1. Consider the following reaction:
\[ 2\text{H}_2(g) + \text{O}_2(g) \rightarrow 2\text{H}_2\text{O}(l) \quad \Delta H = -572 \text{ kJ} \]

a. How much heat is evolved for the production of 1.00 mol of \text{H}_2\text{O}? (1 pt) 286 kJ
b. How much heat is evolved when 4.03 g of hydrogen is reacted with excess oxygen? (1 pt) 572 kJ
c. How much heat is evolved when 186 grams of oxygen is reacted with excess hydrogen? (1 pt) 3.32x10^3 kJ
d. The total volume of hydrogen gas needed to fill the Hindenburg was 2.0 x 10^8 L at 1.0 atm and 25\degree C. How much heat was evolved when the Hindenburg exploded, assuming all of the hydrogen reacted? (1 pt) 2.34 x 10^9 kJ
e. If 2.6 x 10^7 kilojoules of heat are produced, how many liters of hydrogen gas were reacted at 743 mm Hg and 15 \degree C? (1 pt) 2200 L

2. Calculate the change in enthalpy for the following reactions. All heat of formation, \( \Delta H_f \) data can be found in Appendix Four of your textbook. (1 point each)
a. \( 2\text{NH}_3(g) + 3\text{O}_2(g) + 2\text{CH}_4(g) \rightarrow 2\text{HCN}(g) + 6\text{H}_2\text{O}(g) \) \( \Delta H = -940 \text{ kJ} \)
b. \( \text{Ca}_3(\text{PO}_4)_2(s) + 3\text{H}_2\text{SO}_4(l) \rightarrow 3\text{CaSO}_4(s) + 2\text{H}_3\text{PO}_4(l) \) \( \Delta H = -265 \text{ kJ} \)
c. \( \text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s) \) \( \Delta H = -176 \text{ kJ} \)
d. \( \text{MgO}(s) + 2\text{H}_2\text{O}(l) \rightarrow \text{Mg(OH)}_2(s) \) \( \Delta H = 249 \text{ kJ} \)
e. \( \text{SiCl}_4(l) + 2\text{H}_2\text{O}(l) \rightarrow \text{SiO}_2(s) + 4\text{HCl}(g) \) \( \Delta H = -20 \text{ kJ} \)

3. Calculate the \( \Delta H^\circ \) for the following problems using Hess’s law: (5 points)
a. Given:
\( \text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2 \) \( \Delta H^\circ = -23 \text{ kJ} \)
\( 3\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2\text{Fe}_2\text{O}_4 + \text{CO}_2 \) \( \Delta H^\circ = -39 \text{ kJ} \)
\( \text{Fe}_3\text{O}_4 + \text{CO} \rightarrow 3\text{FeO} + \text{CO}_2 \) \( \Delta H^\circ = +18 \text{ kJ} \)
Find: \( \text{FeO} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2 \) \( \Delta H = -11 \text{ kJ} \)
b. Given:
\( \text{P}_4 + 6\text{Cl}_2 \rightarrow 4\text{PCl}_3 \) \( \Delta H^\circ = -1225.6 \text{ kJ} \)
\( \text{P}_4 + 5\text{O}_2 \rightarrow \text{P}_2\text{O}_{10} \) \( \Delta H^\circ = -2967.3 \text{ kJ} \)
\( \text{PCl}_3 + \text{Cl}_2 \rightarrow \text{PCl}_5 \) \( \Delta H^\circ = -84.2 \text{ kJ} \)
\( \text{PCl}_3 + \frac{1}{2} \text{O}_2 \rightarrow \text{Cl}_3\text{PO} \) \( \Delta H^\circ = -285.7 \text{ kJ} \)
Find: \( \text{P}_2\text{O}_{10} + 6\text{PCl}_3 \rightarrow 10\text{Cl}_3\text{PO} \) \( \Delta H = -610.1 \text{ kJ} \)
c. Given:
\( \text{Sr} + \frac{1}{2} \text{O}_2 \rightarrow \text{SrO} \) \( \Delta H^\circ = -592 \text{ kJ} \)
\( \text{SrO} + \text{CO}_2 \rightarrow \text{SrCO}_3 \) \( \Delta H^\circ = -234 \text{ kJ} \)
\( \text{C} + \text{O}_2 \rightarrow \text{CO}_2 \) \( \Delta H^\circ = -394 \text{ kJ} \)
Find: \( \text{Sr} + \frac{3}{2} \text{O}_2 \rightarrow \text{SrCO}_3 \) \( \Delta H = -1220. \text{ kJ} \)
4. One method for producing hydrogen gas on a large scale is this chemical cycle:
   Step 1: \( \text{SO}_2 (g) + 2\text{H}_2\text{O} (g) + \text{Br}_2(g) \rightarrow \text{H}_2\text{SO}_4(l) + 2\text{HBr}(g) \)
   Step 2: \( \text{H}_2\text{SO}_4 (l) \rightarrow \text{H}_2\text{O}(g) + \text{SO}_2(g) + \frac{1}{2} \text{O}_2(g) \)
   Step 3: \( 2 \text{HBr}(g) \rightarrow \text{H}_2(g) + \text{Br}_2(g) \)

All heat of formation, \(\Delta H_f\) data can be found in Appendix Four of your textbook.

a. Calculate the change in enthalpy, \(\Delta H^\circ\) for each step. (1 pt)
   
   \[
   \text{Step 1: } \Delta H = -136 \text{ kJ}, \quad \text{Step 2: } \Delta H = 275 \text{ kJ}, \quad \text{Step 3: } 103 \text{ kJ}
   \]

b. What is the equation for the overall process? (1 pt) \( \text{H}_2\text{O} \rightarrow \text{H}_2 + \frac{1}{2}\text{O}_2 \)

c. What is the overall energy change, \(\Delta H^\circ\)? (1 pt) \(\Delta H = 242 \text{ kJ}\)

d. Is this process endothermic or exothermic? Draw a graph to represent the change in energy for the overall reaction. (1 pt) **endothermic**

e. How do you indicate that a thermodynamic process has been carried out at standard conditions? What are standard conditions for compounds and elements? (1 pt) **By using a \(^\circ\) symbol after the state function.**

**Standard conditions:**

- For a Compound
  - The standard state for a gaseous substance is a pressure of exactly 1 atmosphere.
  - For a pure substance in a condensed state (liquid or solid), the standard state is the pure liquid or solid.
  - For a substance present in a solution, the standard state is a concentration of exactly 1M.

- For An Element
  - The standard state of an element is the form in which the element exists under conditions of 1 atmosphere and 25°C.

5. A diamond weighing 310. mg requires 2.38 J to raise its temperature from 23.4°C to 38.7°C.
   
   a. Calculate the specific heat capacity of diamond. (1 pt) \(0.502 \text{ J/g °C}\)
   
   b. Calculate the molar heat capacity of the diamond. (1 pt) \(6.03 \text{ J/mol °C}\)
   
   c. If 84.8 kJ of energy is used to heat the diamond mentioned above at an initial temperature of 23.4°C, what would be the final temperature? (1 pt) \(5.45 \times 10^5 ^\circ\text{C}\)
   
   d. How much heat is released as the diamond used in Part C is cooled (from the temperature you calculate in Part C) to 4.6°C? (1 pt) \(-84.8 \text{ kJ}\)
   
   e. Explain the difference between heat and temperature. (1 pt) **Heat & temperature are different. Temperature is a property that reflects the random motions of the particles. Heat involves the transfer of energy between two objects due to a temperature difference.**