1. (f) a. Rank in terms of increasing bp: CF₂CH₃OH, MgCl₂, P₄, NO₂, NaCl

\[
\text{MgCl}_2 > \text{P}_4 > \text{NO}_2 > \text{CF}_2\text{CH}_3\text{OH} > \text{NaCl} > \text{MgCl}_2
\]

b. Shown below are two graphs for pure water at 25°C. On the graph on the bottom, superimpose the same graph for carbon dioxide. On the graph on the top, superimpose how the graph would change (still for water) if the temperature was decreased to 15°C.

c. Which outcome (A, B or C) corresponds to each of the following reactions?

\[
\begin{align*}
2\text{Na}^+ + \text{CO}_3^{2-} &\rightarrow \text{A} \\
\text{Ba}^{2+} + \text{CO}_3^{2-} &\rightarrow \text{B} \\
2\text{Ag}^+ + \text{SO}_4^{2-} &\rightarrow \text{C}
\end{align*}
\]

d. Rank in terms of increasing \(\Delta H_{\text{m}}\): He, Na₂O, Sn, H₂S, H₂O

\[
\text{He} < \text{Sn} < \text{H}_2\text{S} < \text{H}_2\text{O} < \text{Na}_2\text{O} < \text{Na}_2\text{O}_2
\]
2. (10) At what temperature does water boil inside a pressure cooker that has a pressure inside of 1.2 atm? Explain why pressure cookers are useful items in the kitchen.

\[
\ln \left( \frac{1.2 \text{ atm}}{1 \text{ atm}} \right) = \frac{46.1 \text{ kJ/mol}}{9.314 \text{ kJ/mol} \text{ mol}^{-1}} \left( \frac{1}{373} - \frac{1}{T} \right)
\]

\[
-1 = \frac{0.00259}{3.7 \times 10^{-5}} - \frac{1}{373}
\]

\[
T = 378 \text{ K} = 105^\circ \text{C}
\]

higher T: cooks faster

3. (14) Complete the table.

<table>
<thead>
<tr>
<th>Most favorable Lewis structure</th>
<th>FCN</th>
<th>SF(_5^+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>:F - C = N:</td>
<td>linear</td>
<td>trig bipyramidal</td>
</tr>
</tbody>
</table>

Sketch of hybrid orbital overlap resulting in bond formation. Label all orbitals. For FCN only.

Sketch of shape, including lone pairs. For SF\(_5^+\) only.
9. \( \text{FeCl}_3 + 3\text{NaOH} \rightarrow \text{Fe(OH)}_3 + 3\text{NaCl} \) (aq) 

\[
\begin{align*}
0.075 \text{ L} & : 0.89 \text{ mol} \\
L & \\
0.0648 \text{ mol} \text{FeCl}_3 & : 1 \text{ mol} \text{FeCl}_3 \\
1 \text{ mol} \text{FeCl}_3 & : 2 \text{ mol} \text{NaOH} \\
2 \text{ mol} \text{NaOH} & : 3 \text{ mol} \text{NaCl} \\
0.0668 \text{ product could form} & 
\end{align*}
\]

\[
\frac{50.2 \text{ kJ}}{\text{mol}} \cdot \frac{\text{mol}}{183 \text{ g}} = \frac{3.35 \text{ kJ}}{\text{g}}
\]

10. (10) A student in lab was conducting an experiment to determine the heat of reaction (precipitation) between silver nitrate and sodium chloride. Using a 1.0 M solution of aqueous AgNO\(_3\) and 2.0 M aqueous NaCl, both initially at 26.0 °C, the student completed the following data table by mixing solutions and observing the change in temperature. But the student forgot to record to pieces of data. A. Complete the following table for the student, showing all work in the space provided. You can assume the density and specific heat of all solutions is the same as for water.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>mL AgNO(_3)</th>
<th>mL NaCl</th>
<th>T(_i), °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.0</td>
<td>50.0</td>
<td>30.0</td>
</tr>
<tr>
<td>2</td>
<td>100.0</td>
<td>40.0</td>
<td>30.0</td>
</tr>
<tr>
<td>3</td>
<td>150.0</td>
<td>30.0</td>
<td>30.0</td>
</tr>
</tbody>
</table>

\[
\text{Expt } 1: 0.05 \text{ mol solid formed} \ 
\Delta T = 5 \text{ m at } 4.18 \cdot 10^3 \text{ J}^\circ C = 2.18 \text{ kJ} \]

\[
\text{Expt } 2: 0.025 \text{ mol solid formed} \ 
\Delta T = 50.2 \text{ kJ} \cdot \frac{0.25 \text{ mol}}{\text{mol}} = 5 \text{ m at } 4.18 \cdot 10^3 \text{ J}^\circ C = 2.18 \cdot 10^3 \text{ kJ} \]

