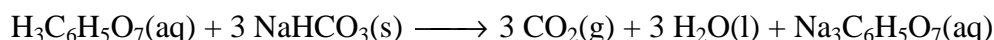


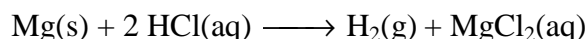
Endothermic and Exothermic Reactions

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



OBJECTIVES

In this experiment, you will

- Observe two chemical reactions.
- Use an EasyTemp probe to measure temperature changes.
- Determine the change in temperature, Δt , for each of the reactions.
- Identify endothermic and exothermic reactions.

MATERIALS

TI-84 Plus or TI-84 Plus Silver Edition
graphing calculator
Vernier EasyTemp
Vernier EasyData application
50 mL graduated cylinder
balance

styrofoam cup
250 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

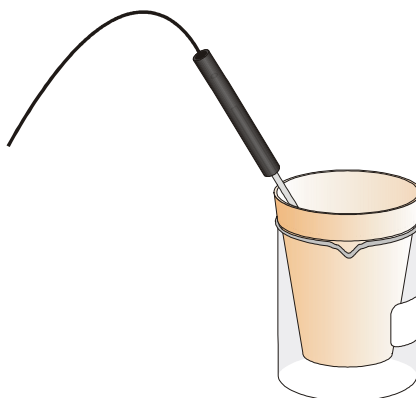


Figure 1

PROCEDURE

1. Obtain and wear goggles.

Part I Citric Acid Plus Baking Soda

2. Turn on your TI-84 Plus (or TI-84 Plus Silver Edition) graphing calculator and make sure that it is on the home screen. Plug the EasyTemp probe into the USB port of the graphing calculator. The EasyData application will automatically start and the Main screen will be displayed.
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 EasyTemp probe into the citric acid solution.
4. Weigh out 10.0 g of solid baking soda on a piece of weighing paper.
5. Set up the data-collection mode.
 - a. Select $\overline{\text{F2}}(\text{EDIT})$ from the Main screen, and then select **New**.
 - b. Select $\overline{\text{F2}}(\text{SETUP})$ from the Main screen.
 - c. Select **Time Graph....**
 - d. Select $\overline{\text{F1}}(\text{EDIT})$.
 - e. Press $\overline{\text{CLEAR}}$ on the calculator and type **10** as the time between samples in seconds. Select $\overline{\text{F2}}(\text{NEXT})$.
 - f. Press $\overline{\text{CLEAR}}$ on the calculator and type **30** as the number of samples. Select $\overline{\text{F2}}(\text{NEXT})$. The length of the data collection will be 300 seconds (5 minutes).
 - g. Confirm that time graph settings are correct. Select $\overline{\text{F4}}(\text{OK})$.
6. You are now ready to begin collecting data.
 - a. Select $\overline{\text{F2}}(\text{START})$ 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 EasyTemp 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 at the top of the graph.
 - e. Data collection will stop after 5 minutes.
7. Dispose of the reaction products as directed by your teacher.
8. Use $\overline{\text{D}}$ to examine the data points along the curve. As you move the cursor, the time (X) and temperature (Y) values of each data point are displayed above the graph. Record the minimum and maximum temperatures in your data table.
9. Sketch or print the graph. Label the graph to identify it as the reaction between citric acid and baking soda.
10. Select $\overline{\text{F2}}(\text{MAIN})$ to return to the Main screen.

Part II Hydrochloric Acid Plus Magnesium

11. Measure out 30 mL of HCl solution into the Styrofoam cup. Place the EasyTemp probe into the HCl solution. Note: The EasyTemp probe must be in the HCl solution for at least 30 seconds before doing Step 13.
12. Obtain a piece of magnesium metal from your instructor.
13. Select $\overline{\text{START}}$ 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 EasyTemp probe to ensure good mixing. **Caution:** Do not breathe the vapors. Data collection will stop after 5 minutes.
14. Dispose of the reaction products as directed by your instructor. Rinse the EasyTemp probe with water.
15. Examine the data points along the graph 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.
16. Sketch or print the graph. Label the graph to identify it as the reaction between hydrochloric acid and magnesium.
17. Select $\overline{\text{MAIN}}$ to return to the Main screen. Select $\overline{\text{QUIT}}$ from the Main screen. Select $\overline{\text{OFF}}$ to exit the EasyData application.

DATA

	Part I	Part II
Minimum temperature	_____ °C	_____ °C
Maximum temperature	_____ °C	_____ °C

OBSERVATIONS

PROCESSING THE DATA

1. Calculate the temperature change, Δt , for each reaction by subtracting the minimum temperature from the maximum temperature ($\Delta t = t_{\text{max}} - t_{\text{min}}$).
2. Tell which reaction is endothermic. Tell which reaction is exothermic. Explain.
3. For each reaction, describe three ways you could tell a chemical reaction was happening.
4. List three important exothermic reactions you have seen. List one endothermic reaction you know.

EXTENSION

1. Determine the energy effect, in J/g Mg, for the Part II reaction. Determine the energy effect, in J/g NaHCO₃, for the Part I reaction.