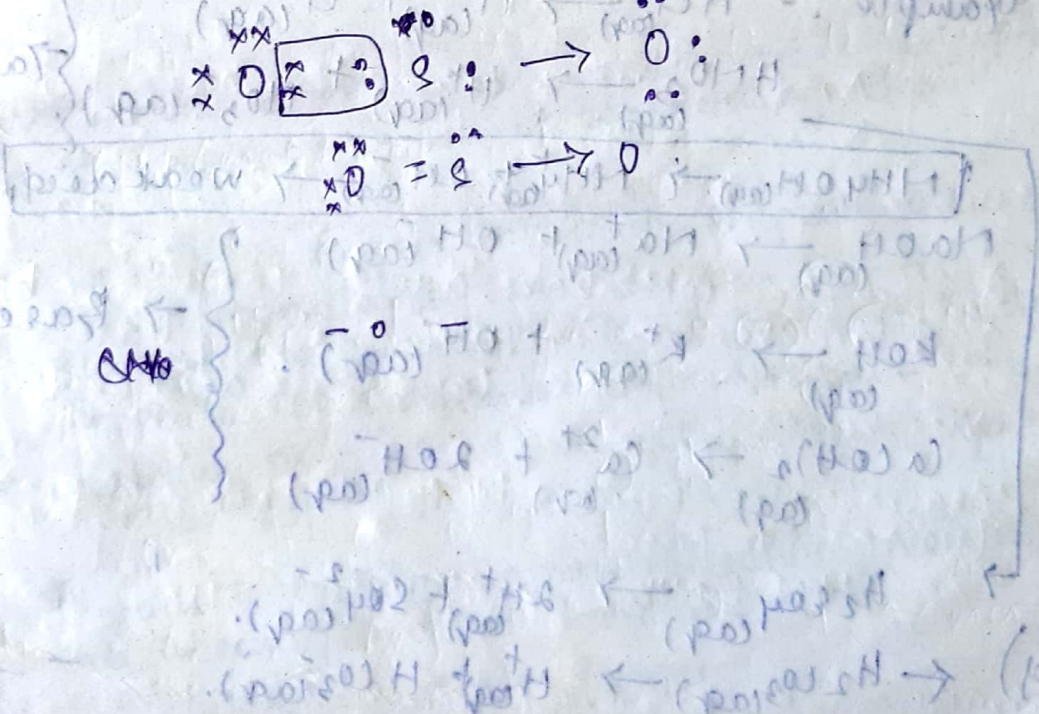
$SO_2$ .

$S \rightarrow 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p_x^2\ 3p_y^1\ 3p_z^1$

$16 \rightarrow 2, 8, 6$

$O \rightarrow 1s^2\ 2s^2\ 2p_x^2\ 2p_y^1\ 2p_z^1$

$8 \rightarrow 2, 6$



Chapter :- 3 Acid, Base Theory

Acid Base Theory
- Arrhenius Theory
- Bronsted Lowry Theory
- Lewis Theory

→ Arrhenius Theory :-

→ ~~Acids~~ According to this theory :-

(i). Acids are the substances which can produce $H^+$ ion in the aqueous solution and Bases are the substance which can produce $OH^-$ ion in the aqueous solution.

Example :- $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

$HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$ } → Acid

$NH_4OH_{(aq)} \rightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$ → weak acid

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

$KOH_{(aq)} \rightarrow K^+_{(aq)} + OH^-_{(aq)}$ } → Base

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

$H_2SO_{4(aq)} \rightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$.

(weak acid) $\leftarrow H_2CO_{3(aq)} \rightarrow H^+_{(aq)} + HCO_3^-{}_{(aq)}$.

(ii). The Acids and Bases which can ionised completely are called strong ~~acid~~ acids and bases & These which doesn't ionise completely are called weak acids and bases.

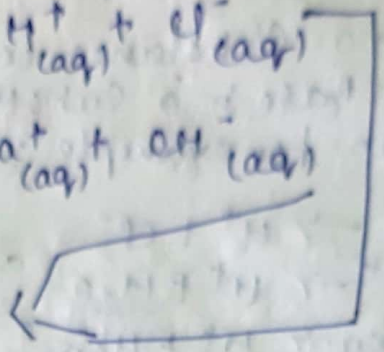
(iii). The ionisation of weak acids and bases are represented by double headed arrow.

(iv) Neutralisation of an acid and base is because of reaction between $H^+$ and $OH^-$ ion to form $H_2O$.

Example :- $HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

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

$NaCl_{(aq)} + H_2O_{(aq)}$



## Limitation of Arrhenius Theory :-

(i). According to Arrhenius Theory, Acid produces $H^+$ ion in aqueous solution but it has been found that $H^+$ ion cannot exist independently rather it exists in the form of $H_3O^+$ (Hydronium ion).

(ii). It fails to explain the acidic and basic property of substances in solvents other than water.

(iii). It fails to explain the acidic property of substances like carbon dioxide ($CO_2$), Sulphur dioxide ($SO_2$) Phosphorous pentoxide ($P_2O_5$) etc and basic properties of substances like Ammonia ($NH_4$), Calcium oxide (CaO) etc which donot contain $H^+$ or $OH^-$ ion.

