Some Basic Concepts of Chemistry

Chemistry :- The branch of science that deals with the studies of the preparation, properties, structure and reactions of material substances is called chemistry.

Some facts that tells about chemistry in Ancient India :-

- In India, chemistry was called Rasayan Shastra, Rastantra, Ras Kriya or Rasvidya.
- Rigveda, describes tanning of leather and dying of cotton.
- Kautilya's Arthashastra describes the production of salt from sea.
- Sushruta Samhita explains importance of Alkalies.
- Charaka Samhita maintioned Indians who Knew how to prepare sulphuric acid, nitric acid, etc.
  It is the oldest Ayurvedic epic of India.
- Rasopanishada describes the preparation of gunpowder mixture.
- Chakrapani discovered mercury sulphide.
- Varahmihir's Brihat Samhita informs preparation of glutinous material to be applied on walls of house & temples.

Nature of Matter

Matter:- Anything which has mass and occupies space.

States of Matter

(i) Solids have definite shape and definite volume.
(ii) Liquids have definite volume but do not have definite shape.
(iii) Gases have neither fixed volume nor fixed shape.

- Matter
  - Mixtures
    - Homogenous
    - Heterogenous
  - Pure Substances
    - Elements
    - Compounds

Pure Substance - All constituent particles of a substance are same in chemical nature.

Mixtures - Contains particles of two or more pure substances.

Homogenous - Components mix uniformly throughout.

Heterogenous - Composition is not uniform.

Elements - Consists of only one type of atoms.

Compound - When two or more atoms of different elements combine together in a definite ratio, the molecules of compound is obtained.

Physical and chemical properties of Matter

- Physical Properties can be measured or observed without changing the identity or the composition of substance.
  e.g. colour, odour, melting point, boiling point, density, etc.

- Chemical Properties can be observed only through performing a chemical reaction.
  e.g. composition, combustibility, reactivity, acidity or basicity, etc.

Measurement of Physical Properties

Earlier, two different system of measurement, i.e. English System and the Metric System were used.

Metric → Developed in France, was based on decimal system.

The International System of Units (SI)

- It was established by the 11th General Conference on Weights and Measures (CGPM from Conference Generale des Poids et Measures).

- The CGPM is an inter-governmental treaty organisation created by a diplomatic treaty known as Metre Convection, which was signed in Paris in 1875.

> - India has a National Metrology Institute (NMI), which maintains standards of measurements.
> - This responsibility has been given to the National Physical Laboratory (NPL), New Delhi.

The SI system has seven base units.

Base Physical Quantity	Symbol for Quantity	Name of SI unit	Symbol for SI unit
Length	l	metre	m
Mass	m	Kilogram	Kg
Time	t	second	s
Electric current	I	Ampere	A
Thermodynamic temperature	T	Kelvin	K
Amount of substance	n	mole	mol
Luminous intensity	I_v	candela	cd

Mass and Weight

- Mass of a substance is the amount of matter present in it.
- Mass is always constant.
- Mass of a substance is determined by analytical balance.
- SI unit is Kilogram (Kg).

▪ Weight is the force exerted by gravity on an object.

Volume

• Volume is the amount of space occupied by a substance. It has unit of $[length]^3$ or $(m)^3$.

$1 L = 1000 mL$

$1000 cm^3 = 1 dm^3$

Density

- Density of a substance is its amount of mass per unit volume.
- Density tells how closely the particles of a substance are packed

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

- SI unit of density = Kg/m^3.

Temperature

- SI unit of Temperature is Kelvin (K).
- There are three common sales to measure temperature, °C (degree celcius), °F (degree Fahren heit), K (Kelvin).

°C: from 0° to 100°
°F: b/w 32° to 212°

- Negative values are possible in Celcius scale but not in Kelvin

Relationship b/w Fahrenheit and Celcius

$$°F = \frac{9}{5}(°C) + 32$$

Relationship b/w Kelvin and celcius

$$K = °C + 273.15$$

Scientific Notation

- Scientific Notation is the exponential notation in which any number can be represented in the form $N \times 10^n$, where n is an exponent having +ve or -ve values and N is a digit term (b/w 1.000 - 9.999).

e.g. $232.508 = 2.32508 \times 10^2$
(Decimal is removed to left)

$0.0016 = 1.6 \times 10^{-4}$
(Decimal is moved to right)

Significant Figures

Significant Figures are meaningful digits which are known with certainity plus one which is estimated or uncertain

e.g. In 11.2 mL,
11 = certain
2 = uncertain

Rules for determining significant figures

- All non-zero digits are significant.
  e.g. in 485, there are 3 significant figures.
  but in 0.85, there are 2 significant fig.

2. Zeros preceding to first non-zero digit are not significant.
e.g. 0.0052 has two significant figures.

3. Zeros between two non-zero digit are significant.
e.g. 2.005 has four significant figures.

4. Zeros at the end or right of a number are significant, provided they are on the right side of decimal point.
e.g. 0.200g has three significant figure.
100 has only 1 significant figure.

