

SHIVALIK BEHROR
MEDICAL/IIT-JEE PRE-FOUNDATION
CLASS XII Appearing
(LESSON IInd) SOLUTIONS
SUBJECT- Chemistry

➤ **Brass:-** mixture of Copper (Cu) and Zinc (Zn)

➤ **German silver:-** Mixture of Cu+Zn+Ni

➤ **Bronze:-** Mixture of Cu + Sn

❖ 1 Part per million (PPM) of fluoride ions in water prevents tooth decay.

❖ 1.5 PPM Causes the tooth to become mottled.

❖ NaF is used in Rat poison.

➤ **Solutions:-**

Homogeneous mixture of two or more than two components.

The solution of two components is referred to as binary solution.



❖ In binary solutions, solvent is that is that component whose physical state is the same as that of the resulting solution while the other component is called solute.

Example:- 62% Aqueous salt solution

Solvent = water

Solute = Salt

❖ For binary solution in which both the components have the same physical state as that of solution, the **Excess** component is **solvent** & other one is solute.

❖ **Types of solution:-**

Types of solutions	Solute	Solvent	Example
Gaseous Solution	Gas	Gas	Mixture of oxygen and nitrogen gas
	Liquid	Gas	Chloroform mixed with nitrogen gas
	Solid	Gas	Camphor is nitrogen gas
Liquid Solution	Gas	Liquid	Oxygen dissolved in water
	Liquid	Liquid	Ethanol dissolved in water
	Solid	Liquid	Glucose dissolved in water.
Solid Solution	Gas	Solid	Solution of hydrogen in palladium
	Liquid	Solid	Amalgam of mercury with sodium

	Solid	Solid	Copper dissolved in gold.
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➤ Expressing concentration of solutions:-

(A) Qualitatively form of concentration:-

- (i) Dilute solution:- When very very small (less) amount of solute present in a solution as compare to solvent that type of solution is known as dilute solution.

$$\text{Amount of Solute} \ll \ll \ll \ll \text{Amount of solvent}$$

- (ii) Concentrated solution:- When less amount of solute or approximate equal amount of solute present in a solution as compare to solvent that type of solution is known as concentrated solution.

$$\text{Amount of Solute} \leq \text{Amount of solvent}$$

(B) Quantitatively form of concentration:-

- (i) Mass percentage (w/w%):- The mass of solute in gram present in 100gm of solution that is known as mass by mass percentage.

$$\text{Mass\% of component} = \frac{\text{Mass of the component in the solutions}}{\text{Total mass of the solution}} \times 100$$

$$\text{Mass\% of Solute} = \frac{\text{Mass of Solute}}{\text{Mass of Solution}} \times 100$$

$$\text{Mass\% of Solvent} = \frac{\text{Mass of Solvent}}{\text{Mass of Solution}} \times 100$$

Example:- 10% w/w aqueous glucose solution means 10 gram glucose in 100gm solution.

Special Note:- The concentration, term in which volume term is involved, depends upon temperature.

- (ii) Volume by volume percentage ($\frac{V}{V}\%$):- The volume of solute in ml present in 100ml of solution is called volume by volume percentage.

$$\text{Volume percentage of Solute} = \frac{\text{Volume of solute}}{\text{Volume of Solution}} \times 100$$

$$\text{Volume percentage of Solvent} = \frac{\text{Volume of Solvent}}{\text{Volume of Solution}} \times 100$$

Special Point:-

(1) Commercial bleaching solution contains 3.62 mass percentage of sodium hypochloride in water.

(2) A 35% ($\frac{V}{V}$) Solution of Ethylene glycol, an antifreeze, is used in cars for cooling the engine. At this concentration the antifreeze lowers the freezing point of water to 255.4k (-17.6⁰C)

(iii) **Mass by volume%** ($\frac{w}{V}$ %) The mass of solute in gm present in 100ml of solution is called mass by volume percentage.

$$\text{Mass by Volume \%} = \frac{\text{Mass of Solute}}{\text{Volume of Solution}} \times 100$$

Note:- It is commonly used in medicine and pharmacy.

NCERT 2.1 Calculate the mass percentage of benzene (C₆H₆) and carbon tetrachloride (CCl₄) if 22gm of benzene is dissolved in 122gm of carbon tetrachloride.

Solⁿ- To be given.

$$\text{Mass of solute (Benzene)} = 22\text{gm}$$

$$\text{Mass of Solvent (CCl}_4\text{)} = 122\text{gm}$$

$$\text{Mass Percentage of solute (Benzene)} = \frac{\text{Mass of Benzene}}{\text{Mass of Solution}} \times 100$$

$$= \frac{22}{22+122} \times 100 = \frac{2200}{144} = 15.28\%$$

Mass Percentage of Solvent (CCl₄)

$$= \frac{\text{mass of CCl}_4}{\text{mass of solution}} \times 100$$

$$= \frac{122}{22+122} \times 100 = \frac{122}{144} \times 100 = 84.73\%$$

(iv) **Parts per million (ppm):-**

Solute present in very- very small quantities

$$\text{PPM} = \frac{\text{amount of solute}}{\text{solution}} \times 10^6$$

Special Point:-

(1) The concentration of pollutants in water or atmosphere is often expressed in terms of $\mu\text{g ML}^{-1}$ or PPM.

(2) 1 litre = 1000gm.

(v) **Mole fraction (χ):-**

Mole fraction may be defined as the ratio of number of moles of one component of the total number of moles of all the components present in the solution.

Suppose Number of moles in solute = n

Number of moles in a solvent = N

$$\text{Mole fraction of solute} = \frac{n}{n+N}$$

$$\text{Mole fraction of solvent} = \frac{N}{n+N}$$

For a binary solution,

mole fraction of solute + mole fraction of solvent = 1

$$\text{For a component } 0 \leq \chi \leq 1$$

(vi) **Molarity:- (M):-** Number of moles of solute dissolved in one litre (or one cubic decimetre) of solution.

$$\text{Molarity} = \frac{\text{moles of solute}}{\text{Volume of solution in litre}}$$

$$M = \frac{\text{moles of solute}}{\text{molar mass of solute}} \times \frac{1}{\text{Volume of solution (litre)}}$$

$$M = \frac{\text{moles of solute}}{\text{molar mass of solute}} \times \frac{1000}{\text{Volume of solution (ml)}}$$

$$\text{Unit} = \text{Mole lit}^{-1} \text{ or mole dm}^{-3}$$

❖ It depends upon temperature. Increases in temperature will decrease molarity.

❖ If molarity is defined at fixed 0°C temperature, it is also known as **Demal unit**.

Example:- 1 Demal (D) means 1 mole solute in 1 lit. solution at 0°C

(vii) **Molality:- (m):** Number of moles of Solute dissolved in 1 kg (100gm) of solvent.

$$M = \frac{\text{moles of solute}}{\text{mass of solvent (kg)}}$$

$$M = \frac{\text{Mass of solute}}{\text{molar mass of solute}} \times \frac{1000}{\text{mass of solvent (gm)}}$$

$$\text{Unit} = \text{mole Kg}^{-1}$$

It is temperature independent term.

