SUBJECT-ENGINEERING CHEMISTRY

SEMESTER-1ST & 2ND

PREPARED BY- ITUSHREE RANI RATH

OMM

CHEMISTRY

What is chemistry?

In Science - It is the classified knowledge of facts gained through observation, generalisation & co-relation

In chemistry - It is the branch of science which deals with the study of composition of matter & chemicals involved with it.

Branches of chemistry -

There are 6 types of chemistry -

1. Physical chemistry - It deals with the relationship between the physical properties of substances & their chemical composition & transformation.
2. Inorganic chemistry - It deals with the synthesis & behaviour of inorganic & organometallic compounds. It does not include the covalently bonded carbon compounds.
3. Organic chemistry - It deals with the study of carbon compounds derived from plants & animals.
4. Analytical chemistry - It deals with the detection & estimation of elements & compounds.
5. Industrial chemistry - It deals with the chemistry who relating to industrial processes.
6. polymer chemistry - It deals with the chemistry that focuses on the structure, chemical & physical properties of polymers. (polymer means molecule)

Units & Measurement -

a. Temperature - Units are

① Degree centrigrade (°C) ② Degree kelvin (°K)
③ Degree Farenheit (°F)

$°K = °C + 273$

$°F = 9/5 \times °C + 32$

Qn - Convert 5°C into °K and °F

$°K = 5 + 273 = 278$ ($5°C = 278°K$)

$°F = 9/5 \times 5 + 32 = 41$ ($5°C = 41°F$)

b. pressure - Units are

a. Atmosphere or Atm
b. Milimetre or mercury (mm)
c. Centimetre or cm

1 Atm = 760 mm = 76 cm

c. Volume - Units are

a. litre (l)
b. mililitre (ml)
c. cubic centimetre (cc)

1 Litre = 1000 ml = 1000 cc

Importance & Scope of chemistry -

chemistry plays a very significant & important role in our every aspect of life.

1. Food - chemistry is playing an active role in providing food. The use of chemicals such as urea (NH_2CONH_2), Calcium ammonium nitrate (CAN, $CaNH_4NO_3$) & Calcium superphosphate ($(CaH_2PO_4)_2$) as fertilizers has led to a multi fold increase in agricultural production. Insecticides such as DDT (Dichloro diphenyl trichloroethane) ($C_{14}H_9Cl_5$) & BHC (Benzene hexachloride or Gammaxen) ($C_6H_6Cl_6$)
Food is preserved in the presence of sodium benzoate ($C_7H_5NaO_2$) & sodium metabisulphide ($Na_2S_2O_5$)
2. Medicine - pain killing medicines like acetyl salicylic acid ($C_9H_8O_4$ or aspirin), paracetamol, Drugs, penicillin, different types of vaccines. Those who wear soft contact lenses for hydroxy ethyl metha crylate polymers ($C_6H_{10}O_3$)
3. Clothing - Fabrics like rayon, nylon, dacron, orlon etc.
4. chemistry in everyday life - Cosmetics such as soap, face powder, nail polishes & perfumes are all chemicals. The fuels like petrol, cooking gas etc. plastics, bakelite, polythene etc.
5. Entertainment - Entertainment such as photographic films, gramophone records, cassttes, modern cinema making etc.
6. Industry - A large number of industries such as manufacture of synthetic fibres, plastics, paints, Varnishes, sugar, cement, glass, pottery, inks, paper, perfumes, caustic soda (NaOH) washing soda (Na_2CO_3) etc.

7. War – High power explosives like TNT (Trinitro-toluene) & RDX, poisonous gases like phosgene & lewisite, bombs, missiles, atom bomb, hydrogen bomb. → $COCl_2$ → $C_2H_2AsCl_3$

RDX – Research department explosive.

PERIODIC CHARTS OF THE ELEMENTS

Atomic Number	Elements	Symbol	Atomic Mass	No. of Neutrons
1	Hydrogen	H	1.0079, 1	1-1 = 0.
2	Helium	He	4.00260, 4	4-2 = 2
3	Lithium	Li	6.941, 7	7-3 = 4
4	Berilium	Be	9.01218, 9	9-4 = 5
5	Boron	B	10.81, 11	11-5 = 6
6	Carbon	C	12.011, 12	12-6 = 6
7	Nitrogen	N	14.0067, 14	14-7 = 7
8	Oxygen	O	15.9994, 16	16-8 = 8
9	Fluorine	F	18.998, 19	19-9 = 10
10	Neon	Ne	20.179, 20	20-10 = 10
11	Sodium	Na	22.989, 23	23-11 = 12
12	Magnesium	Mg	24.305, 24	24-12 = 12
13	Aluminium	Al	26.981, 27	27-13 = 14
14	Silicon	Si	28.085, 28	28-14 = 14
15	phosphorous	P	30.973, 31	31-15 = 16
16	Sulphur	S	32.06, 32	32-16 = 16
17	chlorine	Cl	35.453, 35.5	35.5-17 = 18.5
18	Argon	Ar	39.948, 40	40-18 = 22
19	Potassium	K	39.098, 39	39-19 = 20
20	Calcium	Ca	40.08, 40	40-20 = 20
21	Scandium	Sc	44.955, 45	45-21 = 24
22	Titanium	Ti	47.88, 48	48-22 = 26
23	Vanadium	V	50.941, 51	51-23 = 28
24	chromium	Cr	51.996, 52	52-24 = 28
25	Manganese	Mn	54.938, 55	55-25 = 30
26	Iron	Fe	55.847, 56	56-26 = 30

Atomic Number	Elements	Symbol	Atomic mass	No. of Neutrons
27	Cobalt	Co	58.933, 59	59-27 = 32
28	Nickel	Ni	58.69, 59	59-28 = 31
29	Copper	Cu	63.546, 63	63-29 = 34
30	Zinc	Zn	65.38, 65	65-30 = 35
31	Gallium	Ga	69.72, ≈ 70	70-31 = 39
32	Germanium	Ge	72.59, 73	73-32 = 41
33	Arsenic	As	74.9215, 75	75-33 = 42
34	Selenium	Se	78.96, 79	79-34 = 45
35	Bromine	Br	79.904, 80	80-35 = 45
36	Krypton	Kr	83.80, 84	84-36 = 48
37	Rubidium	Rb	85.467, 86	86-37 = 49
38	Strontium	Sr	87.62, 88	88-38 = 50
39	Yttrium	Y	88.905, 89	89-39 = 50
40	Zirconium	Zr	91.22, 91	91-40 = 51
41	Niobium	Nb	92.90, 93	93-41 = 52
42	Molybdenium	Mo	95.94, 96	96-42 = 54
43	Technetium	Tc	98	98-43 = 55
44	Ruthenium	Ru	101.07, 101	101-44 = 57
45	Rhodium	Rh	102.905, 103	103-45 = 58
46	Paladium	Pd	106.42, 106	106-46 = 60
47	Silver	Ag	107.868, 108	108-47 = 61
48	Cadmium	Cd	112.41, 112	112-48 = 64
49	Indium	In	114.82, 115	115-49 = 66
50	Tin	Sn	118.69, 119	119-50 = 69
51	Antimony	Sb	121.76, 122	122-51 = 71
52	Tellurium	Te	127.60, 128	128-52 = 76
53	Iodine	I	126.9045, 127	127-53 = 74
54	Xenon	Xe	131.29, 131	131-54 = 77
55	Cesium	Cs	132.90, 133	133-55 = 78
56	Barium	Ba	137.33, 137	137-56 = 81
57	Lanthanum	La	138.49, 128	138-57 = 81

SOME IMPORTANT WORDS –

Matter – It is defined as anything that has mass & occupies some space. It is 2 types.
1. Homogeneous – which has uniform composition & identical properties. Ex – H, Cu, O, N etc.
2. Heterogeneous – which has made up of 2 or more compounds & physically distinct. It consist of various phase & one phase.
Ex – mixture of sand & sulphur.
mixture of Immissible liquids like oil & water.
3 states of Matter are there.
1. Solid 2. Liquid 3. Gas
1. Solid – which has definite shape & volume.
Ex – Ag, Cu, Sugar etc.
2. Liquid – which has definite volume but no definite shape.
Ex – H_2O, Oil, Alcohol etc.
3. Gas – which has neither definite shape nor volume.
Ex – H_2, N_2, O_2 etc.

Elements –

An element is that which is made up of same kind of atoms.
Ex – Iron, Copper, Silver etc.
There are 3 types of elements.
1. Metal 2. Non metal 3. Metalloid
a. Metal – which has shining surface & are good conductors.
Ex – Na, Fe, Ag etc.
b. Non-metal – Non metals which are solids & have dull surfaces & bad conductors. ~~Ten.~~ They exist in all states.
Ex – S, P are solids.
"Br" exist in liquid
H, O. are gas.
c. Metalloids – which has both the properties Metals as well as non metals.
Ex – Bismuth, Tin etc.

Compound – A substance which is obtained by the union of 2 or more elements in definite ratio.
Ex – HCl, H_2SO_4.

Atoms -

An atom is defined as the smallest particle of an element contains electrons, protons & neutrons.

Molecules -

A Group of ~~atom~~ 2 or more atoms are called molecules.

Symbol -

It is the shorthand representation for the full name of an element. The first letter is always capital.

Ex - C, O, Na

Valency - Valency is a number that represents the capacity of a single atom or radical to combine with other atoms or radicals to form a stable molecule.

Valency may be defined as the number of electrons lost, gained or shared with an atom of an element in order to acquire the stable configuration of nearest Inert gas element.

Radical or Ion -

A radical may be defined as an atom or group of atoms having +ve or -ve charge

There are 2 types of radicals.