5. Counting number of object - e.g- 2 bats or 2 balls, have infinite significant figures as these are exact no. and can represented by writing infinite no. of zeroes after placing a decimal i.e. 2 = 2.00 - - - .

Some points has to keep in mind while rounding off the numbers.

1. If the rightmost digit to be removed is more than 5, the preceding number is increased by one.
e.g 1.386 ⟶ 1.39

2. If the rightmost digit to be removed is less than 5, the preceding number in not changed.
e.g. 4.334 ⟶ 4.33.

3. If the right most digit to be removed is 5, then the preceding number is not changed if it is even no. but it is increased by one if it is odd number.
e.g. 6.35 ⟶ 6.4
6.25 ⟶ 6.2

Dimensional Analysis

While calculating, there is a need to convert units from one system to the other. The method used to accomplish this is called factor label method or unit factor method or dimensional analysis.

Laws of Chemical Combinations

1. Law of Conservation of Mass

- Given by Antoine Lavoisier in 1789.
- It states that "Matter can neither be created nor destroyed."
- Mass of Reactant = Mass of Product

Ques 1.5g of C_2H_6 on complete combustion give 4.4g of CO_2 and 2.7 g of H_2O. Show that it follows the law of conservation of mass.

Ans Molar mass of $C_2H_6 = 2\times12 + 1\times6 = 24+6 = 30g$

$n = \frac{1.5}{30} = \frac{1}{20}$ or 0.05 mole

2 mole of C_2H_6 require 7 mole of O_2

0.05 mole require $\frac{7}{2} \times 0.05$ mole of O_2

$\Rightarrow \frac{7}{2} \times \frac{1}{20} = \frac{7}{40}$ mol of O_2

$n = \frac{mass}{Molar\ mass}$

$\frac{7}{40} = \frac{mass}{32} \Rightarrow \boxed{mass = 5.6g}$

According to Law of conservation of mass:—

$$1.5 + 5.6 = 4.4 + 2.7$$

$$7.1 = 7.1$$ Hence, proved.

Law of Definite Proportions

- Given by Joseph Proust
- He stated that "a given compound always contains exactly the same proportion of elements by weight, whatever the source from where it is obtained".

e.g Cupric carbonate

	% of Cu	% of C	% of O
Natural	51.35	9.74	38.91
Synthetic	51.35	9.74	38.91

Ques 0.243 g of Mg on burning with oxygen yield 0.4030 g of MgO. In another experiment, 0.182 g of Mg burn with O_2 and give 0.302 g of MgO. Prove that this law follow law of definite Composition.

Ans In experiment I, Mg = 0.243 g

MgO = 0.4030 g

O_2 = 0.4030 − 0.243 = 0.160 g

$$M:O \Rightarrow \frac{0.243}{0.160} = 1.51 \text{ (approx)}$$

In exp. II, Mg = 0.182 g

MgO = 0.302 g

O_2 = 0.302 − 0.182 = 0.120 g

$$M:O \Rightarrow \frac{0.182}{0.120} = 1.51 \text{ (approx)}$$

Law of Multiple Proportions

- Given by John Dalton in 1803.
- "If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element, are in the ratio of small whole numbers."
- Example:—

⇒ $H_2 + O_2 \longrightarrow 2H_2O$
(2g) (16g) (18g)

⇒ $H_2 + O_2 \longrightarrow H_2O_2$ (Hydrogen Peroxide)
(2g) + (32g) (34g)

Diff. masses of O (16g & 32g) which combine with a fixed mass of hydrogen (2g) bear a simple ratio i.e 16 : 32 or 1 : 2.

Ques N_2O, NO, N_2O_3, NO_2, N_2O_5. Show that these compounds of same element follow Law of Multiple Proportion.

Ans

N	O
28	16
14	16
28	48
14	32
28	80

We have to make no. of one element fix

N	O
28	16
28	32
28	48
28	64
28	80

Diff. mass of O (16, 32, 48, 64, 80) which combines with N (28g) bears a simple ratio 1 : 2 : 3 : 4 : 5.

4. Gay Lussac's Law of Gaseous Volumes

- Given by Gay Lussac in 1808.
- "When gases react they do so in a simple ratio by volume, provided all gases are at same temperature and pressure."

Example

$2H_2 + 1O_2 \longrightarrow 2H_2O$ (g)

(2 Volume) (1 volume) (2 volume)

100 mL 50 mL 100 mL

H_2 (g) + Cl_2(g) $\longrightarrow$ 2HCl (g)

(1 volume) (1 vol.) (2 Volume)

20 mL 20 mL 40 mL

Ques When 100 mL of CH_4 burn it produces CO_2 and H_2O. Find volume of O_2 required and CO_2 produced.

Ans CH_4 (g) + $2O_2$ (g) $\longrightarrow$ CO_2 (g) + $2H_2O$ (l) + Heat

(1 volume) (2 volume) (1 vol.) (2 vol.)