❖ **Special Point:-**

(1) Molarity of dilute solution

Before dilution after dilution

$$M_1V_1 = M_2V_2$$

(2) Molarity of mixing:-

$$M_1V_1 + M_2V_2 + M_3V_3 = M(V_1 + V_2 + V_3)$$

NCERT:-

Example:- 2.1 Calculate the mole fraction of ethylene glycol ($C_2H_6O_2$) in a solution containing 20% of $C_2H_6O_2$ by mass.

Solv:- 20% of $C_2H_6O_2$ by mass means

Mass of solute ($C_2H_6O_2$) = 20gm

Mass of solution = 100gm

Mass of solvent (H_2O) = 80gm

Molar mass of solute ($C_2H_6O_2$) = $12 \times 2 + 1 \times 6 + 16 \times 2$

$$= 24 + 6 + 32$$

$$= 62 \text{ gm mol}^{-1}$$

molar mass of solvent (H_2O) = $1 \times 2 + 16 = 18 \text{ gm mol}^{-1}$

$$\text{moles of solute } (C_2H_6O_2) = \frac{\text{mass of slute}}{\text{molar mass of solute}}$$

$$= \frac{20}{62} = 0.322 \text{ mol.}$$

$$\text{Moles of solvent } (H_2O) = \frac{\text{mass of solvent}}{\text{molar mass of solvent}}$$

$$= \frac{80}{18} = 4.444 \text{ mol.}$$

Mole fraction of ethylene glycol ($C_2H_6O_2$) =

$$X_{C_2H_6O_2} = \frac{\text{moles of } C_2H_6O_2}{\text{moles of } C_2H_6O_2 + \text{moles of water}}$$

$$X_{C_2H_6O_2} = \frac{0.322}{0.322+4.444} = \frac{0.322}{4.766} = 0.932$$

NCERT:-

Example:- 2.1 Calculate the molarity of a solution containing 5gm of NaOH in 450ml. solution.

Solv:- To be given M = ?

Mass of solute (NaOH) = 5gm

Volume of solution = 450 ml

Molar mass of solute (NaOH) = 23+16+1 = 40gm mol⁻¹

$$M = \frac{\text{mass of solute}}{\text{molar mass of solute}} \times \frac{1000}{\text{volume of solution (ml)}}$$

$$\begin{aligned} M &= \frac{5}{40} \times \frac{1000}{450} = \frac{50}{4 \times 45} \\ &= \frac{10}{4 \times 9} = \frac{10}{36} = 0.278M \\ &= 0.278 \text{ mol lit}^{-1} \\ &= 0.278 \text{ moldm}^{-3} \end{aligned}$$

NCERT:-

Example:- 2.3 Calculate molality of 2.5 gm of Ethanoic acid (CH_3COOH) in 75gm of benzene.

Solv:- To be given m = ?

mass of solute (CH_3COOH) = 2.5gm

Volume of solvent (Benzene) = 75gm

Molar mass of solute (CH_3COOH) = 12 x 2 + 1 x 4 + 16 x 2
= 24+4+32
= 60 gm mol⁻¹

$$\begin{aligned} m &= \frac{\text{mass of solute}}{\text{molar mass of solute}} \times \frac{1000}{\text{mass of solvent (gm)}} \\ &= \frac{2.5}{60} \times \frac{1000}{75} \end{aligned}$$

$$= \frac{25000}{60 \times 750} = \frac{250}{6 \times 75} = \frac{10}{6 \times 3}$$

$$= \frac{10}{18} = 0.556 \text{ mol Kg}^{-1}$$

$$= 0.556\text{m}$$

➤ **Solubility:-** Maximum amount of solute substance that can be dissolved in a specified amount of solvent at a specified temperature.

❖ Its depend upon the nature of solute and solvent, as well as temperature and pressure.

(A) **Solubility of a solid in a liquid:-**

Solute = solid

Solvent = liquid

Three type of solution.

(1) **Saturated solution:-** A Solution in which no more solute can be dissolved at some temperature and pressure is called saturated solution.

i.e. concentration of solute remains constant.

(2) **Unsaturated solution:-** Solution in which more solute can be dissolved at same temperature and pressure.

(3) **Super saturated solution:-** When more solute can be dissolved at higher temperature in a saturated solution, then the solution becomes super saturated.

➤ **Dissolution:-** When a solid solute is added to the solvent, some solute dissolves and its concentration increases in solution. This process is called dissolution.

➤ **Crystallization:-** Some solute particles collide with solvent particles in solution and get separated out. This process is called crystallization

➤ **Factor affecting of solubility of solid in liquid:-**

(1) **Nature of solute and solvent:-** Polar solute dissolves in polar solvent and non polar solute in non polar solvent.

Example:- NaCl and sugar dissolves readily in water and naphthalene and anthracene dissolves readily in benzene.

(2) **Effect of temperature:-** In general, if in a nearly saturated solution, the dissolution process is endothermic ($\Delta H_{sol} > 0$), the solubility should increase with rise in temperature. If it is exothermic ($\Delta H_{sol} < 0$), the solubility should decrease with rise in temperature.

(3) **Effect of pressure:-** Solid and liquids are highly **Incompressible**, so pressure does not have any significant effect on solubility of solids and liquids.

➤ **(B) Solubility of gas in liquid:-**

Solute = gas

Solvent = liquid

➤ **Factor affecting of solubility of gas in liquid:-**

(1) Nature of gas (2) Temperature (3) Pressure

(1) **Nature of gas:-** Generally, the gases which can be easily liquified are more soluble in common solvents. For CO₂ is more soluble than hydrogen or oxygen in water.

The gases which are capable of forming ions in aqueous solutions are much more soluble in water than other solvents.

Example:- HCl and NH₃ are highly soluble in water but not in organic solvents like Benzene in which they do not ionize.

(2) **Effect of temperature:-**

$$\text{Solubility} \propto \frac{1}{\text{Temp.}}$$

(3) **Effect of pressure:-**

Henry's Law:- The solubility of a gas in a liquid is directly proportional to the pressure of the gas over the solution at a definite temperature.

❖ "The partial pressure of the gas in Vapour phase (P) is proportional to the mole fraction of the gas (χ) in the solution.

$$P \propto \chi$$

$$P = K_H \chi$$

K_H = Henry's Law constant.

K_H depends upon nature of gas

$$K_H \propto \frac{1}{\text{Solubility}}$$

➤ **Special Point:-** K_H values for both N₂ and O₂ increase with increase of temperature indicating that the solubility of gases increase with decrease of temperature. It is due to

this reason that Aquatic species are more comfortable in cold waters rather than in warm waters.

➤ Most gases obey Henry's Law provided:-

- (1) Pressure is not too high.
- (2) Temperature is not too low
- (3) Gas is not highly soluble and does not chemically react with solvent.

➤ Application of Henry's Law :-

(1) To increase the solubility of CO₂ in soft drinks and soda water, the bottle is sealed under high pressure.

