\( \Delta H_f \) and specific heat values found in notes or in table provided.

1. Calculate the heat of the reaction for the following reaction:
   \[ 2C_2H_2(g) + 5/2O_2(g) \rightarrow 4CO_2(g) + 2H_2O(g) \quad \Delta H = ? \text{kJ/mol} \]
   Solve by writing formation equations for each reactant and product and using the \( \Delta H \) values for each. Is the reaction exothermic or endothermic?
   \[ \Delta H_f = \frac{4(-393.5)}{2} - 2(228.2) \]
   Answer: \(-2514.0 \text{kJ/mol (exothermic)}\)

2. Calculate the \( \Delta H \) value heat for the following reaction:
   \[ \text{Ag}_2S(s) + 2HCl(g) \rightarrow 2\text{AgCl(s)} + H_2S(g) \quad \Delta H = ? \text{kJ/mol} \]
   Solve by writing formation equations for each reactant and product and using the \( \Delta H \) values for each.
   \[ \Delta H_f = 2(-127.01) + (-23.9) - (-32.59) + 2(-92.3) = -60.7 \text{kJ/mol} \]
   \( \text{exothermic} \)

3. Calculate the \( \Delta H \) value heat for the following reaction:
   \[ \text{Ca(OH)}_2(s) \rightarrow \text{CaO(s)} + \text{H}_2\text{O(g)} \quad \Delta H = ? \text{kJ/mol} \]
   Solve by writing formation equations for each reactant and product and using the \( \Delta H \) values for each.
   \[ \Delta H_f = \frac{-634.9}{-241.82} - (-983.2) = 106.5 \text{kJ/mol} \]
   \( \text{endothermic} \)

4. Calculate the \( \Delta H \) value heat for the following reaction:
   \[ \text{Fe}_2\text{O}_3(s) + 3\text{CO}(g) \rightarrow 2\text{Fe(s)} + 3\text{CO}_2(g) \quad \Delta H = ? \text{kJ/mol} \]
   Solve by writing formation equations for each reactant and product and using the \( \Delta H \) values for each.
   \[ \Delta H_f = 3(-393.5) - (-118.4) + 3(-110.53) = 269.5 \text{kJ/mol} \]
   \( \text{endothermic} \)

5. Calculate \( \Delta H \) for the reaction of calcium oxide and sulfur trioxide. Is this reaction exothermic or endothermic?
   \[ \text{CaO(s)} + \text{SO}_3(g) \rightarrow \text{CaSO}_4(s) \quad \Delta H = ? \text{kJ/mol} \]
   Use the following equations and data.
   \[ \begin{align*}
   \text{H}_2\text{O(l)} + \text{SO}_3(g) & \rightarrow \text{H}_2\text{SO}_4(l) \quad \Delta H_f = -132.5 \text{kJ/mol} \\
   \text{H}_2\text{SO}_4(l) + \text{Ca(s)} & \rightarrow \text{CaSO}_4(s) + \text{H}_2(g) \quad \Delta H_f = -602.5 \text{kJ/mol} \\
   \text{Ca(s)} + \frac{1}{2}\text{O}_2(g) & \rightarrow \text{CaO(s)} \quad \Delta H_f = +634.9 \text{kJ/mol} \\
   \text{H}_2(g) + \frac{1}{2}\text{O}_2(g) & \rightarrow \text{H}_2\text{O(l)} \quad \Delta H_f = -285.8 \text{kJ/mol}
   \end{align*} \]
   \( \text{exothermic} \)

6. Use enthalpies of combustion to calculate \( \Delta H \) for the oxidation of 1-butanol to make butanoic acid.
   \[ \text{C}_4\text{H}_9\text{OH(l)} + \text{O}_2(g) \rightarrow \text{C}_3\text{H}_7\text{COOH}(l) + \text{H}_2\text{O}(l) \quad \Delta H = ? \text{kJ/mol} \]
   \[ \Delta H_f = -492.3 \text{kJ/mol} \]
   \[ \text{Combustion of butanol:} \quad \Delta H_f = -2675.9 \text{kJ/mol} \]
   \[ \text{Combustion of butanoic acid:} \quad \Delta H_f = +2183.6 \text{kJ/mol} \]

7. The reaction of magnesium with sulfuric acid was carried out in a calorimeter. This reaction caused the temperature of 55. grams of liquid water, within the calorimeter, to raise from 1.0°C to 28.0°C. Calculate the energy associated with this reaction.
   \[ \Delta H_f = 6200 \text{J} \]

8. A 22.0 gram sample of solid gold was heated from 200.K to 300.K. How much energy was involved?
   \[ \Delta H_f = 284J \]
3. \[ E = mc^2 \]

\[ E = \frac{mc^2}{c^2} \quad m = \frac{E}{c^2} = \frac{7.89 \times 10^{-11} J}{(3 \times 10^8 m/s)^2} = 8.77 \times 10^{-28} Kg \]

