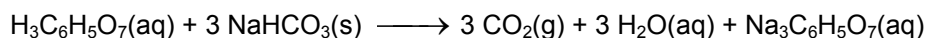


Endothermic and Exothermic Reactions

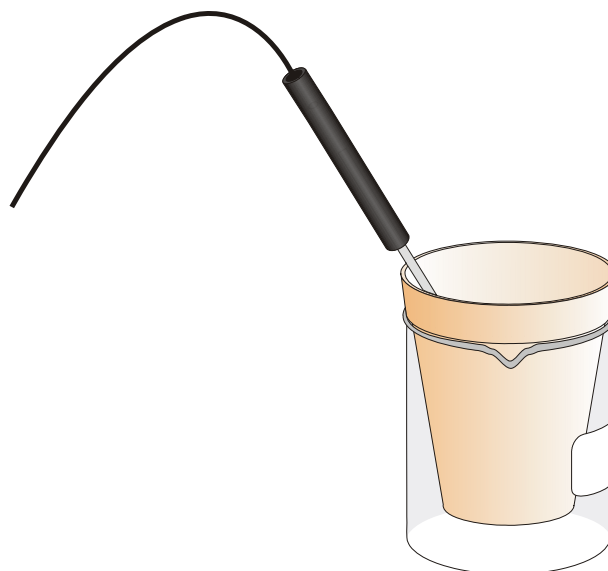
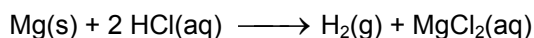
INTRODUCTION

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:



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



PURPOSE

To identify the temperature changes associated with endothermic and exothermic processes

MATERIALS

LabPro interface
TI Graphing Calculator
DataMate program
Temperature Probe
100-mL graduated cylinder
balance

Styrofoam cup
400-mL beaker
citric acid, $\text{H}_3\text{C}_6\text{H}_5\text{O}_7$, solution
baking soda, NaHCO_3
hydrochloric acid, HCl , solution
magnesium, Mg

PROCEDURE

1. **Obtain and wear goggles.**

Part I Citric Acid plus Baking Soda

2. Plug the Temperature Probe into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.
3. 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.
4. Weigh out 10.0 g of solid baking soda on a piece of weighing paper.
5. Turn on the calculator and follow these steps to start the DATAMATE program.

Press **APPS**, then press the calculator key for the *number* that precedes the DATAMATE program. You are now at the main screen of the program. Press **CLEAR** to reset the program.

6. Set up the calculator and interface for the Temperature Probe.
 - a. Select SETUP from the main screen.
 - b. If the calculator displays a Temperature Probe in CH 1, proceed directly to Step 7. If it does not, continue with this step to set up your sensor manually.
 - c. Press **ENTER** to select CH 1.
 - d. Select TEMPERATURE from the SELECT SENSOR menu.
 - e. Select the Temperature Probe you are using (in °C) from the TEMPERATURE menu.
7. Set up the data-collection mode.
 - a. To select MODE, press **▲** once and press **ENTER**.
 - b. Select TIME GRAPH from the SELECT MODE menu.
 - c. Select CHANGE TIME SETTINGS from the TIME GRAPH SETTINGS menu.
 - d. Enter "6" as the time between samples in seconds.
 - e. Enter "50" as the number of samples. The length of the data collection will be 5 minutes.
 - f. Select OK to return to the setup screen.
 - g. Select OK again to return to the main screen.
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.
9. Dispose of the reaction products as directed by your instructor.
10. Use the **▶** or **◀** keys to examine the data points along the displayed curve of temperature vs. time. As you move the cursor right or left, the time (X) and temperature (Y) values of each data point are displayed below the graph. Determine the initial temperature, t_1 , and final (or minimum) temperature, t_2 . Record the temperature values in your data table (round to the nearest 0.1°C).
11. Store the data from the first run so that it can be used later. To do this:
 - a. Press **ENTER** to return to the main screen, then select TOOLS.
 - b. Select STORE LATEST RUN from the TOOLS MENU.

Part II Hydrochloric Acid Plus Magnesium

12. 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 15.
13. Obtain a piece of magnesium metal from your instructor.
14. Choose START on the main 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.
Caution: Do not breathe the vapors. Data collection will stop after 5 minutes.
15. Dispose of the reaction products as directed by your instructor. Rinse the Temperature Probe.

16. Examine the data points along the displayed curve of temperature vs. time. Determine the initial temperature, t_1 , and the final (or maximum) temperature, t_2 . Record the temperature values in your data table (round to the nearest 0.1°C).
17. You can also examine the data by viewing the data lists directly. To do this, press **ENTER** to return to the main screen, and select QUIT. (Also press **ENTER** on a TI-83 Plus). Then follow this procedure for your calculator:
- To view the lists, press **STAT** to display the EDIT menu and then select Edit. Press **▼** to scroll down through the data lists L1 (time) and L2 (temperature) for Part II. **Note:** When you choose to repeat a data collection, as you did in Step 11 of this experiment, the temperature data in L2 of the first data run will be stored in L3. You can view the data for Part I of the experiment in L1 and L3.
18. A good way to compare the two curves is to view both sets of data on one graph.
- Turn on the calculator and start the DATAMATE program.
 - Select GRAPH from the main screen, then press **ENTER**.
 - Select MORE, then select L2 AND L3 VS L1 from the MORE GRAPHS menu.
 - Both temperature runs should now be displayed on the same graph. Each point of Part I (citric acid and baking soda) is plotted with a box, and each point of Part II (hydrochloric acid and magnesium) is plotted with a dot.
19. Sketch a graph of temperature vs. time (with two curves displayed). Label each curve as “endothermic reaction” or “exothermic reaction”. Use graph paper, and include it in your “Calculations and Graphs” section of your lab report.

RESULTS

Data and Observations:

- Record observations of chemical changes that you observe when the sodium bicarbonate (baking soda) is added to the citric acid solution.
- Record observations of chemical changes that you observe when the magnesium metal is added to the hydrochloric acid.

	Part I	Part II
Final temperature, t_2	$^\circ\text{C}$	$^\circ\text{C}$
Initial temperature, t_1	$^\circ\text{C}$	$^\circ\text{C}$
Temperature change, Δt	$^\circ\text{C}$	$^\circ\text{C}$

Calculations:

- Calculate the temperature change, Δt , for each reaction by subtracting the initial temperature, t_1 , from the final temperature, t_2 ($\Delta t = t_2 - t_1$).

	Part I	Part II
Temperature change, Δt	$^\circ\text{C}$	$^\circ\text{C}$