ENDOTHERMIC AND EXOTHERMIC REACTIONS

LAB THC 2.PALM

INTRODUCTION

Many chemical reactions give off energy. Chemical reactions that release energy are called exothermic reactions. Some chemical reactions absorb energy and are called endothermic reactions. You will study one exothermic and one endothermic reaction in this experiment.

In Part I, you will study the reaction between citric acid solution and baking soda. An equation for the reaction is:

\[ \text{H}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq}) + 3 \text{NaHCO}_3(\text{s}) \rightarrow 3 \text{CO}_2(\text{g}) + 3 \text{H}_2\text{O}(\text{aq}) + \text{Na}_3\text{C}_6\text{H}_5\text{O}_7(\text{aq}) \]

In Part II, you will study the reaction between magnesium metal and hydrochloric acid. An equation for this reaction is:

\[ \text{Mg}(\text{s}) + 2 \text{HCl}(\text{aq}) \rightarrow \text{H}_2(\text{g}) + \text{MgCl}_2(\text{aq}) \]

Another objective of this experiment is for you to become familiar with using the Data Pro data-collection program on the Palm handheld. In this experiment, you will use the program to collect and display data as a graph or list, to examine your experimental data values on a graph, and to print graphs and data lists.
PURPOSE
The purpose of this lab is to study an endothermic and exothermic chemical reaction. A Temperature Sensor will be used to measure the amount of heat given off or absorbed during the chemical reaction.

EQUIPMENT/MATERIALS
- LabPro interface with AC adapter
- Palm handheld with Data Pro
- Palm → LabPro interface cable
- Vernier Temperature Sensor
- Graphical Analysis (optional)
- Balance
- Styrofoam cup
- 250-mL beaker
- Citric acid, H$_3$C$_6$H$_5$O$_7$, solution
- Baking soda, NaHCO$_3$
- Hydrochloric acid, HCl, solution
- Magnesium, Mg
- 50-mL graduated cylinder

SAFETY
- Always wear an apron and goggles in the lab.
- Do not breathe the vapors from the reaction between magnesium and hydrochloric acid.

PROCEDURE
1. Obtain and wear goggles.

Part I. Citric Acid plus Baking Soda
2. Plug the Temperature Probe into Channel 1 of the LabPro interface. Connect the Palm handheld to the LabPro using the interface cable. Firmly press in the cable ends.
3. Turn on the handheld. To start the Data Pro program, tap the **Data Pro** icon on the Applications screen. Choose New from the Data pro menu or tap **NEW** to reset the program. Data Pro should automatically detect the Temperature Probe, if it does not, proceed to step 4, otherwise proceed to step 5.
4. Set up the handheld and interface for a Temperature Sensor.
   a. On the main screen, tap **SET UP**.
   b. If the hand held displays Temp(C) in CH1, proceed directly to Step 5. If it does not, continue with this step to set up your sensor manually.
   c. Tap **CH 1** to select Channel 1.
   d. Press the Scroll button on the hand held to scroll through the list of sensors.
   e. Select **Temp(C)** from the list of sensors.
5. Set up the data-collection mode.
   a. On the main screen, tap **SET UP**.
   b. While still on the Setup screen, tap **MODE**; then choose Time Graph from the list.
   c. Select **SETTINGS**; then under Seconds/Sample, enter 6. For Number of Samples, enter 50. The length of data collection will be 5 minutes.
   d. Tap **OK** twice to return to the Main screen.

6. Place a Styrofoam cup into a 250-mL beaker as shown in Figure 1. Measure out 30 mL of citric acid solution into the Styrofoam cup. Place the Temperature Probe into the citric acid solution.

7. Weigh out 10.0 g of solid baking soda on a piece of weighing paper.

8. You are now ready to begin collecting data.
   a. Select **START** on the main screen.
   b. After about 20 seconds have elapsed, add the baking soda to the citric acid solution. Gently stir the solution with the Temperature Probe to ensure good mixing.
   c. A real-time graph of temperature vs. time will be displayed on the calculator screen during data collection.
   d. Temperature readings (in °C) can also be monitored in the upper-right corner of the graph.
   e. Data collection will stop after 5 minutes, and a graph of temperature vs. time will be displayed, this is Run 1.
   f. Select and tap **STORE** from the menu at the bottom of the screen.
   g. Dispose of the reaction products as directed by your instructor.