1. Electro-positive radical or Basic radical or cation -

The radical having a positive charge on it is known as basic radical.

Ex - K^+, Ag^+; Pb^{2+} etc

2. Electro - negative radical or Acid radical or Anion -

The radical having a negative charge on it is known as acid radicals.

Ex - Cl^-, SO_4^{2-} etc.

All inert gas elements are zerovalent i.e., their valency is zero. Ex - He, Ne, Ar, Kr, Xe, Rn

Monovalent Radical - A Radical carrying a unit charge (+ve) or (-ve) is called a monovalent radical
Ex- K^+, Cl^-, NO_3^-

Divalent Radical - A radical which carries 2 units of charge
Ex- Cu^{2+}, SO_4^{2-}

Trivalent Radical - A radical which carries 3 units of charge
Ex- Al^{3+}, N^{3-}

List of Electro-positive Radicals (cations or Basic Radicals)

Monovalent basic radicals -

Radical	Symbol
Hydrogen	H^+
Silver	Ag^+
Sodium	Na^+
Pottasium	K^+
cuprous	Cu^+
Ammonium	NH_4^+
Lithium	Li^+

Divalent basic radicals -

Barium	Ba^{2+}
Beryllium	Be^{2+}
Cadmium	Cd^{2+}
Calcium	Ca^{2+}
Cobalt	Co^{2+}
Cupric	Cu^{2+}
Ferrous	Fe^{2+}
Magnessium	Mg^{2+}
Manganese	Mn^{2+}
Nickel	Ni^{2+}
Zinc	Zn^{2+}

Trivalent basic Radicals -

Radical	Symbol
Aluminium	Al^{3+}
Bismuth	Bi^{3+}
Ferric	Fe^{3+}
Antimony	Sb^{3+}
Boron	B^{3+}
chromium	Cr^{3+}

Tetra valent basic radicals

Radical	Symbol
carbon	C^{4+}
platinum	Pt^{4+}
Tin	Sn^{4+}
Silicon	Si^{4+}

List of Electro-negative or Acid Radicals (Anions) -

Monovalent acid radicals

Radical	Symbol
Acetate	CH_3COO^-
Bicarbonate	HCO_3^-
Bisulphate	HSO_4^-
Bisulphite	HSO_3^-
Bromide	Br^-
chloride	Cl^-
Cyanide	CN^-
Fluoride	F^-
Hydride	H^-
Bisulphide	HS^-
Hydroxide	OH^-
Iodate	IO_3^-
Iodide	I^-
metaaluminate	AlO_2^-
Metaphosphate	PO_3^-
Nitrate	NO_3^-
permanganate	MnO_4^-
sulphocyanide	CNS^-
superoxide	O_2^-

Divalent acid Radicals

Radical	Symbol
carbonate	CO_3^{2-}
chromate	CrO_4^{2-}
Manganate	MnO_4^{2-}
sulphate	SO_4^{2-}
Sulphite	SO_3^{2-}
sulphide	S^{2-}
Oxide	O^{2-}
peroxide	O_2^{2-}
pyrite	S_2^{2-}
Silicate	SiO_3^{2-}
Zincate	ZnO_2^{2-}

Trivalent acid radicals -

Aluminate	AlO_3^{3-}
Antimonate	SbO_4^{3-}
Borate	BO_3^{3-}
Ferricyanide	$[Fe(CN)_6]^{3-}$
Nitride	N^{3-}
phosphate	PO_4^{3-}
Phosphite	PO_3^{3-}
Phosphide	P^{3-}

Tetravalent acid radicals

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

UNIT - I

PHYSICAL CHEMISTRY

chapter-1 (Atomic structure)

The arrangement of subatomic particles in atom is called atomic structure. The subatomic particles are electrons (−ve), protons (+ve) & Neutrons (no charge).

Electrons, protons & Neutrons are called fundamental particles.

About Electron :-

(i) Discovered in cathode ray tube experiment by J.J. Thompson.

(ii) charge = -1.602×10^{-19} coulomb

(iii) Mass = 9.1×10^{-31} kg

(iv) Mass of 1 mole of electrons = 0.55 mg.

(v) charge of 1 mole of electrons = 96500 Coulomb.

About proton -

(i) Discovered in anode ray tube experiment by E. Goldstein.

(ii) charge = 1.602×10^{-19} Coulomb

(iii) Mass = 1.672×10^{-27} kg

(iv) Mass of 1 mole of protons = 1.007 gm

(v) charge of 1 mole of protons = 96500 Coulomb

About Neutron -

(i) Neutron was discovered by J. Chadwick.

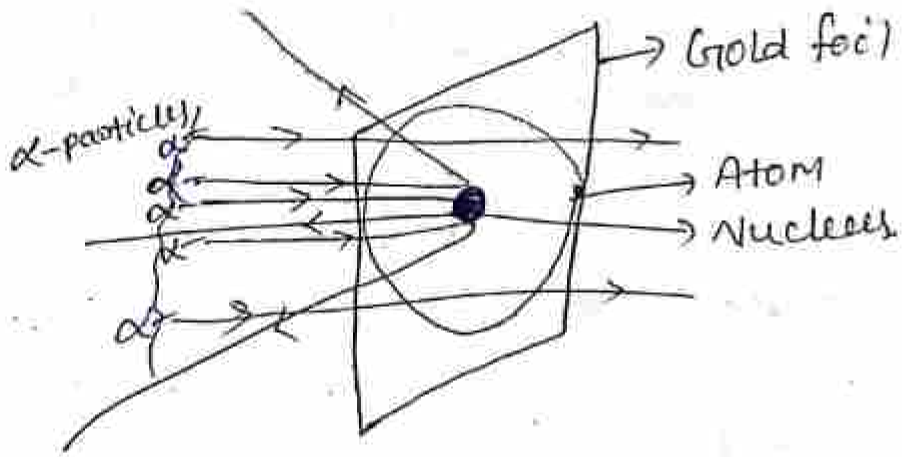
(ii) Mass of Neutron = 1.675×10^{-27} kg

(iii) charge of Neutron = 0

(iv) Mass of 1 mole of neutrons = 1.008 gm

Rutherford's atomic model on Gold foil experiment -

A thin Gold foil was bombarded with α-particles.



(Rutherford's Gold foil experiment)

Observations - From the above experiment, Rutherford observed the following points.

a. Large numbers of α-particles passed through the foil without any deflection.

b. Few α-particles passed with different angle of deflection.

c. One among 10,000 α-particles retraced on the original path but in opposite direction.

Inference - From the above observations, Rutherford derived the following points.

(i) There is a large empty-space present inside the atom.

(ii) There is a high positive charge at the centre of the Gold atom.

(iii) All the masses & positive charges are concentrated at the centre called nucleus.

Atomic model - The main postulates of atomic model are

(i) An atom consist of two parts such as

a. Nucleus

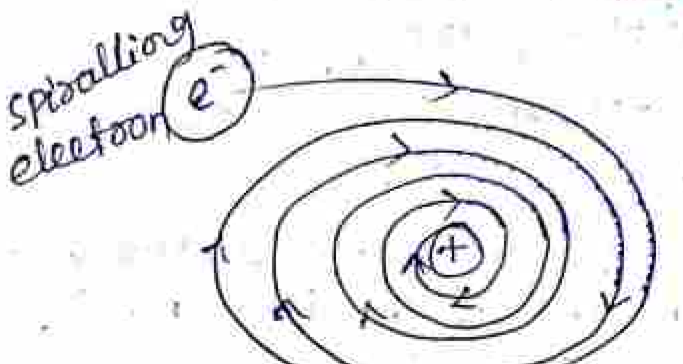
b. Extra nuclear part

(ii) Nucleus is an extremely small positively charged massive part which is present at the centre of the atom ~~called nucleus~~.

(iii) Atom being neutral since the total number of negatively charged electrons = Total number of positively charged protons.

(iv) Negatively charged electrons are revolving around the positively charged nucleus in circular orbits like the planets revolving around the sun.

Drawbacks of Rutherford's atomic model -



(i) According to Rutherford's atomic model an atom consists of a nucleus & the electrons are revolving around it.

(ii) Thus the centrifugal force which is produced by the circulation of electrons balances the force of attraction between the electrons & the nucleus.

(iii) But Clark Maxwell had shown that a charged particle which comes under the influence of an attractive force continuously lose energy.

(क्रिया)

(iv) Electron is also a charged particle, it must emit radiations & thus lose energy continuously.

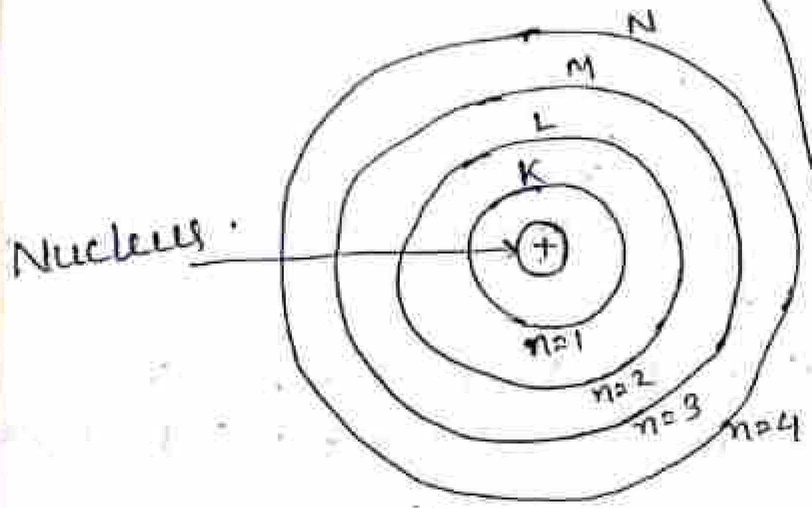
(v) As electron loses energy, it starts coming nearer to the nucleus i.e., its orbit would become smaller & smaller.

