CLAS Chem 1C  
Ch 17 Solutions

1. Consider an 8.40% by mass aqueous solution of HCl. The density of solution is 1.05 g/mL.
   a. Calculate the molarity.
      \[ 8.40 \text{ g HCl} + 91.6 \text{ g H}_2\text{O} = 100 \text{ g solution} \]
      \[ 8.4 \text{ g (1 mol)} \frac{1 \text{ mol HCl}}{36.5 \text{ g}} = 0.23 \text{ mol HCl} \]
      \[ 100 \text{ g solution} \frac{1 \text{ mol}}{1.05 \text{ g}} \frac{1 \text{ L}}{1000 \text{ mL}} = 0.952 \text{ L} \]
      \[ M = \frac{0.23 \text{ mol HCl}}{0.952 \text{ L soln}} = 2.42 \text{ M} \]
   b. Calculate the molality.
      \[ m = \frac{0.23 \text{ mol HCl}}{0.0916 \text{ kg H}_2\text{O}} = 2.51 \text{ m} \]

2. When NH₄NO₃ is dissolved in water, the solution gets cold. Predict the sign of \( \Delta S \) for the dissolution of ammonium nitrate.
   \[ \Delta G = \Delta H - T \Delta S \]
   \( \Theta \)
   \( \text{Always } \Theta \text{ be in } K \)
   \( \text{Note it } \)
   \( \text{dissolves (solv)} \)
   \( + \text{ bec } \)
   \( \\
   \text{must be } + \)

3. A small amount of sodium bromide is dissolved in a large amount of water. Imagine separating this process into the four stages sketched below. When NaBr dissolves in water an endothermic reaction takes place. List the stages in order of increasing enthalpy.

![Diagram of dissolution stages](image)

\( \Delta H_1 > 0 \)
break IMFs to expand solute particles

\( \Delta H_2 > 0 \)
break IMFs to expand solvent particles

\( \Delta H_3 < 0 \)
form IMFs when mix solute & solvent

\[ \text{enthalpy} \]
\[ A < D < B < C \]
4. Consider the following solutes dissolved in water. Circle the one with the highest solubility.

   a. SO₃  
      nonpolar  
      H₂CO  
      polar  
      CCl₄  
      nonpolar  

   b. C₆H₁₂O₆ at 25 °C
      [C₆H₁₂O₆ at 45 °C]
      ↑T for (s)

   c. O₂ at 1 atm, 25 °C
      O₂ at 2 atm, 25 °C
      O₂ at 2 atm, 45 °C
      (g)  
      (g)  
      (g)  
      ¹P § ¹T for gases

5. Fill in the blanks:
   When a nonvolatile solute is dissolved in a solvent, the freezing point  
   the boiling point  
   the vapor pressure  
   and the osmotic pressure  

6. 15.0 g of a nonvolatile, nonelectrolyte solute are dissolved in 100 g water. The freezing point of the solution is -4.65 °C and the mole fraction of solute is 0.043. Calculate the vapor pressure of the solution at 100 °C.

   \[ \rho = \chi_{H_2O} \rho_{H_2O} \]
   \[ \chi_{H_2O} = 1 - 0.043 = 0.957 \]
   \[ \rho_{H_2O} = 1 \text{ atm} \text{ by } 100 ^\circ \text{C} \]
   \[ \rho = (0.957) (1 \text{ atm}) = 0.957 \text{ atm} \]

7. The vapor pressures of pure methanol and propanol at 40 °C are 303 and 44.6 torr

   a. A solution is made by mixing 0.677 moles of propanol and 0.428 moles of methanol at 40 °C. Calculate the vapor pressure of the solution assuming it behaves ideally.

   \[ \rho = \rho_p + \rho_m = \chi_p \rho_p^0 + \chi_m \rho_m^0 \]
   \[ = \left( \frac{0.677}{0.677 + 0.428} \right) (44.6 \text{ torr}) + \left( \frac{0.428}{1.105 \text{ torr}} \right) (303 \text{ torr}) \]
   \[ = 27.3 \text{ torr} + 117 \text{ torr} \]
   \[ = 144 \text{ torr} \]

   b. If the vapor pressure of a methanol-propanol solution is 212 torr at 40 °C, calculate the mole fraction of propanol in solution.

   \[ \rho = \chi_p \rho_p^0 + \chi_m \rho_m^0 \]
   \[ 212 = \chi_p (44.6) + (1 - \chi_p) (303) \]
   \[ 212 = 44.6 \chi_p + 303 - 303 \chi_p \]
   \[ -91 = -258.4 \chi_p \]
   \[ \chi_p = 0.35 \]
8. Predict whether the following will be an ideal solution (obeys Raoult’s Law) or would exhibit a positive or negative deviation. When mixed, what would happen to the temperature of the solution?

a. carbon tetrachloride (CCl₄) and dichloromethane (CH₂Cl₂)
   - nonpolar
   - polar
   - Positive deviation
   - ΔT of soln

b. water and acetone (CH₃COCH₃)
   - H-bonding
   - ΔT of soln
   - Negative deviation
   - ΔT of soln

c. carbon tetrachloride and benzene (C₆H₆)
   - nonpolar
   - nonpolar
   - Ideal soln, no temp change

9. Calculate the boiling point and freezing point of 10.0 g of NaF dissolved in 50.0 g water.
   (NaF: 42 g/mol, Kᵥ = 0.51 °C kg/mol, Kᵢ = 1.86 °C kg/mol)

\[
NaF \rightarrow Na^+ + F^- \quad i = 2
\]

\[
m = \frac{10 \text{ g NaF} \left( \frac{1 \text{ mol}}{42 \text{ g}} \right)}{50 \text{ g H₂O} \left( \frac{1 \text{ kg}}{1000 \text{ g}} \right)} = 4.8 \text{ mol/kg}
\]

\[
ΔT_b = iKᵥm = (2)(0.51 \degree C \text{ kg/mol})(4.8 \text{ mol/kg}) = 4.9 \degree C
\]

\[
BP = 100 \degree C + 4.9 \degree C = 104.9 \degree C
\]

\[
ΔT_f = -iKᵢm = -2(1.86 \degree C \text{ kg/mol})(4.8 \text{ mol/kg}) = -17.9 \degree C
\]

\[
FP = 0 \degree C - 17.9 \degree C = -17.9 \degree C
\]

10. Rank the following 1.0 M solutions from lowest to highest osmotic pressure:

\[
\begin{align*}
C₆H₁₂O₆ & : i = 1 \\
CaCl₂ & : i = 2 \\
K₃PO₄ & : i = 3 \\
HCl & : i = 4 \\
CH₃COOH & : \text{weak acid, } i = 2
\end{align*}
\]

\[
\text{Ti} = iMRT \quad \text{Ti} \propto \text{MRT}
\]

\[
\text{lowest osmotic press.} \quad C₆H₁₂O₆ < CH₃COOH < HCl < CaCl₂ < K₃PO₄
\]

\[
\text{highest osmotic press.}
\]
Equations

\[ P = k_H \chi \quad \text{or} \quad P = k_H C \]

\[ P_a = X_a P_a^\circ \quad \chi_a = \frac{n_A}{n_A + n_B} \]

\[ \Delta T_f = -k_f m \]

\[ \Delta T_b = k_b i m \]

\[ \pi = i MRT \]

PERIODIC TABLE

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\( x \) block

\( d \) block

\( p \) block

Lanthanides

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\( f \) block