TYPES OF PROBLEMS:
Use of thermochemical equations: predicting quantity of heat transferred

How to calculate ΔH…
1) from calorimetric data
2) from ΔH°f
3) from Hess’ Law Relationships
4) from thermochemical equations
5) from bond energies

1. \( \text{P}_4 (s) + 10 \text{Cl}_2 (g) \rightarrow 4 \text{PCl}_5 (s) \quad \Delta H^\circ = -1774.0 \text{ kJ} \)
   How much heat is produced when 15.4 g of \( \text{P}_4 \) reacts?
   How many grams of chlorine must be used in order to produce 2000. kJ?
   If 450. kJ is produced in this reaction, what is the mass of phosphorus pentachloride formed?

2. Given the following thermochemical equations,
   \( \text{P}_4 (s) + 10 \text{Cl}_2 (g) \rightarrow 4 \text{PCl}_5 (s) \quad \Delta H^\circ = -1774.0 \text{ kJ} \)
   \( \text{PCl}_3 (l) + \text{Cl}_2 (g) \rightarrow \text{PCl}_5 (s) \quad \Delta H^\circ = -123.8 \text{ kJ} \)
   Calculate the enthalpy change for the reaction shown below:
   \( \text{P}_4 (s) + 6 \text{Cl}_2 (g) \rightarrow 4 \text{PCl}_3 (l) \)

3. A 150.0-g sample of a metal at 80.0°C is placed in 145.2 g of water at 20.0 °C. The temperature of the water rose to 23.3°C. What is the specific heat of the metal? Show your work clearly.

4. One of the key reactions in the processing of uranium for use as fuel in nuclear power plants is as follows:
   \( \text{UO}_2 (s) + 4 \text{HF} (g) \rightarrow \text{UF}_4 (s) + 2 \text{H}_2\text{O} (g) \)
   a) Calculate the enthalpy change for the reaction above by using the \( \Delta H_f^\circ \) values provided.
<table>
<thead>
<tr>
<th>( \Delta H_f^\circ ) (kJ/mol)</th>
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<tbody>
<tr>
<td>( \text{UO}_2 ) -1085</td>
</tr>
<tr>
<td>( \text{UF}_4 ) -1914</td>
</tr>
<tr>
<td>( \text{HF} ) -271.1</td>
</tr>
<tr>
<td>( \text{H}_2\text{O} ) -241.8</td>
</tr>
<tr>
<td>( \text{H}_2\text{O} ) -285.9</td>
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</tbody>
</table>
   b) What quantity of heat is evolved or absorbed if 500.g HF is allowed to react with a stoichiometric amount of \( \text{UO}_2 \)?
   c) Will the heat be evolved or absorbed?
   d) In order to produce 5.78x10^4 kJ, what mass of gaseous \( \text{H}_2\text{O} \) would be produced?
5. What is $\Delta H_2$?

$$\begin{align*}
\text{A} + \text{B} & \quad \text{C} + \text{D} \\
\text{E} + \text{F} & \quad \Delta H_2 \\
\text{A} + \text{B} & \quad \Delta H_1
\end{align*}$$

6. Calculate the $\Delta H$ for the reaction below from the bond energies provided. Show your work. You will not be given full credit if you break more bonds than is necessary.

$$\text{H} \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{H} + 2 \text{H} - \text{Cl} \quad \rightarrow \quad \text{H} \text{C} \equiv \text{C} \equiv \text{C} \equiv \text{H} + \text{H} \text{H} \text{Cl} \text{H}$$

<table>
<thead>
<tr>
<th>Bond</th>
<th>Bond Energy (kJ mol$^{-1}$)</th>
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<tbody>
<tr>
<td>C–C</td>
<td>348</td>
</tr>
<tr>
<td>C=C</td>
<td>617</td>
</tr>
<tr>
<td>C≡C</td>
<td>961</td>
</tr>
<tr>
<td>C–H</td>
<td>412</td>
</tr>
<tr>
<td>C–Cl</td>
<td>338</td>
</tr>
<tr>
<td>Cl–Cl</td>
<td>243</td>
</tr>
<tr>
<td>H–Cl</td>
<td>431</td>
</tr>
</tbody>
</table>

7. The $\Delta H_f$ of solid ammonium nitrate is $-365.56 \text{ kJ/mole}$. Write the thermochemical equation corresponding to this value. 

*Ans is on the last page.*

8. When 100.0 mL of 0.200 M CsOH with 50.0 mL of 0.400 M HCl in a coffee-cup calorimeter, 1.12 kJ of heat was transferred into the resulting solution.

a) Write the chemical equation for the reaction.

b) What is the $\Delta H$ for the reaction shown in part (a)? Show your work clearly.

9. 

The curve shown is for Cl$_2$ at 55°C. Sketch in the curve for Cl$_2$ at 25°C. Mark on the graph the most probably kinetic energy and the average kinetic energy at 55°C.
10. When a glass of ice-cold water (without ice) is warming to room temperature on a table, what is happening?
   A. The water is undergoing an exothermic process.
   B. The water is undergoing an endothermic process.

11. When a glass of ice-cold water (without ice) is warming to room temperature on a table, what is happening?
   A. \( \Delta T \) of the water is positive.
   B. \( \Delta T \) of the water is negative.

12. Which diagram below corresponds to an endothermic reaction?

   ![Diagram A](image)
   ![Diagram B](image)

13. When is \( q \) equal to \( \Delta H \)?
   A. for all endothermic reactions.
   B. at standard states
   C. when temperature is constant
   D. when pressure is constant

14. Draw an enthalpy diagram to illustrate each of the following reaction:
   a) \( \text{Ca(OH)}_2 (s) \rightarrow \text{CaO} (s) + \text{H}_2\text{O} (l) \quad \Delta H = +65.1 \text{ kJ} \)
   b) \( \text{NO} (g) + \text{NO}_2 (g) \rightarrow \text{N}_2\text{O}_5 (g) + \text{O}_2 (g) \quad \Delta H = -42.68 \text{ kJ} \)

Answers:
#1: 222 kJ is produced. (Incorrect to say \(-222 \text{ kJ is produced.}\); 799.3 g; 211g
#2: \(-1.278.8 \text{ kJ}\)
#3: \(+0.236 \text{ J g}^{-1}\text{C}^{-1}\)
#4a) \(-228 \text{ kJ}\) b) \(1.42 \times 10^3 \text{kJ}\) c) evolved d) \(9.14 \times 10^3 \text{kg}\)
#5: \(\Delta H_2 = \Delta H_3 - \Delta H_1\)
#6: \(-25 \text{ kJ}\)
#7: \(\text{N}_2 (g) + 2\text{H}_2 (g) + 3/2 \text{O}_2 (g) \rightarrow \text{NH}_4\text{NO}_3 (s) \quad \Delta H = -365.56 \text{ kJ}\)
#8: \(-56 \text{kJ/mol}\)

Answers are not provided for questions that you should be able to figure out by going over your lecture material.