(vi) As a result of this, the electron would fall into the nucleus.

(vii) But we know that the revolving electrons never fall into the nucleus.

(viii) Thus Rutherford's atomic model is faulty.

Bohr's atomic model-



(Energy levels)

The main postulates are

(i) An atom consist of a massive positively charged nucleus. The electrons are moving around the nucleus in a fixed circular orbits without radiating energy.

(ii) These non-radiating orbits are known as stationary states or Energy levels.

(iii) These fixed orbits are associated with fixed amount of energy (E_n) & fixed amount of radius (r_n).

$$E_n = -\frac{1312}{n^2} \text{ k·cal mole}^{-1}$$ ('n' is the number of energy level)

where $n = 1, 2, 3, 4 \ldots\ldots$

(iv) The electron moves in the fixed orbit, it neither emits nor absorbs energy.

(v) Different energy levels are not equally spaced i.e., the energy difference between 2 energy levels is not same. It goes on decreasing with the increase in the value o

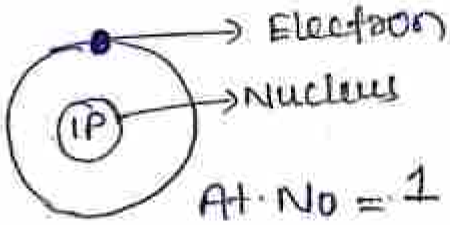
(vi) Energy is emitted or absorbed when an electron jumps from higher to lower orbit or lower to higher orbit respectively.

(vii) The amount of energy ΔE is emitted or absorbed is equal to the difference of energy of higher level (E_2) & energy of lower level (E_1)

$$\Delta E = E_2 - E_1$$

Bohr- Bury scheme -

Bohr & Bury gave the following rules for the distribution of electrons in different orbits.



At. No = 1
Mass = 1
neutrons = 0

At no = 2
Mass = 4
neutrons = 2

(i) The capacity to distribute the electrons in the orbits can be known by $2n^2$ rule.

For K-shell the capacity is $2 \times 1^2 = 2$.
L-shell the capacity is $2 \times 2^2 = 8$
M- shell the capacity is $2 \times 3^2 = 18$
N- shell the capacity is $2 \times 4^2 = 32$ & so on.

(ii) Always it is not necessary to complete the inner shell before moving to the next higher shell.

(iii) The outermost shell cannot contain more than 8 electrons & the penultimate shell cannot contain more than 18 electrons.

Hund's Rule -

Atomic number -

The number of electrons or protons present in an atom is called its atomic number. It is denoted by "Z".

$$Z = e = P$$

Atomic Mass or Mass number -

The number of protons & the number of neutrons present inside the nucleus of an atom is called its mass number. It is denoted by "A".

Atomic mass = No. of proton (P) + No. of Neutron (n)

$(A) = P + n$ or $Z + n$ or $e + n$

$\therefore n = A - Z$

Qn :- An element consist of 9 protons & 10 neutrons. Calculate its mass number & atomic number.

A :- mass number = 9 + 10 = 19

Atomic number = 9

Qn :- The mass number & atomic number of Ca are 40 & 20. Calculate the no. of electrons & neutrons ?

A :- Mass number = 40

Atomic number = 20

No. of electrons = At. no = 20

No. of neutrons = ~~40~~ At. mass − At. no

= 40 − 20 = 20

Isotope -

Same element having same atomic no. & different in mass number are called Isotopes.

Ex - $_1H^1$, $_1H^2$, $_1H^3$ Hydrogen has 3 isotopes.

$_1H^1$ = Protium

$_1H^2$ = Deuterium

$_1H^3$ = Tritium

Carbon has 2 isotopes. ($_6C^{12}$ & $_6C^{13}$)

Oxygen has 3 isotopes ($_8O^{16}$, $_8O^{17}$ & $_8O^{18}$)

Isobar -

Two elements having same mass number but different atomic number are called Isobar.

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

Ca & Ar both have same mass i.e., (40).

Isotone -

Two elements having same no. of neutrons are called Isotone.

Ex - $^{11}_{5}B$ $^{12}_{6}C$

B = 11 - 5 = 6 ⇒ mass no - Atomic no = no. of neutrons
C = 12 - 6 = 6.

Both Boron & Carbon has same no. of neutrons i.e., (6).

Hund's Rule -

According to this rule "No pairing of electrons takes place in each orbitals until each orbitals is half filled".

$_1H$ = 1s [↑]

$_2He$ = 1s [↑↓]

$_3Li$ = 1s [↑↓] 2s [↑]

$_4Be$ = 1s [↑↓] 2s [↑↓]

$_5B$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑ | |]

$_6C$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑ | ↑ |]

$_7N$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑ | ↑ | ↑]

$_8O$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑↓ | ↑ | ↑]

$_9F$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑↓ | ↑↓ | ↑]

$_{10}Ne$ = 1s [↑↓] 2s [↑↓] 2p (x y z) [↑↓ | ↑↓ | ↑↓]

Aufbau principle -

According to this principle, " ~~energy levels~~ The electrons are filled in various orbitals in order to their increasing energies."

(i) Subshell having lower (n+l) value is filled first.

Ex- 4s is filled first than 3d. because (n+l) value of 4s (i.e., 4+0=4) is less than (n+l) value of 3d (i.e., 3+2=5)

(ii) If (n+l) values for two energy levels are equal, the energy level with lower "n" value is filled first.

Ex- 2p is filled first before 3s.

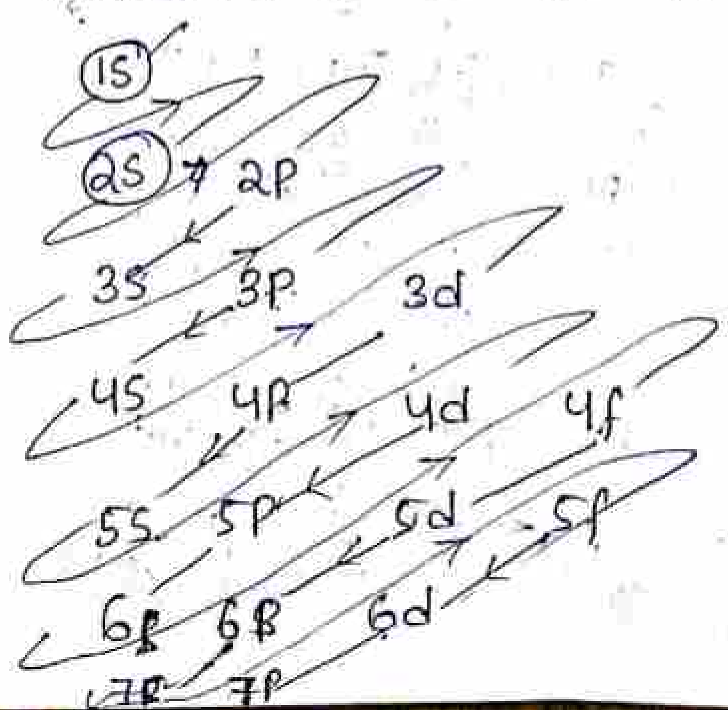
s = 0
p = 1
d = 2
f = 3

(n+l) Rule

	1s	2s	2p	3s	4p	3d	4d	4f	5p	5s
n	1	2	2	3	4	3	4	4	5	5
l	0	0	1	0	1	2	2	3	1	0
n+l	1	2	3	3	5	5	6	7	6	5

5s

1s < 2s < 2p < 3s < 3d < 4p ~~< 4d < 5p~~ < 5s < 4d < 5p < 4f



Electronic Configuration –

[E.C]

Elements	At. NO	Symbol	Electronic Configuration
Hydrogen	1	H	$1s^1$
Helium	2	He	$1s^2$
Lithium	3	Li	$1s^2 2s^1$
Berylium	4	Be	$1s^2 2s^2$
Boron	5	B	$1s^2 2s^2 2p_x^1$
Carbon	6	C	$1s^2 2s^2 2p_x^1 2p_y^1$
Nitrogen	7	N	$1s^2 2s^2 2p_x^1 2p_y^1 2p_z^1$
Oxygen	8	O	$1s^2 2s^2 2p_x^2 2p_y^1 2p_z^1$
Fluorine	9	F	$1s^2 2s^2 2p_x^2 2p_y^2 2p_z^1$
Neon	10	Ne	$1s^2 2s^2 2p_x^2 2p_y^2 2p_z^2$ (or) $1s^2 2s^2 2p^6$
Sodium	11	Na	$1s^2 2s^2 2p^6 3s^1$
Magnessium	12	Mg	$1s^2 2s^2 2p^6 3s^2$
Aluminium	13	Al	$1s^2 2s^2 2p^6 3s^2 3p_x^1$
Silicon	14	Si	$1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1$
phosphorus	15	P	$1s^2 2s^2 2p^6 3s^2 3p_x^1 3p_y^1 3p_z^1$
Sulphur	16	S	$1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^1 3p_z^1$
chlorine	17	Cl	$1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^1$
Argon	18	Ar	$1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^2$ (or) $1s^2 2s^2 2p^6 3s^2 3p^6$
potassium	19	K	$_{18}[Ar]\ 4s^1$
Calcium	20	Ca	$_{18}[Ar]\ 4s^2$
Scandium	21	Sc	$_{18}[Ar]\ 4s^2 3d^1$
Titanium	22	Ti	$_{18}[Ar]\ 4s^2 3d^2$
Vanadium	23	V	$_{18}[Ar]\ 4s^2 3d^3$