(iv). It fails to explain the neutralisation reaction in the absence of water. For example :-

$NH_3 + HCl \rightarrow NH_4Cl$

## * Bronsted Lowry Theory :-

(i). Acid is a substance which can donate a proton and base is a substance which can accept a proton. for example :-

(Conjugate acid)

$HCl \rightarrow H^+ + Cl^-$
$H_3O^+ \rightarrow H^+ + H_2O$
$H_2SO_4 \rightarrow H^+ + HSO_4^-$
$HSO_4^- \rightarrow H^+ + SO_4^{2-}$
(Acids)

$NH_3 + H^+ \rightarrow NH_4^+$
$CH_3COO^- + H^+ \rightarrow CH_3COOH$
$SO_4^{2-} + H^+ \rightarrow HSO_4^-$
$Cl^- + H^+ \rightarrow HCl$
$CO_3^{2-} + H^+ \rightarrow HCO_3^-$
(Base).

(Conjugate base)

(ii). when an acid uses a proton the residue will have a tendency to accept a proton and it acts as a base. Similarly when a base accepts a proton the resulted will have a tendency to lose a proton. This pair of acid and base which differ by a proton is called conjugate acid base pair.

| |
|---|
| Acid $\rightarrow H^+$ + conjugate base |
| ~~Base $\rightarrow H^+$~~ |
| Base $+ H^+ \rightarrow$ conjugate acid |

(iii). A strong acid will have a weak conjugate base and vice-versa. Similarly, a strong base will have ~~similarly~~ weak conjugate acid and vice versa.

(iv). Neutralisation occurs by the transfer of protons from acid to base.

$HCl + NH_3 \rightarrow NH_4Cl$

## * Limitations of Bronsted Lowry Theory :-

(i). It fails to explain the reaction between acidic oxide like carbondioxide ($CO_2$), Sulphur dioxide ($SO_2$) and basic oxides like CaO and BaO.

(ii). It fails to explain the acidic character of $AlCl_3$, $FeCl_3$, $BF_3$.

1. Hydrogen - $_1H = 1s^1$
2. Helium - $_2He = 1s^2$.
3. Lithium - $_3Li = 1s^2 2s^1$.
4. Beryllium - $_4Be - 1s^2 2s^2$
5. Boron - $_5B - 1s^2 2s^2 2p_x^1 2p_y^0 2p_z^0$.
6. Carbon - $_6C - 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$.
7. Nitrogen - $_7N - 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$.
8. oxygen - $_8O - 1s^2 2s^2 2p_x^2 2p_y^1 2p_z^1$.
9. Flourine - $_9F - 1s^2 2s^2 2p_x^2 2p_y^2 2p_z^1$.
10. Neon - $_{10}Ne - 1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2$.
11. Sodium - $_{11}Na - 1s^2 2s^2 2p^6 3s^1$
12. Magnesium - $_{12}Mg = 1s^2 2s^2 2p^6 3s^2$
13. Aluminium - $_{13}Al - 1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^0 3p_z^0$
14. Silicon - $_{14}Si - 1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^0$.
15. Phosphorous - $_{15}P - 1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^1$.
16. Sulphur - $_{16}S - 1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1 3p_z^1$.
17. Chlorine - $_{17}Cl - 1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^1$.
18. Argon - $_{18}Ar - 1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^2$.
19. Potassium - $_{19}K - 1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$.
20. Calcium - $_{20}Ca - 1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$.

21. Scandium $_{21}Sc - [Ar]^{18} 4s^2 3d^1$.
22. Titanium $_{22}Ti - [Ar]^{18} 4s^2 3d^2$
23. Vanadium $_{23}V - [Ar]^{18} 4s^2 3d^3$
24. Chromium $_{24}Cr - [Ar]^{18} 4s^1 3d^5$.
25. Manganese $_{25}Mn - [Ar]^{18} 4s^2 3d^5$.
26. Iron $_{26}Fe - [Ar]^{18} 4s^2 3d^6$.
27. Cobalt $_{27}Co - [Ar]^{18} 4s^2 3d^7$.
28. Nickel $_{28}Ni - [Ar]^{18} 4s^2 3d^8$.
29. copper $_{29}Cu - [Ar]^{18} 4s^1 3d^{10}$
30. Zinc $_{30}Zn - [Ar]^{18} 4s^2 3d^{10}$.

Q1. Find out the conjugate base of the following

$H_3O^+ \longrightarrow H^+ + H_2O$

$H_2O \longrightarrow H^+ + OH^-$

$HSO_4^- \longrightarrow H^+ + SO_4^{-2}$

$H_2PO_4 \longrightarrow H^+ + H_2PO_4^-$

$HPO_4^{-2} \longrightarrow H^+ + PO_4^{-3}$

$CH_3COOH \longrightarrow H^+ + CH_3COO^-$

$H_2 \longrightarrow H^+ + H^-$

Q2 Find out the conjugate acid of the following

$HO_2^- - HO_2^- + H^+ \longrightarrow H_2O_2$

$H_2PO_4^- - H_2PO_4^- + H^+ \longrightarrow H_3PO_4$

$HPO_4^{2-} - HPO_4^{2-} + H^+ \longrightarrow H_2PO_4^-$

$CH_3NH_2 - CH_3NH_2 + H^+ \longrightarrow CH_3NH_3^+$

$NH_2^- - NH_2^- + H^+ \longrightarrow NH_3$

$HS^- - HS^- + H^+ \longrightarrow H_2S$

$S^{2-} - S^{2-} + H^+ \longrightarrow HS^-$

$CH_3COOH - CH_3COOH + H^+ \longrightarrow CH_3COOH_2^+$

$CO_3^{2-} - CO_3^{2-} + H^+ \longrightarrow HCO_3^-$

Confidence internal exam)

## * Lewis Theory :-

→ According to this theory -

(i). An acid is a substance that can accept a pair of electrons and base is a substance that can donate a pair of electrons

(ii). A lewis acid can be of following types -

(a). All cations like $Ca^{2+}$, $Fe^{3+}$ etc

(b). molecules having multiple bonds like $CO_2$, $SO_2$ etc

(c). molecules having vacant d-orbitals like Si, Sn

(iii). lewis base can be of following types -

(a). All anions like $OH^-$, $CN^-$ etc.

