1. A solution is prepared by dissolving 10.0 g of H₃PO₄ (97.99 g/mol) in 100.0 g of water (18.02 g/mol). The volume of the resulting solution is 104 mL.

a. (4 points) Calculate the molality of H₃PO₄ in the solution.

\[ m = \frac{\text{mol H}_3\text{PO}_4}{\text{kg H}_2\text{O}} = \frac{10.0 \text{g H}_3\text{PO}_4}{18.02 \text{g H}_2\text{O}} = 0.55 \text{ mol/kg} \]

b. (4 points) Calculate the molarity of H₃PO₄ in the solution.

\[ 0.55 \text{ mol} = 0.55 \text{ mol/L} \]

2. (4 points) The vapor pressure of pure water at 40.0°C is 55.32 torr. What is the vapor pressure of a solution made by adding 128 g of glycerin (a nonvolatile solute, 98.1 g/mol) to 342 g of water (18.02 g/mol) at 40.0°C?

\[ \frac{128}{98.1} = 1.30 \text{ mol} \]

\[ \frac{342}{18.02} = 18.98 \text{ mol} \]

\[ \chi_w = \frac{18.98}{18.98 + 1.30} = 0.936 \]

\[ P_w = \chi_w P^0 = (0.936)(55.32) = 51.8 \text{ torr} \]

3. (4 points) The boiling point of benzene, C₆H₆, is 80.10°C at 1 atmosphere. Kₜ(Benzene) = 2.53°C/m. In a laboratory experiment, students synthesized a new compound and found that when 14.28 grams of the compound were dissolved in 261.2 grams of benzene, the solution began to boil at 80.682°C. The compound was also found to be nonvolatile and a non-electrolyte. What is the molar mass they determined for this compound?

\[ \Delta T_b = 80.682 - 80.100 = 0.582 \]

\[ m = \frac{\Delta T_b}{K_b} = \frac{0.582}{2.53} = 0.230 \text{ mol/kg} \]

\[ \frac{14.28}{261.2} = \frac{X}{1000} \]

\[ X = 54.67 \text{ g/mol} \]

4. (4 points) Calculate the freezing point of a 0.300 molal solution of Na₂SO₄. The freezing point depression constant Kᵣ for water is -1.86 °C/m, and pure water freezes at 0.00°C. Assume that ion pairing is negligible, so that the van’t Hoff factor is a whole number.

\[ \Delta T_f = K_f m_i = (-1.86)(0.300)(3) = -5.58 \text{ °C} \]

\[ T_f = -1.67 \text{ °C} \]