Element	At. NO	Symbol	Electronic configuration	
chromium	24	Cr	$_{18}[Ar]\ 4s^1\ 3d^5$	Extra stability due to half filled
Manganese	25	Mn	$_{18}[Ar]\ 4s^2\ 3d^5$	
Iron	26	Fe	$[_{18}Ar]\ 4s^2\ 3d^6$	
Cobalt	27	Co	$[_{18}Ar]\ 4s^2\ 3d^7$	
Nickel	28	Ni	$[_{18}Ar]\ 4s^2\ 3d^8$	
Copper	29	Cu	$[_{18}Ar]\ 4s^1\ 3d^{10}$	Extra stability due to completely full filled
Zinc	30	Zn	$_{18}[Ar]\ 4s^2\ 3d^{10}$	

-ve Ion or Acid Radicals

$Br^- \rightarrow 35+1=36$ $[_{18}Ar]4s^2 3d^{10} 4p^6$

$Cl^- \rightarrow 17+1=18 (1s^2 2s^2 2p^6 3s^2 3p^6)$

$F^- \rightarrow 9+1 = Ne \rightarrow 1s^2 2s^2 2p^6$

$H^- \rightarrow 1+1=2 = He \rightarrow 1s^2$

$I^- \rightarrow 53$

$O_2^{2-} \rightarrow 8+2 = 10 = Ne = 1s^2 2s^2 2p^6$

$S^{2-} \rightarrow 16+2 = 18 = Ar \rightarrow$

$P^{3-} \rightarrow 15+3 = 18 = Ar \rightarrow$

$C^{4-} \rightarrow 4+4 = 8 = O \rightarrow$

+ve Ion or Basic Radicals

$H^+ \rightarrow 1-1 = 0$

$Ag^+ \rightarrow 47$

$Na^+ \rightarrow 11-1 = 10 = Ne$

$K^+ \rightarrow 19-1 = 18 = Ar$

$Cu^+ \rightarrow 29-1 = 28 = Ni$

$Li^+ \rightarrow 3-1 = 2 = He$

$Ba^{2+} \rightarrow 56$

$Be^{2+} \rightarrow 4-2 = 2 = He$

$Ca^{2+} \rightarrow 20-2 = 18 = Ar$

$Co^{2+} \rightarrow 27-2 = 25 = Mn$

$Cu^{2+} \rightarrow 29-2 = 27 = Co$

$Fe^{2+} \rightarrow 26-2 = 24 = Cr$

$Mg^{2+} \rightarrow 12-2 = 10 = Ne$

$Mn^{2+} \rightarrow 25-2 = 23 = V$

$Ni^{2+} \rightarrow 28-2 = 26 = Fe$

$Zn^{2+} \rightarrow 30-2 = 28 = Ni$

$Al^{3+} \rightarrow 13-3 = 10 = Ne$

$Fe^{3+} \rightarrow 26-3 = 23 = V$

$B^{3+} \rightarrow 5-3 = 2 = He$

$Cr^{3+} \rightarrow 24-3 = 21 = Sc$

$C^{4+} \rightarrow 4-4 = 0$

chapter-2 CHEMICAL BONDING

Def^n of chemical bond -

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

Types of chemical bond -

It is 3 types.

1. Ionic bond or Electrovalent bond
2. Covalent bond
3. Dative bond or Co-ordinate bond.

① Ionic bond -

Which are formed by the transference of one or more electrons from one atom to other atom are called ionic bond.

Ex - Formation of sodium chloride (NaCl) -

Sodium (Na)
At. NO = 11
(2, 8, 1)

Chlorine (Cl)
At. NO = 17
(2, 8, 7)

There is only one valence electron in Na & 7 valence electrons in Cl.

Sodium transfers its one electron to chlorine

$Na^+ + Cl^- \longrightarrow$ 

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

Formation of calcium chloride ($CaCl_2$) →

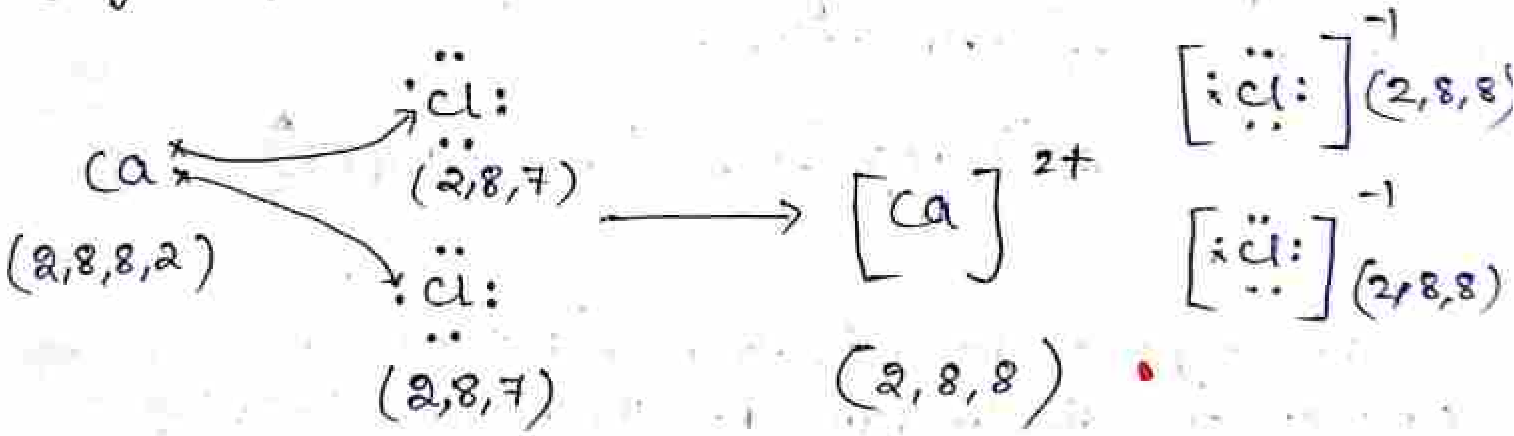
$Ca = 20$ (2,8,8,2)

$Cl = 17$ (2,8,7)

$Cl = 17$ (2,8,7)

There are 2 valence electrons in calcium & it can attain inert gas configuration by loses of 2 electrons.

There are one valence electrons in each Cl atom & it can attain inert gas configuration by gaining of one electron.



The oppositely charged ions get attracted with force of attraction.

$Ca^{2+} + 2Cl^- \longrightarrow CaCl_2$

Formation of $MgCl_2$ (Magnessium chloride) -

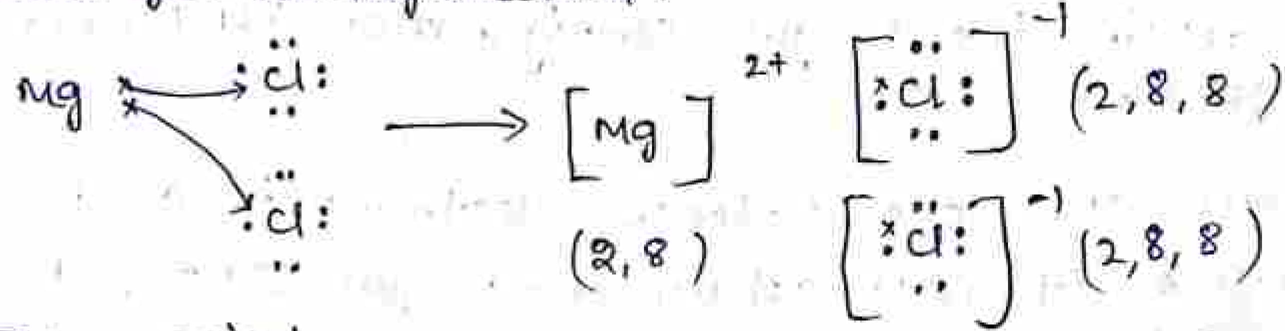
Mg = 12 (2,8,2)

Cl = 17 (2,8,7)

Cl = 17 (2,8,7)

There are 2 valence electrons in magnessium & one valence electron in each chlorine atom.

When magnessium loses its 2 electron to each chlorine atom, both Mg & Cl get inert gas configuration.



The oppositely charged ions get attracted with force of attraction.

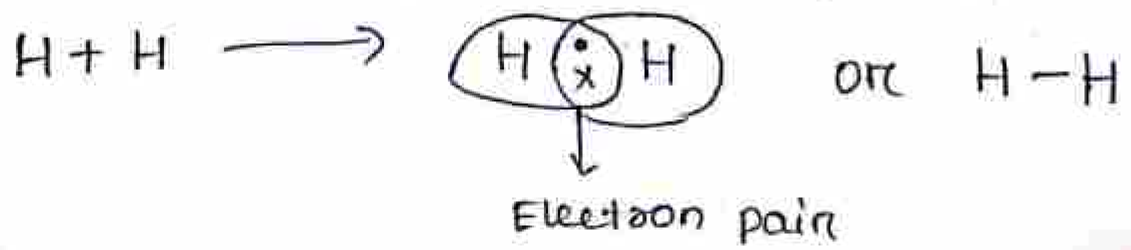
$$Mg^{2+} + 2Cl^{-} \longrightarrow MgCl_2$$

② Covalent bond -

This type of bond is formed between two atoms (similar or dissimilar) by the mutual sharing of electrons.

