Class ⇒ B.Sc.
Subject ⇒ chemistry
Chapter ⇒ colligative properties
Topic ⇒ Elevation of Boiling point

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Elevation of Boiling point

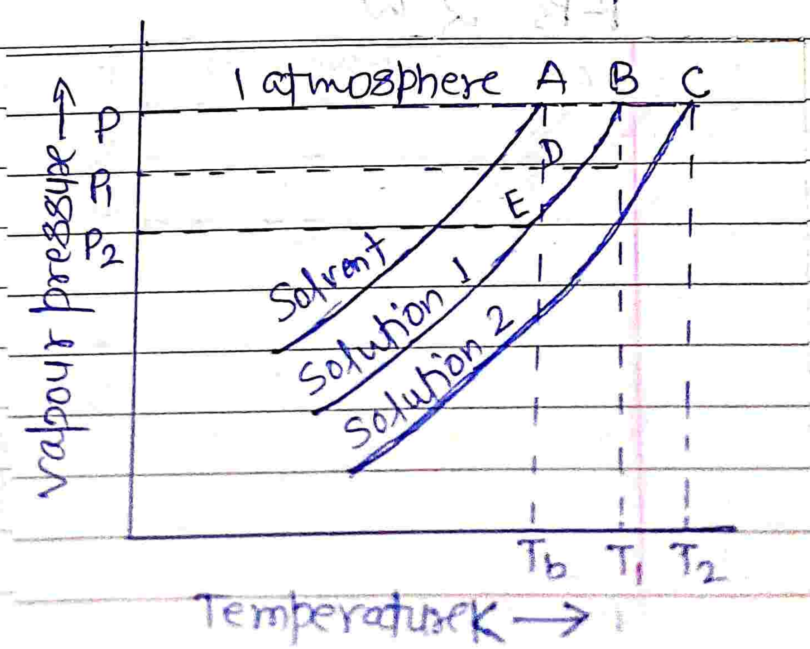
The boiling point, T_b of a liquid is the temperature at which its vapour pressure is equal to the atmospheric pressure.

When a non-volatile solute is added to a liquid, the vapour pressure of the liquid is decreased and consequently elevates the boiling point.

If T_b is the boiling point of the solvent and T is the boiling point of the solution, the difference in the boiling point (ΔT) is called the elevation of boiling point.

$$\Delta T = T_b - T$$

The vapour pressure of the pure solvent and solutions ① and ② with different concentrations of solute are shown in figure.



For dilute solutions, the curves BD and CE are parallel and straight lines approximately. Therefore, for similar triangles ACE and ABD, we have

$$\frac{AB}{AC} = \frac{AD}{AE}$$

or. $$\frac{T_1 - T_b}{T_2 - T_b} = \frac{P - P_1}{P - P_2}$$

Where $P - P_1$ and $P - P_2$ are lowering of vapour pressure for soln (1) and soln (2) respectively.

Thus the elevation of Boiling point is directly proportional to the lowering of vapour pressure.

$$\Delta T \propto P - P_s \quad \text{——— (1)}$$

Determination of molecular Mass from Elevation of Boiling point

Since P is constant for the same solvent at a fixed temperature, from (1) we have

$$\Delta T \propto \frac{P - P_s}{P} \quad \text{——— (2)}$$

But from Raoult's law for dilute solutions,

$$\frac{P - P_s}{P} \propto \frac{wM}{Wm} \quad \text{——— (3)}$$

Since M (Mol. Mass of solvent) is constant, from (3)

$$\frac{P - P_s}{P} \propto \frac{w}{Wm} \quad \text{——— (4)}$$

From eqn (2) and (4)

$$\Delta T \propto \frac{w}{m} \times \frac{1}{W}$$

$$\therefore \quad \Delta T = K_b \times \frac{w}{m} \times \frac{1}{W} \quad \text{——— (5)}$$

Where K_b is a constant called Boiling point constant or Ebullioscopic constant of molal elevation constant.

If $w/m = 1$, $W = 1$, $K_b = \Delta T$ Thus, Molal elevation constant may be defined as the boiling-point elevation produced when 1 mole of solute is dissolved in 1 kg (1000 gm) of the solvent.

If the mass of the solvent (W) is in gms., it has to be converted into kg. Thus the eqn (5) assumes the form

$$\Delta T = K_b \times \frac{w}{m} \times \frac{1}{W/1000}$$

or $$m = \frac{1000 \times K_b \times w}{\Delta T \times W} \quad \text{——— (6)}$$

Where ΔT = Elevation of Boiling point, K_b = molal elevation constant, w = mass of solute in gm., m = mol mass of solute and W = mass of solvent in gm.

The value of K_b is determined by measurement of ΔT by taking a solute of known molecular mass (m) and substituting the values in expression (6).

The unit of $K_b \Rightarrow K\ kg\ mol^{-1}$

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Subject ⇒ Chemistry
Chapter ⇒ Colligative properties
Topic ⇒ Depression of Freezing point

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Depression of freezing point

The freezing point of a liquid is the temperature at which a liquid of specific composition turns into a solid.

The difference in the freezing point of the pure solvent (T_f) and the solution containing a non-volatile solute is called depression of freezing point.

Depression of freezing point is represented by ΔT_f or ΔT.

$$\therefore \Delta T = T_f - T_1$$

Depression of freezing point is directly proportional to the lowering of vapour pressure.

$$\Delta T \propto P - P_s \quad \text{——— (1)}$$

Determination of molecular Mass from depression of freezing point.

Since P is constant for the same solvent at a fixed temperature, from eqn. (1), we can write

$$\Delta T \propto \frac{P - P_s}{P} \quad \text{——— (2)}$$

But from Raoult's law for dilute solution

$$\frac{P - P_s}{P} = \frac{wM}{Wm} \quad \text{——— (3)}$$

Since M (Mol weight) of Solvent is constant, from equation (3)

$$\frac{P-P_s}{P} = \frac{w}{Wm} \quad \text{--- (4)}$$

from equation (2) and (4)

$$\Delta T \propto \frac{w}{m} \times \frac{1}{W}$$

$$\therefore \Delta T = K_f \times \frac{w}{m} \times \frac{1}{W} \quad \text{--- (5)}$$

Where K_f is a constant called freezing point constant or cryoscopic constant or Molal depression constant.

If $w/m = 1$ and $W = 1$, $K_f = \Delta T$ Thus, Molal depression constant may be defined as the freezing-point depression produced when 1 mole of solute is dissolved in one kg (1000 gm) of the solvent.

If the mass of solvent (W) is given in gms. it has to be converted into kg. Thus the expression (5) assumes the form.

$$\Delta T = K_f \times \frac{w}{m} \times \frac{1}{W/1000}$$

or $$\Delta T = K_f \times \frac{w}{m} \times \frac{1000}{W}$$

$$\therefore m = \frac{1000 \times K_f \times w}{\Delta T \times W} \quad \text{--- (6)}$$

Where m = Molecular Mass of solute, K_f = molal depression constant; w = mass of solute, W = mass of solvent, ΔT = depression of freezing point.

Thus Molecular Mass of solute can be calculated.