(2) At high altitudes the partial pressure of oxygen is less than that at the ground level. This leads to low concentrations of oxygen in the blood and tissues of people living at high altitudes or climbers. Low blood oxygen causes climbers to become weak and unable to think clearly, symptoms of a condition known as **anoxia**.

(3) Scuba divers must cope with high concentration of dissolved gases while breathing air at high pressure underwater. Increased pressure increases the solubility of atmospheric gases in blood. When the divers come towards surface, the pressure gradually decreases. This releases the dissolved gases and leads to the formation of bubbles of nitrogen in the blood. This blocks capillaries and creates a medical condition known as **bends**. Which are painful and dangerous to life. To avoid bends as well as, the toxic effects of high concentrations of nitrogen in the blood, the tanks used by scuba divers are filled with air diluted with helium.

(11.7% Helium + 56.2% nitrogen and 32.1 % oxygen)

➤ **Vapour pressure** :- it is the pressure exerted by vapour on the surface layer of liquid at equilibrium between vapour and liquid.

➤ **Raoult's law, for a solution of volatile liquids** :- The partial vapour pressure of each component is directly proportional to its mole fraction (in the solution)

For component A

$$P_A \propto \chi_A$$

$$P_A = P_A^0 \chi_A$$

P_A^0 = Vapour pressure of pure component A

For component B

$$P_B \propto \chi_B$$

$$P_B = P_B^0 \chi_B$$

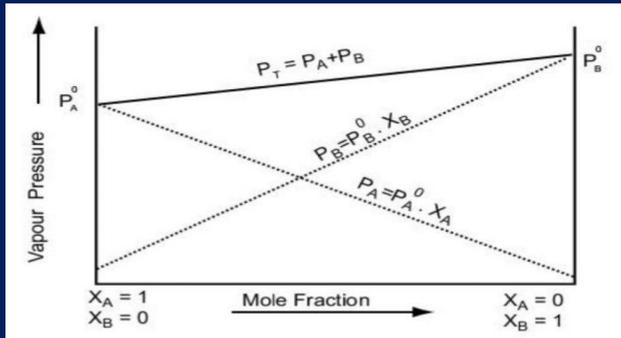
P_B^0 = Vapour pressure of pure component B

➤ According to Dalton's law of partial Pressures :-

The total pressure over the solution phase in the container will be the sum of the partial pressures of the components of the solution.

$$P_{\text{total}} = P_A + P_B$$

$$P_{\text{total}} = P_A^0 \chi_A + P_B^0 \chi_B$$



➤ The composition of *vapour phase* in equilibrium with the solution is determined by the partial pressures of the components. If y_1 and y_2 are the mole fraction of the components A and B is respectively in the vapour phase then using Dalton's law of partial pressures.

$$P_A = y_A P_{\text{total}}$$

$$P_B = y_B P_{\text{total}}$$

Question :- Vapour pressure of chloroform (CHCl_3) and dichloromethane (CH_2Cl_2) at 298K are 200 mmHg and 415 mmHg respectively.

(i) Calculate the vapour pressure of solution prepared by mixing 25.5 gm of CHCl_3 and 40 gm CH_2Cl_2 at 298k.

(ii) mole fractions of each component in vapour phase.

Solution :- To be given

$$T = 298\text{k}$$

$$P_{\text{CHCl}_3}^0 = 200\text{mmHg}$$

$$P_{\text{CH}_2\text{Cl}_2}^0 = 415\text{ mmHg}$$

gm weight of $\text{CHCl}_3 = 25.5 \text{ gm}$

gm weight of $\text{CH}_2\text{Cl}_2 = 40 \text{ gm}$

$P_{\text{total}} = ?$

$$P_{\text{total}} = P_{\text{CHCl}_3} + P_{\text{CH}_2\text{Cl}_2}$$

Raoult's Law

$$P_{\text{CHCl}_3} \propto \chi_{\text{CHCl}_3}$$

$$P_{\text{CH}_2\text{Cl}_2} \propto \chi_{\text{CH}_2\text{Cl}_2}$$

$$P_{\text{CHCl}_3} = P^0_{\text{CHCl}_3} \chi_{\text{CHCl}_3}$$

$$P_{\text{CH}_2\text{Cl}_2} = P^0_{\text{CH}_2\text{Cl}_2} \cdot \chi_{\text{CH}_2\text{Cl}_2}$$

$$\chi_{\text{CHCl}_3} = \frac{\text{mole of CHCl}_3}{\text{mole of CHCl}_3 + \text{CH}_2\text{Cl}_2}$$

$$\chi_{\text{CH}_2\text{Cl}_2} = \frac{\text{mole of CH}_2\text{Cl}_2}{\text{mole of CHCl}_3 + \text{CH}_2\text{Cl}_2}$$

$$\text{mole of CHCl}_3 = \frac{\text{gm weight of CHCl}_3}{\text{molecular weight of CHCl}_3}$$

$$\text{molecular weight of CHCl}_3 = 12 + 1 + 35.5 \times 3 = 119.5 \text{ gm mol}^{-1}$$

$$\text{Mole of CHCl}_3 = \frac{25.5}{119.5} = .21 \text{ mol}$$

$$\text{Mole of CH}_2\text{Cl}_2 = \frac{\text{gm weight of CH}_2\text{Cl}_2}{\text{molecular weight of CH}_2\text{Cl}_2}$$

$$\begin{aligned} \text{molecular weight of CH}_2\text{Cl}_2 &= 12 \times 1 + 1 \times 2 + 2 \times 35.5 \\ &= 85 \text{ gm mol}^{-1} \end{aligned}$$

$$\text{mole of CH}_2\text{Cl}_2 = \frac{40}{85} = .47 \text{ mole}$$

$$\begin{aligned} \chi_{\text{CHCl}_3} &= \frac{.21}{.21 + .47} \\ &= \frac{.21}{.68} = .31 \end{aligned}$$

$$\begin{aligned} \chi_{\text{CH}_2\text{Cl}_2} &= \frac{.47}{.21 + .47} \\ &= \frac{.47}{.68} = .69 \end{aligned}$$

$$\begin{aligned} P_{\text{CHCl}_3} &= P^0_{\text{CHCl}_3} \chi_{\text{CHCl}_3} \\ &= 200 \times .31 = 62 \text{ mmHg} \end{aligned}$$

$$\begin{aligned} P_{\text{CH}_2\text{Cl}_2} &= P^0_{\text{CH}_2\text{Cl}_2} \cdot \chi_{\text{CH}_2\text{Cl}_2} \\ &= 415 \times .69 = 286.35 \text{ mmHg} \end{aligned}$$

$$\begin{aligned} P_{\text{total}} &= P_{\text{CHCl}_3} + P_{\text{CH}_2\text{Cl}_2} \\ &= 62 + 286.35 \\ &= 348.35 \text{ mmHg} \end{aligned}$$

$$(ii) P_{CHCl_3} = Y_{CHCl_3} P_{total} \quad P_{CH_2Cl_2} = Y_{CH_2Cl_2} P_{total}$$

$$Y_{CHCl_3} = \frac{P_{CHCl_3}}{P \text{ कुल}}$$

$$= \frac{62}{348.35} = .1779$$

$$Y_{CH_2Cl_2} = \frac{P_{CH_2Cl_2}}{P \text{ कुल}}$$

$$= \frac{286.35}{348.35} = 0.8220$$

Ques :- Heptane and octane form an ideal solution. At 373k, the vapour pressures of the two liquid components are 105.2 Kpa and 46.8 Kpa respectively. What will be the vapour pressure of a mixture of 26.0 gm of heptane and 35 gm of octane ?