Ex - ① Formation of Hydrogen molecule (H_2) -

Two atoms of Hydrogen combine to form H_2 molecu



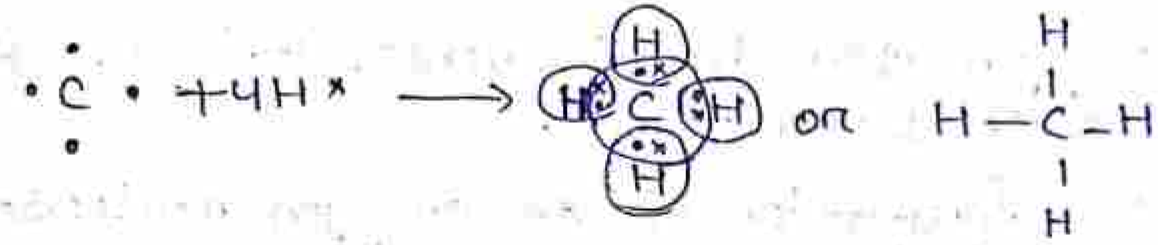
Each hydrogen atom completes its duplet as heliums becomes stable.

② Formation of methane (CH_4) –

→ It is formed by the combination of one carbon atom and four hydrogen atoms.

→ A carbon atom has four electrons in its valence shell & hydrogen atom has one electron.

→ Thus each hydrogen atom mutually shares its electron with an electron of carbon atom to form four bond pairs.



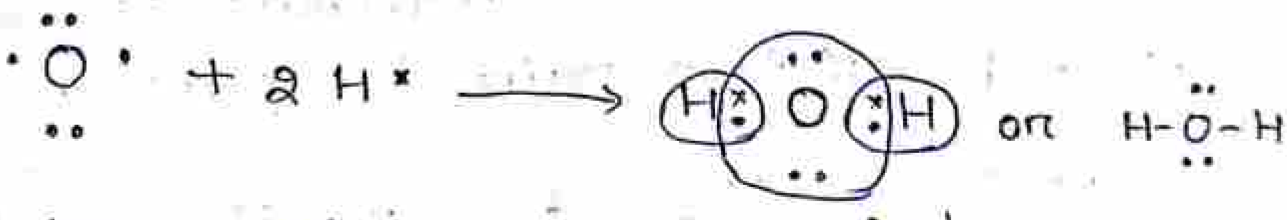
The bond angle of CH_4 is $109^\circ 28'$.

③ Formation of water molecule (H_2O) –

→ It is formed by the combination of one oxygen atom & 2 hydrogen atom.

→ An oxygen atom has six electrons in its valence shell & A hydrogen atom has one electron.

→ Thus each hydrogen atom mutually shares its electron with an electron of oxygen atom to form 2 bond pairs.



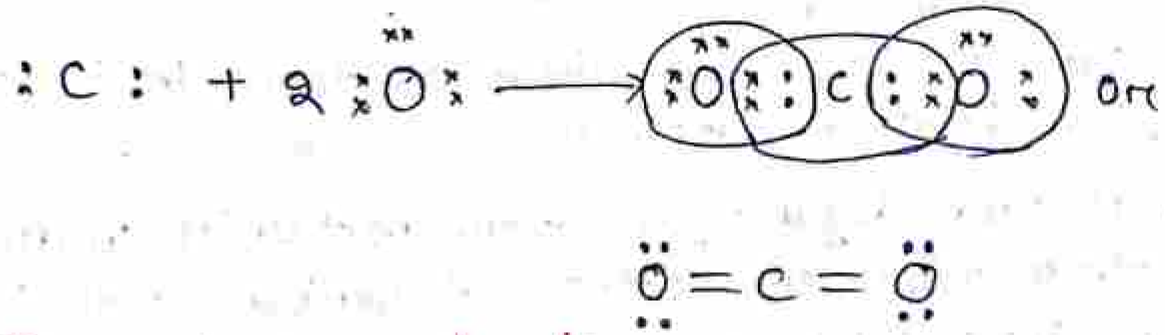
The bond angle of H_2O is $104^\circ 5'$.

④ Formation of Carbon dioxide (CO_2) –

→ It is formed by the combination of one carbon atom & 2 oxygen atoms.

→ A carbon atom has four electrons in its valence shell & an oxygen atom has six electrons.

→ Each oxygen atom mutually shares its one ele[ctron] with carbon atom to form 4 bond pairs.



⑤ Formation of O_2 molecule –

→ Each oxygen atom has 6 valence electrons & it is deficient of 2 electrons.

→ For the formation of an oxygen molecule, each oxygen atom contributes 2 electrons.

→ Thus, 2 electron pairs are formed.

⑥ Formation of chlorine molecule (Cl_2) –

→ Each chlorine atom has 7 valence electrons & it is deficient of 1 electrons.

→ For the formation of a chlorine molecule, each chlorine atom contributes one electron.

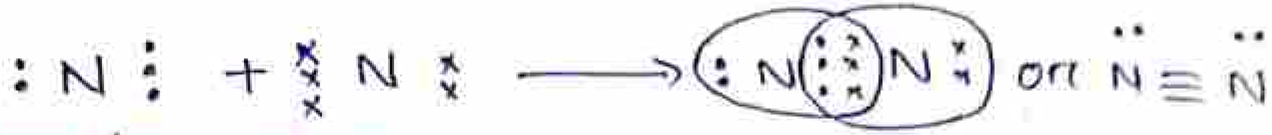
→ Thus, 1 electron pair is formed.

⑦ Formation of Nitrogen molecule (N_2) –

→ Each nitrogen atom has five valence electrons & it is deficient of 3 electrons.

→ To form a nitrogen molecule, each nitrogen atom contributes 3 electrons.

→ Thus 3 electron pairs are formed.

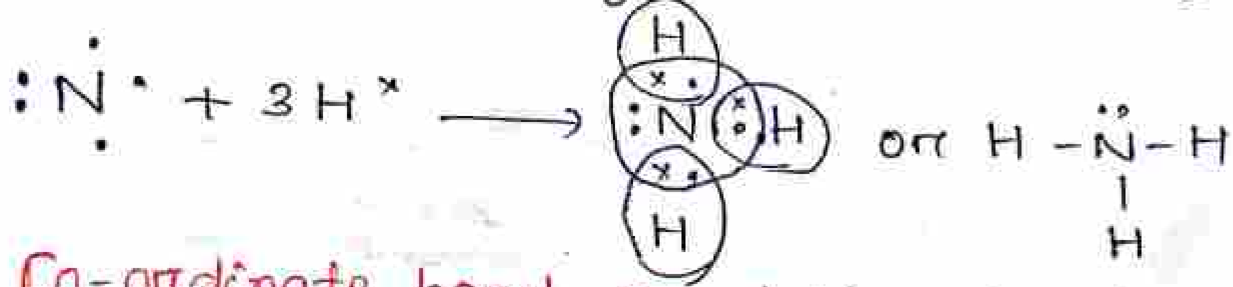


⑧ Formation of Ammonia → (NH_3)

→ It is formed by the combination of 1 Nitrogen atom & 3 hydrogen atoms.

→ A Nitrogen atom has 5 valence electrons & hydrogen atom has one electron.

→ Each hydrogen atom mutually shares its electron with nitrogen atom to form 3 pairs.



3) Co-ordinate bond or dative bond –

→ A co-ordinate bond is formed when an atom with complete octet (after mutual sharing) donates its pair of electrons to the other atom.

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

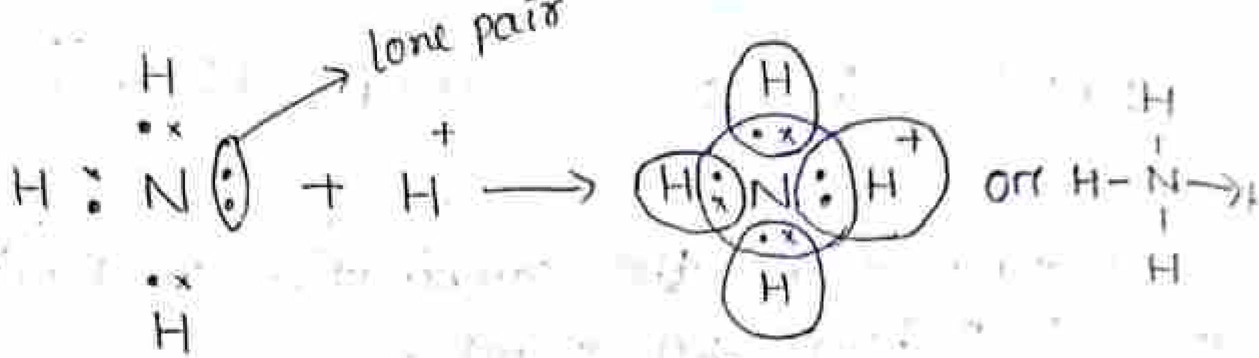
→ This type of bond is formed between two dissimilar atoms A & B.

→ Atom A has one or more lone pair of electrons. Atom B is short of a pair of electrons.

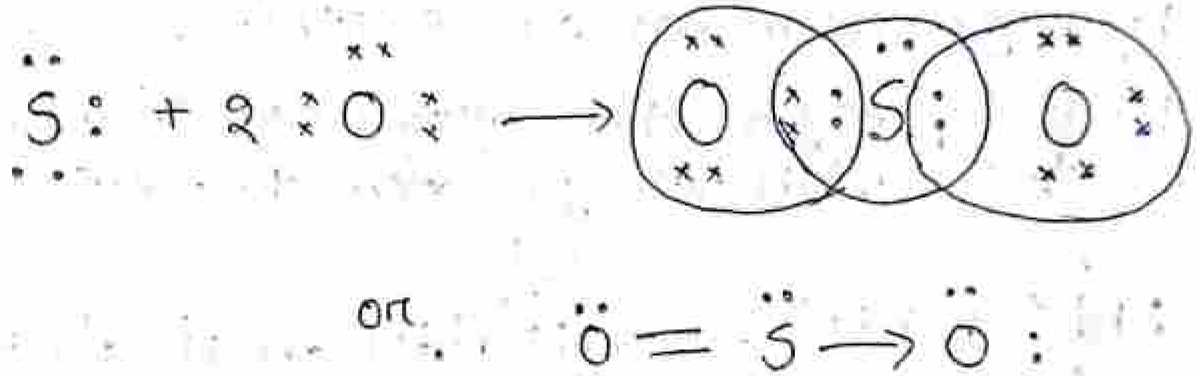
→ Atom A donates its lone pair to atom B. Thus atom A is called donor & atom B is called acceptor.

