1. Which of the following transformations will always result in a decrease in the internal energy of a system?
   a. The system releases heat and work is done on the system
   b. The system absorbs heat and work is done on the system
   c. The system releases heat and the system does work
   d. The system absorbs heat and the system does work

2. A gas releases 3.0 J of heat and then performs 11.8 J of work. What is the change in internal energy of the gas?

3. For a particular chemical reaction, the bonds in the products are on average stronger than the bonds in the reactants. Is the reaction endothermic, exothermic or more information is required?

4. Predict the sign of heat for the following reactions:
   a. $\text{F}_2 (g) \rightarrow 2 \text{F} (g)$
   b. $\text{H}_2\text{O} (l) \rightarrow \text{H}_2\text{O} (s)$
   c. $\text{C}_2\text{H}_4 (g) + 3 \text{O}_2 (g) \rightarrow 2 \text{CO}_2 (g) + 2 \text{H}_2\text{O} (g)$

5. Predict the sign for work ($w$) for the following reactions:
   a. $2 \text{NO} (g) + \text{O}_2 (g) \rightarrow 2 \text{NO}_2 (g)$
   b. $\text{Fe}_2\text{O}_3 (s) + 3 \text{H}_2 (g) \rightarrow 2 \text{Fe} (s) + 3 \text{H}_2\text{O} (l)$

6. At a constant pressure, an equal number of moles of Ne (g) and N$_2$ (g) were decreased in temperature by the same amount.
   a. Which gas will do more work?
   b. Which gas released more heat?

7. When gaseous CH$_4$ is heated at a constant pressure, what percentage of the added heat is converted to work?
   For CH$_4$, $C_p = 35.7 \text{ J mol}^{-1} \text{ K}^{-1}$ and $C_v = 27.4 \text{ J mol}^{-1} \text{ K}^{-1}$

8. 2 moles of a monoatomic ideal gas are heated from 330K to 458K at a constant pressure of 2.6 atm. What is the work for this process in units of joules?

9. 3.0 moles of Ne gas are placed into a cylinder with a moveable piston. The initial volume of the gas is 73 L. What is the final volume of the gas if it performs 6320 J of work at a constant external pressure of 1 atm?

10. Consider the following reaction: $\text{N}_2 (g) + 3 \text{H}_2 (g) \rightarrow 2 \text{NH}_3 (g)$
    Calculate the work in joules when 1 mole of nitrogen gas reacts with 3 moles of hydrogen gas at a constant external pressure of 1 atm and a constant temperature of 298 K.

11. Two moles of liquid water are completely vaporized at 100 °C and 1 atm. Calculate the work in joules for this process.

12. When aqueous sodium hydroxide is neutralized with aqueous hydrochloric acid at a constant pressure the temperature of the resulting solution increases. What is the sign of $\Delta H$ for the neutralization reaction?

13. Consider the following salts and their corresponding enthalpies of dissolution:

<table>
<thead>
<tr>
<th>Compound</th>
<th>$\Delta H$ of dissolution (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>KOH</td>
<td>-57.61</td>
</tr>
<tr>
<td>KClO$_3$</td>
<td>41.38</td>
</tr>
<tr>
<td>NH$_4$NO$_3$</td>
<td>25.69</td>
</tr>
<tr>
<td>Na$_2$CO$_3$</td>
<td>-23.76</td>
</tr>
</tbody>
</table>

You have been given one mole of each of these salts. Which salt when dissolved in enough water to generate 500 grams of solution will produce a solution with the lowest temperature?

14. Consider the following reaction at constant temperature and pressure:
    $\text{CH}_4 (g) + 2 \text{O}_2 (g) \rightarrow \text{CO}_2 (g) + 2 \text{H}_2\text{O} (l)$ \hspace{1cm} $\Delta H = -890 \text{ kJ}$

    What volume of oxygen gas at 25 °C and 1 atm will react with excess CH$_4$ (g) to produce 380. kJ of heat?
15. Consider the following reaction: \( \text{Fe}_2\text{O}_3 (s) + 3 \text{ CO (g)} \rightarrow 2 \text{ Fe (s)} + 3 \text{ CO}_2 (g) \Delta H = -23 \text{ kJ} \)

Calculate the change in enthalpy when 3.3 moles of \( \text{Fe}_2\text{O}_3 \) reacts with 7.7 moles of \( \text{CO} \) at a constant pressure.

