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:

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

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

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

OBJECTIVES

In this experiment, you will

- Study one exothermic and one endothermic reaction.
- Become familiar with using Logger *Pro.*
- Collect and display data on a graph.

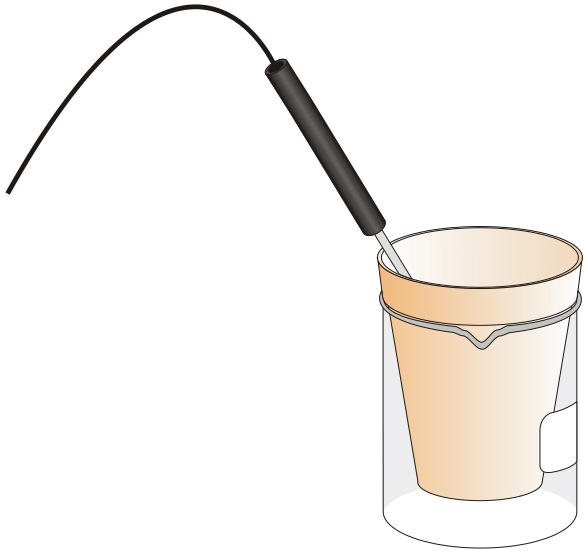

Figure 1

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Temperature Probe
50 mL graduated cylinder
balance
Styrofoam cup
250 mL beaker
citric acid, $H_3C_6H_5O_7$, 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. 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 a Temperature Probe into the citric acid solution.
3. Connect the probe to the computer interface. Prepare the computer for data collection.
4. Weigh out 10.0 g of solid baking soda on a piece of weighing paper.
5. The Temperature Probe must be in the citric acid solution for at least 30 seconds before this step. Begin data collection by clicking collect. 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. Collect data until a minimum temperature has been reached and temperature readings begin to increase. You can click on stop to end data collection or let the computer automatically end it after 300 seconds.
6. Dispose of the reaction products as directed by your teacher.
7. To analyze and print your data:
   a. To confirm the minimum and maximum temperatures, click on view and then graph & table in the upper right hand corner.
   b. To label graph, click on graph options in the lower left hand corner. Add the title "Temperature vs Time" and add your name.
   c. Download data and print graph & table.

Part II Hydrochloric Acid Plus Magnesium

8. 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 45 seconds before doing Step 10. **CAUTION:** *Hydrochloric acid is caustic. Avoid spilling it on your skin or clothing. Wear chemical splash goggles at all times. Notify your teacher in the event of an accident.*
9. Obtain a piece of magnesium metal from the teacher. Record the mass.
10. Begin data collection by clicking collect. After about 20 seconds have elapsed, add the magnesium to the HCl solution. Gently stir the solution with the Temperature Probe to ensure good mixing. Collect data until a maximum temperature has been reached and temperature readings begin to decrease. You can click on stop to end data collection or let the computer automatically end it after 300 seconds. **CAUTION:** *Do not breathe the vapors!*
11. Dispose of the reaction products as directed by your teacher.

12. To analyze and print your data:
    a. To confirm the minimum and maximum temperatures, click on view and then graph & table in the upper right hand corner.
    b. To label graph, click on graph options in the lower left hand corner. Add the title "Temperature vs Time" and add your name.
    c. Download data and print graph & table.

DATA TABLE

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

PROCESSING THE DATA

Part 1:Calculate the heat of reaction

$$\Delta H_r = m_{(HCl)}\, \Delta T\ \ Cp_{(water)}$$

Convert J to kJ

Convert g $NaHCO_3$ to moles $NaHCO_3$

Calculate ΔH_r /mole $NaHCO_3$

Write the balanced equation, including the energy of reaction

Calculate the molarity of the citric acid solution

Part 2: Calculate the heat of reaction

$\Delta H_r = m_{(HCl)} \Delta T \ Cp_{(water)}$

Convert J to kJ

Convert g Mg to moles Mg

Calculate ΔH_r /mole Mg

Write the balanced equation, including the energy of reaction

Calculate the molarity of the hydrochloric acid solution.

IN YOUR CONCLUSION:

1. Calculate the temperature change, Δt, for each reaction by subtracting the initial temperature, t_1, from the final temperature, t_2 ($\Delta t = t_2 - t_1$).
2. Tell which reaction is exothermic. Explain.
3. Which reaction had a negative Δt value? Is the reaction endothermic or exothermic? Explain.
4. For each reaction, describe three ways you could tell a chemical reaction was taking place.