Chemical Principles I

Third Midterm Ch 8-10

You must show all of your work to get full credit.

\[ R = 0.08206 \text{ L-atm/mol-K} \]

8. Put a letter P is the molecule has polar covalent bonds but no dipole moment, PD if it has polar covalent bonds and a dipole, O if it has no polar covalent bonds and non dipole moment, OD if it has no polar covalent bonds but has a dipole moment. (8 pt)

\[ \begin{array}{cccc}
\text{SO}_2 & \text{N}_2 & \text{CCl}_4 & \text{NH}_3 \\
\text{PD} & O & P & \text{PD} \\
\end{array} \]

3. What are allotropes? (4 pt.)

Different forms of an element in the same

\[ \text{state.} \]

4. Give an example of allotropes (2 pt.)

Graphite and diamond

\[ \text{O}_2 \text{ and O}_3 \]
12. Below the molecule indicate whether it has polar covalent by writing YES or NO. Do the same to indicate whether it has a dipole moment or not. (6 pt)

<table>
<thead>
<tr>
<th></th>
<th>S₈</th>
<th>BF₃</th>
<th>CS₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polar Covalent Bonds</td>
<td>NO</td>
<td>YES</td>
<td></td>
</tr>
<tr>
<td>Dipole Moment (Polar Molecule)</td>
<td>NO</td>
<td>NO</td>
<td>NO</td>
</tr>
</tbody>
</table>

11. On the phase diagram above, estimate the temperature of the normal boiling point? (2 pt)

\[ \approx 40^\circ C \]
12. How much energy (kJ) is required to convert a 15.5 g ice cube at \(-5.0^\circ C\) to water vapor at 180\(^{\circ}\)C? (1 pt) The specific heats of ice, water, and steam are 2.09 J/g-K, 4.18 J/g-K, and 1.84 J/g-K, respectively. For H\(_2\)O, \(\Delta H_{\text{fus}} = 6.01 \text{ kJ/mol}\) and \(\Delta H_{\text{vap}} = 40.67 \text{ kJ/mol}\). (10 pt)

\[
\begin{align*}
\text{(1)} & \quad 15.5g \times 2.09 \frac{I\text{J}}{g\text{-K}} \times 5K = 161.95 J \\
\text{(2)} & \quad 0.86 \text{ mol} \times 0.01 \frac{I\text{J}}{\text{mol} \cdot \text{K}} = 5.18 \text{ KJ} \\
\text{(3)} & \quad 15.5g \times 100K \times 4.18 \frac{I\text{J}}{g\text{-K}} = 648.3J \\
\text{(4)} & \quad (0.86 \text{ mol} \times 40.67 \frac{I\text{J}}{\text{mol} \cdot \text{K}}) = 34.98 \text{ KJ} \\
\text{(5)} & \quad (15.5g \times 50K \times 1.84 \frac{I\text{J}}{g\text{-K}}) = 228.8J
\end{align*}
\]

Total = 491.1 KJ

13. Circle the one of the pair with larger dispersion forces. (3 pt)

a. Hexane, C\(_6\)H\(_{14}\) or Nonane, C\(_9\)H\(_{20}\)

b. HF or HCl

c. H\(_2\)Se or H\(_2\)S

14. What is the most important (strongest) intemolecular force present in each of the following substances: (6 pt)

a. Ammonia, NH\(_3\) Hydrogen bonding

b. CO d. pole-dipole

c. Br\(_2\) London Dispersion
15. The vapor pressure of pure ethanol at 60°C is 349 torr. Raoult's law predicts the solution prepared by dissolving 12.8 g of naphthalene (C_{10}H_{8}, MW = 128.17) in 41.5 g of ethanol (C_{2}H_{5}OH, MW = 46.07) will have a vapor pressure of how much? (5 pt)

\[ \text{mol naph} \frac{12.8 \text{g}}{128.17 \text{g/mol}} = 0.10 \text{ mol} \]

\[ \text{ethanol} \frac{41.5 \text{g}}{46.07 \text{g/mol}} = 0.90 \text{ mol} \]

\[ \chi_{\text{ethanol}} = 0.90 \]

\[ P_{\text{soln}} = P_{\text{ethanol}} \chi_{\text{ethanol}} = (349 \text{ torr})(0.90) = 314 \text{ torr} \]

16. A solution is prepared by dissolving 6.00 g of an unknown nonelectrolyte in enough water to make 1.00 L of solution. The osmotic pressure of the solution is 0.750 atm at 25.0°C. What is the molecular weight (g/mol) of the unknown solute? (6 pt)

\[ \Pi = MRT \]

\[ M = \frac{\Pi}{RT} = \frac{0.750 \text{ atm}}{(0.08206 \text{ L atm/mol K})(298 \text{ K})} = 0.0307 \text{ M} \]

\[ 0.0307 \text{ mol/L} \times 1.00 \text{ L} = 0.0307 \text{ mol} \]

\[ \frac{6.00 \text{ g}}{0.0307 \text{ mol}} = 195.6 \text{ g/mol} \]
17. The freezing point of ethanol (C\textsubscript{2}H\textsubscript{5}OH, MW = 46.07) is \(-114.6^\circ\text{C}\). The molal freezing point depression constant for ethanol is 2.00°C/m. What is the freezing point (°C) of a solution prepared by dissolving 50.0 g of glycerin (C\textsubscript{3}H\textsubscript{8}O\textsubscript{3}, a nonelectrolyte, MW = 92.09) in 200 g of ethanol? (5 pt)

\[ \Delta T = K_f m \] 
\[ m = \frac{0.543 \text{ mol}}{0.200 \text{ kg}} = 2.71 \text{ m} \]

\[ \Delta T = (2.00^\circ \text{C/m}) (2.71 \text{ m}) = 5.42^\circ \text{C} \]

