I. The Nature of Energy
   a. Energy
      i. Law of Conservation of Energy
      ii. Kinetic
         1. Thermal
         2. Electrical
         3. Radiant
      iii. Potential
         1. Chemical
         2. Nuclear
         3. Gravitational
      iv. Temperature
   v. Heat
      1. Symbol
      2. Units
         a. calorie
         b. Calorie
         c. Joule
      i. Converting units of heat
      1. A cereal has 155 nutritional Calories per serving. How many calories, kilocalories and Joules is this?
      2. A person on a diet consumed 1350 Calories in one day. How many calories, kilocalories and Joules is this?

II. Thermodynamics
   a. 1st law of thermodynamics
   b. System vs Surroundings
      i. Heat transfer
   c. Thermochemistry
      i. Enthalpy
1. Thermochemical equations

2. $\Delta H_{\text{rxn}}$
   a. Endothermic
   b. Exothermic

3. Heat of Combustion ($\Delta H^\circ_{\text{comb}}$)
   a. How much heat is released by the combustion of 250.0 g of hydrogen gas? $H^\circ_{\text{comb}} = -286$ kJ
      
      \[ 2H_2 + O_2 \rightarrow 2H_2O \]

ii. Standard Enthalpy
   1. Standard Heat of Formation ($\Delta H^\circ_{\text{f}}$)
   2. Standard Heat of Reaction ($\Delta H^\circ_{\text{rxn}}$)
      a. Direct method
         i. Equation:
         ii. Example:

1. Calculate the Standard heat of reaction for the reaction for the combustion of methane.

2. Calculate the Standard heat of reaction for the combustion of hydrogen sulfide gas. (hint: produces liquid water and sulfur dioxide gas)

3. Calculate the Standard heat of reaction for the reaction between nitrogen monoxide gas and oxygen gas. (hint: yields nitrogen dioxide gas)

4. Calculate the Standard heat of reaction for the reaction between carbon monoxide gas and oxygen gas. (hint: yields carbon dioxide gas)

b. Indirect method
   i. Hess’s Law
      1. $2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = ?$
         
         $S(s) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -297$ kJ
         $2SO_3(g) \rightarrow 2SO_2(g) + O_2(g)$ $\Delta H = 198$ kJ

      2. $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$ $\Delta H = ?$
         
         $N_2(g) + O_2(g) \rightarrow 2NO(g)$ $\Delta H = 180.6$ kJ
         $N_2(g) + 2O_2(g) \rightarrow 2NO_2(g)$ $\Delta H = 66.4$ kJ
3. \( 2C(s) + O_2(g) \rightarrow 2CO(g) \Delta H = ? \)
\[ C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = 393.5 \text{ kJ} \]
\[ 2CO(g) + O_2(g) \rightarrow 2CO_2(g) \quad \Delta H = -566 \text{ kJ} \]

4. \( C(s) + 2H_2(g) \rightarrow CH_4(g) \Delta H = ? \)
\[ C(s) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -393.5 \text{ kJ} \]
\[ 2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \Delta H = -571.6 \text{ kJ} \]
\[ CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(l) \Delta H = -890.8 \text{ kJ} \]

III. Calorimetry
   a. Calorimeter
   b. Specific heat
   c. Heat capacity
   d. Calculating heat (change in temp)
      i. The temp. of 56.6 f of ethanol increases from 45.0°C to 80.0°C, how much heat has been absorbed by the ethanol? Specific heat of ethanol = 2.44 J/g°C

   ii. A 4.00 g sample of a substance was heated from 274 K to 314 K and absorbed 32 J of heat, what is the specific heat of the substance?

   iii. If 98,000 J of energy are added to 6200 mL of water at 14°C, what will the final temperature of the water be?

   iv. A 45.0g sample of metal is placed in boiling water until its temp. is 100.0°C. A calorimeter contains 100.0 g of water at a temp. of 24.4°C. The metal sample is removed from the boiling water and immediately placed in water in the calorimeter. The final temp. of the metal and water in the calorimeter is 34.9°C. Assuming that the calorimeter provides perfect insulation, what is the specific heat of the metal?
v. 240g of water (initially at 21°C) are mixed with an unknown mass of ion (initially at 501°C). When thermal equilibrium is reached, the system has a temperature of 42°C. Find the mass of the iron. Specific heat of iron = 0.449 J/g°C

vi. Determine the final temperature when a 25.0 g piece of iron at 85.0 °C is placed into 75.0 grams of water at 20.0 °C.

IV. Phase Changes
   a. Heating curve
      i. Liquid-vapor equilibrium
      ii. Liquid-solid equilibrium
      iii. Solid-vapor equilibrium
   b. Calculating heat
      i. Calculate the heat required to melt 45.6g of water at its melting point.

      ii. Calculate the heat required to vaporize 75.4g of water at its boiling point.

      iii. What mass of ammonia when vaporized absorbs 345 kJ of heat?
   c. Phase diagram