CHEM 1364 (Night)
Test #3
Spring 2010 (Buckley)

1. (10 points) For the following equation:
   a. Complete the equation including the physical states (g, l, s, or aq).
   b. Balance the equation.
   c. Write the total ionic equation being sure to include all charges and physical states.
   d. Write the net ionic equation being sure to include all charges and physical states.

   \[ 2 \text{HC}_2\text{H}_5\text{O}_2(aq) + \text{Ba(OH)}_2(aq) \rightarrow 2\text{HOH}(l) + \text{Ba(C}_2\text{H}_3\text{O}_2)_2(aq) \]
   \[ 2\text{H}_2\text{N}_2\text{O}_2(aq) + \text{Ba}^{2+}(aq) + 2\text{OH}^-(aq) \rightarrow 2\text{HOH}(l) + \text{Ba}^{2+}(aq) + 2\text{C}_2\text{H}_3\text{O}_2(aq) \]
   \[ 2\text{H}_2\text{N}_2\text{O}_2(aq) + 2\text{OH}^-(aq) \rightarrow 2\text{HOH}(l) \]
   Or
   \[ \text{HC}_2\text{H}_3\text{O}_2(aq) + \text{OH}^-(aq) \rightarrow \text{HOH}(l) \]

2. (6 points) Show your work for each of the following.
   a. How many grams of MgBr₂ are contained in 45.00-mL of 0.155 M MgBr₂?

   \[ \frac{g \text{MgBr}_2}{\text{L}} = \frac{0.155 \text{ mol/L} \times 184 \text{ g/mol}}{1 \text{ mol/MgBr}_2} = 1.28 \text{ g MgBr}_2 \]

   b. What is the concentration of each ion in a solution that is 0.345 M (NH₄)₂CO₃?
      (Notice this time I gave you a concentration.)

   \[ \frac{\text{NH}_4^+}{\text{CO}_3^{2-}} = 0.345 \text{ M NH}_4^+ \]

   c. How many mL of 0.276 M CsBr could be prepared from 15.6-g of CsBr?

   \[ \frac{\text{mL}}{15.6 \text{ g CsBr}} \times \frac{1 \text{ mol CsBr}}{213 \text{ g CsBr}} \times \frac{1 \text{ L solution}}{0.276 \text{ mol CsBr}} = 265 \text{ mL} \]
3. (8 points) Show your work on each of the following.

a. The specific heat of liquid mercury is 0.14 J/g-K (or 0.14 J/g°C, the same thing). How much heat would be required to raise the temperature of 50.0-g of mercury from 25 °C to 45 °C?

\[ \Delta Q = \Delta c \times m \times \Delta T = 0.14 \, \text{J/kg} \times 50.0 \, \text{g} \times (45 - 25) \, \text{°C} = 140 \, \text{J} \]

b. The same quantity of heat is added to two blocks. One is 15.0-g of Al and the other 10.0-g of Fe. Which block will experience the largest change in temperature? The specific heat capacity of Al is 0.90 J/g-K and that of Fe is 0.45 J/g-K.

Given by: \( \Delta T = \frac{\Delta Q}{c \times m} \)

For Al, \( c \times m = 0.90 \, \text{J/kg} \times 15.0 \, \text{g} = 13.5 \, \text{J} \)

For Fe, \( c \times m = 0.45 \, \text{J/kg} \times 10.0 \, \text{g} = 4.5 \, \text{J} \)

Since \( c \times m \) is smaller for Fe, it will experience the larger temp change.

4. (8 points) When a 3.88-g of solid ammonium nitrate dissolves in 60.0-g of water in a coffee-cup calorimeter, the temperature of the water drops from 23.0 °C to 18.4 °C.

a. How much heat does the water lose during the dissolving process?

\[ \Delta Q = \frac{4.187 \, \text{J/g°C}}{60.0 \, \text{g}} \times (23.0 - 18.4) \, \text{°C} = -1150 \, \text{J} \]

b. Calculate the enthalpy change (in kJ/mol ammonium nitrate) for the process:

\[
\text{NH}_4\text{NO}_3 (s) \rightarrow \text{NH}_4^+ (aq) + \text{NO}_3^- (aq)
\]

\[ \Delta H = -1150 \, \text{J} \text{ for 3.88 g} \]

\[ \frac{1150 \, \text{J}}{3.88 \, \text{g NH}_4\text{NO}_3} \times \frac{80 \, \text{g NH}_4\text{NO}_3}{1 \, \text{mol NH}_4\text{NO}_3} = \boxed{23.7 \, \text{kJ/mol}} \]

c. Is the dissolving of ammonium nitrate an endothermic or an exothermic process?