100 mL 200 mL 100 mL

Ques 60 mL of N_2(g) combine with 60 mL of H_2 (g). Find the composition of resultant mixture.

Ans N_2 (g) + $3H_2$ (g) $\rightleftharpoons$ $2NH_3$ (g)

(1 vol.) (3 vol.) (2 vol.)

20 mL 60 mL 40 mL

3 volume = 60 mL

1 vol. = 20 mL

Ammonia (NH_3) = 40 mL

Nitrogen = 20 mL

Unreactive Nitrogen = 40 mL

5. **Avogadro's Law**

- Given by Amedo Avagadro in 1811.
- "Equal volumes of all gases at the same temperature and pressure should contain equal number of molecules."
- **Vol. of gas ∝ No. of Molecules**
- Example:—

100 mL of O_2 ⟶ Y molecules
100 mL of CH_4 ⟶ Y molecules
100 mL of CO_2 ⟶ Y molecules
10 mL of H_2 ⟶ $\frac{Y}{10}$ molecules

50 mL of CO_2 ⟶ $\frac{Y}{2}$ molecules.

https://studycart24.com

Dalton's Atomic Theory

- In 1808, Dalton published 'A New System of Chemical Phyilosphy' in which he proposed :—

1. Matter consists of indivisible atom.

2. All atoms of a given element have identical properties, including identical mass. Atoms of different elements have different mass.

3. Compounds are formed when atoms of different elements combine in fixed ratio.

4. Chemical reactions involve reorganisation of atoms. These are neither created nor destroyed in a chemical reaction.

Atomic Mass

- Atomic mass is the mass of an atom.

- The present system of atomic mass is based on C-12 as standard since 1961.

1 atomic mass unit (amu) = $\frac{1}{12}$th mass of C-12 atom

- At present, 'amu' has replaced by 'u' which is known as unified mass.

Molecular Mass

- Molecular mass is the sum of atomic masses of all elements present in the molecule.

- Example - Molecular mass of methane (CH_4) $= 12 \times 1 + 1 \times 4$
$= 12 + 4$
$= 16u$

Molecular mass of glucose ($C_6H_{12}O_6$) $= 6 \times 12 + 12 \times 1 + 6 \times 16$
$= 72 + 12 + 96$
$= 180u$

Formula Mass

- Formula mass of a substance is a sum of the atomic masses of all atoms in a formula unit of the compound.

- Same as molecular mass

- The only difference is that we use word formula unit for those substances whose constituent particles are ions.

e.g NaCl
formula unit mass $= 1 \times 23 + 1 \times 35.5$
$= 58.5u$

Mole Concept and Molar Masses

- Mole is a number which is used to count microscopic particles.
- Mole is the SI unit of the susbtance (7th base quantity)
- 1 mole contains exactly $6.02214076 \times 10^{23}$ elementary entities.
  ↳ (Avagadro Constant) (N_A)
- Molar mass in grams is numerically equal to atomic / molecular / formula mass in u.

e.g. Molecular mass of water = 18 u
Molar mass of water = 18 g.

$$n = \frac{\text{Given mass}}{\text{Molar mass}}$$

$$n = \frac{\text{molecules / atoms Given}}{6.022 \times 10^{23}}$$

$$n = \frac{\text{Volume Given (At STP)}}{22.4 \ (22.4 \, dm^3)}$$

Ques find no. of moles present in

i) 11.2 L of N_2 gas STP → $n = \frac{\text{Volume}}{22.4} = \frac{11.2}{22.2} = 0.5$ mol

ii) 16 g of CH_4 gas → $n = \frac{\text{Mass}}{\text{Molar mass}} = \frac{16}{16} = 1$ mol

iii) 12×10^{24} molecules of O_2 gas

→ $n = \frac{\text{no. of Particles}}{6.022 \times 10^{23}} = \frac{12 \times 10^{24}}{6 \times 10^{23}} = 20$ moles

Percentage Composition

$$\% \text{ composition} = \frac{\text{mass of that element in compound}}{\text{molar mass of compound}} \times 100$$

Example

Mass % of hydrogen in water $= \frac{2}{18} \times 100 = 11.1\%$

Empirical formula for Molecular Formula

- An empirical formula represents the simplest whole number ratio of various atoms present in a compound.
- Molecular formula shows exact no. of atoms in a compound.
- Example.

Ethane (C_2H_6) ⟶ (C_1H_3)

(Molecular formula) (Empirical formula)

Molecular Formula = n × empirical formula

Mol. Weight = n × Empirical weight

Ques A compound has molecular weight 90 and its empirical formula is CHO_2. find moluclalar formula.

