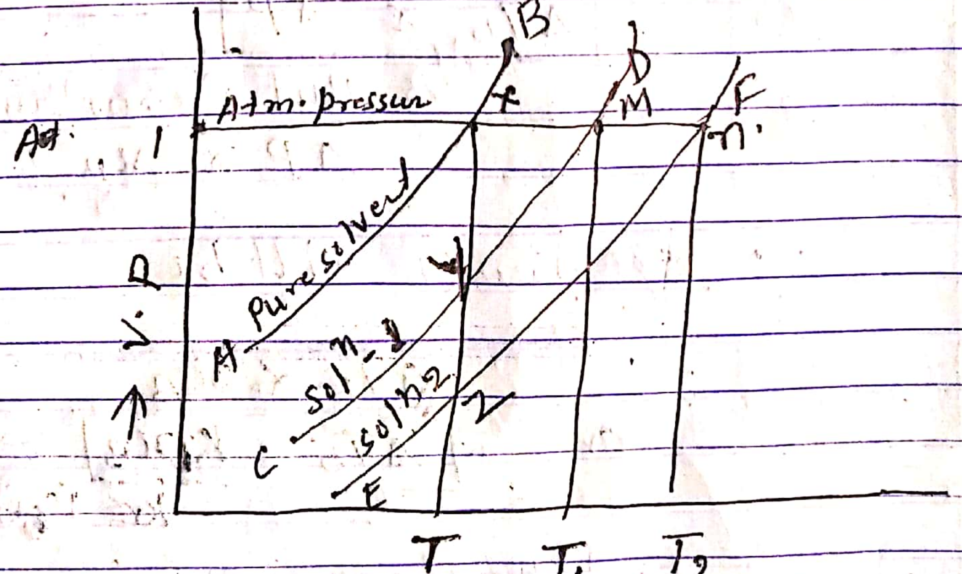
B.Sc. I, Paper - IA

Elevation of boiling point of solution

The temperature at which vapour pressure of liquid become equal to atmospheric pressure is called boiling point of liquid. It is found that boiling point of solvent in solution is higher than the boiling point of pure solvent. This elevation of boiling point is known as elevation of boiling of solvent in solution. This elevation is due to the lower vapour pressure of a solution than the vapour pressure of solvent.

This fact is illustrated as given in below figure.



The vapour pressure of solvent, solution 1 and solution 2 is plotted against the temp.

Here curve AB, CD, EF are curve of solvent, solution 1 and solution 2.

$$T_1 - T = \Delta T_1 \text{ for solution 1}$$
$$T_2 - T = \Delta T_2 \text{ for solution 2}$$

As ΔXZn and ΔXym are equivalent

$$\frac{Xn}{Xm} = \frac{XZ}{XY}$$

or, $$\frac{T_2 - T}{T_1 - T} = \frac{P - P_2}{P - P_1}$$

or, $$\frac{\Delta T_2}{\Delta T_1} = \frac{\Delta P_2}{\Delta P P_1}$$

or $$\boxed{\Delta T_b \propto \Delta P} \quad \text{—— (i)}$$

But from Rault's law
$\Delta P \propto x_B$ (mole fraction of solute).

∴ equation (i) will be:

$$\Delta T_b \propto x_B$$

or $$\boxed{\Delta T_b = K_b x_B} \quad \text{—— (ii)}$$

K_b is proportionality constant

x_B = mole fraction of solute.

or $$\Delta T_b = K_b \times \frac{\frac{W_B}{M_B}}{\frac{W_A}{M_A} + \frac{W_B}{M_B}}$$

Here W_A, M_A are the mass and molecular mass of solvent and W_B and M_B is the mass and molecular mass of solute.

or, $$\Delta T_b = K_b \times \frac{\frac{W_B}{M_B}}{\frac{W_A}{M_A}}$$ [As very dilute solution $\frac{W_B}{M_B} << \frac{W_A}{M_A}$]

or, $$\Delta T_b = K_b \cdot \frac{W_B \cdot M_A}{M_B \cdot W_A}$$

$$\Delta T_b = K_b \cdot x_B \cdot \frac{M_A}{W_A}$$ where $x_B = \frac{W_B}{M_B}$ (iii)

or $\boxed{\Delta T_b = K_b \cdot m \cdot M_A}$ where m = molality of solution as W_A is written Kilogram

or $\boxed{\Delta T_b = K_b \cdot m}$ where $K_b = K \cdot m$. (iv)

K_b is called molal elevation constant.

For one molal solution $m = 1$

$$\boxed{\Delta T_b = K_b}$$

Thus Molal elevation constant is a constant equal to the elevation of boiling point for one molal solution.

From definition of molal solution

$$m = \frac{1000 \cdot W_B}{M_B \cdot W_A}$$

Hence equation (iv) will be

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

$$M_B = \frac{1000 \cdot K_b \cdot W_B}{\Delta T_b \cdot W_A} \quad \text{— (V)}$$

This equation is used to calculate the molecular mass of non-volatile compound by knowing ΔT_b, W_B (wt of solute) and W_A = wt of solvent taken.

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