Solutions to Problems on the Handout

Example 1: What is the weight percent of vitamin C in a solution made by dissolving 1.30 g of vitamin C, $C_6H_8O_6$, in 55.0 g of water?

$$\text{wt\%} = \frac{\text{mass solute}}{\text{total mass solution}} \times 100 = \frac{1.30\text{g vitamin C}}{55.0\text{g}H_2O + 1.30\text{g vitamin C}} \times 100 = 2.31\%$$

Example 2: How much water must be added to 42.0 g of $CaCl_2$ to produce a solution that is 35.0 wt% $CaCl_2$?

$$35.0\%\ CaCl_2 = \frac{35.0\text{g } CaCl_2}{100.0\text{g soln}} = \frac{35.0\text{g } CaCl_2}{100.0\text{g soln} - 35.0\text{g}CaCl_2} = \frac{35.0\text{g } CaCl_2}{65.0\text{g } H_2O}$$

$$42.0\text{gCaCl2} \times \frac{65.0\text{g } H_2O}{35.0\text{g } CaCl_2} = 78.0\text{g}H_2O \text{ must be added to the 35.0g of } CaCl_2$$

$$\text{note that: } \frac{42.0}{(42.0+78.0)} \times 100 = 35.0\%$$

Example 3: What is the mole fraction of ethanol in a solution made by dissolving 14.6 g of ethanol, C_2H_5OH, in 53.6 g of water?

$$X(C_2H_5OH) = \frac{\text{mols } C_2H_5OH}{\text{total mols of solution}} = \frac{14.6\text{g } C_2H_5OH \times \frac{1\text{mol}C_2H_5OH}{46.07\text{g}}}{14.6\text{g } C_2H_5OH \times \frac{1\text{mol}C_2H_5OH}{46.07\text{g}} + 53.6\text{g}H_2O \times \frac{1\text{mol } H_2O}{18.02\text{g}}} = 0.0963$$

Example 4: A solution is prepared by dissolving 17.75 g sulfuric acid, H_2SO_4, in enough water to make 100.0 mL of solution. If the density of the solution is 1.1094 g/mL, what is the mole fraction H_2SO_4 in the solution?

$$100.0\text{mL} \times \frac{1.1094\text{g}}{1\text{mL}} = 110.\overline{9}4 \text{ g solution - } 17.75\text{g } H_2SO_4 = 93.\overline{1}9 \text{ g } H_2O$$

$$X(H_2SO_4) = \frac{17.75\text{g } H_2SO_4 \times \frac{1\text{mol } H_2SO_4}{98.08\text{g}}}{17.75\text{g } H_2SO_4 \times \frac{1\text{mol } H_2SO_4}{98.08\text{g}} + 93.\overline{1}9 \text{ g } H_2O \times \frac{1\text{mol } H_2O}{18.02\text{g}}} = 0.0338$$

Example 5: Aqueous solutions of 30.0% (by weight) hydrogen peroxide, H_2O_2, are used to oxidize metals or organic molecules in chemical reactions. Calculate the molality of this solution.

$$30.0\%\ H_2O_2 = \frac{30.0\text{g } H_2O_2}{100.0\text{g solution}} = \frac{30.0\text{g } H_2O_2}{70.0\text{g } H_2O}$$

$$m(H_2O_2) = \frac{30.0\text{g } H_2O_2 \times \frac{1\text{ mol } H_2O_2}{34.02\text{g}}}{70.0\text{g } H_2O \times \frac{1\text{kg}}{1000\text{g}}} = 12.6\text{m}$$

Example 6: A 1.30 M solution of $CaCl_2$ in water has a density of 1.11 g/mL. What is the molality?

