1. What is the molality of a solution that contains 128 g of CH₃OH in 108 g of water?

\[
\frac{128 \text{ g CH}_3\text{OH}}{0.108 \text{ kg H}_2\text{O}} \times \frac{1 \text{ mol CH}_3\text{OH}}{32.0 \text{ g CH}_3\text{OH}} = \frac{37.0 \text{ mol}}{\text{kg H}_2\text{O}} = 37.0 \text{ m}
\]

2. (a) How many grams of H₂O must be used to dissolve 50.0 g of sucrose, C₁₂H₂₂O₁₁, to prepare a 1.25 m solution of sucrose?

\[
\frac{50.0 \text{ g C}_12\text{H}_22\text{O}_{11}}{342 \text{ g C}_12\text{H}_22\text{O}_{11}} \times \frac{1 \text{ mol C}_12\text{H}_22\text{O}_{11}}{0.146 \text{ mol C}_12\text{H}_22\text{O}_{11}} = \frac{0.117 \text{ kg H}_2\text{O}}{1.25 \text{ mol C}_12\text{H}_22\text{O}_{11}/ \text{kg H}_2\text{O}} = 117 \text{ g H}_2\text{O}
\]

(b) Predict the boiling point of this solution; \(K_b\) for H₂O is 0.512°C/m.

\[
\Delta T_b = (0.512°C/m)(1.25m) = 0.640°C; \quad \text{BP}= 100°C + 0.64°C = 100.64°C
\]

(c) Calculate the freezing point of this solution; \(K_f\) for H₂O is 1.86°C/m.

\[
\Delta T_f = (1.86°C/m)(1.25m) = 2.32°C
\]

\[
T_{f(solution)} = 0.00°C - 2.32°C = -2.32°C
\]

(d) What osmotic pressure would this solution exhibit at 25°C? Its density is 1.34 g/mL.

\[
\frac{167 \text{ g x } 1 \text{ mL}}{1.34 \text{ g}} = \frac{125 \text{ mL}}{0.125 \text{ L}} = 0.125 \text{ L}
\]

\[
M_{sucrose} = \frac{0.146 \text{ mol}}{0.125 \text{ L}} = 1.17 \text{ mol/L}
\]

\[
\pi = MRT = (1.17 \text{ mol/L})(0.0821 \text{ L.atm/mol.K})(298K) = 28.6 \text{ atm}
\]

3. What are the mole fractions of CH₃OH and H₂O in the solution described in #1? It contains 128 g of CH₃OH and 108 g of H₂O.

\[
\frac{128 \text{ g CH}_3\text{OH}}{32.0 \text{ g CH}_3\text{OH}} \times \frac{1 \text{ mol CH}_3\text{OH}}{1 \text{ mol CH}_3\text{OH}} = \frac{4.00 \text{ mol CH}_3\text{OH}}{4 \text{+6 mol}} = 0.400;
\]

\[
\frac{108 \text{ g H}_2\text{O}}{18.0 \text{ g H}_2\text{O}} \times \frac{1 \text{ mol H}_2\text{O}}{1 \text{ mol H}_2\text{O}} = \frac{6.00 \text{ mol H}_2\text{O}}{4 \text{+6 mol}} = 0.600
\]

4. (a) At 40°C, the vapor pressure of pure heptane is 92.0 torr and the vapor pressure of pure octane is 31.0 torr. Consider a solution that contains 1.00 mole of heptane and 4.00 moles of octane. Calculate the vapor pressure of each component and the total vapor pressure above the solution.

\[
X_{\text{heptane}} = \frac{1 \text{ mol heptane}}{(1 \text{ mol heptane} + 4 \text{ mol octane})} = 0.200; \quad X_{\text{octane}} = 1 - X_{\text{heptane}} = 0.800
\]

\[
P_{\text{heptane}} = X_{\text{heptane}}P^0_{\text{heptane}} = (0.2)(92.0 \text{ torr}) = 18.4 \text{ torr}
\]

\[
P_{\text{octane}} = X_{\text{octane}}P^0_{\text{octane}} = (0.8)(31.0 \text{ torr}) = 24.8 \text{ torr}
\]

\[
P_{\text{total}} = P_{\text{heptane}} + P_{\text{octane}} = 18.4 \text{ torr} + 24.8 \text{ torr} = 43.2 \text{ torr}
\]
(b) Calculate the mole fractions of heptane and octane in the vapor that is in equilibrium with this solution.

