In Class Exercise for Chapter 13 – Properties of Solutions

1. When 5.50 g of biphenyl ($C_{12}H_{10}$) is dissolved in 100.0 g of benzene (C_6H_6), the boiling point increases by 0.903°C. Calculate the K_b for benzene. If 6.30 g of an unknown were added to 150.0 g of benzene, the boiling point of the solution increases by 0.597°C. What is the molar mass of the unknown substance?

$$m = \frac{5.50\,g \times \dfrac{1\,mol\ C_{12}H_{10}}{154.21\,g}}{0.100\,kg\ C_6H_6} = 0.357\,\frac{mol\ C_{12}H_{10}}{kg\ C_6H_6}$$

$$k_b = \frac{\Delta T_b}{m} = \frac{0.903^\circ C}{0.357\,\dfrac{mol\ C_{12}H_{10}}{kg\ C_6H_6}} = \boxed{2.53\,\frac{^\circ C \bullet kg}{mol}}$$

$$\Delta T_b = k_b m = k_b\,\frac{n_{unk}}{kg_{solvent}} \rightarrow n_{unk} = \frac{\Delta T_b \bullet kg_{solvent}}{k_b} = \frac{0.903^\circ C \bullet 0.1500\,kg}{2.53\,\dfrac{^\circ C \bullet kg}{mol}} = 0.0354\,moles\ unk$$

$$MW_{unk} = \frac{6.30\,g}{0.0354\,moles} = 177.99\,\frac{g}{mol} \rightarrow \boxed{178\,\frac{g}{mol}}$$

2. At 63.5°C, the vapor pressure of H_2O is 175 torr and that of ethanol, C_2H_5OH, is 400 torr. A solution is generated by mixing equal masses of both solutions. What is the vapor pressure of the solution? What is the mole fraction of the ethanol in the vapor above the solution?

$$P_{\text{soln}} = P_{H_2O}\chi_{H_2O} + P_{eth}\chi_{eth}$$

$$\chi_{H_2O} = \frac{1\,g\ H_2O \times \dfrac{1\,mol}{18.02\,g}}{1\,g\ H_2O \times \dfrac{1\,mol}{18.02\,g} + 1\,g\ eth \times \dfrac{1\,mol}{46.07\,g}} = 0.719$$

$$\chi_{eth} = 1 - \chi_{H_2O} = 0.281$$

$$P_{\text{soln}} = 175\,torr \bullet 0.719 + 400\,torr \bullet 0.281 = \boxed{238\,torr}$$

$$\chi_{eth} = \frac{1\,g\ eth \times \dfrac{1\,mol}{46.07\,g} \bullet 400\,torr}{1\,g\ H_2O \times \dfrac{1\,mol}{18.02\,g} \bullet 175\,torr + 1\,g\ eth \times \dfrac{1\,mol}{46.07\,g} \bullet 400\,torr} = \boxed{0.472}$$

3. The osmotic pressure of a 0.010 M aqueous solution of $CaCl_2$ is found to be 0.674 atm at 25°C. What is the van't Hoff factor for this solution? What is the percent dissociation?

$$\Pi = iMRT \rightarrow i = \frac{\Pi}{MRT} = \frac{0.674\ atm}{0.010\ \frac{mol}{L} \bullet 0.0821 \frac{L \bullet atm}{mol \bullet K} \bullet 298.15 K} = \boxed{2.75}$$

$CaCl_2 \rightarrow Ca^{2+} + 2Cl^-$ therefore for complete dissociation $i = 3$

$$\%\ dissociation = \frac{2.75}{3} \times 100\% = \boxed{91.7\%}$$

4. How many grams are needed to prepare each of the following solutions?

(a) 25 mL of 220 ppm aqueous solution of NaOH

$$\frac{220\ mg\ NaOH}{1\ kg\ H_2O} \times \frac{1\ kg\ H_2O}{1000\ g\ H_2O} \times \frac{1\ g}{1\ mL} \times 25\ mL \times \frac{1\ g}{1000\ mg} = \boxed{5.5 \times 10^{-3}\ g\ NaOH}$$

(b) 10 mL of 0.450 M solution of HCl

$$\frac{0.450\ mol\ HCl}{1\ L} \times 0.010\ L \times \frac{36.461\ g}{1\ mol\ HCl} = \boxed{0.16\ g\ HCl}$$

(c) 50 mL of 2.35 m solution of KI

$$\frac{2.35\ mol\ KI}{1\ kg\ H_2O} \times \frac{1\ kg\ H_2O}{1000\ g\ H_2O} \times \frac{1\ g}{1\ mL} \times 50\ mL \times \frac{166.00\ g}{1\ mol} = 19.5\ g\ NaOH \rightarrow \boxed{20\ g\ NaOH}$$