2. SOLUTION

2.21 Two elements A and B form compounds having formula AB_2 and AB_4. When dissolved in 20g of benzene (C_6H_6), 1 g of AB_2 lowers the freezing point by 2.3 K whereas 1.0 g of AB_4 lowers it by 1.3 K. The molar depression constant for benzene is 5.1 K kg mol^{-1}. Calculate atomic masses of A and B.

Sol.

Using the relation, $M_2 = \dfrac{1000 \times k_f \times w_2}{w_1 \times \Delta T_f}$

$$\therefore \quad M_{AB_2} = \frac{1000 \times 5{\cdot}1 \times 1}{20 \times 2{\cdot}3} = 110{\cdot}87 \text{ g mol}^{-1}$$

$$M_{AB_4} = \frac{1000 \times 5{\cdot}1 \times 1}{20 \times 1{\cdot}3} = 196{\cdot}15 \text{ g mol}^{-1}$$

Let the atomic masses of A and B are 'p' and 'q' respectively.

Then molar mass of

$AB_2 = p + 2q = 110{\cdot}87 \text{ g mol}^{-1}$ ...(*i*)

And molar mass of

$AB_4 = p + 4q = 196{\cdot}15 \text{ g mol}^{-1}$ ...(*ii*)

Substracting equation (*ii*) from equation (*i*), we get $2q = 85.28 \Rightarrow q = 42.64$

Putting $q = 42.64$ in equ. (*i*), we get

$p = 110.87 - 85.28$

$p = 25.59$

Thus, atomic mass of $A = 25.59 \text{ g mol}^{-1}$ and atomic mass of $B = 42.64 \text{ g mol}^{-1}$

2.22 At 300 K, 36g of glucose present in a litre of its solution has an osmotic pressure of 4.08 bar. If the osmotic pressure of the solution is 1.52 bars at the same temperature, what would be its concentration?

Sol.

$$\pi = CRT$$

$$4.98 = \frac{W_1}{M_1} \times R \times 300$$

$$4.98 = \frac{36}{180} \times R \times 300$$

$$4.98 = 60\,R \qquad ...(i)$$

In second case $1.52 = C \times R \times 300$ ...(*ii*)

Diving equation (*ii*) by equation (*i*), we get

$$C = \frac{60 \times 1.52}{300 \times 4.98} = 0.06\ \text{M}$$

2.23 Suggest the most important type of intermolecular attractive interaction in the following pairs:
(i) n-hexane and n-octane
(ii) I_2 and CCl_4.
(iii) $NaCl0_4$ and water
(iv) methanol and acetone
(v) acetonitrile (CH_3CN) and acetone (C_3H_60)
Sol. (i) Both w-hexane and n-octane are non-polar. Thus, the intermolecular interactions will be London dispersion forces.
(ii) Both I_2 and CCl_4 are non-polar. Thus, the intermolecular interactions will be London dispersion forces.
(iii) $NaCl0_4$ is an ionic compound and gives Na^+ and $Cl0_4^-$ ions in the Solution. Water is a polar molecule. Thus, the intermolecular interactions will be ion-dipole interactions.
(iv) Both methanol and acetone are polar molecules. Thus, intermolecular interactions will be dipole-dipole interactions.
(v) Both CH_3CN and C_3H_6O are polar molecules. Thus, intermolecular interactions will be dipole-dipole interactions.

2.24 Based on solute-solvent interactions, arrange the following in order of increasing solubility in n-octanc and explain.
Cyclohexane, KCl, CH_3OH, CH_3CN.
Sol. (a) Cyclohexane and n-octane both are non-polar. They mix completely in all proportions.
(b) KCl is an ionic compound, KCl will not dissolve in n-octane.
(c) CH_3OH is polar. CH_3OH will dissolve in n-octane.
(d) CH_3CN is polar but lesser than CH_3OH. Therefore, it will dissolve in n-octane but to a greater extent as compared to CH_3OH. Hence, the order is KCl < CH_3OH < CH_3CN < Cyclohexane.

2.25 Amongst the following compounds, identify which are insoluble, partially soluble and highly soluble in water?
(i) phenol
(ii) toluene
(iii) formic acid
(iv) ethylene glycol
(v) chloroform
(vi) pentanol

Sol. (i) Phenol (having polar – OH group) – Partially soluble.
(ii) Toluene (non-polar) – Insoluble.
(iii) Formic acid (form hydrogen bonds with water molecules) – Highly soluble.
(iv) Ethylene glycol (form hydrogen bonds with water molecules) Highly soluble.
(v) Chloroform (non-polar)- Insoluble.
(vi) Pentanol (having polar -OH) – Partially soluble.