Quiz 5.2 – Colligative Properties

Name: Key

Phase Change Temperatures

Our textbook gives the following formula for the boiling point elevation constant $K_b = \frac{RT^{*2}}{\Delta H_{vap}}$

Find K_b for water, using $\Delta H_{vap} = 40.7 \frac{kJ}{mol}$

$$K_b = \frac{8.314 \ \frac{J}{mol \cdot K} \cdot (373 K)^2}{40,700 \ \frac{J}{mol}} = 28.4 \ K$$

Our textbook also provides some values of K_b in Table 5B.1, including for water: $K_b = 0.51 \frac{K\ kg}{mol}$
Show how these two values are actually consistent with each other

In the dilute limit, convert kg H_2O to moles H_2O and assume $n_{total} \approx n_{H_2O}$

$$0.51 \frac{K\ kg}{mol} \cdot \frac{1000 g}{1 kg} \cdot \frac{1 mol}{18.015 g} = 28.3 \ K$$

Benzene has $K_f = -5.12 \frac{K\ kg}{mol}$ and a normal freezing point of 5.5°C. If 1.6 g of naphthalene are dissolved into 5.6 g of benzene, what is the new freezing temperature?

→ 0.0125 moles

$$m = \frac{moles}{kg} = \frac{0.0125 \ moles}{0.0056 \ kg} = 2.5 \ m$$

$$\Delta T = K_f \cdot m = -5.12 \frac{K}{m} \cdot 2.5 \ m = 12.8 \ K$$

$$T_f = -7.3$$

Osmotic Pressure

Seawater contains about 35 g of NaCl in every kg of water solvent. Seawater can be purified through reverse osmosis, but requires applying a pressure equal to the osmotic pressure. What is the osmotic pressure of seawater at 25°C?

→ 0.599 moles NaCl → ≈ 1L

2 ions per mole

$$\Pi = \frac{nRT}{V} = \frac{0.599 \cdot 2 \cdot 0.08206 \frac{L \cdot atm}{mol \cdot K} \cdot 298 K}{1L} = 29.3 \ atm$$

2.5 g of an unknown non-electrolyte are dissolved in water to make 100.0 ml of solution. At 25°C the solution exhibits an osmotic pressure of 1.79 atm. What is the molar mass of the unknown?

$$n = \frac{m}{M} \cdot C \rightarrow \Pi = \frac{mRT \cdot C}{M \cdot V} \rightarrow M = \frac{mRTC}{\Pi V} = \frac{2.5g \cdot 0.08206 \frac{L \cdot atm}{mol \cdot K} \cdot 298K \cdot 1}{1.79 atm \cdot 0.1 L} = 342 \ \frac{g}{mol}$$

$C = 1$

What would the molar mass be if the unknown compound were instead a salt of the form A_2B_3? → $C = 5$

$$M = \frac{mRT \cdot C}{\Pi V} = \frac{2.5g \cdot 0.08206 \frac{L \cdot atm}{mol \cdot K} \cdot 298 K \cdot 5}{1.79 \ atm \cdot 0.1 L} = 1708 \ \frac{g}{mol}$$