Sol

Mol. wt = n × Emp. wt.

$$n = \frac{\text{Mol. wt}}{\text{Emp. wt}}$$

$CHO_2 = 12+1+32 = 45$

$$n = \frac{90}{45} = 2$$

Mol. formula = 2 × Emp. formula

$= 2 \times CH_1O_2$

$= C_2H_2O_4$

https://studycart24.com

Ques A compound has vapour density 45 and emp. formula CHO_2. find molecular formula.

Soln

$$\text{Mol. wt.} = 2 \times \text{Vapour Density}$$

$$\text{Mol. wt} = 2 \times 45 = 90$$

$$n = \frac{\text{mol. wt}}{\text{emp. wt}} = \frac{90}{45} = 2$$

Mol. formula = $C_2H_2O_4$.

Ques Find the mol. formula of a compound in which C = 40%, H = 6.7%, O = 53.3% and its molar mass is 60.

Soln

Element	%	At. wt.	mole (At. ratio)	Simplest ratio
C	40	12	$\frac{40}{12} = 3.33$	1
H	6.7	1	6.7	2
O	53.3	16	$\frac{53.3}{16} = 3.33$	1

Empirical form. = $C_1H_2O_1$

$$n = \frac{\text{mol. wt}}{\text{emp. wt}} = \frac{60}{30} = 2$$

Mol. formula = $2 \times CH_2O$
= $C_2H_4O_2$

Stoichiometry

Stoichiometry – Deals with calculation of masses of reactant and products.

$$\textcircled{1}CH_4(g) + \textcircled{2}O_2(g) \longrightarrow \textcircled{1}CO_2(g) + \textcircled{2}H_2O(g)$$

↓

Stoichiometric Coefficient (represent moles)

Ques If 16 g of Methane is burnt, find ① mass ~~② Volume~~ of CO_2 produced?

Sol^n

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

$$n(\text{methane}) = \frac{\text{Mass}}{\text{Molar mass}} = \frac{16}{16} = \underline{1 \text{ moles}}$$

⇒ 1 mole of CH_3 produces 1 mole of CO_2

$$n(\text{carbon dioxide}) = \frac{\text{mass}}{\text{molar mass}}$$

$$1 = \frac{x}{44}$$

$$\boxed{x = 44g}$$

Ques Find the volume of CO_2 produced when 50g of $CaCO_3$ is heated?

$$1\,CaCO_3 \xrightarrow{\Delta} 1\,CaO + 1\,CO_2$$

Sol^n

$$n(CaCO_3) = \frac{80}{100} = \frac{\cancel{2}}{2}$$

$$= \underline{0.5 \text{ moles}}$$

1 mole $CaCO_3$ → 1 mole CO_2

0.5 mole $CaCO_3$ → $\underline{0.5 \text{ mole } CO_2}$

$$\boxed{n = \frac{\text{Volume}}{22.4}}$$

$0.5 \times 22.4 = \text{Vol.}$

$$\boxed{\text{Vol.} = 11.2\,L}$$

Ques $2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

Find mass of CO_2 produced, when 5.8g Butane is burnt.

Sol^n

$n(\text{Butane}) = \frac{5.8}{58} = 0.1$ moles

2 moles of $C_4H_{10} \longrightarrow$ 8 mole of CO_2

0.1 mole of $C_4H_{10} \longrightarrow \frac{8}{2} \times \frac{0.1}{10}$ mole of CO_2

$\Rightarrow$ 0.4 moles of CO_2

$n(CO_2) = \frac{\text{Given Mass}}{\text{Molar mass}}$

$0.4 \times 44 = \text{mass}$

$\Rightarrow$ $\boxed{\text{mass} = 20.6g}$

Ques $CuCO_3 \xrightarrow{\Delta} CuO + CO_2$

Find mass of $CuCO_3$ required to produce 11.2L of CO_2 STP. $\left(n = \frac{\text{Volume}}{22.4\ L(STP)}\right)$

Sol^n

$n = \frac{11.2}{22.4} = 0.5$ moles

1 mole of $CuCO_3 \longrightarrow$ 1 mol. CO_2

0.5 mole " $\longrightarrow$ 0.5 mol. CO_2

$n(CO_2) = \frac{\text{mass}}{\text{molar mass}}$

$0.5 = \frac{\text{mass}}{124}$

$\boxed{\text{mass} = 62g}$

Ques $2Ca(NO_3)_2 \xrightarrow{\Delta} 2CaO + 4NO_2 + O_2$

Find mass of CaO produced when 5.6 L of NO_2 is produced (STP)?