Ans :- To be given

$$T = 373k$$

$$P^0_{C_7H_{16}} = 105.2kpa$$

$$P^0_{C_8H_{18}} = 46.8kpa$$

$$\text{gm weight of } C_7H_{16} = 26\text{gm}$$

$$\text{gm weight of } C_8H_{18} = 35\text{gm}$$

$$P \text{ mixture} = ?$$

$$P \text{ Mixture} = P_{C_7H_{16}} + P_{C_8H_{18}}$$

Raoult's law

$$P_{C_7H_{16}} \propto \chi_{C_7H_{16}} \quad P_{C_8H_{18}} \propto \chi_{C_8H_{18}}$$

$$P_{C_7H_{16}} = P^0_{C_7H_{16}} \chi_{C_7H_{16}} \dots (i)$$

$$P_{C_8H_{18}} = P^0_{C_8H_{18}} \chi_{C_8H_{18}} \dots (ii)$$

$$\chi_{C_7H_{16}} = \frac{\text{mole of } C_7H_{16}}{\text{mole of } C_7H_{16} + C_8H_{18}}$$

$$\chi_{C_8H_{18}} = \frac{\text{mole of } C_8H_{18}}{\text{mole of } C_7H_{16} + C_8H_{18}}$$

$$\text{molecular weight of } C_7H_{16} = 12 \times 7 + 1 \times 16 = 84 + 16 = 100 \text{ gm mol}^{-1}$$

$$\text{molecular weight of } C_8H_{16} = 12 \times 8 + 1 \times 18 = 114 \text{ gm mol}^{-1}$$

$$\text{mole of } C_7H_{16} = \frac{\text{gm weight of } C_7H_{16}}{\text{molecular weight of } C_7H_{16}}$$

$$= \frac{26}{100} = .26 \text{ mole}$$

$$\text{mole of } C_8H_{18} = \frac{\text{gm weight of } C_8H_{18}}{\text{molecular weight } C_8H_{18}}$$

$$= \frac{34}{114} = .31 \text{ mole}$$

$$\chi_{C_7H_{16}} = \frac{.26}{.26 + .31} = \frac{.26}{.57} = .46$$

$$\chi_{C_8H_{18}} = \frac{.31}{.26 + .31} = \frac{.31}{.57} = .54$$

$$P_{C_7H_{16}} = P^0_{C_7H_{16}} \chi_{C_7H_{16}}$$

$$= 105.2 \times .46 = 48.39 \text{ kpa}$$

$$P_{C_8H_{18}} = P^0_{C_8H_{18}} \chi_{C_8H_{18}}$$

$$= 46.8 \times .54 = 25.27 \text{ kpa}$$

$$P_{\text{mixture}} = P_{C_7H_{16}} + P_{C_8H_{18}}$$

$$= 48.39 + 25.27 = 73.66 \text{ kpa}$$

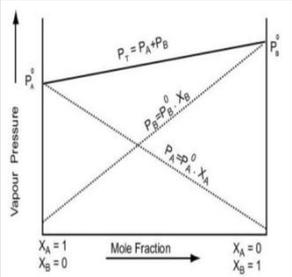
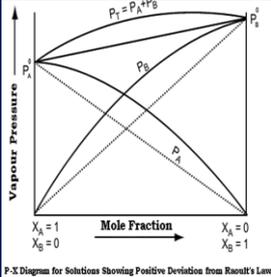
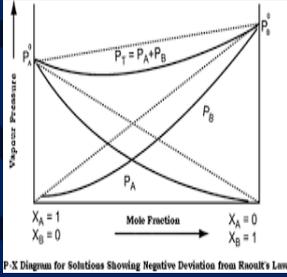
➤ **Ideal and non – ideal solution** :- by combination of two volatile liquids two types of solution may form :- (i) Ideal and (ii) non – ideal solution

❖ **Ideal solution** :- The solutions which **obey Raoult's law** over the entire range of concentration and temp. are known as Ideal solution.

❖ **Non – Ideal solution** :- When a solution **does not obey Raoult's law** over the entire range of concentration and temp are known as non Ideal solution.

❖ Non – ideal solutions are of two types (i) Positive deviation (ii) Negative deviation

S.No.	Characteristics of Ideal solution	Characteristics of non – Ideal solution	Positive deviation	Negative deviation
1	$P_A = P^0_A \chi_A$ $P_B = P^0_B \chi_B$ (Raoult's law is obeyed)	$P_A \neq P^0_A \chi_A$ $P_B \neq P^0_B \chi_B$ (Raoult's law is not obeyed)	$P_A > P^0_A \chi_A$ $P_B > P^0_B \chi_B$ (Raoult's law is not obeyed)	$P_A < P^0_A \chi_A$ $P_B < P^0_B \chi_B$ (Raoult's law is not obeyed)
2	$\Delta H_{\text{mixture}} = 0$ (no heat should be observed or evolved during mixing)	$\Delta H_{\text{mixture}} \neq 0$ (absorb and release heat)	$\Delta H_{\text{mixture}} > 0$ (solution become cold)	$\Delta H_{\text{mixture}} < 0$ (solution become hot)
3	$\Delta V_{\text{mixture}} = 0$ (no change in volume during mixing)	$\Delta V_{\text{mixture}} \neq 0$ (Solution may absorb & release heat)	$\Delta V_{\text{mixture}} > 0$ (expansion of solution take place)	$\Delta V_{\text{mixture}} < 0$ (contraction of solution takes place)
4	$\Delta S_{\text{mixture}} = \text{positive}$	$\Delta S_{\text{mixture}} = \text{positive}$	$\Delta S_{\text{mixture}} = \text{positive}$	$\Delta S_{\text{mixture}} = \text{positive}$

5	A-A + B-B = A-B Solute Solvent Solution (intermolecular force of attraction)	A-A + B-B ≠ A-B Solute Solvent Solution (intermolecular force of attraction)	A-A + B-B > A-B Solute Solvent Solution (intermolecular force of attraction)	A-A + B-B < A-B Solute Solvent Solution (intermolecular force of attraction)
Exam.	n- hexane and n- heptane bromoethane+ chloroethane benzene + toluene chloro benzene + Bromo benzene CCl ₄ + SiCl ₄		Exam. Acetone + Ethanol (CH ₃ COCH ₃) (C ₂ H ₅ OH) Acetone + CS ₂ Acetone + Benzene Ethyl alcohol + water CCl ₄ + CHCl ₃	Exam. HCl + H ₂ O HI + H ₂ O HNO ₃ + H ₂ O HClO ₄ + H ₂ O CHCl ₃ + C ₆ H ₆
				

➤ **Azeotrope OR Azeotropic Mixture** :— Azeotrope are binary mixtures having the same composition in liquid and vapour phase and boil at a constant temperature. In such cases, it is not possible to separate the components by fractional distillation

- ❖ Non – ideal solution show such type of behaviour.
- ❖ These are of two types.

