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

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

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

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

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

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

- 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.

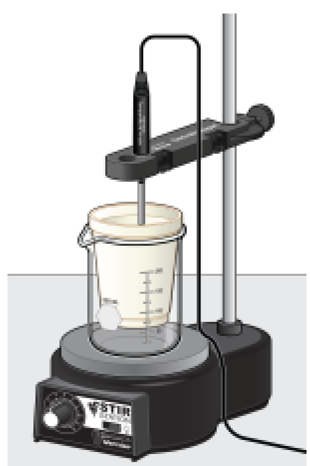

Figure 1

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis app
Vernier data-collection interface
Temperature Probe
1.00 M HCl
magnesium oxide, MgO
magnesium ribbon, Mg
100 mL graduated cylinder
400 mL beaker
polystyrene foam cup
Stir Station and magnetic stirring bar
Electrode Support
balance

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 Temperature Probe the data-collection interface, and then connect the interface to your Chromebook, computer, or mobile device. Launch Graphical Analysis.

3. Click or tap Mode to open Data Collection Settings. Change Rate to 1 samples/s and End Collection to 480 s. Click or tap Done.

4. Use an Electrode Support to suspend the Temperature Probe from a Stir Station as shown in Figure 1.

Reaction 1

5. Place a polystyrene foam cup into a 400 mL beaker as shown in Figure 1. Measure out 100.0 mL of 1.00 M HCl into the polystyrene foam cup. Lower the Temperature Probe into the solution. Add a magnetic stirring bar to the cup and start stirring at a gentle speed. The stirring bar should not strike the probe. **DANGER**: *Hydrochloric acid solution,* HCl: *Causes severe skin and eye damage. Do not breathe mist, vapors, or spray. May cause respiratory irritation. May be harmful if swallowed*.

6. 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. **DANGER**: *Solid magnesium,* Mg: *Keep away from heat, sparks, open flames, and hot surfaces—flammable solid*.

7. Click or tap Collect to start data collection and obtain the initial temperature, t_1. Monitor temperature (in °C) on the screen. It may take several seconds for the Temperature Probe to equilibrate at the temperature of the solution. After three or four readings at the same temperature (t_1) have been obtained, add the white magnesium oxide powder to the solution. Stir the cup contents until a maximum temperature has been reached and the temperature starts to drop. Record the maximum temperature, t_2.

8. Data collection will stop after 8 minutes, or you can stop data collection before 8 minutes have elapsed if the maximum temperature has been recorded.

9. To confirm the initial (t_1) and final (t_2) values you recorded earlier, examine the data points along the curve on the displayed graph.

10. Discard the solution as directed by your teacher.

Reaction 2

11. Repeat Steps 5–10 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!* **Note**: The previous data set is automatically saved.

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

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

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. **Hint**: $\Delta H = -q$

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)