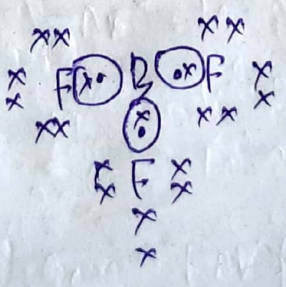
(b). Molecules (Neutral) having one or more lone pair of electrons like Amonia, water ($NH_3$) ($H_2O$)

(iv). According to this theory, Neutralisation occurs when an acid reacts with a base and coordinate bond is formed. for example -

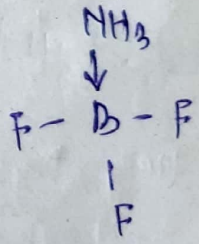
$BF_3$ (electron deficient) → shortage of 2 electron.

$_5B$ → 2, 3

$_9F$ → 2, 7



+ $NH_3$ ⟶




→ limitations of lewis Theory :-

(i). It fails to explain the strength of acids and bases.

(ii). According to this theory, when an acid reacts with a base a coordinate bond is formed but no such bond is formed when HCl reacts with NaOH

(iii). Acid, Base reactions are fast and instantaneous. but formation of coordinate bond is a slow process

~~Neutralisation of acid and base :-~~

## Neutralisation of Acids and Bases :-

i). When an aqueous solution of acid is added to aqueous solution of base a chemical reaction occurs producing a salt and water this reaction is called Neutralisation

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(aq)}$$

ii). When a strong acid reacts with strong base a neutral solution is formed as both acids and bases are completely ionised

iii). When a strong acid reacts with a weak base the solution becomes slightly acidic because of the presence of free $H^+$ ions.

$$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$$

$$H^+ + Cl^- \quad NH_4^+ + OH^-$$

iv). When a weak acid reacts with strong base the solution becomes slightly basic because of the presence of free $OH^-$ ions.

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O.$$

$$CH_3COO^- + H^+ \quad Na^+ + OH^-$$

(v). When a weak acid reacts with weak base, the solution can be acidic, basic or neutral depending on the proportion of $H^+$ or $OH^-$ ion produced.

Salt :- A salt is define as a crystalline compound which is formed by the Neutralisation of acids and bases
(imp.).

Types of salt :-

(i). Normal
(ii). Acidic
(iii). Basic
(iv). Double
(v). Complex
(vi). Mixed

(i). Normal Salt :- These are formed by complete Neutralisation of strong acids and strong bases for example :- NaCl, $Na_2SO_4$.

(ii). Acidic Salt :- These are the salts formed by incomplete neutralisation of poly-basic acids (Basicity) = No. of $H^+$ ions (Basicity more than 1) produced by an Acid

Basicity 71.

$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$.

$H_2SO_4 \rightarrow H^+ + HSO_4^-$ $\quad$ $NaOH \rightarrow Na^+ + OH^-$

$NaHSO_4$ (Acidic Salt).

(iii). Basic Salt :- These are formed by incomplete neutralisation of poly-acidic bases (Acidity) = No. of $OH^-$ ions (Acidity more than 1) Produced by a base

Acidity 71.

$Ca(OH)_2 + HCl \longrightarrow Ca(OH)Cl$.

$Ca(OH)_2 \rightarrow Ca(OH)^+ + OH^-$ $\quad$ $HCl \rightarrow H^+ + Cl^-$

(iv) Double salt :- These are the addition compound formed by combination of two simple salts. Eg :- $K_2SO_4$, $Al_2(SO_4)_3$,

$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$ (water of crystallisation)
(potash alum)
(stable in solid form)

$(K^+ \; SO_4^{2-} \; Al^{3+} \; H^+)$ → when becomes solution

(v) Complex salt :- These are formed by combination of simple salts or molecular compounds. They are stable both in solid state and in solution.

for example :- $K_4[Fe(CN)_6]$
potassium ferrocyanide

$[Cu(NH_3)_4]SO_4$
Tetramine copper(II) sulphate

(vi) Mixed salt :- These are the salts which can produce more than one cation or more than one anion when dissolved in water. for example:- $CaOCl_2$, $NaKSO_4$

Chapter : 4 Solutions :-

Equivalent mass of an acid :-

Equivalent mass of acid = molecular mass / basicity

for example :-

HCl → H = 1
Cl = 35.5

HCl ⇒ 35.5 + 1 = 36.5

Equivalent mass of HCl = 36.5 / 1 = 36.5.

$H_2SO_4$ = 2 + 32 + 64
= 98

Equivalent mass of $H_2SO_4$ = 98 / 2 = 49.

Cor H
Cor H

⇒ 12 × 2 + 16 × 4 + 1 × 2
⇒ 24 + 64 + 2
⇒ 90.

Equivalent mass = 90 / 2 = 45.

$CH_3COOH$

→ Molecular mass = $12 + 1\times3 + 12 + 16\times2 + 1$

= $12 + 3 + 12 + 32 + 1$

= $15 + 12 + 33$

= 60

Equivalent mass = $\frac{60}{1} = 60$.

$CH_3COOH$

* Equivalent mass of a base = $\frac{\text{molecular mass}}{\text{Acidity}}$

Example: NaOH

→ 23 + 16 + 1

→ 40.

Equivalent mass of NaOH = $\frac{40}{1} = 40$.

