Endothermic and Exothermic Reactions

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:

$$H_3C_6H_5O_7(aq) + 3\ NaHCO_3(s) \longrightarrow 3\ CO_2(g) + 3\ H_2O(aq) + Na_3C_6H_5O_7(aq)$$

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

$$Mg(s) + 2\ HCl(aq) \longrightarrow H_2(g) + MgCl_2(aq)$$

Another objective of this experiment is for you to become familiar with using the DataMate data-collection program on the TI Graphing Calculator. 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.

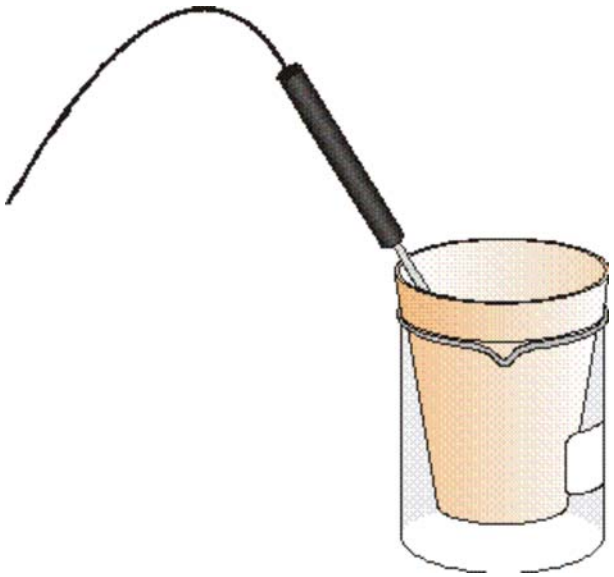

Figure 1

MATERIALS

LabPro or CBL 2 interface
TI Graphing Calculator
DataMate program
Temperature Probe
50-mL graduated cylinder
balance
calorimeter
250-mL beaker
1.5M citric acid ($H_3C_6H_5O_7$) solution (to be made)
baking soda, $NaHCO_3$
1.0M hydrochloric acid, HCl, solution
magnesium, Mg

PROCEDURE

1. Obtain and wear goggles and aprons.

Part I Citric Acid plus Baking Soda

2. Plug the Temperature Probe into Channel 1 of the LabPro interface. Use the USB cable to connect the to the computer. Firmly press in the cable ends.

3. Place a Styrofoam cup into a 250-mL beaker as shown in Figure 1or use a calorimeter. 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. Open the Logger Pro software on the computer.

   Set the **TIME OF COLLECTION** to 30 minutes

   Change the collection rate to 180 per minute

6. You are now ready to begin collecting data.
   a. Select **COLLECT** 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 screen during data collection.
   d. Temperature readings (in °C) can also be monitored in the upper-right corner of the graph. Click on the **AUTOSCALE** Button to set the graph
   e. Stop Data collection when the temperature begins to rebound from its maximum or minimum.

7. Dispose of the reaction products as directed by your instructor.

8. Save the data from the first run so that it can be used later.

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 15.

10. Obtain a 8.0cm piece of magnesium metal.

11. You are now ready to begin collecting data.

    Select **COLLECT** on the main screen.

    After about 20 seconds have elapsed, add the magnesium to the Hydrochloric acid 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.

    A real-time graph of temperature *vs.* time will be displayed on the screen during data collection.

    Temperature readings (in °C) can also be monitored in the upper-right corner of the graph. Click on the **AUTOSCALE** Button to set the graph

    Stop Data collection when the temperature begins to rebound from its maximum or minimum.

12. Dispose of the reaction products as directed by your instructor.

13. Save the data so that it can be used later.

14. Dispose of the reaction products as directed by your instructor. Rinse the Temperature Probe.

15. 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). You can also examine the data by viewing the data lists directly.

DATA TABLE

	Part I	Part II
Final temperature, t_2	°C	°C
Initial temperature, t_1	°C	°C
Temperature change, Dt	°C	°C

Make a second data table to include the masses and volumes of your reactants

PROCESSING THE DATA

CALCULATIONS

1. Show the calculation for the mass of citric acid required to make the required solution.
2. Calculate the temperature change, Dt, for each reaction by subtracting the initial temperature, t_1, from the final temperature, t_2 ($Dt = t_2 - t_1$).
3. Calculate the heat transferred to the water in each reaction
3. Show the calculations for the Molar and per gram heat of Citric acid and sodium bicarbonate and HCl and Magnesium

ANALYSIS

1. Tell which reaction is exothermic. Explain.
2. Which reaction had a negative Dt value? Is the reaction endothermic or exothermic? Explain.
3. For <u>each</u> 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.