**Exothermic & Endothermic**

**Background**
In chemical and physical changes, energy can be transferred to or from the surroundings. For example, when a fire burns, it transfers heat energy to the surroundings. Objects near a fire become warmer and the temperature rises. In this experiment, you will make observations and evaluate whether heat energy is released or absorbed.

**Purpose**
To determine whether a process is exothermic or endothermic.

**Safety**
- Always wear safety goggles when working with chemicals in a laboratory setting.
- Handle acid carefully. If any gets on your skin, alert your teacher and immediately flush the area with water.

**Materials**
- NH₄Cl
- Water
- Thermometer
- Balance
- Test tubes (2)
- Weigh boat
- 10-mL graduated cylinder
- Zinc
- <1.0-M HCl

**Procedure**

*Part I*
1. Measure 5.0 mL of distilled water. Pour the water into a test tube.
2. Find the temperature and record in your data table.
3. Measure 1.0 g of NH₄Cl. Place your sample into the test tube with the water.
4. Measure the final temperature and complete your data table.

*Part II*
1. Measure 5.0 mL of hydrochloric acid. Pour the acid into a test tube.
2. Find the temperature and record in your data table.
3. Add a small piece of zinc to the hydrochloric acid. Gently stir until all zinc has reacted.
4. Measure the final temperature and record in your data table.

**Data**

*Part I*

<table>
<thead>
<tr>
<th>Initial temperature, T₁</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final temperature, T₂</td>
<td>°C</td>
</tr>
<tr>
<td>Change in temperature, $\Delta T$</td>
<td>°C</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>----</td>
</tr>
</tbody>
</table>

**Part II**

<table>
<thead>
<tr>
<th>Initial temperature, $T_1$</th>
<th>°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final temperature, $T_2$</td>
<td>°C</td>
</tr>
<tr>
<td>Change in temperature, $\Delta T$</td>
<td>°C</td>
</tr>
</tbody>
</table>

**Analysis**

1. Did you observe a physical or chemical change when you added NH$_4$Cl to the distilled water? Describe the evidence to support your answer.

2. Did you observe a physical or chemical change when you added zinc metal to hydrochloric acid? Describe the evidence to support your answer.

3. When you added NH$_4$Cl to distilled water, that was an (endothermic / exothermic) process and energy was (absorbed / released) by the system. Explain.

4. When you added zinc metal to hydrochloric acid, that was an (endothermic / exothermic) process and energy was (absorbed / released) by the system. Explain.

5. What you observed in part I is $\text{NH}_4\text{Cl}(s) \rightarrow \text{NH}_4^+(aq) + \text{Cl}^-(aq) \Delta H = 20 \text{ kJ/mol}$
   Rewrite this equation with the heat energy on the reactant or product side. Explain.
6. What you observed in part II is \( \text{Zn}(s) + 2 \text{HCl}(aq) \rightarrow \text{ZnCl}_2(aq) + \text{H}_2(g) \)

Is its \( \Delta H_{\text{rxn}} \) positive or negative? Explain.

7. Draw the general potential energy diagram for each part.

\( \text{Part I} \)  \hspace{2cm}  \( \text{Part II} \)