(Key)

Colligative Properties Worksheet

Answer each of the following questions in the space provided or on a separate sheet of paper.
Show all work. Round final answers to three significant figures and label with appropriate units..

1. What is the vapor pressure of water at 80.0°C when 200. g $C_{12}H_{22}O_{11}$ is dissolved in 150. g water?

200g → 342 g/mol = 0.585 mol $C_{12}H_{22}O_{11}$

↳ = 8.33 mol H_2O

$VP_{solution} = X_{solvent} \cdot VP_{solvent}$

$VP_{solution} = \left(\frac{8.33 \text{ mol } H_2O}{(0.585 + 8.33)}\right) \times 47.3$ ← Vapor Pressure of water from Table H or 18.2

$\boxed{VP_{solution} = 44.2 \text{ kPa}}$

2. 1.20 mol of a nonelectrolyte is dissolved in 1000 g of water. What is the value of the freezing point depression of this solution given the K_f of water is 1.86 °C/*m*?

$\Delta T_{fp} = K_f \times m \times i$

$\Delta T_{fp} = (1.86°C/m) \times \left(\frac{1.20 \text{ mol}}{1 \text{ kg}}\right)(1)$

$\boxed{\Delta T_{fp} = 2.23°C}$

3. Calculate the freezing point depression if 0.400 mol of a nonelectrolyte is dissolved in 2000 g phenol. [K_f phenol = 7.40°C/*m*]

= 2 kg

$\Delta T_{fp} = K_f \times m \times i$

$= (7.40°C/m)\left(\frac{0.400 \text{ mol}}{2 \text{ kg}}\right)(1)$

$= \boxed{1.48°C}$

4. Calculate the freezing point depression for a 0.877 m water solution of a nonelectrolyte. [K_f of water is 1.86 °C/*m*]

$\Delta T_{fp} = K_f \times m \times i$

$\Delta T_{fp} = (1.86°C/m)(0.877 m)(1)$

$\boxed{\Delta T_{fp} = 1.63°C}$

5. Calculate the molality of a solution of a nonelectrolyte, given that the freezing point depression is 3.56°C and K_f solvent = 2.77°C/*m*. Then calculate the mass of the solute dissolved in 8600 g of solvent, given that the molar mass of the solute is 62.6 g/mol.

$\Delta T_{fp} = K_f \times m \times i$

$3.56°C = (2.77°C/m) \times m \times 1$

$\boxed{1.285 = m}$

$m = \frac{\text{mol solute}}{\text{kg solvent}}$ $\quad 1.285 = \frac{x \text{ moles}}{8.6 \text{ kg}}$ $\quad x = 11.051 \text{ mol} \times \frac{62.6 \text{ g}}{1 \text{ mol}} = \boxed{692 \text{ g}}$

6. Determine the freezing point of a solution containing 77.0 gram of $Mg(ClO_4)_2$ in 2.00×10^2 grams water. (Assume 100% dissociation)

$77.0\,g \times \frac{1\,mol}{223.3\,g} = 0.3448\,mol$

$= 0.200\,kg$ water

$\Delta T_{fp} = K_{fp} \times m \times i$

$\Delta T_{fp} = (1.853\,°C/m)\left(\frac{0.3448\,mol}{0.200\,kg}\right)(3)$

$\Delta T_{fp} = 9.58°C$

$0°C - 9.58°C = \boxed{-9.58°C}$

7. A mass of 78.1 g of a nonelectrolyte that has a molar mass of 60.3 g/mol is dissolved in 10.5 kg of chloroform. Calculate the boiling point elevation given that [K_b for chloroform is 3.63°C/*m*]

moles solute $= 78.1\,g \times \frac{1\,mol}{60.3\,g} = 1.295\,mol$ solute

$\Delta T_{bp} = K_{bp} \times m \times i = (3.63°C/m)\left(\frac{1.295\,mol}{10.5\,kg}\right)(1)$

i = 1 for nonelectrolyte

$\boxed{\Delta T_{bp} = 0.448°C}$

8. Calculate the mass of the nonelectrolyte carbon tetrachloride, CCl_4, dissolved in 298 g of the solvent benzene if the boiling point elevation for the solution is 7.45°C.[K_b benzene = 2.53 °C/*m*]

$\Delta T_{bp} = K_{bp} \times m \times i$

$\frac{7.45}{2.53} = \frac{(2.53)(m) \times 1}{2.53}$

$2.945 = m$

$m = 2.945 = \frac{\text{moles solute}}{\text{kg solvent}}$

$2.945 = \frac{x\ \text{moles}}{.298\,kg}$

$x = 0.8776\,mol$

gfm = 154.0 g/mol

want mass, so use gfm: $0.8776\,mol \times \frac{154.0\,g}{1\,mol} = \boxed{135\,g}$

9. Calculate the molecular mass of a nonelectrolyte, given that 151 g of the substance depresses the freezing point of 3.500 kg of water by 2.53°C. [K_f = 1.86 °C/*m*]

$\Delta T_{fp} = K_{fp} \times m \times i$

$2.53 = (1.86)(m)$

$1.360 = m$

$1.360 = \frac{\text{moles solute}}{\text{kg solvent}}$

$1.360 = \frac{x\ mol}{3.500\,kg}$

$x = 4.76\,mol$

$\text{molec mass} = \frac{g}{mol} = \frac{151\,g}{4.76\,mol} = \boxed{31.7\,g/m}$

10. The freezing point depression of a solution of a nonelectrolyte in the solvent phenol is 9.21°C. Calculate the molecular mass of the solute given that the solution contains 13.9 g of it dissolved in 55.1 g of phenol. [K_f phenol = 7.40°C/*m*]

$= .0551\,kg$

$\Delta T_{fp} = K_{fp} \times m \times i$

$9.21 = 7.40 \times m$

$1.245 = m$

$1.245 = \frac{x\ mol}{.0551}$

$x = 0.06860\,mol$

$\text{molec. mass} = \frac{g}{mol} = \frac{13.9}{0.06860} = \boxed{203\,g/m}$