ENDOTHERMIC
5. (16 points) Meals-ready-to-eat (MREs) are military meals that can be heated on a flameless heater. The heat is produced by the following reaction:

\[ \text{Mg}(s) + 2 \text{H}_2\text{O}(l) \rightarrow \text{Mg(OH)}_2(s) + \text{H}_2(g) \]

Show your work to receive full credit.

a. Using the data in the table below, find \( \Delta H^\circ \) for this reaction.

\[
\Delta H^\circ = \Delta H_f^\circ (\text{Mg(OH)}_2(s)) + 2 \Delta H_f^\circ (\text{H}_2O(l)) - \Delta H_f^\circ (\text{Mg}(s)) = -924.7 \text{ kJ/mol} + 0 - 0 - 2(-285.83) = -353 \text{ kJ}
\]

b. How much energy is released in this reaction per gram of Mg reacted?

\(-353 \text{ kJ} \text{ for 1 mol Mg.} \)  
\[-353 \frac{\text{kJ}}{246g} = -14.7 \frac{\text{kJ}}{g} \text{ or } 14.7 \frac{\text{kJ}}{g} \text{ RELEASEd} \]

c. How much heat would be required to raise the temperature of 25 mL of water from 15 °C to 85 °C?

\[ q = \frac{4.184 \text{ J}}{\text{g} \cdot ^\circ \text{C}} \times 25 \text{ g} \times (85^\circ \text{C} - 15^\circ \text{C}) = 7300 \text{ J} \]

d. If this reaction is used to heat the water, how many grams of Mg must be reacted to produce the amount of heat required in part c?

\[ \text{Want } 7300 \text{ J, RELEASED } 14.7 \frac{\text{kJ}}{g}. \]

\[ ? \text{ g Mg} = \frac{7300 \text{ J}}{14.7 \text{ kJ}} \times \frac{1}{1470 \text{ g}} = 0.50 \text{ g Mg} \]

<table>
<thead>
<tr>
<th>Substance</th>
<th>( \Delta H^\circ ) (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{Mg}(s)</td>
<td>0</td>
</tr>
<tr>
<td>\text{H}_2\text{O}(l)</td>
<td>-285.83</td>
</tr>
<tr>
<td>\text{Mg(OH)}_2(s)</td>
<td>-924.7</td>
</tr>
<tr>
<td>\text{H}_2(g)</td>
<td>0</td>
</tr>
</tbody>
</table>
6. (5 points) Given the information below find the enthalpy of formation of acetone, C\textsubscript{3}H\textsubscript{6}O (l). Show your work.

\[ \text{C}_3\text{H}_6\text{O}(l) + 4 \text{O}_2(g) \rightarrow 3 \text{CO}_2(g) + 3 \text{H}_2\text{O}(l) \quad \Delta H^\circ = -1790 \text{ kJ} \]

\[ \Delta H^\circ = 3\Delta H_f^\circ (\text{CO}_2(g)) + 3\Delta H_f^\circ (\text{H}_2\text{O}, l) - \Delta H_f^\circ (\text{C}_3\text{H}_6\text{O}, l) - 4\Delta H_f^\circ (\text{O}_2(g)) \]

\[ -1790 \text{ kJ} = 3 \times (-393.5 \text{ kJ/mol}) + 3 \times (-285.83 \text{ kJ/mol}) - \Delta H_f^\circ (\text{C}_3\text{H}_6\text{O}, l) - 4 \times (0 \text{ kJ/mol}) \]

\[ -1790 \text{ kJ} = -2037.99 \text{ kJ} - \Delta H_f^\circ (\text{C}_3\text{H}_6\text{O}, l) \]

\[ \Delta H_f^\circ (\text{C}_3\text{H}_6\text{O}, l) = -248 \text{ kJ/mol} \]

<table>
<thead>
<tr>
<th>Substance</th>
<th>( \Delta H_f^\circ ) (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{O}_2 ) (g)</td>
<td>0</td>
</tr>
<tr>
<td>( \text{CO}_2 ) (g)</td>
<td>-393.5</td>
</tr>
<tr>
<td>( \text{H}_2\text{O} ) (l)</td>
<td>-285.83</td>
</tr>
</tbody>
</table>