SOLVED PROBLEMS ON ELEVATION IN BOILING POINT

Example 1. A solution of 12.5 g of urea in 170 g of water gave boiling point elevation of 0.63 K. Calculate the molar mass of urea. $K_b = 0.52$ K kg mol^{-1}.

Solution. From the given data

$$\text{Wt. of the solute, } w = 12.5 \text{ g}$$

$$\text{Wt. of the solvent } W = 170 \text{ g}$$

$$\text{Elevation of boiling point } \Delta T_b = 0.63 \text{ K}$$

$$\text{Elevation constant } K_b = 0.52 \text{ K kg mol}^{-1}$$

$$\text{Let the molecular mass of solute (urea)} = m$$

Calculation of molality

$$170 \text{ grams of water contain urea} = 12.5 \text{ gram}$$

$$\therefore 1000 \text{ grams of water contain urea} = \frac{1000 \times 12.5}{170} \text{ g}$$

$$= \frac{1000 \times 12.5}{170 \times m} \text{ mole}$$

$$\therefore \text{ molality (no. of mole in 1000 g of solvent)} = \frac{1000 \times 12.5}{170 \times m}$$

We know, $\quad \Delta T_b = K_b \times \text{molality}$

Substituting the value in the above relation,

We have, $\quad 0.63 = 0.52 \times \left(\frac{1000 \times 12.5}{170 \times m} \right)$

$$m = \frac{0.52 \times 1000 \times 12.5}{170 \times 0.63} = 60.69 \text{ a.m.u.}$$

Example 2. A solution prepared from 0.3 g of an unknown non-volatile solute in 30.0g of CCl_4 boils at 350.392 K. Calculate the molecular mass of the solute. The boiling point of CCl_4 and its K_b values are 350.0 K and 5.03 respectively.

Solution. From the given data

$$\text{Wt. of the solute, } w = 0.3 \text{ g}$$

$$\text{Wt. of the solvent } W = 30.0 \text{ g}$$

$$\text{Elevation of boiling point} = \Delta T_b = 350.392 - 350.0 = 0.392 \text{ K}$$

$$\text{Elevation constant } K_b = 5.03 \text{ K kg mol}^{-1}$$

Calculation of molality

$$30 \text{ g of } CCl_4 \text{ contain} = 0.3 \text{ g of solute}$$

$$\therefore \quad 1000 \text{ g of } CCl_4 \text{ contain} = \frac{1000 \times 0.3}{30} \text{ g}$$

$$= \frac{1000 \times 0.3}{30 \times m} \text{ moles}$$

$$\therefore \quad \text{Molality (no. of moles in 1000 g of } CCl_4 = \frac{1000 \times 0.3}{30 \times m}$$

Substituting the values in the relation

$$\Delta T_b = K_b \times \text{molality}$$

$$0.92 = 5.03 \times \frac{1000 \times 0.3}{30 \times m}$$

$$m = \frac{5.03 \times 1000 \times 0.3}{30 \times 0.392} = 128.3$$

$$\therefore \quad \text{Molecular mass} = \mathbf{128.3}$$

Example 3. Find the b.p. of a solution containing 0.36 g of glucose ($C_6H_{12}O_6$) dissolved in 100 g of water ($K_b = 0.52$ K/m).

Solution.

$$\text{Mass of glucose (w)} = 0.36 \text{ g}$$
$$\text{Mass of water (W)} = 100 \text{ g}$$
$$\text{Mol. Mass of glucose (M)} = 180$$
$$\text{Molal elevation constant for water } (K_b) = 0.52$$

Substituting the values in the relation

$$\Delta T_b = \frac{1000 \times K_b \times w}{W \times m}$$

or

$$\Delta T_b = \frac{1000 \times 0.52 \times 0.36}{100 \times 180}$$

$$\text{Elevation in b.p.} = 0.0104$$
$$\text{B. P. of pure water} = 373 \text{ K}$$
$$\text{Hence b.p. of the solution} = 373 + 0.0104 = 373.0104 \text{ K}$$

Example 4. 10 g of a non-volatile solute when dissolved in 100g of benzene raises its b.p. by 1°. What is the molecular mass of the solute (K_b for benzene $= 2.53$ K mol^{-1})?

Solution. In this problem

$$\text{Mass of the solute (w)} = 10 \text{ g}$$
$$\text{Mass of the solvent (W)} = 100 \text{ g}$$
$$\text{Elevation in b.p. } (\Delta T_b) = 1°, \quad K_b = 2.53$$

Substituting the values in the equation

$$m = \frac{1000 \times K_b \times w}{W \times \Delta T_b} = \frac{1000 \times 2.53 \times 10}{100 \times 1} = 253$$