(H.W.) $Ca(OH)_2$

→ $40 + 16\times2 + 2$

→ $40 + 34$

→ 74

Equivalent mass of NaOH → $\frac{74}{2} = 37$.

$Al(OH)_3$

Al = 27

O = 16 × 3 = 48

H = 3

$= \frac{78}{3} = 26$

27 + 48 + 3 = 78

→ Equivalent mass of a salt :-

Eq. mass of a salt = $\frac{\text{molecular mass}}{\text{Total valency of metal atom in the salt}}$

$NaHCO_3$

→ 23 + 1 + 12 + 16 × 3

→ 24 + 12 + 48

→ 84

Eq mass of $NaHCO_3$ = $\frac{84}{1} = 84$.

$Na_2CO_3$.

→ 23 × 2 + 16 × 3 + 12

→ 46 + 48 + 12

→ 106

Eq mass of $Na_2CO_3$ = $\frac{106}{1 \times 2}$

= 53.

NaCl
$FeCl_2$
$FeCl_3$

NaCl

→ 23 + 35.5
→ 58.5

Eq. mass of NaCl = $\frac{58.5}{1}$ = 58.5

$FeCl_2$

→ 56 + 35.5 × 2
→ 56 + 71.0
→ 127

Eq mass of $FeCl_2$ = $\frac{127}{2}$

= 63.5

$FeCl_3$

→ 56 + 35.5 × 3
→ 56 + 106.5
→ 162.5

Eq mass of $FeCl_3$ = $\frac{162.5}{3}$

= 54.16

$Al_2(SO_4)_3$

→ 27×2 + 32×3 + 16×12
→ 54 + 96 + 192
→ 342

Eq mass of $Al_2(SO_4)_3$ = $\frac{342}{6}$ = 57

Equivalent mass of an ion :-

$$\text{Eq. mass of an ion} = \frac{\text{ionic mass}}{\text{Total charge on ion}}$$

$Cl^-$ = Eq. mass of an ion = $\frac{35.5}{1}$

$= 35.5$.

$Al^{3+}$ = Eq. mass of an ion = $27/3 = 9$.

$CO_3^{2-}$ = " " = $60/2 = 30$.

$SO_4^{2-}$ = " " = $96/2 = 48$.

Molarity :- (M).

(i). When 1 mole of solute is dissolved 1 litre of solution we get a molar solution.

(ii). Molarity is the nos. of moles of solute present per litre of solution.

$$M = \frac{w}{\text{molecular mass}} \times \frac{1000}{V}$$

where, $w$ = amount of solute in gram / volume of solution in ml

Normality :- (N)

(i). When gram equivalent of a solute is dissolved in one litre of solution we get a Normal solution

(ii). Normality is defined as the nos. of gram equivalent of the solute present in 1 litre of solution

$$M = \frac{w}{\text{equivalent mass}} \times \frac{1000}{V}$$

where, $w$ = amount of solute in gram

$V$ = volume of solution in ml

Q1. 200 ml of a solution contains 0.754 g of $Na_2CO_3$. Find out the molarity and normality

$$M = \frac{0.754}{106} \times \frac{1000}{200}$$

$$= \frac{37.70}{1060}$$

$$= \frac{3770}{100} \times \frac{1060}{1000}$$

$$= 3.962 \text{ mol/lt}$$

$$N = \frac{0.754}{2} \times \frac{1000}{200}$$

$$= \frac{0.754 \times 5}{2}$$

$$= 0.377 \times 5$$

$$= 6.885$$

$$= \frac{0.754}{106} \times \frac{1000}{200}$$

$$= \frac{3.770}{106}$$

$$= 0.035$$

$$= 1.885$$

$$= \frac{1885}{1000} \times 53$$

$$= 1.885$$

6.9 g of $K_2CO_3$ is present in 0.5 L of its solution find out the Normality and molarity.

10 g of dibasic acid whose molecular weight 90 is present in 2 L of its solution. find out the Normality and molarity

1. Molarity → 6.9

Given:-

$w = 6.9$ gms.

$V = 0.5\,L = 500$ ml.

$K_2CO_3$ : $K = 2 \times 39 = 78$

$C = 12$

$O_3 = 16 \times 3 = 48$

138

Eq. M = 138/2 = 69.

$$m = \frac{w}{m.m} \times \frac{1000}{V}$$

$$= \frac{6.9}{138} \times \frac{1000}{500}$$

$$= 0.1.$$

$$N = \frac{w}{Eq.m} \times \frac{1000}{V}$$

$$= \frac{6.9}{69} \times \frac{1000}{500}$$

$$= 0.2.$$

2. $w = 10\ g$

$v = 2L = 2000\ ml$

molecular weight $= 90$

$$M = \frac{w}{m.m} \times \frac{1000}{v}$$

$$= \frac{10}{90} \times \frac{1000}{2000}$$

$$= \frac{10}{180} = 0.05$$

Eq. mass of acid $= \frac{m.m}{\text{basicity}} = 90/2 = 45$.

$$N = \frac{w}{eq.m} \times \frac{1000}{v}$$

$$= \frac{10}{45} \times \frac{1000}{2000}$$

$$= \frac{10}{90} = 0.11$$

Q3. How many grams of $CaCl_2$ are required to prepare 2L of its semi-molar solution

molar mass of $CaCl_2$

$\rightarrow Ca = 20$

$\rightarrow Cl_2 = 35.5 \times 2 = 71.0 = 71$

$\rightarrow M = 1/2 = 0.5$.