16. A monoatomic ideal gas is heated at constant pressure.
   a. The change in internal energy is less than the heat for this process (\( \Delta E < q \))
   b. The change in internal energy is greater than the heat for this process (\( \Delta E > q \))
   c. The change in internal energy is equal to the heat for this process (\( \Delta E = q \))

17. What is the relationship between heat and change in internal energy for the condensation of water vapor at 1 atm and 373K?

18. The volume of a 3.5 mole sample of \( \text{C}_2\text{H}_6 \) gas (\( C_v = 52.92 \text{ J mol}^{-1} \text{ K}^{-1} \)) was decreased from 29 L to 18 L at a constant pressure of 3.9 atm. What is the change in internal energy \( \Delta E \) for this process in unit of kJ?

19. The pressure of 6.5 mole sample of \( \text{N}_2\text{O} \) gas (\( C_v = 30.08 \text{ J mol}^{-1} \text{ K}^{-1} \)) was decreased from 4.1 atm to 2.4 atm at a constant volume of 14 L. What is the change in enthalpy \( \Delta H \) for this process in units of joules?

20. Predict the relationship between \( \Delta H \) and \( \Delta E \) for the following reaction at 1 atm and 298 K.

\[
\text{N}_2 (g) + 3 \text{ H}_2 (g) \rightarrow 2 \text{ NH}_3 (g)
\]

21. In a constant pressure calorimeter 250. grams of a liquid (specific heat capacity of 1.42 \( \text{ J g}^{-1} \text{ °C}^{-1} \)) initially at 25 °C is combined with 100. grams of aluminum metal (specific heat capacity = 0.89 \( \text{ J g}^{-1} \text{ °C}^{-1} \)) initially at 75 °C. What is the final temperature?

22. In a coffee cup calorimeter, 27 grams of \( \text{NaNO}_3 \) (85.00 g/mol) is dissolved in enough water to make 150 grams of solution. The following reaction occurs:

\[
\text{NaNO}_3 (s) \rightarrow \text{Na}^+ (aq) + \text{NO}_3^- (aq) \Delta H = 20.5 \text{ kJ/mol NaNO}_3
\]

The initial temperature of the water and the \( \text{NaNO}_3 \) is 24.4 °C. What is the final temperature of the solution? The heat capacity of the solution is 4.18 \( \text{ J g}^{-1} \text{ °C}^{-1} \). Assume no heat is lost to the calorimeter.

23. In a constant pressure calorimeter, 180 mL of 1.4 M \( \text{Ba(OH)}_2 \) is mixed with 290 mL of 1.1 M HCl. The following neutralization reaction occurs:

\[
2 \text{ HCl (aq)} + \text{Ba(OH)}_2 (aq) \rightarrow \text{BaCl}_2 (aq) + 2 \text{ H}_2\text{O (l)} \quad \Delta H = -118 \text{ kJ}
\]

Assuming that the temperature of both solutions was initially 22 °C and the final mixture has a mass of 470 grams and a heat capacity of 4.18 \( \text{ J g}^{-1} \text{ °C}^{-1} \), calculate the final temperature of the solution.

24. Given the following data at 25 °C:

\[
\begin{align*}
2 \text{ C}_2\text{H}_2 + 5 \text{ O}_2 & \rightarrow 4 \text{ CO}_2 + 2 \text{ H}_2\text{O} \quad \Delta H = -2600. \text{ kJ} \\
\text{C} + \text{ O}_2 & \rightarrow \text{CO}_2 \quad \Delta H = -394 \text{ kJ} \\
2 \text{ H}_2 + \text{ O}_2 & \rightarrow 2 \text{ H}_2\text{O} \quad \Delta H = -572 \text{ kJ}
\end{align*}
\]

Calculate the \( \Delta H \) for the following reaction at 25 °C.

\[
2 \text{ C} + \text{ H}_2 \rightarrow \text{C}_2\text{H}_2
\]

25. Calculate the change in enthalpy for the combustion of 1 mole of ethanol (\( \text{C}_2\text{H}_5\text{OH} \)) given the following data:

<table>
<thead>
<tr>
<th>Substance</th>
<th>( \Delta H^\circ ) (kJ/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{C}_2\text{H}_5\text{OH} )</td>
<td>-277.6</td>
</tr>
<tr>
<td>( \text{CO}_2 )</td>
<td>-393.5</td>
</tr>
<tr>
<td>( \text{H}_2\text{O} )</td>
<td>-285.8</td>
</tr>
</tbody>
</table>