SOLUTION

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- **A homogenous mixture whose composition can be varied within certain limits is termed as true solution.**
- **The solution of liquid in gas or solid in gas is not possible.**
- **Method of expressing concentration of solution:-**

$$\text{Mass \%} = \frac{W_A}{W_A + W_B} \times 100$$

$$\text{Volume \%} = \frac{V_A}{V_A + V_B} \times 100$$

$$\text{Normality (N)} = \frac{\text{gram/litre}}{\text{Equivalent mass}}$$

$$\text{Molarity (M)} = \frac{\text{gram/litre}}{\text{Molar mass}}$$

$$\text{ppm} = \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 10^6$$

$$\text{Molality (m)} = \frac{\text{Number of moles of solute}}{\text{Weight of solvent(kg)}}$$

$$\text{Mole fraction } x_B = \frac{\text{Number of moles of solute}}{\text{Total moles}}$$

$$x_A + x_B = 1 \quad x_B \text{ for solute}$$

$$x_A \text{ for solvent}$$

- **Important relation –**

$$\text{Molality} = \frac{\text{Molarity}}{1000\,d - (\text{molarity x molecular mass of solute})} \times 1000$$

where d = density of solution

$M_1V_1 = M_2V_2$ Before and after dilution.

$$\text{Molality} = \frac{1000 \times A}{(1 - x_A)\, M_B}$$

- **Colligative properties**

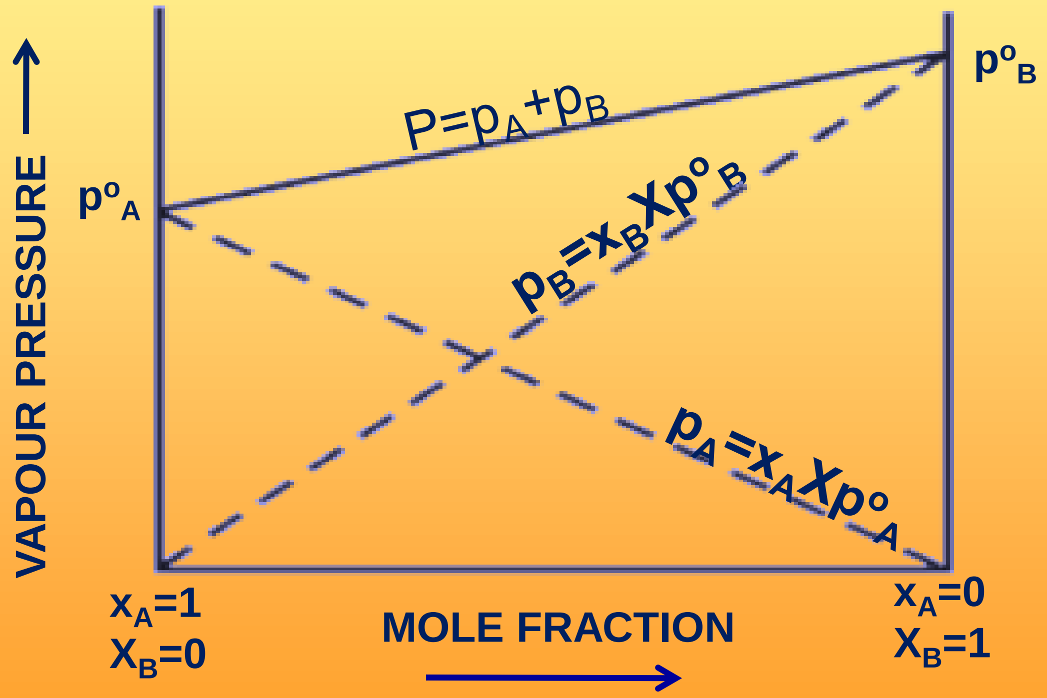
  1 Relative lowering of vapour pressure

$$\frac{p^o - p^s}{p^o} = \frac{W_B M_A}{W_A M_B}$$

2 According to Raoult's law for a solution having volatile solute

$$p_{total} = p^o_A + (p^o_B - p^o_A)x_B$$

plot of p_{total} Vs x_B should be a straight line.