$$M = \frac{w}{m.m} \times \frac{1000}{v} = 0.5.$$

$$\rightarrow \frac{w}{71} \times \frac{1000}{2000} = 0.5$$

$$\rightarrow \frac{w}{142} = 0.5 \quad (\rightarrow w = 142 \times 0.5$$

$$= 142 \times \frac{5}{10}$$

$$= 710/10 =$$

Molality :- (m)

It is the no. of moles of solute present in 1000 grms. of solvent.

$$m = \frac{w}{M.m} \times \frac{1000}{\text{mass of solvent in kg}}$$

Q. Calculate the molality of $K_2CO_3$ solution which is formed by dissolving 2.51g of it in 1 litre solution. density of solution = 0.88 g/ml

molar mass of $K_2CO_3$ = $K_2$ = 78
C = 12
$O_3$ = 16 × 3 = 48

78 + 12 + 48 = 138

$$\text{Molality} = \frac{2.51}{138} \times \frac{1000}{847.49}$$

$$= \frac{2511}{1173}$$

m = d × v

mass of solution = 0.88 × 1000 = 850 gm.

mass of solute = 2.51 g.

$$\text{mass of solvent} = \frac{850.00}{2.51}$$

847.49 gm

$$m = \frac{2.871}{138} \times \frac{1000}{847.49}$$

$$= \frac{2510}{}$$

## Ionization of water :-

$$H_2O \rightleftharpoons H^+ + OH^-$$

$$K = \frac{[\text{Product}]}{[\text{Reactants}]}$$

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

$$K[H_2O] = [H^+][OH^-]$$

$H_2O$ is a weak electrolyte because it can't produce more ion. So its concentration remains same or constant.

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

$K_w$ = Ionic product of water

$$K_w = K[H_2O]$$

At room temperature, $K_w = 1 \times 10^{-14}$

$$K_w = [H^+][OH^-] = 1 \times 10^{-14}$$

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

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

$$[H^+] = 10^{-7}$$

$$[H^+] = [OH^-] = 10^{-7}$$

pH :- pH is defined as negative logarithum of hydrogen ion concentration.

$$pH = -\log_{10}[H^+]$$

for water, $[H^+] = 10^{-7}$ at 25°C.

$$pH = -\log_{10}(10^{-7}) = -(-7)\log_{10} = 7 \times 1 = 7$$

$$pOH = -\log_{10}[OH^-]$$

for water, $[OH^-] = 10^{-7}$ at 25°C

$$pOH = -\log_{10}(10^{-7}) = -(-7)\log_{10} = 7 \times 1 = 7$$

$$\boxed{pH + pOH = 14}$$

* pH of Neutral solution will be seven (7). for acidic solution, it is less than (7) and for a basic solution, it is more than (7).

Q. 6.3 grams of Nitric acid ($HNO_3$) is present in 2l of its solution. find the pH of the solution.

$$pH = -\log_{10}[H^+]$$

$w = 6.3$ gram

$V = 2000$ ml

$HNO_3 \rightarrow H^+ + NO_3^-$

$$M = \frac{w}{m.m} \times \frac{1000}{V} = \frac{6.3}{63} \times \frac{1000}{2000} = \frac{6.3}{126}$$

$= 0.05$ mol/lit.

$pH = -\log_{10}(5 \times 10^{-2})$

$= -\log_{10}(5) - (-2)\log_{10}(10)$

$= 2 - \log_{10}(5) = 1.3$

Q. 9.8 Grams of ($H_2SO_4$) is present in 2l of Solution. Calculate the Normality, molarity and PH of the solution.

$W = 9.8$

$V = 2000\ ml$

$H_2SO_4$ (molar mass) $= 2 + 32 + 16 \times 4$

$= 34 + 64$

$= 98$

Eq. m $= 49$

$M = \frac{9.8}{98} \times \frac{1000}{2000}$

$= \frac{1}{10} \times \frac{1}{2} = \frac{1}{20}$

$= 0.05\ mol/lit.$

$N = \frac{9.8}{49} \times \frac{1000}{2000}$

$= \frac{9.8}{98}$

$= \frac{1}{10} = 0.1$

$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$

$pH = -\log_{10}[H^+]$.

$= -\log_{10}(2 \times 0.05)$

$= -\log_{10}(0.1)$

$= -\log_{10}(10^{-1})$

$= -(-1)\log_{10}(10)$

$= 1.$

Q. Find the pH of a solution containing 8 grams of NaOH in 2 litres of solution.

Molarmass of NaOH =

Na = 23
O = 16
H = 1
40

$$M = \frac{w}{m.m} \times \frac{1000}{V} = \frac{8}{40} \times \frac{1000}{2000} = \frac{1}{10} = 0.1$$

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

$$pOH = -\log_{10}[OH^-]$$

$$= -\log_{10}[10^{-1}]$$

$$= -(-1)\log_{10}(10)$$

$$= 1.$$

$$pH + pOH = 14$$

$$pH = 14 - 1 = 13.$$

Q. How many grams of NaOH is required to prepare 4L of the solution having $pH_{10}$ 10.

V = 4L = 4000 ml.
pH = 10
w = ?