→ This bond is directional (→) (A → B)

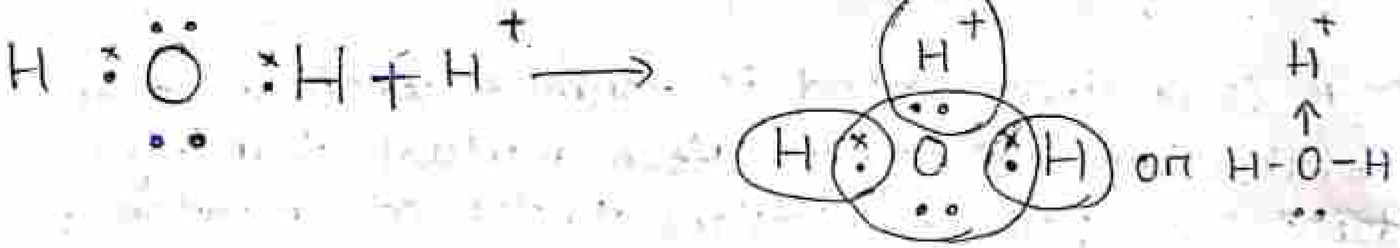
Ex (a) Formation of Amonium ion (NH_4^+) –



(b) Formation of sulphur dioxide (SO_2) –



(c) Formation of Hydronium ion (H_3O^+) –



Chapter-3 ‖ACID- BASE THEORY‖

Various theories are based on the structure of acids & bases. Those theories are -

1. Arrhenious theory
2. Bronsted - lowry theory
3. Lewis theory.

1. Arrhenious theory-

According to Arrhenious theory

(i) Acids are those substances which gives H^+ ions in aqueous solution.

$$HCl + aq \rightleftharpoons H^+(aq) + Cl^-(aq)$$

$$H_2SO_4 + aq \rightleftharpoons 2H^+(aq) + SO_4^{2-}(aq)$$

$$HNO_3 + aq \rightleftharpoons H^+(aq) + NO_3^-(aq)$$

$$CH_3COOH + aq \rightleftharpoons H^+(aq) + CH_3COO^-(aq)$$

$$H_2CO_3 + aq \rightleftharpoons 2H^+(aq) + CO_3^{2-}(aq)$$

(ii) Bases are those substances which gives OH^- ions in aqueous solution.

$$NaOH + aq \rightleftharpoons Na^+(aq) + OH^-(aq)$$

$$NH_4OH + aq \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

$$KOH + aq \rightleftharpoons K^+(aq) + OH^-(aq)$$

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

$$Ba(OH)_2 + aq \rightleftharpoons Ba^{2+}(aq) + 2OH^-(aq)$$

Limitations of Arrhenious Theory -

(i) H^+ ion does not exist in aqueous solution. It combines with H_2O to give H_3O^+ (Hydronium ion)

$$H^+ + H_2O \rightleftharpoons H_3O^+$$

(ii) This theory fails to explain the acidic & basic nature of the substances other than water.

(iii) This theory fails to explain the acidic nature of the substances like SO_2, CO_2, SiO_2, P_2O_5, BF_3, $AlCl_3$ etc. which can not provide H^+ ions.

(iv) This theory fails to explain the basic nature of the substances like NH_3, PH_3, Na_2O, K_2O, CaO etc which can't provide OH^- ions.

(v) This theory fails to explain neutralisation reactions between some acids & some bases.

$$\underset{\text{(Acid)}}{HCl} + \underset{\text{(Base)}}{NaOH} \rightleftharpoons \underset{\text{(Salt)}}{NaCl} + H_2O$$

2. Bronsted - Lowry theory -

Bronsted & Lowry put forward a theory for acids & bases. These theories are -

Acid

(i) Acid is a substance which has a tendency to donate a proton to any other substance.

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

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

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

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

(ii) Ions having capacity to donate a proton (H^+ ion)

HS^-, HCO_3^-, HPO_4^{2-}, HSO_4^- etc.

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

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

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

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

(iii) All Arrhenious acids are Bronsted - Lowry acids - Ex- HCl, HNO_3, H_2SO_4, H_3PO_4, CH_3COOH..

Base :

(i) Base is a substance which has a tendency to accept a proton from other substances.

$$NH_3 + H^+ \rightleftharpoons NH_4^+$$

$$H_2O + H^+ \rightleftharpoons H_3O^+$$

(ii) Ions having capacity to receive a proton (H^+ ion)

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

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

$$CN^- + H^+ \rightleftharpoons HCN$$

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

All Bronsted Bases may not be Arrhenious Bases-

Reason -

According to Arrhenious a base must furnish OH^- ions in aq. solution. & According to Bronsted theory a base must accept a proton.

Ex- According to Bronsted theory CO_3^{2-} ion is a base bcoz it accept a proton to form HCO_3^- ion.

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

According to Arrhenious concept, CO_3^{2-} is not a base bcoz it cannot produce OH^- ions in aq. solution.

Hence all Arrhenious acids are also Bronsted acids but all Bronsted bases are not Arrhenious Bases.

Conjugate acid & base pairs –

ⓐ When an acid loses a proton, the residue will have a tendency to accept a proton. so, it is a base.

$$Acid \rightleftharpoons Base + H^+$$

Thus, (when an acid leaves a proton, it gives its conjugate base.)

ⓑ When a base accepts a proton, the result an acid is formed.

$$Base + H^+ \rightleftharpoons Acid.$$

Thus (when a base takes up proton, it gives its conjugate acid)

ⓒ According to this theory an acid reacts with a base to form another pair of acid & base.

EX –

$$\underset{(Acid-1)}{HCl} + \underset{(Base-1)}{NH_3} \rightleftharpoons \underset{(Acid-2)}{NH_4^+} + \underset{(Base-2)}{Cl^-}$$

Conjugate Acid & Base.

$$\underset{(Acid-1)}{H_2O} + \underset{(Base-1)}{NH_3} \rightleftharpoons \underset{(Acid-2)}{NH_4^+} + \underset{(Base-2)}{OH^-}$$

conjugate Acid & base

(d) (i) A strong acid has a weak conjugate base, while a weak acid has a strong conjugate base.

(ii) A strong base has a weak conjugate acid, while a weak base has a strong conjugate acid.

Ex – (i) $H_2SO_4 \rightleftharpoons 2H^+ + SO_4^{2-}$

(Strong Acid) (weak conjugate base)

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

(weak acid) (strong conjugate base)

(ii)

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

(Strong base) (weak conjugate acid)

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

(weak base) (strong conjugate acid)

Amphoteric substance –

An amphoteric substance which acts both as an acid as well as a base [consider water (H_2O)]

Ex – $HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$

(Acid) (Base) (Acid) (Base)

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$

(Base) (Acid) (Acid) (Base)

With HCl, water acts as a base & with NH_3 water reacts as an acid.

Advantages of Bronsted-Lowry theory over Arrhenius theory →

(i) It can explain the acid-base neutralisation reactions even in the absence of water.

Ex - $CaO + SO_3 \longrightarrow CaSO_4$
(Base) (Acid) (Salt)

(ii) It can explain the basic nature of the substance like NH_3, Na_2CO_3 etc, which do not contain OH group. These are acts as a proton acceptors & are bases.

$$NH_3 + H^+ \rightleftharpoons NH_4^+$$
(Base) (Acid)

$$CO_3^{2-} + H^+ \rightleftharpoons HCO_3^-$$
(Base) (Acid)

Limitations of Bronsted-Lowry theory -

(i) It fails to explain the acidic nature of the substances like SiO_2, CO_2, SO_2, BF_3 etc which cannot ~~donate~~ produce H^+ ion.

(ii) It fails to explain the basic nature of the substance like Na_2O, K_2O, CaO etc which can't accept H^+ ion.

(iii) It fails to explain the reaction between some acids & bases which do not give another pair of acid & a base.

Ex - $HCl + NaOH \longrightarrow NaCl + H_2O$
(Acid) (Base) (Salt)

3. Lewis Theory :-

Some conjugate acid - base Pairs -

Acids -

$H_3O^+ \rightleftharpoons H^+ + H_2O$

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

$HNO_2 \rightleftharpoons H^+ + NO_2^-$

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

$NH_4^+ \rightleftharpoons H^+ + NH_3$

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

Base -

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

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

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

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

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

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

$HCO_3^- + H^+ \rightleftharpoons H_2CO_3$

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

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

3. Lewis Concept :-

An acid is defined as any substance which can accept a pair of electrons while a base is a substance which can donate a pair of electrons.

Ex- **Acids**.

(i) All positive ions (cations) are Lewis's acids.

Ex - Cu^{2+}, Ag^{+}, Ca^{2+}, Fe^{3+} etc.

(ii) Molecules having electron deficient atoms.

Ex - $FeCl_2$, $ZnCl_2$, $AlCl_3$ etc.

(iii) Molecules having multiple bonds between 2 atoms.

Ex - CO_2 (O=C=O), SO_2 etc.

Bases.

