Multiple Choice: (4 points each. Put answers in left margin as capital letters.)

1. Which pair of elements should have similar properties?
   A) C/Sn  B) Ca/Li  C) Cl/Na  D) Ga/Ge  E) K/Li

2. Ti(SO)₃₂ is
   A) titanium(II) sulfate  B) titanium sulfide  C) titanium (IV) sulfite

3. Which of the following generic salts is least likely to be soluble?
   A) M⁺X⁻  B) M²⁺X⁻  C) M⁺X²⁻  D) M³⁺X⁻  E) M²⁺X²⁻

4. Which of the following is an oxidation-reduction (redox) reaction?
   A) Cu(OH)₂(aq) + 2 HNO₃(aq) → Cu(NO₃)₂(aq) + 2 H₂O(l)
   B) Fe₂O₃(s) + 3 CO(g) → Fe(s) + 3 CO₂(g)
   C) 2 SrS(s) + 2 HCl(aq) → SrCl₂(aq) + H₂S(g)
   D) H₂SO₄(aq) + 2 NH₃(aq) → (NH₄)₂SO₄(aq)
   E) None are oxidation-reduction reactions.

5. What is the oxidation number of the phosphorus atom in H₃PO₃?
   A) -1  B) +1  C) +3  D) +5  E) +7

6. Which of the following is an isolated system?
   A) a bonfire  B) the Earth  C) the human body  D) a pressure cooker  E) a Thermos® bottle

7. Which of the following sets of conditions possesses the greatest amount of kinetic energy?
   (FYI: All speeds are approximately correct for the sport.)
   A) a 2 kg bowling ball traveling at 10³ m/hr  B) a 10 kg shot put traveling at 10⁴ m/hr
   C) a 150 g baseball traveling at 10⁵ m/hr  D) a 400 g football traveling at 10⁵ m/hr
   E) a 500 g basketball traveling at 10³ m/hr

8. What is ΔH for the net reaction below?
   2 Al(s) + 1.5 O₂(g) → Al₂O₃(s)  ΔH = -1601 kJ
   2 Na(s) + O₂(g) → Na₂O₂(s)  ΔH = -505 kJ
   6 Na(s) + 2 Al₂O₃(s) → 4 Al(s) + 3 Na₂O₂(s)  ΔH = ?
   A) -2106 kJ  B) -86 kJ  C) +86 kJ  D) 1687 kJ  E) 2106 kJ
Discussion Questions: (Show your work to receive credit.)

1. Isopropyl alcohol (C₃H₈O) is mixed with water to produce a solution that is 35.0% alcohol by volume. How many milliliters of each component are present in 805 mL of this solution? What is its molar concentration? (density_C₃H₈O = 0.7863 g/mL) What would its molar concentration be if 75.0 mL of water was added to the original solution? (10 points)

a) vol_C₃H₈O = (0.350)(805 mL) = 282 mL
   vol_H₂O = 805 mL – 282 mL = 523 mL

b) \[ [C₃H₈O] = \left( \frac{0.7863 \text{ g C₃H₈O}}{1 \text{ mL C₃H₈O}} \right) \left( \frac{1 \text{ mol C₃H₈O}}{60.10 \text{ g C₃H₈O}} \right) \left( \frac{1}{0.805 \text{ L}} \right) = 4.58 M \]

c) \[(805 \text{ mL})(4.58 M) = (805 \text{ mL} + 75.0 \text{ mL})[C₃H₈O]_f \]
   \[ [C₃H₈O]_f = 4.19 M \]

2. Aluminum reacts with chlorine gas according to the reaction:
   \[ 2 \text{ Al(s)} + 3 \text{ Cl}_2 (g) \rightarrow 2 \text{ AlCl}_3 (s) \]

What is the limiting reactant when 34.0 g of aluminum is combined with 39.0 g of chlorine gas? What is the maximum mass of aluminum chloride that can be produced? What is the percent yield if 45.0 g of AlCl₃ is made? (15 points)

a) \[ \text{mol Al} = 34.0 \text{ g Al} \left( \frac{1 \text{ mol Al}}{26.98 \text{ g Al}} \right) = 1.26 \text{ mol Al} \]
   \[ \text{mol Cl}_2 = 39.0 \text{ g Cl}_2 \left( \frac{1 \text{ mol Cl}_2}{70.90 \text{ g Cl}_2} \right) = 0.550 \text{ mol Cl}_2 \]