1. Maximum boiling Azeotrope :— Such azeotropes have higher boiling point than components.

These azeotropes are formed by those liquid pairs which show negative deviation from ideal behaviour.

Ex. HCl (B.P = 85⁰C) + H₂O (B.P = 100⁰C) = Azeotrope B.P. => 108⁰C

2- Minimum boiling Azeotrope :— Such azeotropes have lower b.p. than either of components.

These azeotropes are formed by those liquid pairs which show positive deviation from ideal behaviour :-

Ex. H₂O (B.P = 100⁰C) + C₂H₅OH (B.P = 78.3⁰) = BP (78.1⁰C)

➤ **Colligative properties** :— The properties of dilute solution which depends only on **number of particles of solute**. [molecules or ions] present in the solution and not on their nature are called colligative properties.

➤ **Colligative from Latin word, Co means 'together', ligare means 'to bind'.**

The important colligative properties are :-

- 1- Relative lowering of vapour pressure.
- 2- Elevation of boiling point.
- 3- Depression of In freezing point.
- 4- Osmotic pressure.

Sp. Point :- Colligative properties are the properties of **only dilute solutions** which are supposed to behave as Ideal solutions.

(A) Relative lowering of vapour pressure :-

'Raoult's law for Non - volatile solutes :-

Raoult's law states that the relative lowering of vapour pressure of a solution containing a non - volatile solute is equal to the mole fraction of the solute in the solution.

$$\frac{P_0 - P_s}{P_0} = \frac{n}{n+N}$$

P_0 = Vapour pressure of pure solvent

P_s = Vapour pressure of Solution

n = mole of salute

N = mole of solvent

In case of dilute solution $n \ll \ll N$

$$\frac{P_0 - P_s}{P_0} = \frac{n}{N}$$

$$n = \frac{w}{m}$$

$$N = \frac{W}{M}$$

$$\frac{P_0 - P_s}{P_0} = \frac{\frac{w}{m}}{\frac{W}{M}}$$

$$\frac{P_0 - P_s}{P_0} = \frac{w}{m} \times \frac{M}{W}$$

w = gm weight of solute

W = gm weight of solvent

m = molecular weight of solute

M = molecular weight of solvent

Ques :— The vapour pressure of pure benzene at a certain temperature is 0.850 bar. A non – volatile ,non electrolyte solid weighing 0.5 gm when added to 39.0 gm of benzene (molar mass 78 gm mol⁻¹). Vapour pressure of the solution, then is 0.845 bar. What is the molar mass of the solid substance ?

Ans :— To be given

$$P_0 = 0.850 \text{ bar}$$

$$w = 0.5 \text{ gm}$$

$$W = 39 \text{ gm}$$

$$M = 78 \text{ gm mol}^{-1}$$

$$P_s = 0.845 \text{ bar}$$

$$m = ?$$

Acc. To Raoult's law for dilute solution.

$$\frac{P_0 - P_s}{P_0} = \frac{w}{m} \times \frac{M}{W}$$

$$\frac{0.850 - .845}{.850} = \frac{.5 \times 78}{m \times 39}$$

$$\frac{.005}{.850} = \frac{.5 \times 2}{m}$$

$$\frac{5}{850} = \frac{1}{m}$$

$$m = \frac{850}{5} = 170 \text{ gm mol}^{-1}$$

Ques :— Vapour pressure of water at 293k is 17.535 mmHg. Calculate the vapour pressure of water at 293k. When 25gm of glucose is dissolved in 450gm of water.

Ans :— To be given

$$T = 293 \text{ k}$$

$$P_0 = 17.535 \text{ mmHg}$$

$$w = 25 \text{ gm}$$

$$W = 450 \text{ gm}$$

$$P_s = ?$$

$$m (\text{C}_6\text{H}_{12}\text{O}_6) = 12 \times 6 + 1 \times 12 + 6 \times 16 = 180 \text{ gm mol}^{-1}$$

$$M (\text{H}_2\text{O}) = 1 \times 2 + 16 = 18 \text{ gm mol}^{-1}$$

Raoult's law for dilute soln.

$$\frac{P_0 - P_s}{P_0} = \frac{w}{m} \times \frac{M}{W}$$

$$\frac{P_0 - P_s}{P_0} = \frac{wM}{mw}$$

$$1 - \frac{P_s}{P_0} = \frac{wM}{mW}$$

$$\frac{P_s}{P_0} = 1 - \frac{25 \times 18}{180 \times 450}$$

$$\frac{P_s}{P_0} = 1 - \frac{1}{180}$$

$$\frac{P_s}{P_0} = \frac{180-1}{180}$$

$$\frac{P_s}{P_0} = \frac{179}{180}$$

$$P_s = \frac{179}{180} \times P_0$$

$$P_s = \frac{179}{180} \times 17.535$$

$$P_s = 17.432 \text{ mmHg.}$$

Ques :— Calculate the mass of a non volatile solute (molar mass 40 gm mol^{-1}). Which should be dissolved in 114 gm octane to reduce its vapour pressure to 80%.

Ans :— To be given

$$W = 114 \text{ gm}$$

$$w = ?$$

$$m = 40 \text{ gm mol}^{-1}$$

$$P_0 = 100$$

$$P_s = 80$$

$$M (\text{C}_8\text{H}_{18}) = 12 \times 8 + 1 \times 18 = 114 \text{ gm mol}^{-1}$$

Acc. To Raoult's law (non dilute soln)

