

6) formality: It is the no. of formula masses of the solute dissolved per litre of sol<sup>n</sup>.

$$\text{formality} = \frac{\text{No of formula masses of solute}}{\text{Vol. of the sol<sup>n</sup> in litre.}}$$

eg 2.82 gm of glucose (molar mass = 180) are dissolved in 30 gm of water. Calculate (a) molality (b) mole fraction of glucose and water.

$$\text{mass of glucose} = 2.82 \text{ gm.}$$

$$\text{moles of glucose} = \frac{2.82}{180} \quad (\text{molar mass} = 180)$$

$$\text{mass of water} = 30 \text{ gm.}$$

$$\text{molality} = \frac{\text{moles of glucose} \times 1000}{\text{mass of water}}$$

$$= \frac{2.82 \times 1000}{180 \times 30} = 0.522 \text{ m.}$$

b) Calculation of mole fraction.

$$\text{moles of glucose} = \frac{2.82}{180} = 0.0157$$

$$\text{moles of water} = \frac{30}{18} = 1.67$$

$$\text{mole fraction of glucose} = \frac{0.0157}{0.0157 + 1.67} = 0.009$$

$$\text{mole fraction of water} = \frac{1.67}{0.0157 + 1.67} = 0.991$$

Calculate the molality of pure water (density of water = 1 gm/ml)

$$\text{density of water} = 1 \text{ gm/ml}$$

$$\begin{aligned} \text{mass of 1000 ml of water} &= \text{Vol} \times \text{density} \\ &= 1000 \times 1 = 1000 \text{ gm.} \end{aligned}$$

$$\text{moles of water} = \frac{1000}{18} = 55.55$$

55.55 moles of H<sub>2</sub>O are present in 1000 ml or 1 L of water. Molality = 55.55 M

Solubility of gases: The most soluble gases are those which chemically react with the liquid solvent.

Henry's law: The mass of a gas dissolved per unit volume of the solvent at a given temp. is proportional to the pressure of the gas in equilibrium with the sol<sup>n</sup>.

Mole fraction of the gas in the sol<sup>n</sup> is proportional to the partial pressure of the gas in the sol<sup>n</sup>.

The pressure of a gas over a sol<sup>n</sup> in which the gas is dissolved is proportional to the mole fraction of the gas dissolved in the solution.

Solubility: The amt of the solid that dissolves in 100g<sup>m</sup> of the solvent at a given temp to form a saturated sol<sup>n</sup>.

Vapour pressure: The pressure exerted by the vapour above the liquid surface in equilibrium with the liquid at a given temp.

Vapour pressure of solution: The vapour pressure of the solution is found to be less than that of the pure solvent.

Raoult's law: Binary solution of volatile liquids

Raoult's law: At a given temp. for a sol<sup>n</sup> of volatile liquid the partial vapour pressure of each component in solution is equal to the product of the vapour pressure of the pure component and its mole fraction.

Suppose a binary sol<sup>n</sup> consists of two volatile liquids A and B. If  $p_A$  and  $p_B$  are the partial vapour pressure of the two liquids and  $x_A$  and  $x_B$  are their mole fractions in sol<sup>n</sup>

$$p_A = p_A^{\circ} x_A \quad p_B = p_B^{\circ} x_B \quad p_A^{\circ} \text{ \& } p_B^{\circ} \text{ are vapour press of pure liquids}$$

Raoult's law for sol<sup>n</sup> containing non volatile solutes: The vapour pressure of the sol<sup>n</sup> will be the vapour pressure due to solvent only.

Order of derivation: Rault's law at a given temp the vapour pressure of a solution containing non-volatile solute is directly proportional to the mole fraction of the solvent.

$$\frac{P}{P_A^0} = x_A \quad 1 - \frac{P}{P_A^0} = 1 - x_A \quad \frac{P_A^0 - P}{P_A^0} = 1 - x_A = x_B$$

$$x_A + x_B = 1 \quad 1 - x_A = x_B$$

$$x_{\text{solute}} = \frac{P_{\text{solvent}}^0 - P_{\text{sol}}}{P_{\text{solvent}}^0}$$

$\frac{P_A^0 - P_A}{P_A^0}$  is relative lowering in vapour pressure.