3 For non-volatile solute

$$x_B = \frac{p^o - p^s}{p^o}$$

4 For ideal solution $p = p^o_A\, x_A + p^o_B\, x_B$

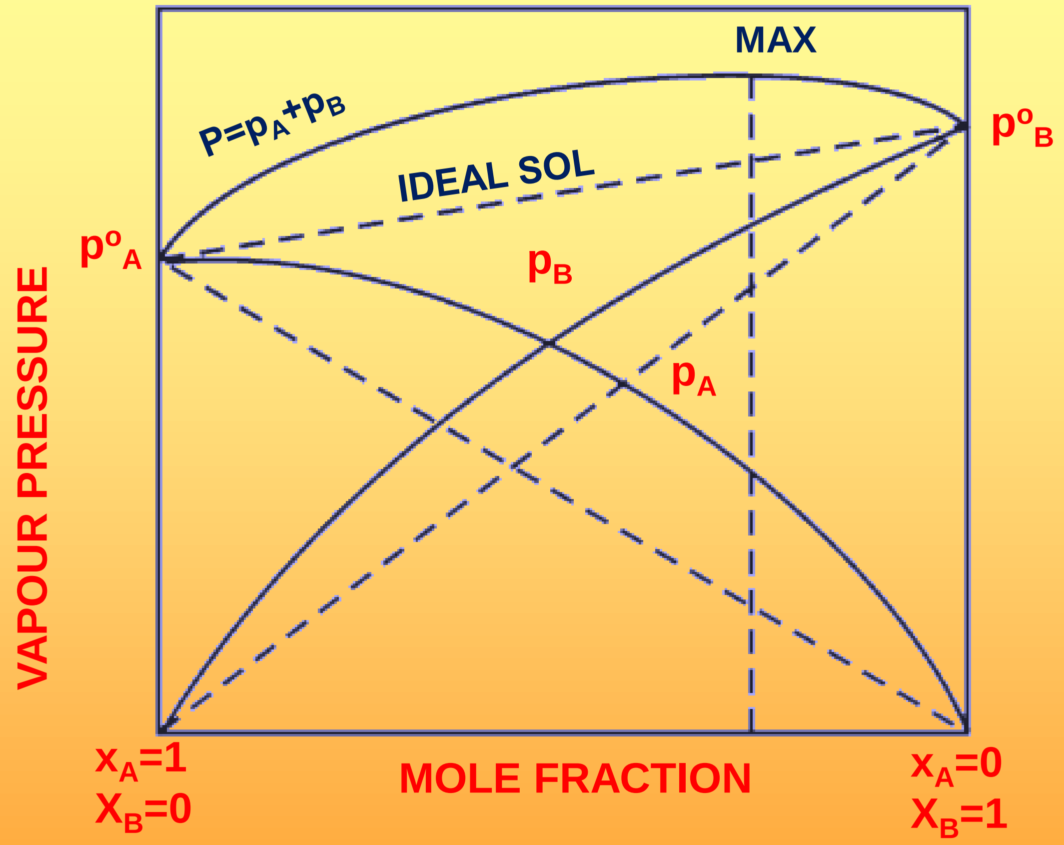
5 For non-ideal solution $p \neq p^o_A x_A + p^o_B x_B$

