(V)

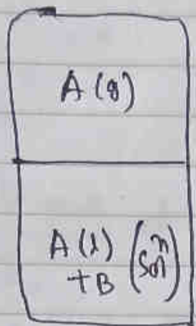
Elevation of b. pt

The heterogeneous equilibrium when considering boiling point between the solvent vapour and solvent in solution at constant pressure (1 atmos)

We denote the solvent by A and the solute by B.

The equilibrium is established at a temperature for which

$$\mu_A^*(g) = \mu_A^*(l) + RT_b \ln X_A. \rightarrow (1)$$



$\mu_{A(g)}^*$

$\mu_{A(l)}^*$

At equilim $\mu_{A(g)}^* = \mu_{A(l)}^*$

The heterogeneous equilibrium involved in the elevation of boiling point

where $\mu_A^*(g)$ is the chemical potential of pure gas (A) and $\mu_A^*(l)$ is the chemical potential of A in the solution of the solution. T_b = b. pt

$$\text{or } RT_b \ln X_A = \mu_{A(g)}^* - \mu_A^*(l)$$

$$\text{or } \ln X_A = \frac{\mu_{A(g)}^* - \mu_A(l)}{RT_b} \rightarrow (2)$$

The chemical potential of a pure substance μ^* is equal to the molar Gibbs energy G_m^*.

$$\text{Thus } \ln X_A = \frac{G_{mA(g)}^* - G_{m.A}^*(l)}{RT_b}.$$

$$\ln X_A = \frac{\Delta_{(vap)} G_{m.A}}{RT_b} \rightarrow (3)$$

we have. $\frac{d}{dT_b}\left(\frac{-\Delta_{vap} G_{m.A}}{RT_b}\right) = \frac{\Delta_{vap} H_{m.A}}{RT_b^2}$ [Vant Hoff equation]

VI

Putting the value in equⁿ (3)

$$\frac{d}{dT_b}\left[\ln x_A\right] = \frac{\Delta_{vap} H_{m.A}}{RT_b^2}.$$

$$\frac{d}{dT_b}\left[(1-x_B)\right] = \frac{\Delta_{vap} H_{m.A}}{RT_b^2}$$

$$d\left[1-x_B\right] = \frac{\Delta_{vap} H_{m.A}}{RT_b^2}\, dT_b \rightarrow (4)$$

Integrating within the limit. T_b^* (b. pt of the pure vapour) and T_b (b. pt of the solution).

$$\int d(1-x_B) = \int_{T_b^*}^{T_b} \frac{\Delta_{vap} H_{m.A}}{RT_b^2}\, dT_b.$$

$$\ln(1-x_B) = \frac{\Delta_{vap} H_{m.A}}{R} \int_{T_b^*}^{T_b} \frac{1}{T_b^2}\, dT_b.$$

$$\ln(1-x_B) = \frac{\Delta_{vap} H_{m.A}}{R}\left(\frac{1}{T_b} - \frac{1}{T_b^*}\right) \rightarrow (5)$$

Since the amount of solute is very small $x_B \ll 1$ we can write $\ln(1-x_B) \approx -x_B$

$$-x_B = \frac{\Delta_{vap} H_{m.A}}{R}\left(\frac{T_b^* - T_b}{T_b T_b^*}\right)$$

$$\text{or } x_B = \frac{\Delta_{vap} H_{m.A}}{R}\left(\frac{T_b - T_b^*}{T_b T_b^*}\right). \rightarrow (6)$$

Since T is almost equal to T^* so $T_b T_b^*$ can be replaced by $(T_b^*)^2$

(VII)

$$x_B = \frac{\Delta_{vap} H_{m.A}}{R}\left(\frac{\Delta T_b}{(T_b^*)^2}\right) \rightarrow (7)$$

Where $\Delta T_b = T_b - T_b^*$ is the elevation of boiling point

or $$\Delta T_b = \frac{x_B (T_b^*)^2 R}{\Delta_{vap} H_{m.A}} \rightarrow (8)$$

$$x_B = \frac{n_B}{n_A + n_B}.$$ n_B = no. of moles of solute. n_A = no of moles of solvent.

Since $n_B << n_A$ [Since the solution is very dilute].

$$x_B = \frac{n_B}{n_A}.$$

The solute molality $m_B = \dfrac{n_B}{n_A \times M_A}$.

where M_A = Molar mass of the solvent.

or $$\frac{n_B}{n_A} = m_B M_A.$$

$$x_B = m_B M_A. \rightarrow (9)$$

Putting the value of x_B in eqn (8)

$$\Delta T_b = \frac{M_A (T_b^*)^2 R}{\Delta_{vap} H_{m.A}} m_B$$

$$\Delta T_b = K_b m_B.$$ Where K_b is called molal b.Pt elevation constant and

$$K_b = \frac{R (T_b^*)^2 M_A}{\Delta_{vap} H_{m.A}}$$