Rault's law - The relative lowering in vapour pressure of an ideal sol<sup>n</sup> containing the non-volatile solute is equal to the mole fraction of the solute at a given temp.

$$\frac{P_A^0 - P_A}{P_A^0} = x_B \quad P_A^0 \text{ is the vapour pressure of pure component}$$

$$P_A \text{ is the vapour pressure in sol<sup>n</sup> having } x_A \text{ mole fraction.}$$

Ideal and non ideal solution: The binary solution

1) Ideal solution: An ideal sol<sup>n</sup> the solution which obeys Rault's law exactly at all conc<sup>n</sup> and at all temperatures. These sol<sup>n</sup> are formed by mixing the two component which are identical in molecular size, in structure and have almost identical intermolecular forces. The intermolecular forces between the component A-B and between A-A > B-B

$$P_A = P_A^0 x_A$$

$$P_B = P_B^0 x_B$$

$$P = P_A + P_B$$

$$P = P_A^0 x_A + P_B^0 x_B$$

Characteristics of ideal sol<sup>n</sup>

- 1) Heat change on mixing is zero
- 2) Volume change on mixing is zero.

Ex 1) Benzene toluene

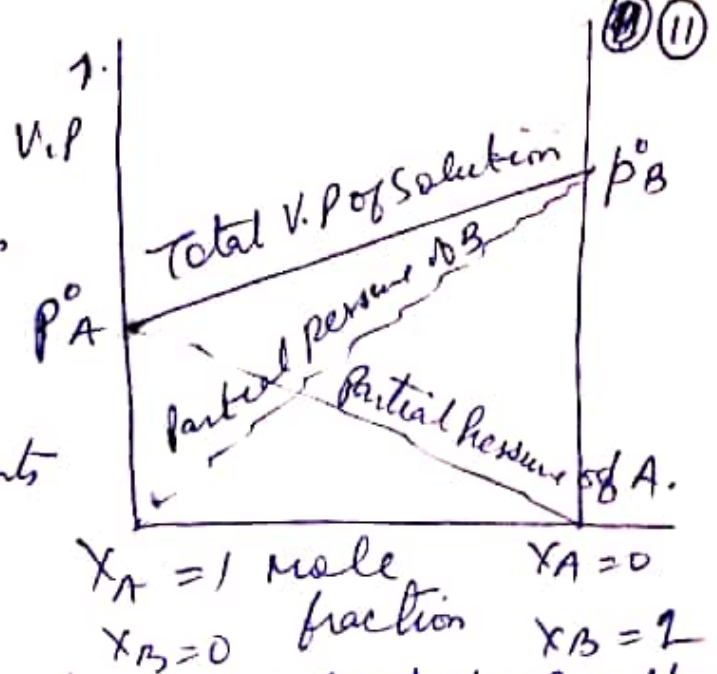
2) n-hexane and n-heptane

Ethyl bromide and ethyl iodide  
Chlorobenzene & bromobenzene

$$P = P_A + P_B$$

$$= P_A^\circ x_A + P_B^\circ x_B$$

The vapour pressure of solution of different composition in case of ideal sol<sup>n</sup> lies between vapour pressure of pure components  $P_A^\circ$  and  $P_B^\circ$



Non ideal solution: Solution which does not obey's Raoult law as called non ideal solutions:

