Determining Heats of Reaction

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:

$$C_6H_8O_7(aq) + 3\ NaHCO_3(s) \longrightarrow 3\ CO_2(g) + 3\ H_2O(l) + Na_3C_6H_5O_7(aq)$$

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

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

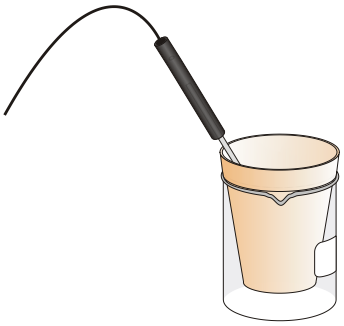

Figure 1

MATERIALS

Computer with LoggerPro	250-mL beaker
Vernier computer interface	water (H_2O)
Temperature Probe	citric acid ($C_6H_8O_7$)
50-mL graduated cylinder	baking soda ($NaHCO_3$)
Balance	0.5 M hydrochloric acid (HCl) solution
Styrofoam cup	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 water into the Styrofoam cup and add 6.5 g of citric acid. Stir the solution to dissolve the crystals of citric acid. Place a Temperature Probe into the solution.

3. Prepare the computer for data collection by opening the Experiment 1 folder from the *Chemistry with Computers* folder of Logger*Pro*. Then open the experiment file that matches the probe you are using. The vertical axis has temperature scaled from -10 to 40°C. The horizontal axis has time scaled from 0 to 300 seconds.

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. RECORD YOUR OBSERVATIONS.

6. Dispose of the reaction products in the sink with running water.
7. Copy and fill in the data from your experiment into the table below:

Mass $C_6H_8O_7$	
Mass $NaHCO_3$	
Initial Temp (°C)	
Final Temp (°C)	
ΔT (°C)	

8. Calculate the temperature change, ΔT, for each reaction by subtracting the initial temperature from the final temperature ($\Delta T = T_f - T_i$).

Part II: Hydrochloric Acid Plus Magnesium

9. Measure out 30 mL of 0.5 M 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.*
10. Obtain a piece of magnesium metal from the reagent bench.
11. Begin data collection by clicking Collect. After about 20 seconds, 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!* Collect data until a maximum temperature has been reached and the temperature readings begin to decrease. RECORD ALL OBSERVATIONS.
12. Dispose of the reaction products in the "acid waste" beaker on the reagent bench.
13. Copy and fill in the data from your experiment into the table below:

Volume 0.5 M HCl	
Mass Mg	
Initial Temp (°C)	
Final Temp (°C)	
ΔT (°C)	

OBSERVATIONS

Record your observations from each of the reactions in Parts 1 and 2.

PROCESSING THE DATA

1. Which reaction is exothermic? Endothermic?

2. Which reaction had a negative ΔT value? Is the reaction endothermic or exothermic? Explain.

3. From your observations, what was the limiting reagent in Part 1?

4. From your observations, what was the limiting reagent in Part 2?

5. Calculate the amount of heat (q) released or used up during the two reactions.

6. How many moles of $NaHCO_3$ were reacted in Part 1?

7. How many moles of Mg were reacted in Part 2?

8. Calculate the heat of reaction for each of the two reactions.

9. Calculate ΔH_{rxn} for Part 2 based on the literature values provided.

Substance	**$\Delta H°_f$ (kJ/mol)**
hydrochloric acid (HCl)	-92.30
magnesium (Mg)	0.00
hydrogen (H_2)	0.00
magnesium chloride ($MgCl_2$)	-641.6

10. How did your experimental ΔH_{rxn} compare to the ΔH_{rxn} calculated from literature values? Can you account for any errors that may have occurred?