Sol^n

$$n(NO_2) = \frac{\text{Volume}}{22.4\,L\,(STP)} = \frac{5.6}{22.4} = 0.25 \text{ moles}$$

4 mol. of NO_2 ⟶ 2 Mole of CaO

0.25 mol. of NO_2 ⟶ $\frac{2}{4} \times 0.25$ Mole of CaO

$$= \frac{1}{8} \text{ moles}$$

$$n(CaO) = \frac{\text{mass}}{\text{molar mass}}$$

$$\frac{1}{8} \times 56 = \text{mass}$$

$$\Rightarrow \boxed{\text{mass} = 7g}$$

Reactions in Solutions

The concentration of a solution, can be expressed in any of the following ways:-

1. weight by weight percentage (w/w %]
2. Volume by volume percentage [V/V%]
3. Weight by volume percentage [W/V %
4. ppM (Parts Per Million]
5. PPB [Parts Per Billion]
6. Mole fraction
7. Morality
8. Molality
9. Normality

1. Weight by Weight Percentage [W/W%]

e.g. A solution of NaCl in water is 5% (W/W%)
it means, 5g NaCl is present in 100g water.

$$(W/W\%) = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 100$$

Ques 10g sucrose is dissolved in 100 g of water find weight by weight%.

Sol^n
solute = 10 g sucrose
sol^n = 100 + 10 = 110g sol^n

$$[W/W\%] = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 100 = \frac{10}{110} \times 100 = \frac{100}{11} = 9.09\%$$

Ques 10 g of NaCl is present in 100 mL of solution, find (w/w %). If density of sol^n is 1.2 g/mL.

Sol^n

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$1.2 \times 100 = \text{Mass}$$

$$\Rightarrow \text{Mass} = 120g$$

$$(w/w\%) = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 100$$

$$= \frac{10}{120} \times 100$$

$$= \frac{100}{12} = 8.33\%$$

Ques A solution prepared by adding 2g of a substance A to 18g of water. Calculate mass percent of solute.

Sol^n

Mass of solute (A) = 2g

Mass of solution = 2g + 18g = 20g

$$\text{Mass percent of A} = \frac{\text{Mass of A}}{\text{Mass of sol}^n} \times 100$$

$$\Rightarrow \frac{2}{20} \times 100 = 10\%$$

2. Volume by Volume Percentage (V/V %)

e.g. A $HNO_3(aq)$ sol^n is 7% (V/V%)

7 mL of HNO_3 is present in 100 mL of sol^n

$$(V/V\%) = \frac{\text{Volume of solute}}{\text{Vol. of sol}^n} \times 100$$

3. Weight by Volume Percentage (W/V %)

A sugar solution is 3% (W/V %)

⇒ 3g of sugar is present in 100 mL of solⁿ

$$[W/V\%] = \frac{\text{Mass of solute}}{\text{Vol. of Sol}^n} \times 100$$

Ques A sugar solution is 10% (w/v), find (W/w) if density of solution is 1.25 g/mL.

Solⁿ 10 g sugar is present in 100 mL solⁿ

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$1.25 \times 100 = \text{Mass}$$

$$\Rightarrow \text{Mass} = 125\,g$$

$$(w/w\%) = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 100$$

$$= \frac{10}{125} \times 100 = \frac{2}{25} \times 100 = \frac{2 \times 4}{1}$$

$$= 8\%$$

Ques A sugar solution is 10% (W/W). Find (W/V%) if density is 1.2 g/mL.

Solⁿ 10 g sugar is present in 100 g solⁿ.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$1.2 = \frac{10}{\text{Volume}}$$

$$\text{Volume} = 8.33\% \text{ or } \frac{100}{12}$$

$$(w/v\%) = \frac{\text{Mass of solute}}{\text{Vol. of sol}^n} \times 100$$

$$= \frac{10}{\frac{100}{12}} \times 100$$

$$= 10 \times 12$$

$$= 120\%$$

Ques A solution of HNO_3 is 5% (w/w). Find the mass of HNO_3 present in 100 mL of solution [density of sol^n = 1.4 g/mL].

Sol^n

$5g\ HNO_3 \longrightarrow 100g$ solution

Density = $\frac{\text{Mass}}{\text{volume}}$

$1.4 \times 100 = $ Mass

$\Rightarrow$ Mass = 140g

$(W/W) = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 100$

$5 = \frac{x}{140} \times 100$

$x = 7g$

4. PPM (Part Per Million) = 10^6 part

$$\text{no. of PPM} = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 10^6$$

Ques O_2 is dissolved in water as 8×10^{-4} g of O_2 in 100 g of water. find concentration of O_2 is PPM.

Sol^n

$$\text{no. of PPM} = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 10^6$$

$$= \frac{8 \times 10^{-4}}{100} \times 10^6$$

$$= \frac{8 \times 10^2}{100}$$

$= 8$ PPM

Ques Sea water contains 53 PPM of Na_2CO_3. Find mass of Na_2CO_3 present in a glass of water (250 mL).

Sol^n

$$\text{no. of PPM} = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 10^6$$

$$53 = \frac{x}{250} \times 10^6$$

$$\frac{53 \times 25}{10^5} = x$$

$$\Rightarrow x = \frac{53 \times 25}{1000 \times 100} = \frac{53}{4 \times 10^3} = 13.25 \times 10^{-3}$$

5. PPB (Part Per Billion) = 10^9 part

NCl → 5 PPB

⇒ 5g NaCl is present in 10^9 g of sol^n

$$\text{no. of PPB} = \frac{\text{Mass of solute}}{\text{Mass of sol}^n} \times 10^9$$

6. **Mole Fraction**

It is the ratio of numbers of moles of a particular component to the total number of moles of the solution.

