Computer 19

Heat of Combustion: Magnesium

In Experiment 18, you learned about the additivity of reaction heats as you confirmed Hess's Law. In this experiment, you will use this principle as you determine a heat of reaction that would be difficult to obtain by direct measurement—the heat of combustion of magnesium ribbon. The reaction is represented by the equation

(4) $Mg(s) + 1/2\ O_2(g) \longrightarrow MgO(s)$

This equation can be obtained by combining equations (1), (2), and (3):

(1) $MgO(s) + 2\ HCl(aq) \longrightarrow MgCl_2(aq) + H_2O(l)$

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

(3) $H_2(g) + 1/2\ O_2(g) \longrightarrow H_2O(l)$

The pre-lab portion of this experiment requires you to combine equations (1), (2), and (3) to obtain equation (4) before you do the experiment. Heats of reaction for equations (1) and (2) will be determined in this experiment. As you may already know, ΔH for reaction (3) is –285.8 kJ.

OBJECTIVES

In this experiment, you will

- Combine three chemical equations to obtain a fourth.
- Use prior knowledge about the additivity of reaction heats.
- Determine the heat of combustion of magnesium ribbon.

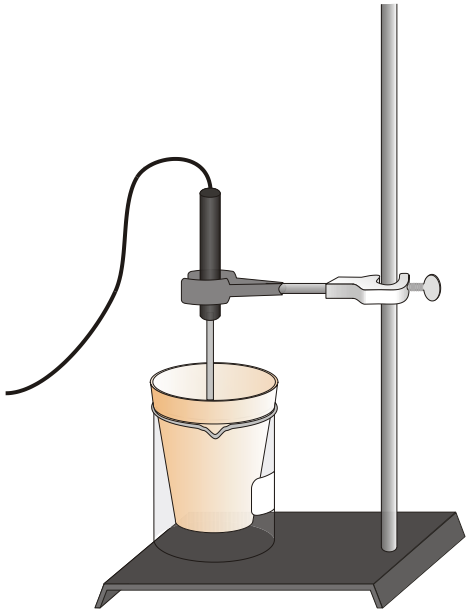

Figure 1

MATERIALS

computer
LabPro interface
Logger*Pro*
Temperature Probe
ring stand
utility clamp
100 mL graduated cylinder
250 mL beaker
Styrofoam cup
1.00 M HCl
magnesium oxide, MgO
magnesium ribbon, Mg
stirring rod
balance
weighing paper

PRE-LAB EXERCISE

In the space provided below, combine equations (1), (2), and (3) to obtain equation (4).

(1) _____

(2) _____

(3) _____

(4) _____

PROCEDURE

1. Obtain and wear safety glasses and an apron.

2. Connect the probe to the computer interface. Prepare the computer for data collection by opening the file "19 Heat of Combustion" from the *Chemistry with Vernier* folder.

Reaction 1

3. Place a Styrofoam cup into a 250 mL beaker as shown in Figure 1. Measure out 100.0 mL of 1.00 M HCl into the Styrofoam cup. **CAUTION:** *Handle the HCl solution with care. It can cause painful burns if it comes in contact with the skin.*

4. Use a utility clamp and a slit stopper to suspend a Temperature Probe from a ring stand as shown in Figure 1. Lower the Temperature Probe into the solution in the Styrofoam cup.

5. Weigh out about 1.00 g of magnesium oxide, MgO, on a piece of weighing paper. Record the exact mass used in your data table. **CAUTION:** *Avoid inhaling magnesium oxide dust.*

6. Click ▶ Collect to begin data collection and obtain the initial temperature, t_1. After three or four readings at the same temperature (t_1) have been obtained, add the white magnesium oxide powder to the solution. Use a stirring rod to stir the cup contents until a maximum temperature has been reached and the temperature starts to drop. Click ■ Stop to end data collection.

7. Examine the initial readings in the table to determine the initial temperature, t_1. To determine the final temperature, t_2, click the Statistics button, . The maximum temperature is listed in the statistics box on the graph. Record t_1 and t_2 in your data table.

8. Discard the solution as directed by your teacher.

Reaction 2

9. Repeat Steps 3–8 using about 0.50 g of magnesium ribbon rather than magnesium oxide powder. The magnesium ribbon has been pre-cut to the proper length by your teacher. Be sure to record the measured mass of the magnesium. **CAUTION:** *Do not breathe the vapors produced in the reaction!*

PROCESSING THE DATA

1. In the spaces provided, calculate the change in temperature, Δt, for Reactions 1 and 2.

2. Calculate the heat released by each reaction, q, using the formula

$$q = C_p \cdot m \cdot \Delta t$$

   C_p = 4.18 J/g°C, and m = 100.0 g of HCl solution. Convert joules to kJ in your final answer.

3. Determine ΔH. ($\Delta H = -q$)

4. Determine the moles of MgO and Mg used.

5. Use your Step 3 and Step 4 results to calculate ΔH/mol for MgO and Mg.

6. Determine ΔH/mol Mg for Reaction 4. (Use your Step 5 results, your pre-lab work, and ΔH = –285.8 kJ for Reaction 3).

7. Determine the percent error for the answer you obtained in Step 6. The accepted value for this reaction can be found in a table of standard heats of formation.

DATA AND CALCULATIONS

	Reaction 1 (MgO)	Reaction 2 (Mg)
1. Volume of 1.00 M HCl	g	g
2. Final temperature, t_2	°C	°C
3. Initial temperature, t_1	°C	°C
4. Change in temperature, Δt	°C	°C
5. Mass of solid	g	g
6. Heat, q	kJ	kJ
7. ΔH	kJ	kJ
8. Moles	mol MgO	mol Mg
9. ΔH/mol	kJ/mol	kJ/mol
10. Determine ΔH/mol Mg for reaction (4)*. (1) _____ _____ (2) _____ _____ (3) _____ _____ (4)* _____ _____		
11. Percent error		kJ/mol