

THEORY OF DILUTE SOLUTIONS

I. Mole percent of a component

$$= \frac{\text{Number of moles of that component}}{\text{Total number of moles in solution}} \times 100$$

II. Molarity of the solution

$$= \frac{\text{Number of moles of the solute}}{\text{Volume of the solution in litres}}$$

III. Molality of the solution

$$= \frac{\text{Number of moles of the solute}}{\text{Mass of the solvent in kg}}$$

IV. Formality of the solution

$$= \frac{\text{Number of formula masses of the solute}}{\text{Volume of the solution in litres}}$$



V. Normality of the solution

$$= \frac{\text{Number of gram equivalents of the solute}}{\text{Volume of the solution in litres}}$$

$$\text{VI. Normality} = \text{Molarity} \times \frac{\text{Molar mass}}{\text{Equivalent mass}}$$

$$\text{VII. Normality (for acids)} = \text{Molarity} \times \text{Basicity}$$

$$\text{VIII. Normality (for bases)} = \text{Molarity} \times \text{Acidity}$$

Types of Solutions

| S.No. | Physical state of | | | Examples |
|-------|-------------------|---------|----------|--|
| | Solute | Solvent | Solution | |
| I | Solid | Solid | Solid | Alloys like steel etc. |
| II | Liquid | Solid | Solid | Mercury in zinc or gold (amalgams) etc. |
| III. | Gas | Solid | Solid | Hydrogen in palladium etc. |
| IV. | Solid | Liquid | Liquid | Sugar in water, salt in water etc. |
| V. | Liquid | Liquid | Liquid | Alcohol in water, benzene in toluene etc. |
| VI. | Gas | Liquid | Liquid | Oxygen in water, CO ₂ in water etc. |
| VII. | Solid | Gas | Gas | Dust particles in air, iodine in air etc. |
| VIII. | Liquid | Gas | Gas | Water in air (like humidity) etc. |
| IX. | Gas | Gas | Gas | Mixture of various gases, air etc. |



Solution, Solute and Solvent

A solution is a homogeneous mixture of two or more substances. A solution of two substances is called a binary solution. Its two components are called as solute and solvent.

A substance which is dissolved into another substance is called as **solute** and another substance which dissolves the solute into it is called as solvent. In sugar solution sugar is solute and water is **solvent**.

Solubility

The maximum amount of any solute that can be dissolved in 100 g of solvent at a particular temperature is called the solubility of that solute at particular temperature. Which depends upon

- (i) nature of solute
- (ii) nature of solvent
- (iii) temperature of the solution
- (iv) pressure (for gases)

1. Normality (N) = $\frac{w}{W} \times \frac{1000}{E}$; where, V in ml.



$$2. N = \frac{\text{gm. litre}^{-1}}{\text{Eq. wt}}$$

$$= \frac{\text{wt. of solute in gm./litre soln.}}{\text{Eq. wt. of solute}}$$

$$3. \text{Molarity (M)} = \frac{\text{gram. litre}^{-1}}{\text{Molecular wt.}}$$

$$4. M = \frac{w}{V} \times \frac{1000}{\text{Mol. wt.}}; \text{ where, } V \text{ in ml.}$$

$$5. V_1S_1 + V_2S_2 + V_3S_3 + \dots = V_m \times S_m.$$

For mixture containing all acids or alkalies.

$$6. \{V_1S_1 \text{ (acid one)} + V_2S_2 \text{ (acid two)} + \dots\} - V'S' \text{ (alkali one)} + V''S'' \text{ (alkali two)} + \dots = V_m S_m; \text{ For mixture containing acids and alkalies.}$$

7. Factor

$$= \frac{\text{wt. of the solute taken}}{\text{wt. of the solute required for desired strength}}$$

8. Actual Strength = Factor \times Approximate Strength.

- (a) For mono-basic acid (HCl) or mono-acidic base (KOH); Molarity (M) = Normality (N);
[\therefore Mol. wt. = Eq.wt.]
- (b) For di-basic acid (H_2SO_4) or di-acidic base [$Ca(OH)_2$];
 $M = 2(N)$; [\therefore Mol. wt. = $2 \times$ Eq. wt.]
- (c) For tri-basic acid (H_3SO_4) or tri-acidic base [$Al(OH)_3$]; $M = 3(N)$;
[\therefore Mol. wt. = $3 \times$ Eq. wt.]