ans. 1.35 *m* $CaCl_2$

$$1.30\text{M } CaCl_2 = \frac{1.30\text{mol } CaCl_2}{1 \text{ L Solution}}$$

$$1.30\text{mol } CaCl_2 \times \frac{111.0\text{g } CaCl_2}{1.30\text{mol } CaCl_2} = 14\bar{4}.3 \text{ g } CaCl_2$$

$$1.00\text{L of solution} \times \frac{1000\text{mL}}{1\text{L}} \times \frac{1.11\text{g solution}}{1.00\text{mL}} = 1110 \text{ g of solution}$$

$$1110 \text{ g solution - } 144.3 \text{ g } CaCl_2 = 96\bar{4}.7 \text{ g } H_2O$$

$$m = \frac{1.30\text{mol } CaCl_2}{96\bar{4}.7 \text{ g } H_2O \times \frac{1\text{kg}}{1000\text{g}}} = 1.35\text{m}$$

Colligative Properties:

Example: A KCl solution is prepared by dissolving 40.0 g KCl in 250.0 g of water at 25°C. What is the vapor pressure of the solution if the vapor pressure of water at 25°C is 23.76 mm Hg?

$$P_{solution} = P^0_{solvent} \times X_{solvent}$$

$$P_{solution} = 23.76 \text{ mm Hg} \times \frac{250.0\text{g}H_2O \times \frac{1\text{mol}}{18.02\text{g}}}{250.0\text{g}H_2O \times \frac{1\text{mol}}{18.02\text{g}} + 40.0\text{gKCL} \times \frac{1\text{mol KCl}}{74.55\text{g}} \times \frac{2\text{mols ions}}{1\text{mol KCl}}} = 22.05 \text{ mm Hg}$$

Boiling Point Elevation and Freezing Point depression:

Examples:

What is the freezing point of a solution of 1.43 g $MgCl_2$ in 100. g of water? K_f = –1.86°C/*m* for water.

ans. -0.84°C

$$Tf = 0.00^\circ C + \Delta T = 0.00^\circ C - 1.86 \tfrac{^\circ C}{m} \times \frac{1.43\text{g } MgCl_2 \times \frac{1\text{mol } MgCl_2}{95.21\text{g}}}{100.\text{g} \times \frac{1\text{kg}}{1000\text{g}}} \times 3 = -0.84^\circ C$$

Which of the following solutions will have the lowest freezing point? Why?

a. 0.010 *m* NaCl

b. 0.010 *m* Li_2SO_4

c. 0.035 *m* C_3H_8O

d. 0.015 *m* $MgCl_2$

ans. 0.045 m in total dissolved particles

Molar mass calculations base on freezing point depression:

Example: When 1.60g of a molecular compound is dissolved in 20.0g of benzene (C_6H_6) the freezing point of the solution is found to be 2.8°C. If the normal freezing point is 5.5°C and $K_f = -2.53\frac{^{o}C}{m}$, then what is the molar mass of the unknown compound?

$$\Delta T_f \rightarrow m_{solute} \rightarrow \text{moles solute} \rightarrow \text{molar mass (knowing mass of solute)}$$

1.33

0.08206/

Osmosis:

$$\Pi = cRT$$

$$\Pi = \text{ Osmotic Pressure (atm)}$$

$$\text{c = concentration in } \frac{\text{moles}}{\text{L}}$$

$$R = 0.08206\frac{L \cdot atm}{mol \cdot K}$$

$$T = \text{ absolute temperature}$$

A solution is prepared by dissolving 4.78 g of an unknown nonelectrolyte in enough water to make 375 mL of solution. The osmotic pressure of the solution is 1.33 atm at 27 °C. What is the molar mass of the solute? (*R* = 0.08206 L·atm/mol·K)

$$\Pi = cRT$$

$$c = \frac{\Pi}{RT} = \frac{1.33}{0.08206\frac{L \cdot atm}{mol \cdot K} \times 300.15K} = 0.0540M$$

$$mols = c(mols/L) \times V = 0.0540\frac{mols}{L} \times 0.375L = 0.020\overline{2}5 \text{ mols}$$

$$M_{wt} = \frac{4.78g}{0.02025mols} = 236 \text{ g/mol}$$

I