A → 1 mole ⇒ Mole fraction of A = $\frac{1}{4}$
B → 3 moles

Symbol for mole fraction ⇒ X_A (zeta) η_A (eta)

$A \longrightarrow n_A$ mol
$B \longrightarrow n_B$ mol
$C \longrightarrow n_C$ mol

$$X_C = \frac{n_C}{n_A + n_B + n_C}$$

$$X_A + X_B + X_C = 1$$

Ques It is given that NaOH is 40 g and H_2O is 54 g. find X_{NaOH} and X_{H_2O}.

Sol^n

NaOH = 23 + 16 + 1
= 40 g

$n_{NaOH} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{40}{40}$
= 1 mole

$H_2O = 2 \times 1 + 16$
= 18 g

$n_{H_2O} = \frac{54}{18}$
= 3 moles

$$X_{NaOH} = \frac{1}{4}$$ $$X_{H_2O} = \frac{3}{4}$$

Ques A solution has 46% (w/w) ethyle alcohol (C_2H_5OH) in water. find mole fraction of ethyle alcohol.

$C_2H_5OH = 46g$

Sol^n

Ethyle Alcohol = 46 g
Water = 100 - 46 = 54 g

$n_{C_2H_5OH} = \frac{46}{46} = 1$ mole

$n_{water} = \frac{54}{18} = 3$ moles

$$X_{C_2H_5OH} = \frac{1}{4}$$

7. Molarity

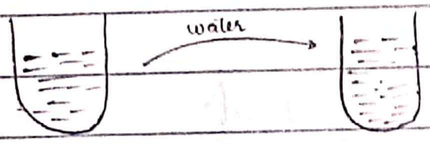
Molarity (M) – Number of moles of the solute present in 1 litre (L) of the solution.

1 M of NaOH – 1 mol of NaOH is present in 1 Litre of sol^n.

$$\text{Molarity (M)} = \frac{\text{No. of moles of solute}}{\text{Vol. of solution in litres}}$$

- Morality depends on temp.
  - Molar solution – $M = 1$ (1M)
  - Bi Molar – $M = 2$
  - Semi Molar – $M = 1/2$
  - Decimolar – $M = 10/10$
  - Centi Molar – $M = 1/100$

Molarity of Dilution



M_1, V_1 $\qquad$ M_2, V_2

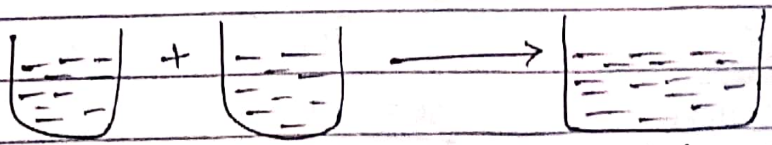
$M_1 = \frac{n}{V_1}$ $\qquad$ $M_2 = \frac{n}{V_2}$

$n = M_1 \times V_1$ — (I) $\qquad$ $n = M_2 \times V_2$ — (II)

from (I) and (II), we get

$$M_1 \times V_1 = M_2 \times V_2$$

Molarity of Mixture



M_1, V_1 $\qquad$ M_2, V_2 $\qquad$ $M, (V_1 + V_2)$

$$M = \frac{M_1V_1 + M_2V_2}{V_1 + V_2}$$

$M_1V_1 + M_2V_2 = M(V_1 + V_2)$

Ques Find molarity of :-

(I) 40g NaOH dissolved in 250 ml solution.

Sol^n

$n = \frac{\text{Given mass}}{\text{Molar Mass}}$

$n = \frac{40 g}{40 g}$

$\boxed{n = 1 \text{ mole}}$

$M = \frac{n \text{ (in solute)}}{V \text{ (in L)}}$

$\Rightarrow \frac{1}{\frac{250}{1000}} = 4M$

$1L = 1000 \text{ mL}$

$1L = 1000 \text{ cm}^3$

(II) 4.9 of H_2SO_4 present in 500 cm^3 solution.