(i) All anions are Lewis's bases (F^-, Cl^-, CO_3^{2-} etc)

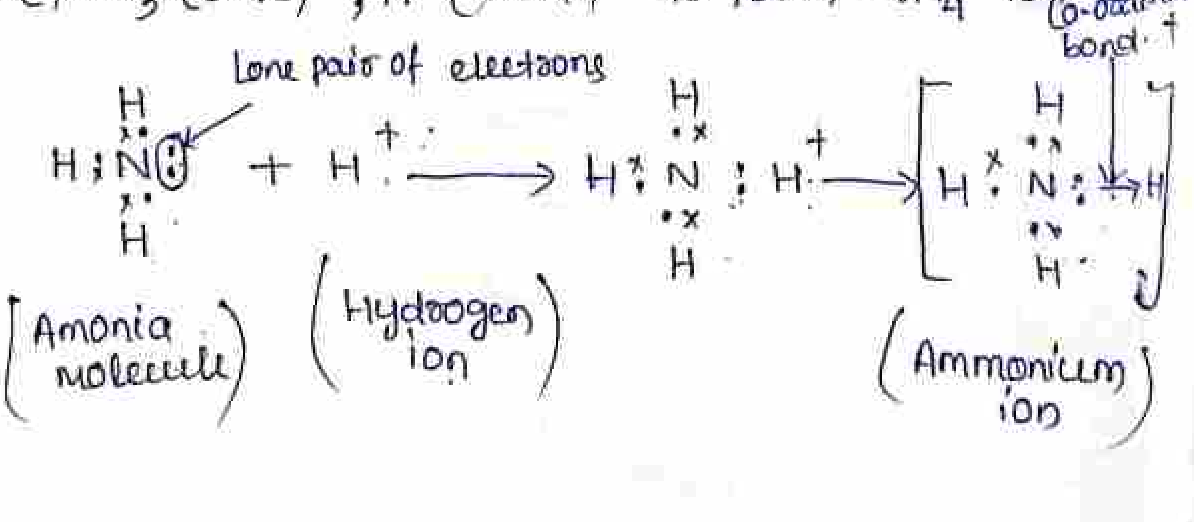
(ii) Neutral molecules having one or more lone pair of electrons.

Ex - $\ddot{N}H_3$, $H_2\ddot{O}:$, $R\ddot{N}H_2$ etc.

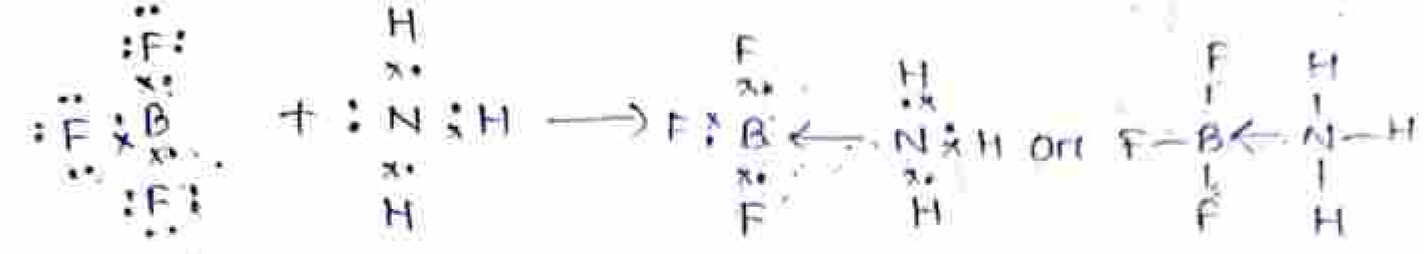
Acid - Base Reactions -

According to this theory, an acid reacts with a base to form co-ordinate bond.

Ex-(i) NH_3 (Base), H^+ (acid) to form NH_4^+ ion.



(ii) BF_3 (Acid) & NH_3 (Base).



(Acid) (Base)

All Bronsted lowry bases are Lewis bases but all acids may not be.

Limitations of Lewis Theory -

(i) It fails to explain reaction between some acids & bases where no co-ordinate bond is formed.

(ii) It fails to explain the acidic nature of some acids like HCl, HNO_3, H_2SO_4 etc which can not accept electrons.

(iii) It fails to explain the basic nature of some bases like $NaOH$, KOH etc which can not donate electrons.

(iv) Acid - Base reactions are fast, but the formation of a dative bond is a slow process.

Salt

It is defined as, salt is a crystalline compound formed by the complete neutralisation of acid & base.

Types of salts - salts are mainly 6 types.

a. Normal salt - These are the salts which are formed from strong acids & strong bases.

Ex - NaCl (sodium chloride)
KCl (potassium chloride)
K_2SO_4 (potassium sulphate)
Na_2SO_4 (sodium sulphate)

b. Acidic salt - Acidic salts are formed by the neutralisation of polybasic acids. These types of salts ~~are obtained~~ contain one or more Hydrogen atoms.

Ex - $NaHCO_3$ (Sodium bicarbonate)
$NaHSO_4$ (sodium bi sulphate)

c. Basic salt - Basic salts are formed by the neutralisation of polyacid bases. These types of salts contain one or more hydroxyl groups.

Ex - Mg(OH)Cl (Magnessium hydroxide chloride)
Zn(OH)Cl (Zinc hydroxide chloride)

d. Double salt - These are formed by the combinat of 2 simples salts. These are stable in Solid State

Ex - $K_2SO_4 \cdot Al_2(SO_4)_3 24H_2O \rightarrow$ Aleum
$KCl \cdot MgCl_2 \cdot 6H_2O \rightarrow$ Carnalite

e. Complex salt - These are formed by the combination of 2 simple salts. These are stable in solid & liquid state.

Ex - $K_4[Fe(CN)_6] \rightarrow$ (potassium ferrocianide)
$[Cu(NH_3)_4]SO_4 \rightarrow$ Tetraamine copper sulphate

f. Mixed salt - These are the salts which furnish more than one cation or more than one anion when dissolves in water.

Ex - $CaOCl_2 \rightarrow$ calcium oxychloride
$NaKSO_4 \rightarrow$ potassium sodium sulphate

Neutralisation of acid & base -

→ When an aq sol^n of an acid is added to an aq sol^n of a base, a chemical reaction occurs. resulting salt & water.

→ This process is called acid - base neutralisation.

$$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O$$

(i) A strong acid reacts with a strong base in aq sol^n solution is neutral.

EX - HNO_3 (acid) & KOH (base)

$$H^+(aq) + NO_3^-(aq) + K^+(aq) + OH^-(aq) \longrightarrow K^+(aq) + NO_3^-(aq) + H_2O$$

(ii) A strong acid reacts with a weak base. sol^n is acidic.

EX - HCl (acid) & NH_4OH (base) $NH_4Cl(aq)$

$$H^+(aq) + Cl^-(aq) + NH_4^+(aq) + OH^-(aq) \longrightarrow NH_4^+(aq) + Cl^-(aq) + H_2O$$

(iii) A weak acid reacts with a strong base. The sol^n is basic.

EX - CH_3COOH (acid) & NaOH (base)

$$H^+(aq) + CH_3COO^-(aq) + Na^+(aq) + OH^-(aq) \longrightarrow Na^+(aq) + CH_3COO^-(aq) + H_2O$$

(iv) A weak acid reacts with a weak base. The sol^n depends upon on the H^+ & OH^- ions.

EX - CH_3COOH (Acid) & NH_4OH (Base)

$$H^+(aq) + CH_3COO^-(aq) + NH_4^+(aq) + OH^-(aq) \longrightarrow CH_3COO^-(aq) + NH_4^+(aq) + H_2O$$

chapter-4 SOLUTIONS

Defination of Molecular Mass or Molecular weight.

Molecular weight of a substance is calculated by adding the atomic weights of the atoms present in that molecule.

unit - AMU (Atomic mass unit)

EX- NaCl - $1 \times Na + 1 \times Cl$

$= 23 + 35.5 = 58.5$

H_2SO_4 - $2 \times (H) + 1 \times (S) + 4 \times (O)$

$(2 \times 1) + (1 \times 32) + (4 \times 16) = 98$

NaOH - $(1 \times Na) + (1 \times O) + (1 \times H)$

$(1 \times 23) + (1 \times 16) + (1 \times 1) = 40$

CH_3COOH - $(C \times 2) + (2 \times O) + (4 \times H)$

$(2 \times 12) + (2 \times 16) + (4 \times 1) = 60$

H_2O - $(2 \times H) + (1 \times O)$

$(2 \times 1) + (1 \times 16) = 18$

CO_2 - $(1 \times C) + (2 \times O)$

$(1 \times 12) + (2 \times 16) = 44$

NH_3 - $(1 \times N) + (3 \times H)$

$= (1 \times 14) + (3 \times 1) = 17$

$Ca(OH)_2$ - $(1 \times Ca) + (2 \times O) + (2 \times H)$

$(1 \times 40) + (2 \times 16) + (2 \times 1)$

$= 74$

Equivalent Mass -(or) Equivalent weight -

Eq. Mass of an Acid -

The eq. mass of an acid is equal to the molecular mass of the acid divided by the basicity.

$$\text{Eq. Mass of an acid} = \frac{\text{Molecular Mass}}{\text{Basicity}}$$

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

Basicity - 1

Mol. Mass of HCl = 36.5

Eq. mass of $HCl = \frac{36.5}{1} = 36.5$ amu

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

Basicity - 2

Mol. Mass of H_2SO_4 = 98

Eq. Mass of $H_2SO_4 = \frac{98}{2} = 49$ amu.

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

Basicity - 1

Mol. Mass of HNO_3 = 63

Eq. Mass of $HNO_3 = \frac{63}{1} = 63$ amu.

