Chem1403 Worksheet
Colligative Properties Problems Key

1. **What is the vapor pressure of 450.0g of water when 68.0g of galactose ($C_6H_{12}O_6$) is added? Knowing vapor pressure of water at room temperature is 23.8 torr.**

$$n_{water} = \frac{450.0\ g}{18.015\ g/mol} = 24.98\ mol$$

$$n_{water} = \frac{68.0\ g}{180.156\ g/mol} = .377\ mol$$

$$P_{solvent} = X_{solvent} P^o_{solvent}$$

$$P_{solvent} = \left(\frac{24.98}{24.98 + .377}\right) 23.88 = 23.52\ torr$$

2. **About 10.56g Omeprazole ($C_{17}H_{19}N_3O_3S$) was added to 50.0g of ethyl acetate ($C_4H_8O_2$) for analysis. The vapor pressure of this solution is found to be 89.02 torr. Calculate the initial vapor pressure of ethyl acetate before adding in Omeprazole**

$$n_{ethyl\ acetate} = \frac{50.0\ g}{88.105\ g/mol} = 0.568\ mol$$

$$n_{Omeprazole} = \frac{10.56\ g}{345.42\ g/mol} = .0306\ mol$$

$$X_{solvent} = \left(\frac{0.568}{0.568 + .0306}\right) = .948$$

$$P_{solvent} = X_{solvent} P^o_{solvent}$$

$$P^o_{solvent} = \frac{P_{solvent}}{X_{solvent}} = \frac{89.02}{.948} = 93.81\ torr$$

3. **An unknown solid was added to 100.0g of acetonitrile and decreased the solvent's vapor pressure to 89.05 torr. With the initial vapor pressure of acetonitrile is 97.51, calculate the number of mol for this unknown solid**

$$n_{ethyl\ acetate} = \frac{50.0\ g}{41.052\ g/mol} = 2.44\ mol$$

$$P_{solvent} = X_{solvent} P^o_{solvent}$$

$$X_{solvent} = \frac{P_{solvent}}{P^o_{solvent}} = \frac{89.05}{97.51} = \frac{2.44\ mol}{2.44\ mol + n_{unknown}}$$

$$.9132 = \frac{2.44\ mol}{2.44\ mol + n_{unknown}}$$

$$.9132\ (2.44 + n_{unknown}) = 2.44$$

$$.9132\ n_{unknown} + 2.228 = 2.44$$

$$n_{unknown} = .232\ mol$$

4. **NaCl was added to water to increases water's boiling point. After adding NaCl solution, boiling point of water increased to 102.5°C. With k_{bp} of water is .5121°C/m, what is the molality of this salt solution?**

*Note: take in account of Van't Hoff Factor, NaCl is soluble in water so it dissociates into Na^+ and Cl^-. Therefore, Van't Hoff Factor is 2

$$\Delta T = ik_{bp}m$$

$$(102.5 - 100.0) = 2(.5121°\text{C/m})m$$

$$\frac{102.5 - 100.0}{2\left(\frac{.5121°\text{C}}{\text{m}}\right)} = m = 2.441\ m$$

5. **About 1.78g of CBD ($C_{21}H_{30}O_2$) was added to 400.0g of benzene and raise benzene's boiling point to 82.1°C. Calculate k_{bp} for benzene, knowing its normal boiling point is 80.1°C**

$$mol\ of\ CBD = \frac{1.78\ g}{314.464\ g/mol} = .00566\ mol$$

$$m = \frac{mol\ of\ solute}{kg\ of\ solvent} = \frac{.00566\ mol}{.4000\ kg} = 0.01415m$$

$$\Delta T = ik_{bp}m$$

$$\frac{\Delta T}{m} = k_{bp} = \frac{82.1 - 80.1}{.1415} = 14.13\ °\text{C/m}$$

6. **What is the change in freezing point for an aqueous solution of 4.00m of K_2SO_4? Given k_f for water is 1.86°C/m**

$$K_2SO_4 \rightarrow 2K^{2+} + SO_4^{2-}$$

Van't Hoff Factor = 3

$$\Delta T = ik_{fp}m$$

$$\Delta T = 3(1.86)(4.00) = 22.32$$

7. **The melting point of pure benzene is 278.70 K and K_f = 4.90 K/m. When 5.83 g of an unknown solute is added to 50.0g of benzene, the freezing point of the solution is 272.4 K. Determine the molecular weight of the unknown.**

$$\Delta T = ik_{fp}m$$

$$\frac{\Delta T}{ik_{fp}} = m = \frac{278.70 - 272.4}{4.90} = 1.3m$$

$$\frac{5.83g\ solute}{1.3\ \frac{mol\ solute}{kg\ solvent}\left(\frac{.05kg\ solvent}{1}\right)} = 89.69\ g/mol$$

8. **A solution prepared by dissolving .80g of cocaine ($C_{17}H_{21}NO_4$) in water to make 16mL of solution at 25°C. What is the osmotic pressure of this solution?**

$$n\ cocaine = \frac{.80\ g\ cocaine}{303.353\ g/mol} = .002637 mol$$

$$\pi = MRT$$

$$\pi = \left(\frac{.002637\ mol}{.016 L}\right)\left(0.0821 \frac{L\ atm}{mol\ K}\right)(25 + 273.15) = 4.034\ atm$$

9. **About .260g of unknown solid was dissolved in 50.0g of water at 30.0°C resulting in osmotic pressure of 2.18 atm. What is the molar mass of this unknown**

$$\pi = MRT$$

$$M = \frac{\pi}{RT} = \frac{2.18\ atm}{\left(.0821 \frac{L\ atm}{mol\ K}\right)(303.15\ K)} = .0876\ M$$

$$\frac{.260 g\ solute}{.0876\ \frac{mol\ solute}{L\ solution}\left(\frac{.05 L\ solution}{1}\right)} = 59.36\ g/mol$$