\[ X_{\text{heptane}} = \frac{P_{\text{heptane}}}{P_{\text{total}}} = \frac{18.4 \text{ torr}}{43.2 \text{ torr}} = 0.426; \quad X_{\text{octane}} = \frac{P_{\text{octane}}}{P_{\text{total}}} = \frac{24.8 \text{ torr}}{43.2 \text{ torr}} = 0.574 \]

5. When 15.0g of ethyl alcohol, \( \text{C}_2\text{H}_5\text{OH} \), is dissolved in 750 grams of formic acid, the freezing point of the solution is 7.20°C. The freezing point of pure formic acid is 8.40°C. Solve for \( K_f \) for formic acid.

\[
15.0 \text{g C}_2\text{H}_5\text{OH} \times \frac{1 \text{ mol C}_2\text{H}_5\text{OH}}{46.0 \text{ g C}_2\text{H}_5\text{OH}} = 0.435 \text{ m}
\]
\[
\Delta T_f = (T_f(\text{formic acid})) - (T_f(\text{solution})) = 8.40°C - 7.20°C = 1.20°C
\]
\[
K_f = \Delta T_f = \frac{1.20°C}{m} = \frac{1.20°C}{0.435m} = 2.76°C/m
\]

6. A 1.20 gram sample of an unknown covalent compound is dissolved in 50.0 g of benzene. The solution freezes at 4.92°C. Calculate the molecular weight of the compound. The freezing point of pure benzene is 5.48°C and \( K_f \) is 5.12°C/m.

\[
\Delta T_f = 5.48°C - 4.92°C = 0.56°C;
\]
\[
m = \frac{\Delta T_f}{K_f} = \frac{0.56°C}{5.12°C/m} = 0.11m
\]
\[
\frac{0.11m)(0.0500kg) = 0.0055 \text{ mol solute}}{1.20 \text{ g solute}} = 0.022 \text{ g/mol}
\]
\[
0.0055 \text{ mol solute}
\]

7. 0.500 grams of a sample is dissolved in 30mL of aqueous solution. If this solution has an osmotic pressure of 8.92 torr at 27.0°C, estimate its molecular weight.

\[
\pi = MRT = \frac{n}{V}RT; \quad n = \pi V = \frac{8.92 \text{ torr} \times 1 \text{ atm/760 torr}(0.0300L)}{(0.0821 \text{ L.atm/mol.K})(300K)} = 0.0000143 \text{ mol}
\]
\[
0.500 g/0.0000143 \text{ mol} = 3.50 \times 10^4 \text{ g/mol}
\]

8. For each of the following solutions, predict whether the solubility of the solute would be high or low and justify your answer:

(a) LiCl in hexane, \( \text{C}_6\text{H}_{14} \)  
low; hexane is nonpolar

(b) BaCl\(_2\) in \( \text{H}_2\text{O} \)  
high

(c) \( \text{C}_6\text{H}_{14} \) in \( \text{H}_2\text{O} \)  
low; hexane is nonpolar

(d) CHCl\(_3\) in \( \text{C}_6\text{H}_{14} \)  
low; hexane is nonpolar

(e) \( \text{C}_6\text{H}_{14} \) in CCl\(_4\)  
high

(f) HCl in \( \text{H}_2\text{O} \)  
high

(g) \( \text{C}_6\text{H}_{14} \) in \( \text{H}_2\text{O} \)  
low; hexane is nonpolar

(h) \( \text{Al}_2\text{O}_3 \) in \( \text{H}_2\text{O} \)  
low; Al and O are multiply-charged

(i) Na\(_2\)SO\(_4\) in \( \text{C}_6\text{H}_{14} \)  
low; hexane is nonpolar

9. Choose the ion in each pair that would be more strongly hydrated in aqueous solution and justify your answer:

(a) Na\(^+\) or Rb\(^+\)  
Na\(^+\) because it has a smaller radius

(b) Cl\(^-\) or Br\(^-\)  
Cl\(^-\) because it has a smaller radius

(c) Fe\(^{3+}\) or Fe\(^{2+}\)  
Fe\(^{3+}\) because it has more charge

(d) Na\(^+\) or Mg\(^{2+}\)  
Mg\(^{2+}\) because it has more charge