9. Uranium - 238

Atomic # = 92 protons \times 1.007276 amu = 239.9849532 amu

Atomic # = 92 electrons \times 0.0005486 amu = -238.050784 amu

138 - 92 = 146 neutrons \times 1.008665 amu

\[ E = mc^2 \]

\[ E = (3.212 \times 10^{-27} Kg)(3 \times 10^8 m/s)^2 = 2.89 \times 10^{-10} J \]

\[ m = \frac{E}{c^2} = \frac{2.89 \times 10^{-10} J}{1 \text{ amu}} \]

10. Sodium - 23

Atomic # = 11 protons \times 1.007276 amu = 23.190056 amu

Atomic # = 11 electrons \times 0.0005486 amu = -22.989767 amu

23 - 11 = 12 neutrons \times 1.008665 amu

\[ E = mc^2 \]

\[ E = (3.326 \times 10^{-28} Kg)(3 \times 10^8 m/s)^2 = 2.99 \times 10^{-11} J \]

\[ m = \frac{E}{c^2} = \frac{2.99 \times 10^{-11} J}{1 \text{ amu}} \]
11. If $\frac{3}{4}$ decays only $\frac{1}{4}$ remains so: \( \left(\frac{1}{2}\right)^x = \left(\frac{1}{4}\right) \) \( x = 2 \) half lives

\( 2(18.72 \text{ days}) = 37.44 \text{ days} \)

12. \( x = \frac{26.76 \text{ hrs}}{6.69 \text{ hrs}} = 4 \) half lives \( \left(\frac{1}{2}\right)^4 = \frac{1}{16} \)

13. \( x = \frac{4797 \text{ yrs}}{1599 \text{ yrs}} = 3 \) half lives \( 0.250 \text{ g} \left(\frac{1}{2}\right)^3 = 0.03125 = 0.0131 \text{ g} \)

14. \( x = \frac{7.32 \text{ days}}{3.66 \text{ days}} = 2 \) half lives Original Mass \( \left(\frac{1}{2}\right)^2 = 0.05 \text{ g} \) Original Mass = \( \frac{0.05 \text{ g}}{\left(\frac{1}{2}\right)^2} = 0.200 \text{ g} \)
9. Use $\Delta H_f$ values solve the following problems. Determine the $\Delta H$ for each of the following reactions. Classify each reaction as either exothermic or endothermic.

a. $\text{C}_1\text{H}_4(g) + 5\text{O}_2(g) \rightarrow 3\text{CO}_2(g) + 4\text{H}_2\text{O}(g)$  
   $\Delta H = ? \text{kJ/mol} = -2043.1 \text{ kJ/mol}$  
   exo.

b. $\text{CH}_4(g) + 2\text{O}_2(g) \rightarrow \text{CO}_2(g) + 2\text{H}_2\text{O}(g)$  
   $\Delta H = ? \text{kJ/mol} = -802.2 \text{ kJ/mol}$  
   exo.

c. $2\text{F}_2(g) + 2\text{H}_2\text{O}(l) \rightarrow 4\text{HF}(g) + \text{O}_2(g)$  
   $\Delta H = ? \text{kJ/mol} = -521.6 \text{ kJ/mol}$  
   exo.

**Nuclear Chemistry**

Review all problems found on the Nuclear Chemistry Worksheet. Be able to define fission and fusion and list examples of each.

**Complete the following nuclear equations:**

1. $239 \rightarrow \beta + \text{Pu}$
   
2. $9 + 4 \rightarrow \text{Be} + \text{He}$
   
3. $32 + 1 \rightarrow \text{P}$

**Complete the following nuclear reactions and state the type of radioactive decay:**

4. $43 \rightarrow \text{Ca} + \text{K}$
   
5. $233 \rightarrow \text{He} + \text{U} \rightarrow \text{Th}$
   
6. $11 \rightarrow \text{B} + \text{C}$

7. Write the nuclear equation for the release of a beta particle by lead-210.

**Mass Defect and Nuclear Binding Energy Problems:**

8. The energy released by the formation of a nucleus of iron-56 is $7.89 \times 10^{-11} \text{J}$. Determine the mass defect of iron-56.  
   **Answer:** $8.77 \times 10^{-25} \text{kg}$

9. Calculate the nuclear binding energy of one uranium-238 atom. The actual measured atomic mass is $238.050784 \text{amu}$.  
   **Answer:** $2.890519161 \times 10^{-10} \text{J}$

10. Calculate the binding energy of one sodium-23 atom. The actual measured atomic mass is $22.989767 \text{amu}$.  
    **Answer:** $2.9932429 \times 10^{-10} \text{J}$

**Half Life Problems:**

11. The half-life of thorium-227 is 18.72 days. How many days are required for three-fourths of a given amount to decay?  
    **Answer:** 37.44 days

12. The half-life of protactinium-234 is 6.69 hours. What fraction of a given amount remains after 26.76 hours?  
    **Answer:** 1/16

13. After 4797 years, how much of an original 0.250 grams of radium-226 remains? Its half-life is 1599 years.  
    **Answer:** 0.0313g

14. The half-life of radium-224 is 3.66 days. What was the original mass of radium-224 if 0.0500 grams remains after 7.32 days?  
    **Answer:** 0.200g