Ch. 12 Discussion ?’s

- Concentration Units
  - 12.20, 12.22, 12.27, 12.117, 12.129
- Gas Solubility
  - 12.34, 12.38, 12.112
- Colligative properties
  - 12.53, 12.64, 12.71, 12.74, 12.107
12.20 For dilute aqueous solutions in which the density of the solution is roughly equal to that of the our solvent, the molarity of the solution is equal to its molality. Show that this statement is correct for a 0.010 M aqueous urea (NH₂)₂CO solution.

Assume 1 L of solution & ρ = 1.0 g/mL

mol/mL Urea → mol Urea

\[ g_{\text{solvent}} = g_{\text{soln}} - g_{\text{solute}} \]

\[ \text{molality} = \frac{\text{mol}_{\text{solute}}}{\text{kg}_{\text{solvent}}} \]
The concentrated sulfuric acid we use in the laboratory is 98.0 percent $\text{H}_2\text{SO}_4$ by mass. Calculate the molality and molarity of the acid solution. The density of the solution is 1.83 g/mL.

**Answer:**

Assume 100.0 g soln

\[
\%\text{wt} \ \text{H}_2\text{SO}_4 \rightarrow g \ \text{H}_2\text{SO}_4 \rightarrow \text{mol} \ \text{H}_2\text{SO}_4
\]

\[
100\% - \%\text{wt}_{\text{solute}} = \%\text{wt}_{\text{solvent}}
\]

\[
\%\text{wt}_{\text{solvent}} \rightarrow \text{kg solvents}
\]

\[
\text{molality} = \frac{\text{mol}_{\text{solute}}}{\text{kg}_{\text{solvent}}}
\]
A 3.20 g sample of a salt dissolves in 9.10 g of water to give a saturated solution of 25°C. What is the solubility (in g salt/100 g of \( \text{H}_2\text{O} \)) of the salt?

**Answer:**

\[
g \text{ salt/g H}_2\text{O} \rightarrow g \text{ salt/100 g H}_2\text{O}
\]
12.117 A 2.6 L sample of water contains 192 µg of lead. Does this concentration of lead exceed the safety limit of 0.050 ppm of lead per liter of drinking water? [Hint: 1 µg = 1 X 10^{-6} g. Parts per million (ppm) is defined as (mass of component/mass of solution) X 10^6.]

**Answer:**

\[ \mu g \text{ Pb} \rightarrow g \text{ Pb} \]

\[ 2.6 \text{ L sol’n} \rightarrow g \text{ sol’n} \text{ (assume 1.0 g/mL)} \]

\[ \text{ppm} = \frac{g_{\text{Pb}}}{g_{\text{sol’n}}} \times 10^6 \]
a) Derive the equation relating the molality (m) of a solution to its molarity (M)

\[ m = \frac{M}{d - \frac{MM}{1000}} \]

Where \( d \) is the density of the solution (g/mL) and \( M \) is the molar mass of the solute (g/mol). (*Hint:* Start by expressing the solvent in kilograms in terms of the difference between the mass of the solution and the mass of the solute.)

**Answer:**

1. \[ \text{mass}_{\text{solvent}} = \text{mass}_{\text{soln}} + \text{mass}_{\text{solute}} \]
2. Calculate \( \text{mass}_{\text{soln}} \) from \( d \) & \( \text{mass}_{\text{solute}} \) from \( M \)
3. \[ \text{mass}_{\text{solvent}} = \frac{\text{mol}_{\text{solute}}}{m} \]
b) Show that, for dilute aqueous solutions, \( m \) is approximately equal to \( M \).

**Answer:**

\[
d \text{ of dilute aqueous soln} \approx 1 \text{ g/mL}
\]

\[
d \gg \frac{MM}{1000} \quad \text{for dilute aq soln}
\]

\[
m \approx \frac{M}{d} \approx M
\]
A man bought a goldfish in a pet shop. Upon returning home, he put the goldfish in a bowl of recently boiled water that had been cooled quickly. A few minutes later the fish was found dead. Explain what happened to the fish.

**Answer:**

Henry’s law

Solubility of $O_2$ decrease when $T$ increase, causing there to be little to no $[O_2]$ in water, so the fish couldn’t breathe. 😞
12.38 The solubility of N\textsubscript{2} in blood at 37°C and at a partial pressure of 0.80 atm is 5.6 \times 10^{-4} mol/L. A deep-sea diver breathes compressed air with the partial pressure of N\textsubscript{2} equal to 4.0 atm. Assume that the total volume of blood in the body is 5.0 L. Calculate the amount of N\textsubscript{2} gas released (in liters at 37°C and 1 atm) when the diver returns to the surface of the water, where the partial pressure of N\textsubscript{2} is 0.80 atm.