Molecular mass of NaOH = 40.

we know, pH + pOH = 14.

$$\therefore pOH = 14 - pH$$

$$= 14 - 10 = 4.$$

$pOH = -\log_{10}[OH^-]$

$4 = -\log_{10}[OH^-]$

$e^4 = e^{-\log[OH^-]}$ $\quad \therefore [OH^-] = e^4$

$\Rightarrow [OH^-] = e^{-4}$

$= 0.01 = 10^{-2}$

$M = \frac{w}{m.m} \times \frac{1000}{V}$

$\Rightarrow M \times m.m \times V = w \times 1000$

$\Rightarrow w = \frac{M \times mm \times V}{1000}$

$w = \frac{0.01 \times 40 \times 4000}{1000}$

$w = \frac{1}{100} \times 40 \times 4$

$w = \frac{16}{10} = 1.6\,g$

Q. How many grams of $Ca(OH)_2$ must be dissolved to produce 250 mls of an aqueous solution of pH 10.6?

Caustic potash :- KOH (Potassium hydroxide)

Caustic soda :- NaOH (Sodium hydroxide)

## importance of pH in industries :- (Long Q) imp.

1. Sugar industry :- ($C_{12}H_{22}O_{11}$)

The pH of sugar cane juice must be carefully controlled to 7 that is neutral before further processing. If the juice becomes acidic then, it will produce glucose and fructose. If the juice becomes alkaline then, undesirable acids and coloured substances will be produced. pH is also controlled during crystallization of sugar otherwise the yield is affected.

2. Textile industry :-

Many processes of Textile industries are pH dependent. Scouring of cottons requires alkaline condition. Bleaching also requires proper pH to be maintained.

3. Sewage Treatment :-

pH control helps to decide which particular organism will decompose the wastes properly.

4. Electroplating :-

In order to get smooth and shining deposit the pH of the electrolyte must be carefully maintained.

# Chapter :- 5 Electrochemistry :-

## → Electrolyte or Electrolytic conduction :-

The substance which allows electricity to pass through its aqueous solution or in fused state (molten state) is called an electrolyte

for example :- NaCl solution, fused NaCl

| | Strong Electrolyte | Weak electrolyte |
|---|---|---|
| (i). | These are the substances which get completely ionised in their solution. | These are the substances which are not ionised completely in their solution |
| (ii). | There electrical conductivity is very high. | There electrical conductivity is low. |
| (iii). | Ex :- NaCl solution, NaOH, etc. | Ex :- $NH_4OH$ solution, $CH_3COOH$ solution etc. |

## → Electrolysis :-

The process of chemical decomposition of an electrolyte by the passage of electric current is called electrolysis.

## → Process of Electrolysis :-

(i). Electrolysis is carried out in a container called Electrolytic tank which is made up some insulating material such as glass, stone etc.

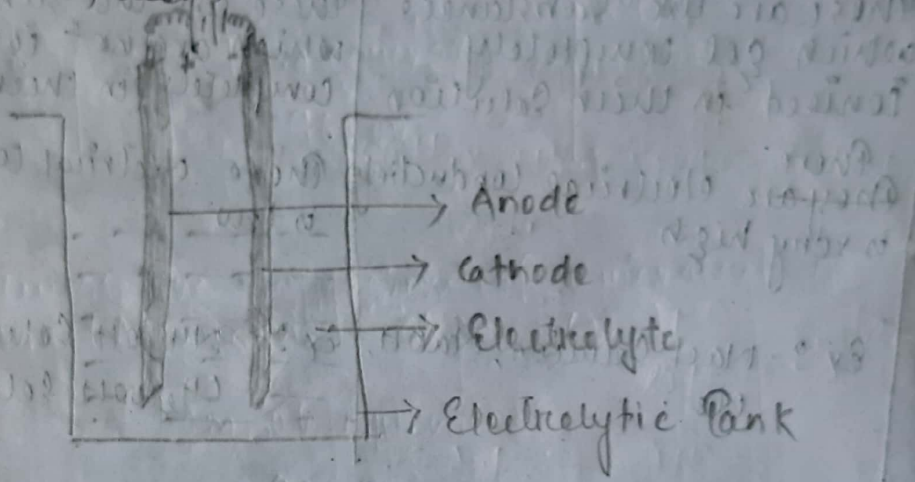
(ii). Fused solution or aqueous solution (electrolyte) is taken in the electrolytic tank and two metallic rods or plates are dipped in it which are called electrodes.

(iii). The electrodes which is connected to the +ve terminal of the battery is called Anode and the one which is connected to the negative terminal of the battery are called Cathode.

(iv) When the electric current is passed the cations move towards the cathode and the anions move towards the anode.

(v). At the cathode, cations gain electrons to form neutral atoms which get deposited on it

(vi). At Anode, the anions loose electron to form neutral atoms.




when the circuit is connected, NaCl ionises as -

$NaCl \longrightarrow Na^+ + Cl^-$

here, Platinum rods are taken as electrode

→ At cathode,

here $Na^+$ ion moves towards the cathode where they gain electrons to form neutral atoms.

$Na^+ + e^- \longrightarrow Na$ (metal)

(Reduction)

→ At Anode,

the +vely charged $Cl^-$ ion move towards the anode where it looses an electron to form chlorine atom

$Cl^- \longrightarrow Cl + e^-$ (oxidation)

The chlorine atom is unstable and hence, immediately combines with another chlorine atom to form chlorine molecule.

$$Cl + Cl \longrightarrow Cl_2 \uparrow$$

↑ :- Evaporation
↓ :- Precipitation

H.W

1. Explain the electrolysis of aqueous NaCl solution.

→ Faraday's laws of Electrolysis :-

1. Faraday's 1st law of electrolysis :-

It states that the mass of the substance liberated at the electrode as a result of electrolysis is directly proportional to the quantity of electricity passed through the electrolyte.

If, w = mass of substance deposited at the electrode
Q = Quantity of electric charge in coulomb.