Part II. Hydrochloric Acid plus Magnesium

9. Measure out 30 mL of HCl solution into the Styrofoam cup. Place the Temperature Probe into the HCl solution. Note: The Temperature Probe must be in the HCl solution for at least 30 seconds before doing Step 12.

10. Obtain a piece of magnesium metal (0.10g) from your instructor.

11. You are now ready to begin collecting data.
   a. Select and tap **START** on the graph screen to begin data collection. After about 20 seconds have elapsed, add the Mg to the HCl solution. Gently stir the solution with the Temperature Probe to ensure good mixing.
   b. **CAUTION:** Do not breathe the vapors from the reaction.
   c. Data collection will stop after 5 minutes, and a graph of temperature vs. time will be displayed, this is Run 2.
d. Dispose of the reaction products as directed by your instructor. Rinse the Temperature Probe.

e. By tapping Run in the upper right corner, you can display the first run graph, the second run graph, or by selecting All Runs, you can display both runs at the same time.

f. Select and tap **Run 1** and display graph of the citric acid and baking soda reaction.

g. Examine the data points along the displayed curve of temperature vs. time. Select the last point (at time 300) by tapping on it and read the TEMP value. Record this in the data table under PART I, \( t_2 \). Record the temperature values in your data table (round to the nearest 0.1 °C).

h. After you have determined the final temperature, \( t_2 \), do the same for the initial (or maximum) temperature, \( t_1 \). Record the temperature values in your data table (round to the nearest 0.1 °C).

i. Select **Run 2** and display graph of the hydrochloric acid and magnesium reaction.

12. Examine the data points along the displayed curve of temperature vs. time. Select the last point (at time 300) by tapping on it and read the TEMP value. Record this in the data table under PART II, \( t_2 \). Record the temperature values in your data table (round to the nearest 0.1 °C).

13. After you have determined the final temperature, \( t_2 \), do the same for the initial (or minimum) temperature, \( t_1 \). Record the temperature values in your data table (round to the nearest 0.1 °C).

14. Finally, select **All Runs** to show both graphs at once. You will need to make a copy of these graphs for question #5 at the conclusion of the lab.

15. When finished with your data and reaction graphs, select **OK** to return to the main screen. Next, select and confirm **Quit**.

**Reference:**
DATA SHEET

Name ________________________
Name ________________________
Period _______ Class ___________
Date ___________

ENDOTHERMIC AND EXOTHERMIC REACTIONS

DATA TABLE

<table>
<thead>
<tr>
<th></th>
<th>Part I</th>
<th>Part II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final temperature, $t_2$</td>
<td>°C</td>
<td>°C</td>
</tr>
<tr>
<td>Initial temperature, $t_1$</td>
<td>°C</td>
<td>°C</td>
</tr>
<tr>
<td>Temperature change, $\Delta t$</td>
<td>°C</td>
<td>°C</td>
</tr>
</tbody>
</table>

PROCESSING THE DATA

1. Calculate the temperature change, $\Delta t$, for each reaction by subtracting the initial temperature, $t_1$, from the final temperature, $t_2$ ($\Delta t = t_2 - t_1$). Record values in the Data Table.

QUESTIONS

1. Which reaction is exothermic? Explain.

2. Which reaction had a negative $\Delta t$ value? Is the reaction endothermic or exothermic? Explain.

3. For each reaction, describe three ways you could tell a chemical reaction was taking place.
4. Which reaction took place at a greater rate? Explain your answer. (Hint: which reaction graph had the steepest slope, or curve?)

5. Sketch a simple graph of your results for part I and part II below. Be sure to label the X and Y-axis of your graphs and supply the proper units.

Part I: Endothermic reaction

Part II: Exothermic reaction