\textbf{Answer:}

Calculate Henry’s law constant (k); \( k = \frac{C}{P} \)

Calculate conc. when \( P=4.0 \text{ atm} \)

\( \text{mol N}_2 = \text{mol N}_2 \text{ @ 4.0 atm} - \text{mol N}_2 \text{ @ 0.80 atm} \)

\( V = \frac{\text{NRT}}{P} \)
Ammonia (NH$_3$) is very soluble in water, but nitrogen trichloride (NCl$_3$) is not. Explain.

**Answer:**

“Like dissolves like”

NH$_3$ is capable of H-bonding, while NCl$_3$ is not

H$_2$O is capable of H-bonding
The vapor pressure of ethanol (C$_2$H$_5$OH) at 20°C is 44 mmHg, and the vapor pressure of methanol (CH$_3$OH) at the same temperature is 94 mmHg. A mixture of 30.0 g of ethanol and 45.0 g of ethanol is prepared (and can be assumed to behave as an ideal solution).

a) Calculate the vapor pressure of methanol and ethanol above this solution at 20°C.

**Answer:**

\[
P_{\text{solute}} = X_{\text{solute}} P_{\text{total}}
\]

\[
X_{\text{solute}} = \frac{\text{mol}_{\text{solute}}}{\text{mol}_{\text{total}}};
X_{\text{CH}_3\text{OH}} = \frac{\text{mol}_{\text{CH}_3\text{OH}}}{\text{mol}_{\text{CH}_3\text{OH}} + \text{mol}_{\text{C}_2\text{H}_5\text{OH}}}
\]

\[
X_{\text{C}_2\text{H}_5\text{OH}} = 1 - X_{\text{CH}_3\text{OH}}
\]
b) Calculate the mole fraction of methanol and ethanol in the vapor above this solution at 20°C.  

\[ X_{\text{solute}} = \frac{P_{\text{solute}}}{P_{\text{total}}} \; ; \; P_{\text{total}} = \Sigma P_{\text{solute}} \]

\[ X_{\text{CH}_3\text{OH}} = \frac{P_{\text{CH}_3\text{OH}}}{P_{\text{CH}_3\text{OH}} + P_{\text{C}_2\text{H}_5\text{OH}}} \]

\[ X_{\text{C}_2\text{H}_5\text{OH}} = 1 - X_{\text{CH}_3\text{OH}} \]

c) Suggest a method of separating the two components of the solution.  

**Answer:**  
Fractional Distillation  
See Section 12.6
12.64 A solution containing 0.8330 g of a polymer of unknown structure in 170.0 mL of an organic solvent was found to have an osmotic pressure (π) of 5.20 mmHg at 25°C. Determine the molar mass of the polymer.

**Answer:**

\[
\pi = MRT
\]

\[
\pi \rightarrow \text{mol/L} \rightarrow \text{mol}_\text{polymer}
\]

\[
g/\text{mol} = \frac{0.8330 \text{ g}}{\text{mol}_\text{polymer}}
\]
Arrange the following solutions in order of decreasing freezing point: 0.10 m Na$_3$PO$_4$, 0.35 m NaCl, 0.20 m MgCl$_2$, 0.15 m C$_6$H$_{12}$O$_6$, 0.15 m CH$_3$COOH.

**Answer:**
Assume that all electrolytes completely dissociate

\[ \Delta T_f = i \times K_f \times m \]

\[ i = \text{van't Hoff factor} = \frac{\# \text{ particles after diss.}}{\text{formula units dissolved}} \]

Calculate $i$ & $\Delta T_f$ for each solute
12.74 At 25°C the vapor pressure of pure water is 23.76 mmHg and that of seawater is 22.98 mmHg. Assuming that seawater contains only NaCl, estimate its molal concentration.

**Answer:**

Calculate mole fraction; Eqn 12.5 \( \Delta P = X_{NaCl} P_{H_2O} \)

Calculate \( mol_2 \); \( X_{NaCl} = \frac{mol_2}{mol_2 + mol_{H_2O}} \)

NaCl dissociates to 2 ions; \( mol_{NaCl} = mol_2 \times \frac{1}{2} \times \frac{NaCl}{ions} \)

\( m_{NaCl} = \frac{mol_{NaCl}}{kg \ H_2O} \)
12.107 A solution contains two volatile liquids A and B. Complete the following table, in which the symbol ↔ indicates attractive intermolecular forces.

<table>
<thead>
<tr>
<th>Attractive Forces</th>
<th>Deviation from Raoult’s Law</th>
<th>$\Delta H_{\text{soln}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leftrightarrow A$, $\leftrightarrow B \succ A \leftrightarrow B$</td>
<td>Positive</td>
<td>Positive</td>
</tr>
<tr>
<td>$A \leftrightarrow B &gt; A \leftrightarrow A$, $B \leftrightarrow B$</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>$A \leftrightarrow B = A \leftrightarrow A = B \leftrightarrow B$</td>
<td>Obey exactly</td>
<td>Zero</td>
</tr>
</tbody>
</table>

**Answer:**
See Section 12.6