$w \propto Q$

we know, that, $Q = It$

I = current in Ampere.
t = time in Second.
z = electrochemical equivalent

→ $w \propto It$
→ $w = zIt$

If $I = 1\,amp$, $t = 1\,sec$,

→ $z = w$
→ $z = \frac{w}{ct}$

Thus, Electrochemical Equivalent is the mass of the substance deposited when 1 ampere of electric current is passed through the electrolyte for 1 second.

1F = 96500 C.

It is found that when 1F of electricity is passed = 1 gm of equivalent of the substance is deposited

when 96500 C of electricity is passed = 1 gm of equivalent of substance is deposited

when 1C of electricity is passed = $\frac{1 \text{ gm equivalent}}{96500}$.

$$z = \frac{1 \text{ gm equivalent}}{96500}$$

Q. Calculate the electrochemical equivalent of Zinc (Atomic mass of Zn = 65)

$$z = \frac{1 \text{ gm of equivalent}}{96500}$$

equivalent mass of an atom = $\frac{\text{atomic mass}}{\text{valency}}$

$= \frac{65}{2} = 32.5$

$$z = \frac{32.5}{96500} = \frac{325}{965000}$$ 65 19

Q. Find the mass of copper (Cu) deposited from cupric solution by current of 0.2 A flowing for 1 hour (Atomic mass of Cu = 63)

$Z = \frac{w}{It}$

$= \frac{63}{0.25 \times 60 \times 60}$ $= \frac{31.5}{0.25 \times 60}$

$= \frac{63}{\frac{25}{100} \times 60}$ $= \frac{31.5}{1.5}$

$= \frac{63}{1.50}$ $= \frac{63}{10}$

$= 6.3$

Atomic mass of Cu = 63

current passed (I) = 0.25 A

Time (t) = 1 hr = 3600 sec.

w = ?

Eq. mass of Cu in CuSO4 = $\frac{\text{Atomic mass}}{\text{valency in Cu (CuSO4)}}$

$= \frac{63}{2} = 31.5$.

$Z = \frac{31.5}{96500}$

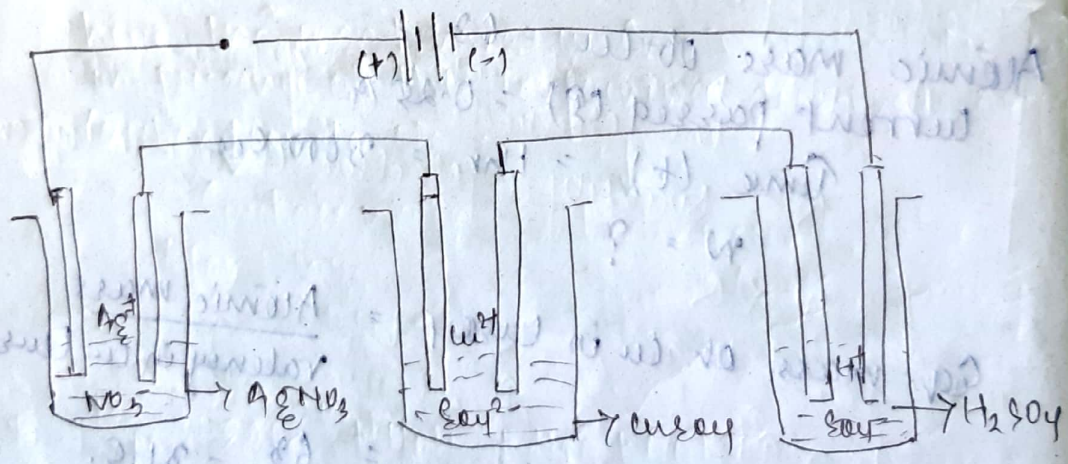
$\therefore w = Zit$

$= \frac{31.5}{96500} \times 0.25 \times 3600 = 0.293$ gm.

## * Faraday's Second law of electrolysis :-

It states that "when the same quantity of electricity is passed through different electrolyte solution, the weight of different substances produced at the electrode is proportional to their equivalent weights"

for example :- let us considered three electrolytic cells $AgNO_3$, $CuSO_4$, $H_2SO_4$ solutions respectively which are connected in series. So that on passing of electric current all the three cells received same quantity of electricity.




The weight of Ag, Cu and H deposited on the electrodes will be proportional to their equivalent weights - that is

$$\frac{\text{weight of Ag deposited}}{\text{weight of Cu deposited}} = \frac{\text{Eq. weight of Ag}}{\text{Eq. weight of Cu}}$$

$$\frac{\text{weight of H deposited}}{\text{weight of Cu deposited}} = \frac{\text{Eq. weight of H}}{\text{Eq. weight of Cu}}$$

*. Electroplating :-

Electroplating is done for decoration, protection, and Repair.