Sol^n

$n = \frac{\text{Given mass}}{\text{Molar mass}}$

$H_2SO_4 \rightarrow 2 \times 1 + 1 \times 32 + 16 \times 4$

$\rightarrow 2 + 32 + 64$

$\Rightarrow 98g$

$n = \frac{4.9}{98}$

$\boxed{n = 1/20 \text{ moles}}$

$M = \frac{\frac{1}{20}}{\frac{500}{1000}} = \frac{1}{10} = 0.1 M$

(III) mass of Na_2CO_3 present in 100 mL of 3M solution
(Na = 23, C = 12, O = 16)

Sol^n

$M = \frac{n}{V \text{ (in L)}}$

$3 = \frac{n}{\frac{100}{1000}}$

$\boxed{n = 0.3 \text{ moles}}$

$n = \frac{\text{Given mass}}{\text{Molar mass}}$

$0.3 = \frac{x}{106}$

$\boxed{x = 31.8 g}$

(iv) 10% (w/w) (aq) solution of H_2SO_4. If density of sol^n is 1.1 g/mL

Sol^n 10 g of H_2SO_4 is present in 100 g of solution

~~(w/w%)~~ = ~~4~~

$$M = \frac{n}{V(\text{in L})} = \frac{\frac{\text{Given mass}}{\text{Molar mass}}}{\text{Vol (in L)}}$$

$$M = \frac{\frac{10}{98}}{\frac{100}{1.1 \times 1000 (L)}} = \frac{10 \times 11}{98} = \frac{55}{49}$$

$\frac{\text{Mass}}{\text{Density}}$ = ~~Densil~~ Vol.

$\frac{100}{1.1}$ = Volume

Volume = $\frac{100}{1.1}$

(V) If 120 g Urea (NH_2CONH_2) is dissolved in 1000 g water, find molarity of the solution. If density of solution is 1.12 g/mL. (N = 14, H = 1, C = 12, O = 16)

Sol^n Molar mass of NH_2CONH_2 = 60 g

$$n = \frac{\text{Given mass}}{\text{molar mass}}$$

$$n = \frac{120 g}{60 g}$$

n = 2 moles

$$M = \frac{\text{no. of moles in solute}}{\text{Vol. of } sol^n \text{ (in L)}}$$

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

M = 2 M

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

$$\Rightarrow \text{Volume} = \frac{\text{Mass}}{\text{Density}}$$

$$= \frac{1120 \times 100}{112}$$

Vol. = 1000 mL = 1 L

(vi) Find molarity of water in density is 1g/mL.

Sol^n Let us consider 100 mL of water is present.

$$\text{Mass of water} = 1 \times 100\,mL$$
$$= 100g$$

$$M = \frac{\frac{\text{Given mass}}{\text{Molar mass}}}{\text{Vol (mL)}} = \frac{\frac{100}{18}}{\frac{100}{1000}} = \frac{1000}{18} = 55.555M$$

Ques Find the mass of KOH present in 150 cm^3 of semi molar aq. solution. (K = 19)

Sol^n

$$M = \frac{\text{no. of moles in solute}}{\text{Vol. of solution in Litre}}$$

$$150\,cm^3 = \frac{150}{1000} = 3/20\,L$$

$$\frac{1}{2} = \frac{n}{3/20}$$

$$\Rightarrow \boxed{n = 3/40}$$

$$n = \frac{\text{Mass}}{\text{Molar mass}}$$

$$\frac{3}{40} = \frac{\text{Mass}}{36}$$

$$\text{Mass} = \frac{3}{40} \times 36$$

$$\boxed{\text{Mass} = 2.7g}$$

Molarity of ions.

Ques If 53g Na_2CO_3 is dissolved in 500 mL solution. Find Molarity of (i) Na_2CO_3 (ii) Na^+ (iii) CO_3^{2-}
(Na = 23)

Sol^n

$$500\ mL = \frac{1}{2}\ Litres$$

$$n = \frac{Mass}{Molar\ mass}$$

$$n = \frac{53}{106}$$

(i) $$M = \frac{\frac{53}{106}}{\frac{1}{2}} = \frac{\frac{1}{2}}{\frac{1}{2}} = 1M$$

(ii) $$Na_2CO_3 \rightleftharpoons Na_2^+ + CO_3^{2-}$$
(1 mole) (2 mole) (1 mole)

$Na^+ = 2M$

(iii) $CO_3^{2-} = 1M$

Molarity of Dilution

Ques 0.2 M, 100 ML of HNO_3 solution is diluted with 100 mL water, find new Molarity.

Sol^n

$M_1 = 0.2$, $V_1 = 100$ mL
$M_2 = x$, $V_2 = 200$ mL

$$M_1 \times V_1 = M_2 \times V_2$$

$$\frac{0.2 \times 100}{200} = M_2$$

$$\boxed{M_2 = 0.1\ M}$$

Ques If 0.2 M, 100 mL of HCl is mixed with 0.1 m, 300 mL HCl solution, find molarity of mixture.

Soln

$M_1 = 0.2$, $V_1 = 100$ mL

$M_2 = 0.1$, $V_2 = 300$ mL

$$M = \frac{M_1 \times V_1 + M_2 \times V_2}{V_1 + V_2}$$

$$M = \frac{0.2 \times 100 + 0.1 \times 300}{100 + 300}$$

$$= \frac{20 + 30}{400}$$

$$= \frac{50}{400}$$

$$\boxed{M = 1/8}$$

8. Molality

- No. of moles of solute present in 1 Kg of solvent.
- Denoted by 'm'.
- Does not change with temperature.