- **positive deviation** $p_A > P^o_A\, x_A$

  $p_B > p^o_B\, x_B$

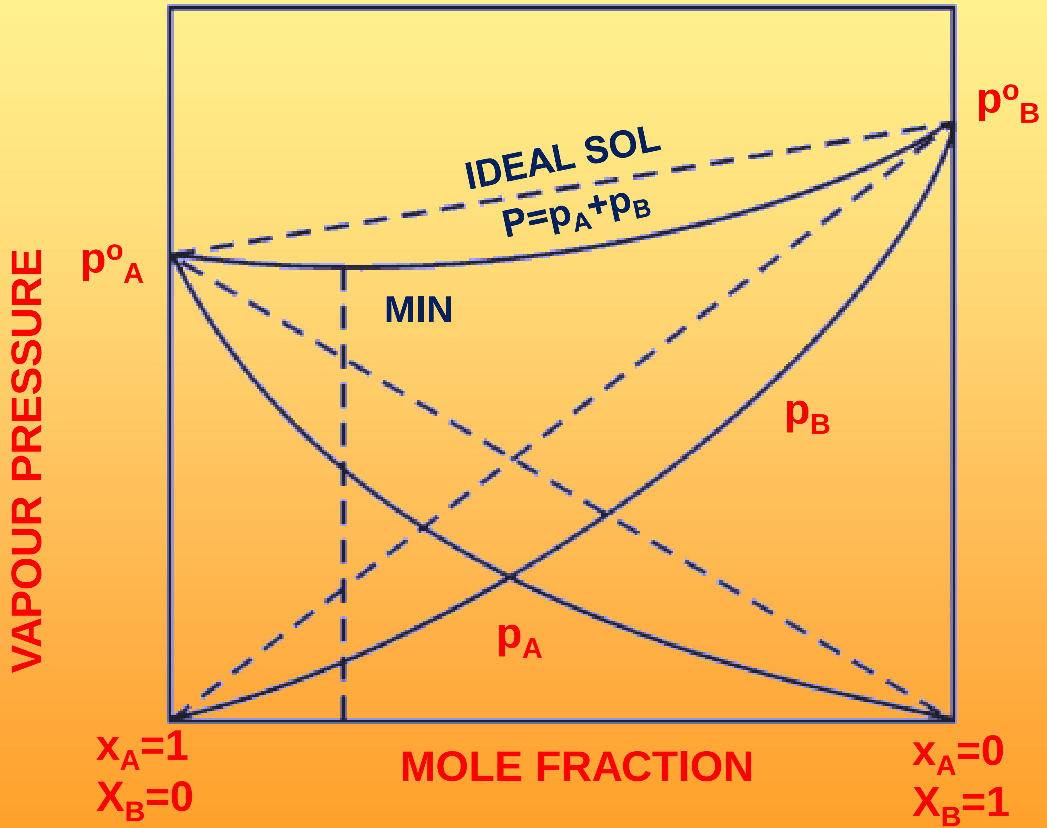
  $\Delta V > 0$

  $\Delta H > 0$



Non-ideal solution showing positive deviation

- **negative deviation $p_A < p^o_A x_A$**
  $p_B < p^o_B x_B$
  $\Delta V < 0$
  $\Delta H < 0$



Non-ideal solution showing negative deviation

- **Elevation in boiling point**

$\Delta T_b = K_b \times m$

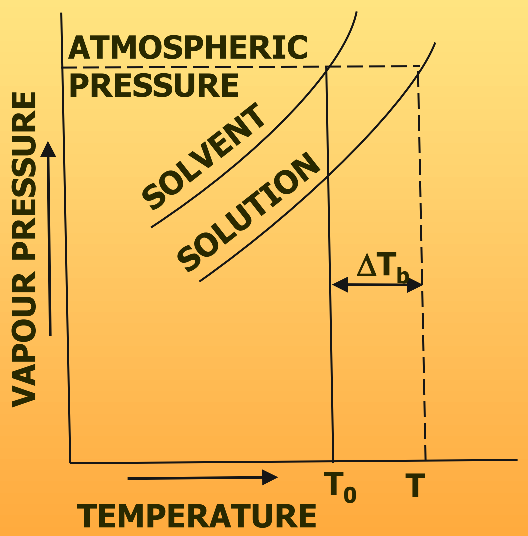
m = molality

K_b = molal elevation or ebullioscopic constant

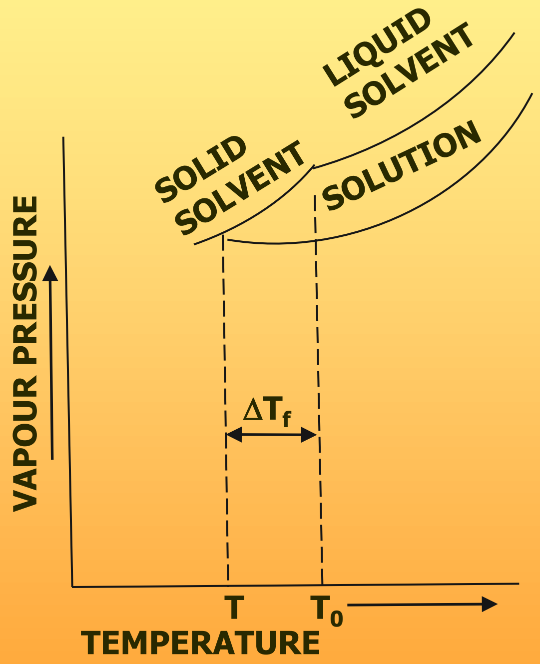
For water K_b = 0.5 K m^{-1} or 0.5 K Kg mol^{-1}

$$\Delta T_b = \frac{K_b \times W_B 1000}{M_B \times W_A}$$

(W_A & W_B Mass of solvent & solute respectively)



Elevation in boiling point



Depression in freezing point

The increase is called elevation in boiling point i.e., $\Delta T_b = T - T_0$.

$$K_b = \frac{RT_o^2}{1000\, L_v} = \frac{RT_o^2 M_A}{\Delta H\ vap.},\ L_v = \text{Latent heat of vapourisation}$$