New freezing point = \(-114.6^\circ \text{C} - 5.42^\circ \text{C} = -120^\circ \text{C} \)

18. Classify the following solids as molecular, covalent, or ionic. (4 pt)

a. graphite  \text{covalent}  

b. I\textsubscript{2}  \text{molecular}  

c. sucrose (sugar)  \text{molecular}  

d. KBr  \text{ionic}  

20. A cubic unit cell contains oxide ions in the center of each face, a titanium ion in the center of the cell, and calcium ions at the corners of the cell. What is the empirical formula of this oxide? (3 pt)

\[ O = 6 \times \frac{1}{2} = 3 \]
\[ Ti = 1 \times 1 = 1 \]
\[ Ca = 8 \times \frac{1}{8} = 1 \]

\[ \text{CaTiO}_3 \]
13. On the following phase diagram identify (3 pt)
   a. the triple point
   b. the gas phase
   c. the liquid phase

![Phase Diagram]

14. On the phase diagram above, what is temperature of the **normal melting point**? (2 pt)
   \[ \sim 10^\circ C \]

15. On the following heating curve identify (2 pt)
   a. the heat of vaporization
   b. the heat of fusion

![Heating Curve]

16. In general, which is larger, $\Delta H_{\text{fus}}$ or $\Delta H_{\text{vap}}$? (1 pt)
17. Is condensation endothermic or exothermic? (1 pt)

18. Circle the one of the pair with larger dispersion forces. (3 pt)
   a. Ethane, C₂H₆ or octane, C₈H₁₈
   b. HI or HCl
   c. H₂O or H₂S

19. What the most important intermolecular forces present in each of the following substances: (6 pt)
   a. Chloroform, CH₃Cl
   b. Oxygen, O₂
   c. Methanol, CH₃OH

20. The vapor pressure of pure water at 25°C is 23.8 mm Hg. What is the vapor pressure of water above a solution prepared by dissolving 35 g of urea (a nonvolatile, non-electrolyte, MW = 60 g/mol) in 75 g of water. (6 pt)

   \[
   \text{urea} \quad \frac{35 \text{ g}}{60 \text{ g/mol}} = 0.58 \text{ mol}
   \]

   \[
   \text{water} \quad \frac{75 \text{ g}}{18 \text{ g/mol}} = 4.17 \text{ mol}
   \]

   \[
   \text{total} \quad \frac{4.75 \text{ mol}}{4.17 \text{ mol}} = 0.88
   \]

   \[
   P_{\text{soln}} = P_{\text{H₂O}} \cdot X_{\text{H₂O}} = (23.8 \text{ mm Hg}) \cdot 0.88 = 20.9 \text{ mm Hg}
   \]

21. A solution is prepared by dissolving 0.60 g of nicotine (a nonelectrolyte) in water to make 12 mL of solution at 25°C. What is the osmotic pressure of the solution? The molecular weight of nicotine is 162 g/mol? (5 pt)

   \[
   \Pi = MRT \quad M = \frac{0.60 \text{ g}}{162 \text{ g/mol}} / 0.012 = 0.31 \text{ M}
   \]

   \[
   \Pi = (0.31 \text{ M})(0.08206 \text{ L atm/mol K})(298 \text{ K}) = 7.58 \text{ atm}
   \]

22. A solution containing 100 g unknown liquid and 900 g water has a freezing point of -3.33°C.

   Given \( K_f = 1.86 \degree C/m \) for water, what is the molecular weight of the unknown liquid? (6 pt)

   \[
   -\Delta T = K_f m \quad m = \frac{-\Delta T}{K_f} = \frac{-3.33 \degree C}{1.86 \degree C/m} = 1.79 \text{ mol}
   \]

   \[
   \text{mol} = (1.79 \text{ mol}) \cdot \frac{0.900 \text{ kg}}{1 \text{ kg}} = 1.61 \text{ mol}
   \]

   \[
   \text{MW} = \frac{100 \text{ g}}{1.61 \text{ mol}} = 62.2 \text{ g/mol}
   \]
23. Classify the following solids as molecular, covalent, or ionic. (4 pt)

a. LiCl \text{ ionic}

b. diamond \text{ covalent}

c. ice \text{ molecular}

d. SiO\text{2} \text{ covalent}

24. A face centered cubic cell contains 8 X atoms at the corners of the cell and 6 Y atoms at the faces. What is the empirical formula of the solid? (3 pt)

\[X = 8 \times \frac{1}{8} = 1\]
\[Y = 6 \times \frac{1}{2} = 3\]

\text{Emp Form} = \text{X} \text{Y}_3