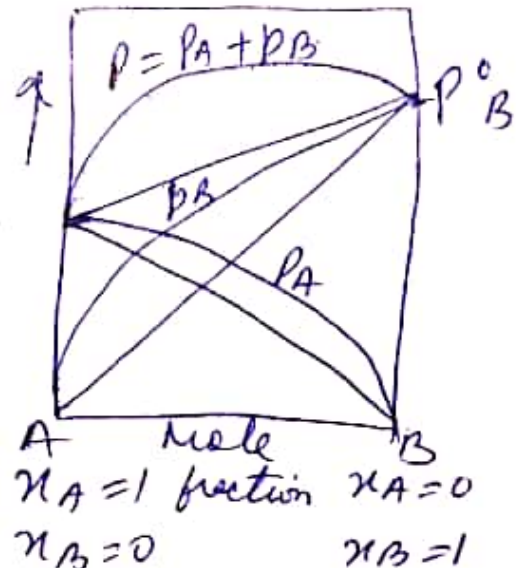
$$P_A \neq P_A^\circ x_A \quad P_B \neq P_B^\circ x_B$$

When components are mixed there is change in heat energy & volume  $\Delta V \neq 0 \quad \Delta H \neq 0$ .

Types of non ideal solution:

1) Non ideal solution showing positive deviation from Raoult's law:

of binary sol<sup>n</sup> of two component A & B. A-B are weaker than A-A & B-B then escaping tendency of A & B types of molecules from solution becomes more than from pure liquids. Each component has greater partial vapour pressure than expected from Raoult's law.



$$P_A > P_A^\circ x_A \quad P_B > P_B^\circ x_B \quad P = P_A + P_B > P_A^\circ x_A + P_B^\circ x_B$$

eg ethyl alcohol & cyclohexane, Benzene acetone  
~~the~~ When cyclohexane is added to ethyl alcohol then cyclohexane occupy space between ethyl alcohol and

Hydrogen bond in alcohol is weakened. Thus more alcohol molecules escape.  $\Delta H$  is positive as reaction is endothermic. Because of decrease in intermolecular distance volume increases. (2)

n) Non ideal solution showing negative deviation from Raoult's law:

A-B interactions are stronger than A-A and B-B interaction present in two liquids. Due to stronger A-B interaction the escaping tendency of A and B types of molecule from sol<sup>n</sup> becomes less than from pure liquids. Each component has partial vapour pressure less than expected.

$$P_A < P_A^0 \times x_A \quad P_B < P_B^0 \times x_B$$

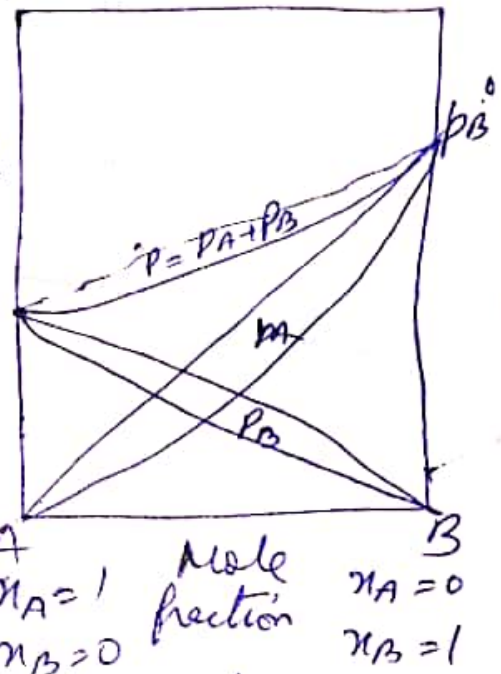
$$P_A = P_A + P_B < P_A^0 x_A + P_B^0 x_B \quad \text{V.P.}$$

eg acetone, chloroform.

on addition of acetone & chloroform the attractive forces due to hydrogen bond, these forces become stronger escaping tendency decreases.

$\Delta H$  is -ve exothermic

$\Delta V$  = negative due to attraction volume decreases



Azeotropes: The sol<sup>n</sup> which boils at const temp and can distil unchanged in composition.

Azeotropes distil over as pure liquids. eg ethanol water.

There are minimum boiling azeotropes where boiling takes place at lower value than that of boiling point of the two component. Ethanol boils at 78.5°C and water at 100°C but mixture boils at 78°C and the two cannot be separated by distillation. They show +ve deviation from Raoult's law