T_0 = boiling point of pure solvent (Kelvin)

R = 8.314 $JK^{-1}\ mol^{-1}$

- **Depression in freezing point**

$$\Delta T_f = K_f \times m$$

K_f = molal depression or cryoscopic constant

For water K_f = 1.86 K m^{-1} or 1.86 K kg/mol.

$$\Delta T_f = \frac{K_f \times W_B\ 1000}{M_B \times W_A}$$

$$K_f = \frac{RT_o^2}{1000\,L_f}, L_f = \text{Latent heat of fusion}$$

Osmotic Pressure

- **It can be determined by Berkley-Hartley method**
- **Isotonic solution – Two solutions having same osmotic pressure**
- **Hypertonic solution – Higher osmotic pressure solution**
- **Hypotonic solution – Lower osmotic pressure solution**

$$\pi = CRT = \frac{W_B}{M_B} \times \frac{RT}{V}$$

R = 0.0821 L atm K^{-1} mol^{-1}
V = volume in litres
π = osmotic pressure in atmosphere

$$\Delta T_b = \frac{k_b 1000}{W_A} \times \frac{\pi V}{RT}$$

$$\Delta T_f = \frac{k_f 1000}{W_A} \times \frac{\pi V}{RT}$$

Vont Hoff's Factor (Abnormal behaviour of solution)

$$i = \frac{\text{Molecular mass (normal)}}{\text{Molecular mass (observed)}}$$

i = 1 for ideal solution

i > 1 Dissociation $\alpha_d = \frac{i - 1}{n - 1}$ $n = \text{no. of moles after dissociation}$

i < 1 Association $\alpha_a = \frac{1 - i}{1 - 1/n}$ $n = \text{no. of moles after association}$

Important Point :-

1 **Modified colligative properties formula considering Vont Hoff's Factor**

$$\frac{P^{o} - P^{s}}{P^{o}} = i\,x_B$$

$\pi = i\,CRT$

$\Delta T_b = iK_b \times m$

$\Delta T_f = iK_f \times m$

2 Classius Clapeyron equation

$$\ln\left(\frac{P_1}{P_2}\right) = \frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Check your Knowledge

Q. **At 80°C, the vapour pressure of pure liquid 'A' is 520 mmHg and that of pure liquid 'B' is 1000 mm Hg. If a mixture solution of 'A' and 'B' boils at 80°C and 1 atm pressure, the amount of 'A' in the mixture is (1 atm = 760 mmHg)**

(a) 52 mole percent

(b) 34 mole percent

(c) 48 mole percent

(d) 50 mole percent

Ans. (d)

Q. **The vapour pressure of water at 20°C is 17.5 mmHg. If 18 g of glucose ($C_6H_{12}O_6$) is added to 178.2 g of water at 20°C, the vapour pressure of the resulting solution will be**

(a) 17.675 mmHg

(b) 15.750 mmHg

(c) 16.500 mmHg

(d) 17.325 mmHg

Ans. (d)

Q. **The density (in g mL^{-1}) of a 3.60 M sulphuric acid solution that is 29% H_2SO_4 (molar mass = 98 g mol^{-1}) by mass will be**

(a) 1.64

(b) 1.88

(c) 1.22

(d) 1.45

Ans. (c)

Q. **A mixture of ethyl alcohol and propyl alcohol has a vapour pressure of 290 mm at 300 K. The vapour pressure of propyl alcohol is 200 mm. If the mole fraction of ethyl alcohol is 0.6, its vapour pressure (in mm) at the same temperature will be**

(a) 350
(b) 300
(c) 700
(d) 360
Ans. (a)

Q. Equal masses of methane and oxygen are mixed in an empty container at 25°C. The fraction of the total pressure exerted by oxygen is

(a) $\frac{2}{3}$

(b) $\frac{1}{3} \times \frac{273}{298}$

(c) $\frac{1}{3}$

(d) $\frac{1}{2}$

Ans. (c)

Q. **A 5.25% solution of a substance is isotonic with a 1.5% solution of urea (molar mass = 60 g mol^{-1}) in the same solvent. If the densities of both the solutions are assumed to be equal to 1.0 g cm^{-3}, molar mass of the substance will be**

(a) 90.0 g mol^{-1}

(b) 115.0 g mol^{-1}

(c) 105.0 g mol^{-1}

(d) 210.0 g mol^{-1}

Ans. (d)

Thank You.