$$\frac{P_0 - P_s}{P_0} = \frac{n}{n+N}$$

$$\frac{P_0 - P_s}{P_0} = \frac{\frac{w}{m}}{\frac{w}{m} + \frac{W}{M}}$$

$$\frac{100-80}{100} = \frac{\frac{w}{40}}{\frac{w}{40} + \frac{114}{114}}$$

$$\frac{20}{100} = \frac{\frac{w}{40}}{\frac{w}{40} + 1}$$

$$\frac{1}{5} = \frac{\frac{w}{40}}{\frac{w}{40} + 1}$$

$$\frac{1}{5} = \frac{w}{40} \times \frac{40}{w+40}$$

$$\frac{1}{5} = \frac{w}{w+40}$$

$$5w = w + 40$$

$$4w = 40$$

$$w = 10 \text{ gm}$$

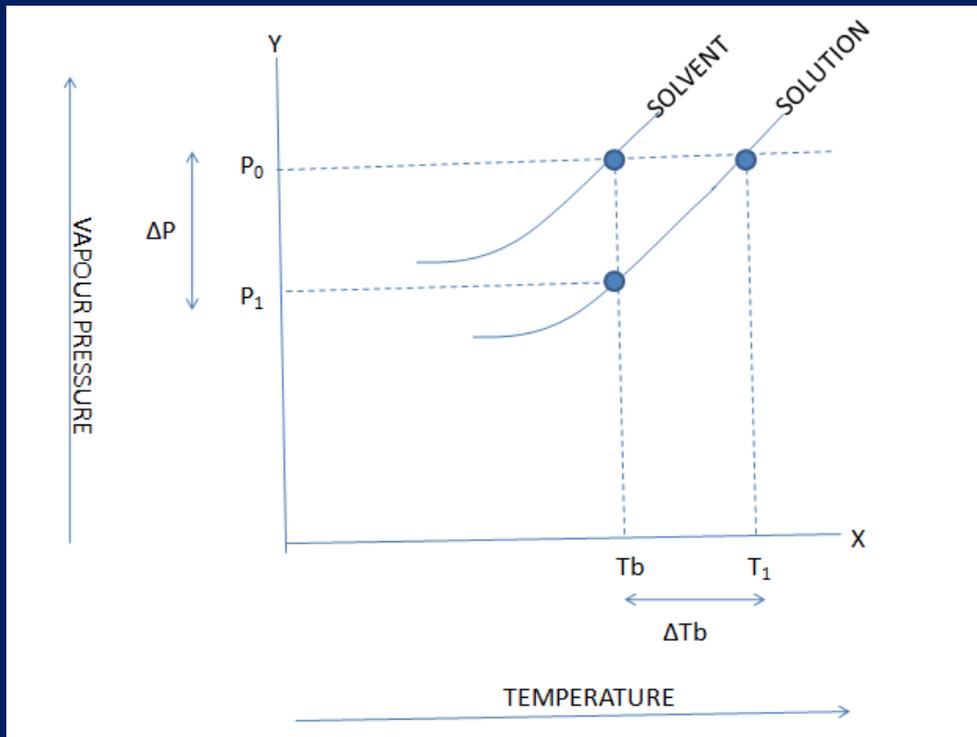
(B) Elevation of Boiling point :-

Boiling Point (B.P.) :- Boiling point of a liquid is a characteristic temperature at which its vapour pressure become equal to external atmospheric pressure.

For Exam. :- water boils at 373.15K (100°C) because at this temperature the vapour pressure of water is 1.013 bar (1 atm).

Sp. Point:- B.P. of a liquid depends upon the atmospheric pressure.

- ❖ By increasing atmospheric pressure, B.P. always increase.
- ❖ A liquid boils at relatively low temperature at mountains where atmospheric pressure is low.
- ❖ Liquid boils at relatively higher temperature in pressure cooker as well as at sea level where pressure is relatively high.
- ❖ Addition of a non – volatile solute in a solvent lowers its vapour pressure and therefore more heat is required to increase the vapour pressure of solution upto atmospheric pressure. Thus B.P. of solution is always higher than pure solvent. This increase in B.P. is known as elevation in B.P.



T_b = Boiling point of pure solvent

T_1 = Boiling point of solution

$\Delta T_b = T_1 - T_b$ = Elevation in B.P.

P_0 = Vapour pressure of pure solvent

P_1 = Vapour pressure of solution

Δ_p = Lowering of vapour pressure

$\Delta P \propto \Delta T_b$

- ❖ For dilute solutions the elevation of boiling point ΔT_b , is directly proportional to the molal concentration of the solute in a solution thus :-

$\Delta T_b \propto m$

$\Delta T_b = K_b m$ (1)

- ❖ m (molality) is the number of moles of solute dissolved in 1kg of solvent.

K_b = Boiling point Elevation Constant

Or molal elevation constant or Ebullioscopic constant

Unit of $K_b = K \text{ kg mol}^{-1}$

m (मोललता) = $\frac{\text{mole of solute}}{\text{mass of solvent (kg)}}$

$m = \frac{n}{W (kg)}$

$$m = \frac{n \times 1000}{W \text{ (gm)}}$$

$$m = \frac{w \times 1000}{m \times W \text{ (gm)}} \quad \dots\dots\dots (2)$$

Put the value of m in equation no. 1

$$\Delta T_b = K_b \times \frac{w \times 1000}{m \times W \text{ (gm)}} \quad \text{Or} \quad m = \frac{K_b \times w \times 1000}{\Delta T_b \times W}$$

Where ΔT_b = Elevation in B.P.

K_b = B.P. Elevation constant

w = gm weight of solute

m = molecular weight of solute

W = gm weight of solvent

Ques:- 18g of glucose (C₆H₁₂O₆) is dissolved in 1kg of water in saucepan. At what temperature will water boil at 1.013 bar ? (K_b for water is 0.52 K kg mol⁻¹)

Sol :- To be given

$$w = 18 \text{ gm}$$

$$W = 1\text{kg} = 1000\text{gm}$$

$$K_b = 0.52 \text{ K kg mol}^{-1}$$

$$P_0 = 1.013 \text{ bar}$$

$$T_b = 373.15\text{k}$$

$$T_1 = ?$$

$$\Delta T_b = K_b \times \frac{w \times 1000}{m \times W}$$

$$\Delta T_b = \frac{0.52 \text{ k kg mol}^{-1} \times 18 \text{ gm} \times 1000 \text{ gm kg}^{-1}}{180 \text{ gmol}^{-1} \times 100 \text{ gm}}$$

$$\Delta T_b = \frac{0.52}{10} \text{ k}$$

$$\Delta T_b = 0.052 \text{ k}$$

$$\begin{aligned} M (\text{C}_6\text{H}_{12}\text{O}_6) &= 6 \times 12 + 1 \times 12 + 6 \times 16 \\ &= 180 \text{ gm mol}^{-1} \end{aligned}$$

$$\Delta T_b = T_1 - T_b$$

$$T_1 = \Delta T_b + T_b$$

$$T_1 = 0.052 + 373.15$$

$$T_1 = 373.202 \text{ k}$$

Ques :- The boiling point of benzene is 353.23 k. When 1.80 gm of a non – volatile solute was dissolved in 90 gm of benzene, the boiling point is raised to 354.11 K. Calculate the molar mass of the solute K_b for benzene is 2.53 k kg mol⁻¹.