Molality of HCl is 3m ⇒ 3 moles of HCl is present in 1 Kg water (Solvent)

$$\boxed{m = \frac{\text{no. of moles of solute}}{\text{Mass of solvent in 1 Kg}}}$$

Ques Find molality of 20g of NaOH (40 g) dissolved in 100g solution.

Soln

$$m = \frac{n}{\text{mass of solvent (in Kg)}} = \frac{\frac{20}{40}}{\frac{80}{1000}} = \frac{25}{4} = 6.25\,m$$

Equivalent Weight and Gram

↳ The reactants have always same number of Gram Equivalent.

- No. of moles of Reactants can be different but no. of Gram equivalent will always same.

$$Eq.\ mass = \frac{Mol.\ wt}{x\ (valency\ factor)}$$

* For Acids, x = Basicity (No. of H^+ ions released)
* For Bases, x = Acidity (No. of OH^- ions released)
* For salts, x = Total positive charge of cation.

Ques Find eq. wt of ① H_2SO_4, ② NaOH and ③ Na_2CO_3

Sol^n^

1. $Eq.\ wt = \frac{Mol.\ wt}{x} = \frac{98}{2} = 49g$

2. $Eq.\ wt = \frac{Mol.\ wt}{x} = \frac{40}{1} = 40g$

3. $Eq.\ wt = \frac{Mol.\ wt}{x} = \frac{106}{2} = 53g$

⇒ Equivalent weight depends on Reaction.

$$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$$

x = 1

$$No.\ of\ gm\ equivalent = \frac{Mass}{Eq.\ wt}$$

$$No.\ of\ gm\ eq. = no.\ of\ moles \times x$$

Page No.
Date

Ques Find no. of gm eq. present in

① 0.4g of NaOH

No. of gm eq. = $\frac{Mass}{Eq. wt}$

= $\frac{Mass}{Mol. wt / x}$

= $\frac{0.4}{40}$

= 0.01g

② 0.98 g of H_2SO_4

Eq. wt = $\frac{Mol. wt}{x}$

=> $\frac{98}{2}$ = 49g

No. of gm eq. = $\frac{Mass}{Eq. wt}$ = $\frac{0.98}{49}$

= 0.02g

Ques Find no. of gm eq. present in 3 moles of H_2SO_4.

Soln

no. of gm eq. = no. of moles × X

= 3 × 2

= 6 g. eq.

Page No.
Date

9. Normality (N)

↳ No. of gm. eq. of solute which are present in 1L solⁿ.

$$N = \frac{\text{no. of gm.eq. of solute}}{\text{Vol. of sol}^n \text{ (in L)}}$$

Relationship b/w Normality & Molarity

$$N = \frac{\text{No. of gm eq. solute}}{\text{Vol. of sol}^n \text{ (in L)}} \quad \text{—(I)} \qquad M = \frac{\text{No. of moles of solute}}{\text{Vol. of sol}^n \text{ (in L)}} \quad \text{—(II)}$$

Divide (I) and (II), we get

$$\frac{N}{M} = \frac{\text{No. of gm. eq. solute}}{\text{No. of moles of solute}} = \frac{\frac{\text{Mass}}{\text{Eq. wt}}}{\frac{\text{Mass}}{\text{Mol. wt}}} \qquad \frac{\text{Mol. wt}}{= \text{Eq. wt}}$$

$$\frac{N}{M} = \frac{\text{Mol. wt}}{\frac{\text{Mol. wt}}{x}} = x$$

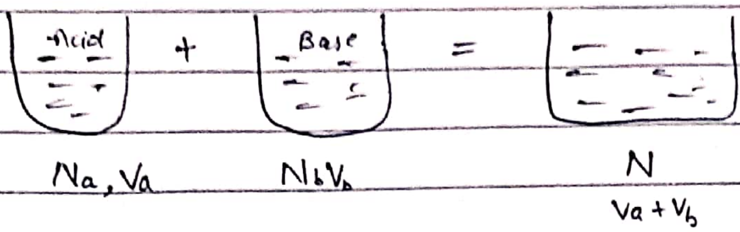
$$\Rightarrow \frac{N}{M} = x$$

$$N = M \times X$$

Normality of Mixtures
(Acid + Acid / Base + Base)

$$N = \frac{N_1V_1 + N_2V_2}{V_1 + V_2}$$

Acid + Base



If $N_aV_a > N_bV_b \longrightarrow$ Acidic Sol^n

$N_aV_b < N_aV_a \longrightarrow$ Basic Sol^n

$N_aV_a = N_aV_b \longrightarrow$ Neutral Sol^n

⇒ Acid Sol^n

$$N = \frac{N_aV_a - N_bV_b}{V_a + b_b}$$

⇒ Basic sol^n

$$N = \frac{N_bV_b - N_aV_a}{V_a + V_b}$$

⇒ Neutral Sol^n

$$N_aV_a = N_bV_b$$