Osmotic Pressure (P)

$$1. P = \frac{nRT}{V} = \frac{m}{M} \times \frac{RT}{V} = CRT$$

where, n = no. of moles of solute

T = temp. in $^{\circ}K$

V = volume in litres containing x gm mole of solute,

C = molar concentration of a solution

R = solution constant and is analogous to gas constant.

$$2. PV = RT; \text{ where } V = \text{vol. in litre containing 1 gm mole}$$

3. $\frac{P_1 V_1}{n_1 T_1} = \frac{P_2 V_2}{n_2 T_2}$ (in case of two solutions)

4. For two isotonic solutions at the same

temp., $\frac{V_1}{n_1} = \frac{V_2}{n_2}$

5. For two isotonic solutions, if $V_1 = V_2$ then $n_1 = n_2$ at the same temp.

6. In case of dissociation : $\frac{M_c}{M_o} = \frac{P_o}{P_c} = 1 +$

$(n - 1)\alpha$ where, α is degree of dissociation.

7. In case of association of molecules, $\frac{M_c}{M_o}$

$$= \frac{P_o}{P_c} = \left(\frac{n - 1}{n} \right) \alpha$$

where, o stands for observed or abnormal value and c stands for theoretical or calculated or normal value.



- In case of dissociation : Actual concentration = $\{1 + (n - 1)\alpha\} C$ and $P_c = \{1 + (n - 1)\alpha\} CRT$

Lowering of Vapour Pressure (ΔP)

1. Lowering of vapour pressure (ΔP) = $P - P_s$
where, P = V.P. of pure solvent and P_s = V.P. of solution.

$$2. \frac{\Delta P}{P} = \frac{P - P_s}{P} = \frac{n}{n + N};$$

$$\left[\frac{n}{n + N} = \text{mole fraction of the solute} \right]$$

$$3. \frac{\Delta P}{P} = \frac{P - P_s}{P} = \frac{m}{w} \times \frac{W}{M}$$

where, M = mol. wt. of solute

W = mol. wt. of solvent

m = wt. of solute in gm. and

w = wt. of solvent in gm.



$$\frac{\Delta P}{P} = \frac{P - P_s}{P} = \text{Relative lowering of V.P.}$$

Elevation in Boiling Point (B.P.) (ΔT_b)

1. $\Delta T_b = \text{B.P. of solution} - \text{B.P. of pure solvent}$
2. $\Delta T_b \propto C_m$ (Raoult's law)
where, C_m is the molal or molar concentration of solution.

$$3. \Delta T_b = \frac{K_b \times 10^3 \times w}{W \times M}$$

where w = mass of solute in gm.

W = mass of solvent in gm

M = mol. wt of solute and

K_b = molal elevation constant of a solute

$$4. K_b = \frac{RT^2}{10^3 \times L} = \frac{0.002T^2}{L}$$



where, L = Latent heat

T = Boiling point and

R = 2 cal $\text{s deg}^{-1} \text{mole}^{-1}$

$$5. M = \frac{K_b \times 10^3 \times w}{\Delta T_b \times W}$$

Depression in Freezing Point (ΔT_f)

1. $\Delta T_f = \text{F.P. of pure solvent} - \text{F.P. of solution}$

$$2. \Delta T_f = \frac{K_f \times 10^3 \times w}{W \times M}$$

$$3. K_f = \frac{0.002T^2}{L}$$

where, K_f is molal depression const. of a solvent and T is F.P.

$$4. \text{Mol. wt. (M)} = \frac{K_f \times 10^3 \times w}{W \times \Delta T_f}$$

$$5. \text{For same solution } \frac{\Delta T_b}{\Delta T_f} = \frac{K_b}{K_f}$$