Solu :- To be given

$$T_b = 353.23\text{k}$$

$$T_1 = 354.11\text{k}$$

$$w = 1.80 \text{ gm}$$

$$m = ?$$

$$W = 90\text{g}$$

$$K_b = 2.53 \text{ k kg mol}^{-1}$$

$$\Delta T_b = \frac{K_b \times w \times 1000}{m \times W}$$

$$(T_1 - T_b) = \frac{K_b \times w \times 1000}{m \times W}$$

$$m = \frac{2.53 \text{ k kg mol}^{-1} \times 1.80 \text{ gm} \times 1000 \text{ gm kg}^{-1}}{(354.11 - 353.23) \text{ k} \times 90 \text{ gm}}$$

$$m = \frac{2.53 \times 1.80 \times 1000}{.88 \times 90} \text{ gmmol}^{-1}$$

$$m = \frac{2.53 \times 1800}{.88 \times 90}$$

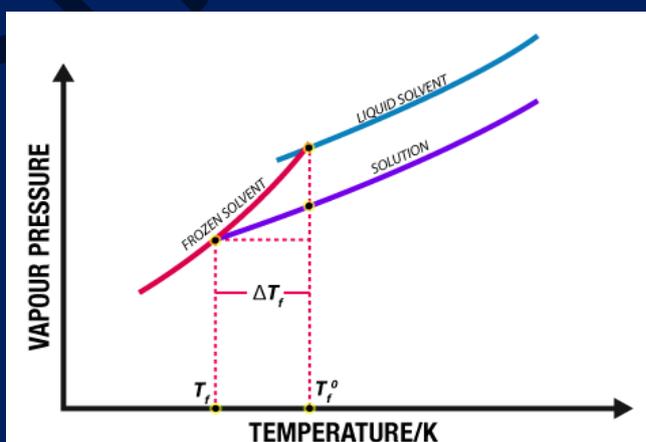
$$= \frac{2.53 \times 20}{.88} \text{ gmmol}^{-1}$$

$$= \frac{50.6}{.88} = 57.5 \text{ gmmol}^{-1}$$

(c) Depression of freezing point :-

Freezing point :- The temperature at which the vapour pressure of the substance in its liquid phase is equal to its vapour pressure in the solid phase.

(Freezing point of solvent > freezing point of solution)



P_0 = Vapour pressure of solvent

P_1 = Vapour pressure of solution

T_f = Freezing point of pure solvent

T_1 = Freezing point of solution

ΔT_f = Depression of Freezing point

ΔP = Elevation of Vapur Pressure

For dilute solutions the depression of freezing point ΔT_f is directly proportional to the molal concentration of the solute in a solution thus :-

$$\Delta T_f \propto m$$

$$\Delta T_f = k_f m \quad \dots\dots\dots(1)$$

m (molality) is the number of moles of solute dissolved in 1 kg of solvent.

k_f = Freezing point depression constant

molal depression constant

cryoscopic constant

Unit of $k_f = k \text{ kg mol}^{-1}$

$$m \text{ (molality)} = \frac{\text{mole of solute}}{\text{mass of solvent}}$$

$$m = \frac{n}{w(\text{kg})}$$

$$m = \frac{n \times 1000 \text{ gm kg}^{-1}}{w (\text{gm})}$$

$$m = \frac{w \times 1000 \text{ gm kg}^{-1}}{m \times w (\text{gm})} \quad \dots\dots\dots (2)$$

Put the value of m in equation 1

$$\Delta T_f = k_f \times \frac{w \times 1000 \text{ gm kg}^{-1}}{mw (\text{gm})}$$

$$m = \frac{k_f \times w \times 1000 \text{ gm kg}^{-1}}{\Delta T_f \times w (\text{gm})}$$

ΔT_f = Depression in freezing point

k_f = Freezing point depression constant

w = gm weight of solute

m = molwcular weight of solute

W = gm weight of solvent

Special Point :- The value of k_f and k_b . Which depend upon the nature of the solvent. Can be calculate this formula.

$$k_f = \frac{R \times M \times T_f^2}{1000 \times \Delta H}$$

$$k_b = \frac{R \times M \times T_b^2}{1000 \times \Delta H}$$

R = gas constant

M = molar mass of solvent

K_f = Freezing point of the pure solvent in Kelvin.

K_b = boiling point of the pure solvent in Kelvin.

$\Delta H_{\text{Fussion}}$ = Enthaply for the fussion of the solvent

ΔH_{vap} = Enthaply for the vapourisation of the solvent.

Ques :- 1.00gm of a non – electrolyte solute dissolved in 50 gm of benzene lowered the freezing point of benzene by 0.40K. The freezing point depression constant of benzene is 5.12K kg mol⁻¹. Find the molar mass of the solute.

Ans :- To be given

$$w = 1.00\text{gm}$$

$$W = 50\text{gm}$$

$$\Delta T_f = 0.40\text{k}$$

$$k_f = 5.12\text{k kg mol}^{-1}$$

$$m = ?$$

$$m = \frac{k_f \times w \times 1000 \text{ gm kg}^{-1}}{\Delta T_f \times w \text{ (gm)}}$$

$$= \frac{5.12\text{k kg mol}^{-1} \times 1.00\text{gm} \times 1000 \text{ gm kg}^{-1}}{0.40\text{k} \times 50 \text{ gm}}$$

$$= \frac{5.12 \times 1000}{.40 \times 50} \text{ gm mol}^{-1}$$

$$= \frac{512}{2} = 256 \text{ gm mol}^{-1}$$

Ques :- 45 gm of ethylene glycol (C₂H₆O₂) is mixed with 600 gm of water.

Calculate (a) the freezing point depression and (b) the freezing point of the solution .

Ans :- To be given ($k_f = 1.86 \text{ k kg mol}^{-1}$)

$$w = 45 \text{ gm}$$

$$m = (\text{C}_2\text{H}_6\text{O}_2) = 12 \times 2 + 1 \times 6 + 16 \times 2 \\ = 24 + 6 + 32 = 62 \text{ gm mol}^{-1}$$

$$W = 600 \text{ gm}$$

$$k_f = 1.86 \text{ k kg mol}^{-1}$$

$$\Delta T_f = ?$$

$$\Delta T_1 = ?$$

$$(i) \Delta T_f = \frac{k_f \times w \times 1000}{m \times W}$$

$$\Delta T_f = \frac{1.86 \times 45 \times 1000}{62 \times 600}$$

$$\Delta T_f = \frac{1.86 \times 450}{62 \times 6} = \frac{837}{372}$$

$$\Delta T_f = 2.25 \text{ k}$$

(ii) $\Delta T_f = \text{Freezing point of solvent} - \text{freezing point of solution}$

$$2.25 = 273.15 - \text{freezing point of solution}$$

$$\text{Freezing point of solution} = 273.15 - 2.25 \\ = 270.95 \text{ k}$$

(d) Osmotic Pressure :- Osmosis is the spontaneous flow of the solvent molecules from a less concentrated solution (dilute) to a more concentrated solution through a semi permeable membrane.

Osmotic pressure :- The minimum excess pressure that has to be applied on the solution to prevent the osmosis (entry of the solvent into the solution through the semi permeable membrane).

Semi - Permeable membrane (SPM) :- A membrane that permits the passage of solvent molecules only, not solute molecules is known as SPM.