Since they react 1:1 mol, in Expt 2, AgNO\(_3\) is the lim. reagent. In Expt 3, there is the perfect ratio 1:1 in Expt 4, NaCl is the lim. reagent. - Expt 3+4 produce the same atm heat - same T atm E

\[
\text{Expt } 3: 0.5 \text{ mol solid formed} \ 
\Delta T = 50.2 \text{ kJ} \cdot \frac{0.5 \text{ mol}}{\text{mol}} = 5 \text{ m at } 4.18 \cdot 10^3 \text{ J}^\circ C = 2.18 \cdot 10^3 \text{ kJ} \]

\[
\text{Expt } 4: \triangle T = 4.18 \cdot 10^3 \text{ J}^\circ C = 2.51 \cdot 10^3 \text{ kJ} \]

\[
\text{At } 20 ^\circ C
\]

\[
\text{Candide's same exp 3, exp 4 will give different answers}
\]

\[
\text{Candide's same exp 3, exp 4 will give different answers}
\]
4. (10) Rocket fuel, CH₄N₂, has a heat of combustion of -1.30 x 10³ kJ/mol. When 4.00 g of rocket fuel are combusted in a calorimeter that has a heat capacity of 3.610 kJ/°C when empty, the observed temperature increase is 14.50 °C. Determine the mass of water that was in the calorimeter when the sample was combusted.

\[
\frac{4\text{g}}{2} \times 1\text{mol CH₄N₂} \times \frac{1\text{mol}}{1.30 \times 10^3 \text{kJ}} = -113 \text{kJ released} \]

\[
+113 \text{kJ} = +113,000 \text{J} = \frac{3.610 \times 10^3 \text{J/°C} \times 14.5^\circ \text{C}}{\text{m} \times \text{14.5^\circ C}} \quad \text{m} = 1000 \text{g}
\]

5. (10) What would be the mole fraction of pentane in the vapor be for a solution consisting of pentane \( P_{\text{vap}} = 511 \text{ mm Hg at 25^\circ \text{C}} \), \( C_5H_{12} \) and hexane \( P_{\text{vap}} = 150 \text{ mm Hg at 26^\circ \text{C}} \), \( C_6H_{14} \) if the total vapor pressure of the solution is 350 mm Hg at 25 °C?

\[
350 = (x_P \times 511) + (1-x_P) \times 150
\]

\[
= 511x_P + 150 - 150x_P
\]

\[
200 = 361x_P \quad \Rightarrow \quad x_P = 0.554 \text{ in sol}
\]

In vapor: \( x_P = \frac{0.554\times 511}{350} = 0.81 \)

6. (6) Explain what is wrong with each reaction/equation in less than 10 words/reaction or just correcting the error in the equation.

\[
\text{Cu + Ag}^{+} \rightarrow \text{Ag} + \text{Cu}^{2+} \quad \text{balance e}^{-}
\]

\[
\text{CH₃OCH₃ + 3 O₂ → 2 CO₂ + 3 H₂O} \quad \Delta H = 3365 \text{kJ}
\]

\[
\text{Na₂CO₃ (aq) + K₂SO₄ (aq) → Na₂SO₄ (aq) + K₂CO₃ (aq)}
\]

\[
\text{No r}_x
\]
10. (9) Commercial nitric acid is an aqueous 16M solution that has a density of 1.42 g/mL. Determine both the concentration of nitric acid in units of molality and the mole fraction of nitric acid in the solution.

\[
m = \frac{16 \text{ mol HNO}_3}{1420 \text{ g}} = 0.112 \text{ kg H}_2\text{O}
\]

\[
x = \frac{16}{16 + 22.9} = 0.41
\]

11. (6) a. Explain why epoxides, such as the molecule shown below, tend to be very reactive.

\[\text{C}_3\text{H}_3\text{O}\]

- C3 is sp² hybridized: want a \(\text{sp}^2\) bond angle but must be 106° to form a 3-member ring

b. \(\text{NH}_3\text{Cl}\) has a higher vapor pressure than \(\text{C}_3\text{H}_6\text{CH}_2\text{CH}_2\text{CH}_3\) at any given temperature. Explain this based on its strength.

- Octane is such a large molecule it has relatively strong IMF's (LDF)
- Strong LDF's can hold molecules together more tightly than weak ionic interactions
7. (10) a. Construct a molecular orbital diagram for cyanide, CN.

b. Rank in terms of increasing bond strength: CN, CN⁻, and CN⁺.

c. Where you listed your ranking, circle any compound that is paramagnetic.

8. (9) Given the heat of formation of NO is 186.7 kJ/mol, use the following enthalpies of reaction to determine ΔH₂ for the formation of NO from dinitrogen oxide and nitrogen dioxide:

\[
\begin{align*}
2\text{NO} + \text{O}_2 &\rightarrow 2\text{NO}_2 \quad \Delta H = -113.1 \text{ kJ} \\
2\text{N}_2\text{O} &\rightarrow 2\text{N}_2 + \text{O}_2 \quad \Delta H = 163.2 \text{ kJ}
\end{align*}
\]

\[
\begin{align*}
\text{N}_2 + \text{O}_2 &\rightarrow 2\text{NO} \quad \Delta H = 186.7 \times 2 \\
\text{N}_2\text{O} &\rightarrow \frac{3}{2}\text{N}_2 + \frac{1}{2}\text{O}_2 \quad \Delta H = \frac{3}{2} \times 163.2 \text{ kJ} \\
\frac{3}{2}\text{N}_2\text{O}_2 &\rightarrow \text{O}_2 + 2\text{NO} \quad \Delta H = \frac{3}{2} \times 113.1 \text{ kJ}
\end{align*}
\]

\[
\Delta H = 443.5 \text{ kJ}
\]