Properties of Solution

Practice Exam Solutions

Read all questions before you start. Show all work and explain your answers. Report all numerical answers to the proper number of sig. figs using scientific notation. Please keep your eyes on your own paper.

Useful Equations

<table>
<thead>
<tr>
<th>Solution Conc.</th>
<th>Symbol</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molarity</td>
<td>M</td>
<td>moles solute / liter solution</td>
</tr>
<tr>
<td>Molality</td>
<td>m</td>
<td>moles solute / Kg solvent</td>
</tr>
<tr>
<td>Mass percent</td>
<td>m %</td>
<td>(mass solute / mass solution) * 100</td>
</tr>
</tbody>
</table>
| Mole fraction  | x      | moles a / moles a + moles b ...

Solubility and Colligative Properties

<table>
<thead>
<tr>
<th>Pressure effects</th>
<th>P</th>
<th>( = \frac{x}{k} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Henry’s Law</td>
<td></td>
<td>where ( x ) = solubility</td>
</tr>
<tr>
<td>Raoult’s Law</td>
<td>( P_{\text{solv}} )</td>
<td>( = \Delta p_{\text{solv}} )</td>
</tr>
<tr>
<td></td>
<td>( \Delta P_{\text{solv}} )</td>
<td>( = P_{\text{solv}} - P_{\text{solvent}} = x_{\text{solute}} \cdot P_{\text{solvent}} )</td>
</tr>
<tr>
<td>Boiling Point Elevation</td>
<td>( \Delta T_{\text{bpt}} )</td>
<td>( = m \cdot K_b )</td>
</tr>
<tr>
<td>Freezing Point Depression</td>
<td>( \Delta T_{\text{fpt}} )</td>
<td>( = m \cdot K_f )</td>
</tr>
<tr>
<td>Osmotic Pressure</td>
<td>P</td>
<td>( = \frac{\text{MRT}}{R} / 0.08206 \text{ L} \cdot \text{atm} / \text{mol} \cdot \text{K} )</td>
</tr>
<tr>
<td>Van’t Hoff Factor</td>
<td>i</td>
<td>( i = \frac{\text{moles particles solution (expt)}}{\text{moles solute dissolved (calculated conc)}} )</td>
</tr>
</tbody>
</table>

Equilibrium constant

| K_p & K_c | \( K_p = K_c \cdot (RT)^n \) |

Quadratic Equation

| ax^2 + bx + c = 0 | \( x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \) |

Chapter 12  Properties of Solution

1 Ways of Expressing Solution Concentration
   Molarity (M)
   Molality (m)
   Percent mass (%m)
   Mole fraction (c)
   Normality (N)

2 The Solution Process
   Solution formation, spontaneity and disorder

3 Factors affecting solubility
   Solute - Solvent
   Temperature
   Pressure
   Henry’s Law

3 Colligative Properties of Solution
   Vapor Pressure & Raoult’s Law
   Mixture of Volatile Substances
   Pois. & neg. dev. of Raoults Law

4 Colligative Prop. of Electrolyte Solution
   Boiling Point Elevation
   Freezing Point Depression
   Osmotic Pressure
   Van’t Hoff Factor
1. **Concentration Conversion:**
0.0500 M NaOH solution in water has a density of 1.112 g/ml. Express the concentration in:
   a) mass percent (%m)
   b) molality (m)
   c) mole fraction (X).

2. **Colligative Properties:**
List the following aqueous solution in order of increasing boiling point:
0.03 m MgSO\(_4\), 0.03 m CaCl\(_2\), 0.04 m sucrose. Explain your selection.

3. **Henry's Law:**
The solubility of CO\(_2\) gas in water is 0.240 g per 100 ml at a pressure of 1.00 atm and 10.0°C.
(a) How much pressure must be exerted in order to compress 3.00 grams of CO\(_2\) (g) in a 12.0 oz can of beverage?
(b) What volume of CO\(_2\) (MWt = 44.00 g/mol) is released when the 12.0 oz can is left open to equilibrate to a
   pressure of 1.00 atm and a temperature of 10.0 °C? (12 oz. = 354.9 ml, STP, 1 mol = 22.4 L for ideal gas).

4. **Raoult's Law:**
At 60°C the vapor pressure of benzene is 384 torr, and that of toluene is 133 torr. A mixture is made by combining
   1.20 mol of toluene and 3.60 mol of benzene. Find:
a) the mole fraction of toluene in the liquid
b) the partial pressure of toluene above the liquid
c) the partial pressure of benzene above the liquid
d) the total vapor pressure
e) the mole fraction of toluene in the vapor phase.

5. **Colligative Properties:**
The osmotic pressure for an aqueous solution of sucrose is 2.4500 atm at 25.000°C.
a) Calculate the concentration of sucrose in molarity (M), molality (m), mole fraction (X) and % mass in this solution.
   (Sucrose is C\(_{12}\)H\(_{22}\)O\(_{11}\) MWt = 342 g/mol) The density of the solution is \(\rho = 1.0800 \text{ g/ml}\)
b) What are the boiling point and the freezing point of this solution? (\(K_b = 0.512 \degree\text{C/m}\) \(K_f = 1.86 \degree\text{C/m}\)) What is the
   vapor pressure of the solution? \(P^\circ (\text{H}_2\text{O}) = 23.796 \text{ torr at 25.000} \degree\text{C}\)?

6. **Solubility Concept:**
   Explain why the solubility of a gas in a liquid always decreases when the temperature increases.

7. **Concentration Conversion:**
   An aqueous solution of 30% hydrogen peroxide is used to oxidize metals or organic molecules in chemical reactions.
   Given that the density of the solution is 1.11 g/ml, calculate the molality of the solution.
Which solution is the lowest concentration?

a) $\% m = 25.0 \% m/m \text{Na}_2\text{CO}_3$  
b) $\chi = .0262 \text{HF}$  
c) $m = 1.45 \text{m CH}_3\text{OH}$  
d) $1.70 \text{M NaI (} \rho_{\text{soln}} = 1.00\text{g/cc)}$  
e) all the same

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The solubility of CO\textsubscript{2} gas in water is 0.240 g per 100 ml at a pressure of 1.00 atm and 10.0°C. Consider a 100-mL solution that is saturated with CO\textsubscript{2} at 1.00 atm and 10°C. You can assume that the partial pressure of CO\textsubscript{2} is 1.00 atm. Answer the following question concerning this solution.

i) If the pressure is changed to 760 mmHg:
   a) more CO\textsubscript{2} can be dissolved in solution  
   b) The solution is saturated with CO\textsubscript{2}  
   c) The solution will release CO\textsubscript{2} gas  
   d) the temperature of the solution will drop  
   e) none

ii) If the temperature is raised to 25°C:
    a) The solution is saturated with CO\textsubscript{2}  
    b) more CO\textsubscript{2} can be dissolved in solution  
    c) The solution will release CO\textsubscript{2} gas  
    d) the pressure of the solution will drop  
    e) none

iii) If an additional 50-mL of solvent is added:
     a) The solution is saturated with CO\textsubscript{2}  
     b) the mole fraction, $\chi$, of CO\textsubscript{2} will increase  
     c) The solution will release CO\textsubscript{2} gas  
     d) more CO\textsubscript{2} can be dissolved in solution  
     e) none

iv) Calculate the molar concentration (M), molality (m), parts per million concentration (ppm), and mole fraction ($\chi$) of CO\textsubscript{2} at 10.0 °C. Assume the density of the solution = 1.00 g/cc