According to Van't Hoff for dilute solution

$$\pi = CRT$$

$$\pi = \frac{n}{v} RT$$

$$\pi = \frac{w RT}{m \times v}$$

$$\pi = \frac{RT}{m} \times d$$

π = Osmotic Pressure

c = Molar Concentration

R = gas constant = $0.0821 \text{ lit. atm k}^{-1} \text{ mol}^{-1}$

T = Temp.

n = Number of solute mole

w = gm weight of solute

m = molecular weight of solute

d = density of solution

v = volume of solution

Special Point :-

1. This method is widely used to determine molar masses of proteins, polymer and other macromolecules.
2. The osmotic pressure method has the advantage over other methods as pressure measurement is around the room temp. And the molarity of the solution is used instead of molality.

Isotonic solutions :- Two solutions having same osmotic pressure are called isotonic solutions :-

$$\pi_1 = \pi_2$$

$$C_1 = C_2$$

$$\frac{n_1}{v_1} = \frac{n_2}{v_2}$$

$$\frac{w_1}{m_1 v_1} = \frac{w_2}{m_2 v_2}$$

Special Point :-

1. In cell numerical problems on osmotic pressure, percentage means weight volume percentage unless density of the solution is given.
2. If a number of solutes are present in the solution. The total osmotic pressure becomes sum of partial osmotic pressure. $P = P_1 + P_2 + P_3 + \dots$

❖ Two solutions are isotonic at a given temperature when such a solution are separated by semipermeable membrane. No osmosis occurs between them. Osmotic pressure associated with the fluid inside the blood cell is equivalent to that of 0.9% (Mass/volume) NaCl solution called normal saline solution and it is

safe to inject it intravenously. On the other hand, If we place the cells in a solution containing more than 0.9% solution water will flow out of cells and they would shrink. Such a solution is called hypertonic sol. If the salt concentration is less than 0.9% water will flow into the cells and they would swell. Such a solution is called hypotonic sol.

Ques :- A 2% Sucrose solution is isotonic with 1.5% solution of an unknown substance calculate molecular mass of the unknown substance.

Ans :- To be given

2% Sucrose solution means

Volume of solution = 100 ml

gm weight of solute = 2gm

$$\begin{aligned} \text{molecular weight of solute (C}_{12}\text{H}_{22}\text{O}_{11}) &= 12 \times 12 + 1 \times 22 + 11 \times 16 \\ &= 144 + 22 + 176 \\ &= 342\text{gm mol}^{-1} \end{aligned}$$

1.5% solution of an unknown substance means

volume of solution = 100ml

gm wright of unknown substance = 1.5g

molecular mass of unknown substance = ?

acc. To question isotonic solution

$$C_1 = C_2$$

$$\frac{n_1}{V_1} = \frac{n_2}{V_2} \quad \therefore V_1 = V_2 = 100\text{ml}$$

$$n_1 = n_2$$

$$\frac{w_1}{m_1} = \frac{w_2}{m_2}$$

$$\frac{2}{342} = \frac{1.5}{m_2}$$

$$m_2 = \frac{1.5 \times 342}{2} = 1.5 \times 171 = 256.5\text{gm mol}^{-1}$$

Ques :- 200cm³ of an aqueous solution of a protein contains 1.26 gm of the protein. The osmotic pressure of such a solution at 300K is found to be 2.57 x 10⁻³ bar. Calculate the molar mass of the protein.

Ans :- To be given

$$v = 200\text{cm}^3 = 200\text{ml} = .200\text{lit}$$

$$w = 1.26\text{gm} \quad T = 300\text{k}$$

$$\pi = 2.57 \times 10^{-3} \text{ bar}$$

$$R = 0.083 \text{ L bar mol}^{-1} \text{ k}^{-1}$$

$$\pi v = nRt$$

$$\pi v = \frac{wrt}{m}$$

$$m = \frac{wrt}{\pi v}$$

$$m = \frac{1.26\text{gm} \times 0.083 \text{ L bar mol}^{-1} \text{ k}^{-1} \times 300\text{k}}{2.57 \times 10^{-3}\text{bar} \times .200 \text{ L}}$$

$$m = \frac{1.26 \times .083 \times 300}{2.57 \times 10^{-3} \times .200} \text{ gm mol}^{-1}$$

$$m = \frac{126 \times 83 \times 300 \times 10^3}{257 \times 200}$$

$$m = \frac{126 \times 83 \times 3000}{257 \times 2} = \frac{126 \times 83 \times 1500}{257}$$

$$m = \frac{10458 \times 1500}{257} = \frac{15687000}{257}$$

$$m = 61038.91 \text{ gm mol}^{-1}$$

Application of osmosis :-

1. A raw mango placed in concentrated salt solution loses water via osmosis and shrivel into pickle.
2. Wilted flowers revive when placed in fresh water.
3. Water movement from soil into plant roots and subsequently into upper portion of the plant is partly due to osmosis.
4. The preservation of meat by salting and of fruits by adding sugar protects against bacterial action. Through the process of osmosis, a bacterium on salted meat or stinky fruit loses water, shrivels and dies.

❖ People taking a lot of salt or salty food experience water retention in tissue cells and intercellular spaces because of osmosis. The resulting spaces because of osmosis. The resulting puffiness or swelling is called Edema.

❖ π mixture can be calculated as follows :-

$$\pi = \frac{\pi_1 v_1 + \pi_2 v_2}{v_1 + v_2}$$

$$\pi = \frac{m_1 v_1 + m_2 v_2}{v_1 + v_2} \times RT$$

Reverse Osmosis :-

The direction of osmosis can be reversed if a pressure larger than the osmotic pressure is applied to the solution side.

OR

Pure solvent flows out of the solution through the semi permeable membrane.

Use :- Reverse osmosis is used in desalination of sea water.

- ❖ Cellulose acetate semi permeable membrane used in reverse osmosis.

Van't Hoff factor and Abnormal molecular mass :-

When the solute associated or dissociates in solution abnormal results (for all colligative properties and molar masses) are obtained i.e. experimental value for colligative properties and molar mass deviates from calculated or normal value.

This deviation or dissociation or association of solute.

- ❖ To calculate the extent of association or dissociation Van't Hoff in 1886 introduced a factor i called Van't Hoff factor.
- ❖ Van't Hoff factor i is defined as ratio of the experimental value of colligative property to the calculated value (normal value) of colligative property.

$$i = \frac{\text{Experimental colligative properties (observed)}}{\text{Calculated (normal colligative properties)}}$$

$$i = \frac{\text{No of particles after association or dissociation}}{\text{Experimental molecular mass (observed)}}$$

- ❖ Using Van't Hoff factor the colligative properties are modified as follows :-

1. Relative lowering of vapour pressure $\frac{P_o - P_s}{P_o} = i \frac{n}{n+N}$

2. Elevation of boiling point $\Delta T_b = i k_b \times m$

3. Depression of melting point $\Delta T_f = i k_f \times m$

4. Osmotic pressure $\pi = i CRT$

- ❖ i may be more, less or equal to unity

$$i = 1 \Rightarrow \text{no dissociation or no association}$$

$$i > 1 \Rightarrow \text{in case of dissociation}$$

$$i < 1 \Rightarrow \text{in case of association}$$

Salt

Van't Hoff factor (i) for complete