Eq. Mass of a base -

The eq. mass of a base is equal to the molecular mass of the base divided by the acidity.

$$\text{Eq. Mass of a base} = \frac{\text{Molecular mass}}{\text{Acidity}}$$

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

Acidity - 1

Mole. Mass of NaOH = 40

Eq. Mass of NaOH = $\frac{40}{1}$ = 40 amu

KOH – potassium Hydroxide

$KOH \rightarrow K^+ + OH^-$

Acidity = 1

Molecular Mass of KOH = 56

Eq. Mass of KOH = $\frac{56}{1}$ = 56 amu

$Mg(OH)_2$ 24 32 2 / 58/2 = 29

NH_4OH: 14 + 4 + 1 + 16 = 35

$Ca(OH)_2$ –

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

Acidity = 1

Mol. Mass of $Ca(OH)_2$ = 74

Eq. Mass of $Ca(OH)_2$ = $\frac{74}{2}$ = 37 amu

Eq. Mass of Salt –

The eq. Mass of a salt is equal to the Molecular weight of the salt divided by the ~~to~~ total number of +ve or –ve charges (Valency)

$$\text{Eq. Mass of Salt} = \frac{\text{Mol. Mass}}{\text{Valency}}$$

Na_2SO_4: 46 + 32 + 64 = 142; $\frac{142}{2}$ = 71

Ex – **NaCl** –

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

Valency = 1

Mol. Mass of NaCl = 58.5

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

$NaHCO_3$ –

$NaHCO_3 \longrightarrow Na^+ + HCO_3^-$

Valency = 1

Mol. Mass of $NaHCO_3$ = 84

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

Na_2CO_3 – $Na_2CO_3 \rightarrow 2Na^+ + CO_3^{2-}$

Valency = 2

Mol. Mass of Na_2CO_3 = 106

Eq. Mass of Na_2CO_3 = $\frac{106}{2}$ = 53 amu.

MOLARITY -(M) -

Molarity is the number of moles of the solute present per 1 ltr of the solution.

It is denoted by the letter 'M'.

$$\text{Molarity (M)} = \frac{\text{Mass of solute}}{\text{Molecular Mass} \times \text{volume}} \times 1000$$

Qn.:- 2.5 gm of H_2SO_4 is dissolved in 400 ml solⁿ. Find M.

A!-

Mass of solute = 2.5 gm

volume = 400 ml

Mol. mass of H_2SO_4 = 98

$$\text{Molarity } M = \frac{2.5}{98 \times 400} \times 1000 = \frac{12.5}{49 \times 4}$$

$$= 0.063 \text{ M}$$

Normality -(N) -

It is defined as the number of gram equivalents of the solute present per 1 ltr of the solution.

$$\text{Normality (N)} = \frac{\text{Mass of solute}}{\text{Equivalent mass} \times \text{Volume}} \times 1000$$

Qn:- Calculate the Normality of Sodium carbonate solution, 2.62 g of which are dissolved in 600 ml solⁿ. ?

Solute = Na_2CO_3

Mass of solute = 2.62 gm

volume = 600 ml

Mol. mass of Na_2CO_3 = 106

Eq. mass of Na_2CO_3 = $\frac{106}{2}$ = 53

$$\text{Normality (N)} = \frac{\text{Mass of solute}}{\text{Volume} \times \text{eq. mass}} \times 1000$$

$$= \frac{2.62}{600 \times 53} \times 1000 = \frac{2620}{31800}$$

$$= 0.082\ N$$

Molality (m) — It is the number of moles of solute present in 1000 gms of solvent.

$$\text{Molality (m)} = \frac{\text{Mass of solute} \times 1000}{\text{Molecular mass} \times \text{Mass of solvent}}$$

Qn:- If 13.8 gms of K_2CO_3 is present in one ltr soln having density 1.09 gm/ml. Calculate M, N & m.?

A:-

Solute = K_2CO_3

Mass of solute = 13.8 gm

Volume = 1 ltr = 1000 ml

Density = 1.09 gm/ml.

$$\text{Molarity } M = \frac{13.8}{138 \times 1000} \times 1000 = 0.1\ M$$

$$\text{Normality } N = \frac{13.8}{69 \times 1000} \times 1000 = 0.2\ N$$

$$\text{Molality } m = \frac{13.8}{138 \times 1076.2} \times 1000 = \frac{13800}{148515.6}$$

$$= 0.09\ m$$

$1000 \times 1.09 = 1090 - 13.8 = 1076.2$ = Mass of solvent

pH - (power to Hydrogen) -

pH of a solution is defined as the negative logarithm of Hydrogen ion concentration.

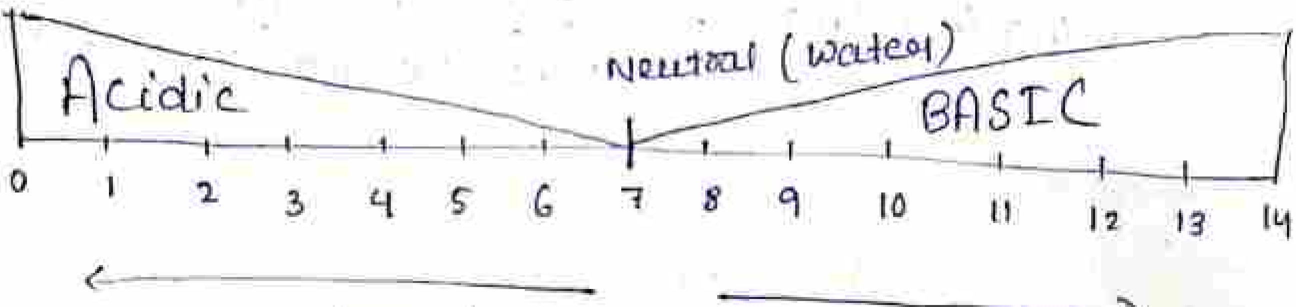
$$pH = -\log[H^+]$$

pH of pure water $= -\log[10^{-7}] = 7$ (Neutral)

In acidic solutions, $pH = -\log[10^{-6}] = 6$

In basic solutions, $pH = -\log[10^{-8}] = 8$

pH scale.



Increasing in acidic character

Increasing in basic character.

- pH = 7, the solution is neutral.
  pH < 7, the solution is acidic.
  pH > 7, the solution is basic.

In Acidic

(i) solutions having pH between 0 to 2 are strong acid
(ii) solutions having pH between 2 to 4 are moderate acids.
(iii) solutions having pH between 4 to 7 are weak acids.

similarly in basic -

(i) solutions having pH between 7 to 10 are weak base
(ii) solutions having pH between 10 to 12 are moderate base
(iii) solutions having pH between 12 to 14 are strong base.

concentration of $[H^+]$ usually varies from 1M to 10^{-14}M at 22°C in aqueous solutions.

∴ The pH values vary from 0 to 14.

Importance of pH in different industries.

1. In sugar Industry-

(i) The pH value of the sugar cane juice should be nearly 7. i.e., it should be neutral.

(ii) If the pH value of sugar cane juice becomes less than 7, the sucrose in the juice is hydrolysed in to glucose & fructose.

2. In paper industry-

(i) paper is used in every aspect of our life. From newspapers, books, magazines, printing, writing papers to cardboard boxes & bags, paper napkins, etc.

(ii) The most important use of paper is writing. The quality of paper of printing depends up on Cobb. Cobb control is nothing but the control of quality of binding by any source such as ink,

(iii) Cobb variation is minimized by maintaining pH of the pulp range 5-6.

3. In Textile industry -

(i) In all textile process aq. sol^{n}s are used to balance the pH sol^n.

(ii) The amount of chemicals required is direct related to pH.

(iii) The solubility of Substances, such as dyes & impurities, vary with pH.

Qn – 2.45 gm of H_2SO_4 is present in 250 ml solⁿ. Calculate pH.?

Ans –

Solute = H_2SO_4

Mass of solute = 2.45 gm

volume = 250 ml

Mol. mass of H_2SO_4 = 98

$$M = \frac{2.45}{98 \times 250} \times 1000$$

$$= 0.1\ M$$

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

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

$$= -\log [2 \times 0.1]$$

$$= -[\log 2 + \log 0.1] = 0.6990$$

$$\therefore pH = 0.6990$$

Acids

Acid	Formula	Basicity	Mol. Mass	Eq. Mass
Hydrochloric acid	HCl	1	36.5	$\frac{36.5}{1} = 36.5$
Acetic acid	CH_3COOH	1	60	$\frac{60}{1} = 60$
Sulphuric acid	H_2SO_4	2	98	$\frac{98}{2} = 49$
Nitric acid	HNO_3	1	63	$\frac{63}{1} = 63$
Oxalic acid	COOH | COOH	2	90	$\frac{90}{2} = 45$
phosphoric acid	H_3PO_4	3	98	$\frac{98}{3} = 32.66$

Bases

Base	Formula	Acidity	Mol. Mass	Eq. Mass
Sodium hydroxide	$NaOH$	1	40	$\frac{40}{1} = 40$
potassium hydroxide	KOH	1	56	$\frac{56}{1} = 56$
Calcium hydroxide	$Ca(OH)_2$	2	74	$\frac{74}{2} = 37$
Aluminium hydroxide	$Al(OH)_3$	3	78	$\frac{78}{3} = 26$
Ammonium hydroxide	NH_4OH	1	35	$\frac{35}{1} = 35$
	$Mg(OH)_2$		58	29

Caustic soda = Sodium hydroxide = $NaOH$

$$\begin{array}{r} 24 \\ 32 \\ 2 \\ \hline 58 \end{array}$$

Baking soda = Sodium bicarbonate = $NaHCO_3$

Washing soda or soda ash = Sodium Carbonate = Na_2CO_3