Now calculate how much chlorine is needed to completely react with aluminum
\[ (1.26 \text{ mol Al})(\frac{3 \text{ mol Cl}_2}{2 \text{ mol Al}}) = 1.89 \text{ mol Cl}_2 \text{ but you only have 0.550 mol of chlorine, so it is the limiting reagent.} \]

Calculate the mass of aluminum chloride produced:
\[ \text{mass } \text{AlCl}_3 = 39.0 \text{ g Cl}_2 \left( \frac{1 \text{ mol Cl}_2}{70.90 \text{ g Cl}_2} \right) \left( \frac{1 \text{ mol AlCl}_3}{3 \text{ mol Cl}_2} \right) \left( \frac{133.3 \text{ g AlCl}_3}{\text{mol AlCl}_3} \right) = 48.9 \text{ g AlCl}_3 \]

b) \[ \% \text{ yield} = \frac{45.0 \text{ g AlCl}_3}{48.9 \text{ g AlCl}_3} \times 100\% = 92.0 \% \]

3. Complete the following: (10 points)
   \[ \text{MnO}_2 (s) + 4 \text{ HCl}_{(aq)} \rightarrow \text{MnCl}_2_{(aq)} + \text{Cl}_2_{(g)} + 2 \text{ H}_2\text{O}_{(l)} \]

Ammonium nitrate decomposes to produce gaseous dinitrogen oxide and water.
   \[ \text{NH}_4\text{NO}_3 (s) \rightarrow \text{N}_2\text{O}_{(g)} + 2 \text{ H}_2\text{O}_{(l)} \]

4. Write out the net ionic equation for the reaction of Ba(NO₃)₂ (aq) with Na₂CO₃ (aq): (4 points)
   \[ \text{Ba}^{2+}_{(aq)} + \text{CO}_3^{2-}_{(aq)} \rightarrow \text{BaCO}_3 (s) \]
5. The molar heat capacity of ethanol, \( \text{C}_2\text{H}_5\text{OH} \), is 110.4 J/mol\( \cdot \)K. When 1567 J of heat energy is added to a sample of ethanol, \( \text{C}_2\text{H}_5\text{OH} \), the temperature increases by 9.61 °C. What mass of ethanol was in the sample? (8 points) (Homework 5.6)

\[
\text{mass} = \left( \frac{\text{mol} \cdot \text{K}}{110.4 \text{ J}} \right) \left( \frac{1}{9.61 \text{ K}} \right) \left( \frac{46.10 \text{ g} \text{EtOH}}{\text{mol} \text{EtOH}} \right) = 68.1 \text{ g EtOH}
\]

6. Circle the ENDOthermic processes. (10 points) Homework problem 5.2

- a car using gasoline  
- baking a cake  
- ice melting
- the chemical reaction inside a cold pack  
- water condensing on a surface

7. For the following reaction, (11 points)
   a) What is the heat of reaction? and 
   b) What is the energy change associated with the consumption or production of 5.25 g \( \text{NH}_3 \)?

\[
\text{4 NH}_3(\text{g}) + 5 \text{ O}_2(\text{g}) \rightarrow 4 \text{ NO}(\text{g}) + 6 \text{ H}_2\text{O}(\text{g})
\]

a) \( \Delta H_{\text{rxn}}^\circ = \sum n \Delta H(\text{products}) - \sum n \Delta H(\text{reactants}) \)
\[
\Delta H_{\text{rxn}}^\circ = [(4 \text{ mol})(90.4 \text{ kJ/mol}) + (6 \text{ mol})(-241.8 \text{ kJ/mol})] \\
- [(4 \text{ mol})(-45.9 \text{ kJ/mol}) + (5 \text{ mol})(0 \text{ kJ/mol})] \\
= -905.6 \text{ kJ}
\]

b) \( \Delta H^\circ = (5.25 \text{ gNH}_3) \left( \frac{1 \text{ molNH}_3}{17.03 \text{ gNH}_3} \right) \left( \frac{-905.61}{4 \text{ molNH}_3} \right) = -69.8 \text{ kJ} \)