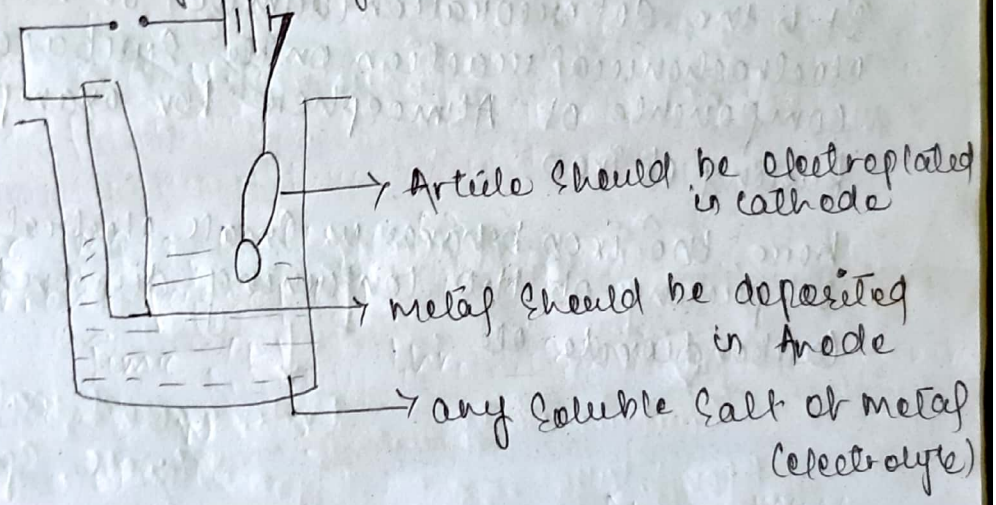
Procedure :-

(i). The article to be electroplated is properly cleaned and is made cathode.

(ii). The metal to be deposited on the article is made Anode.

(iii). The electrolytic tank in which electroplating is done is made up cement, Glass, or wood.

(iv). The electrolyte is any soluble salt of the metal.




*. Zincplating :-

(i) For zincplating, boric acid and alkaline solution can be used.

(ii). The acidic solution contains $ZnSO_4$, NaCl, $AlCl_3$, $H_2B_4O_7$, Dextrin in 1L of water.

(iii). The Alkaline solution contains ZnO, NaCN, $Na_2CO_3$ in 1L of water.

(iv). The temperature of the solution is maintained between 30° to 40° C.

v). Zincplating is done generally on iron objects to protect from rusting.

here, zinc act as sacrificial metal

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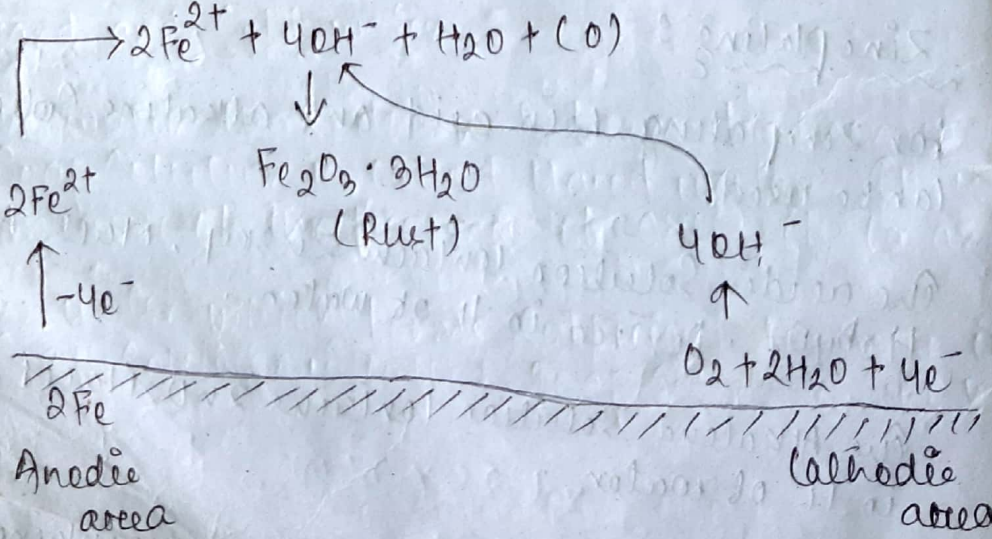
## Chapter :- 6 Corrosion :-

*. It is the process of conversion of a metal into an undesirable compound on exposure to the atmospheric condition that is moisture and oxygen. for example :- Rusting of iron, Tarnishing of silver.

*. Atmospheric Corrosion :-

It is the deterioration (damage) of metal due to electrochemical reaction on its surface with the components of Atmosphere. for example - Rusting of iron

here, the iron behaves as small electrolytic cell in presence of $H_2O$ containing dissolved oxygen, carbondioxide etc.



At Anode :-

$$2Fe \longrightarrow 2Fe^{2+} + 4e^-$$

At cathode :-

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

further following reaction take place :-

$$2Fe^{2+} + H_2O + (O) \longrightarrow 2Fe^{3+} + 2OH^-$$

$$2Fe^{3+} + 6OH^- \longrightarrow Fe_2O_3 \cdot 3H_2O$$

(Rust)

* Waterline Corrosion :-

It is a type of differential oxygen concentration corrosion. when the water is stored in a steel tank, the area just above the water line behaves as a cathode (where oxygen concentration is more) and the area just below the waterline behaves as anode (where the oxygen concentration is less). This leads to corrosion. Such type of corrosion occurs in ship and water tanks.

(i) It can be prevented to a greater extend by applying special paint on the surface of the container.

* Protection from Corrosion :-

(i) Alloying :- Alloying of metal makes the object corrosion resistant. It increases the homogenity of metal there by decreasing the rate of electrochemical reaction. for example :- The loss of iron by rusting can be minimised by alloying with chromium. In certain cases an oxide layer is formed on the surface which increases the resistance of metal towards corrosion. for example :-

Duricron (an Iron, Silica alloy)

($SiO_2$)

(ii)

$\cdot xH_2O$

A Durcion is highly resistant to corrosion.

(2). Galvanisation :- It is the process of depositing a thin layer of zinc on iron. The iron coated with zinc is called Galvanised Iron. It can be done in two ways :-

(i). By spraying molten zinc on iron surface.
(ii). By dipping the iron strip into molten zinc.

Here, the zinc act as sacrificial metal which undergoes corrosion more easily than iron. As long as zinc is there on the surface iron will not get corroded.

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