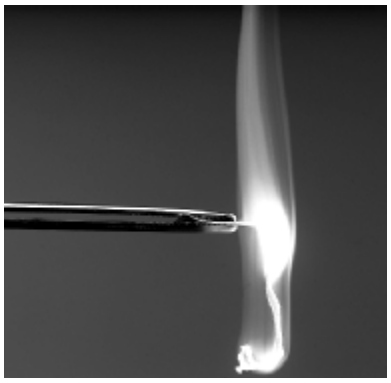
DATE: NAME: CLASS:

CHAPTER 10		BLM 10.1.4
HANDOUT		

Investigation 10.A: Hess's Law and the Enthalpy of Combustion of Magnesium



Magnesium ribbon burns in air in a highly exothermic combustion reaction. (See equation (1).) A very bright flame accompanies the production of magnesium oxide, as shown in the photograph on the right. It is impractical and dangerous to use a simple calorimeter to determine the enthalpy change for this reaction.

(1) $Mg(s) + \frac{1}{2}O_2(g) \rightarrow MgO(s)$

Instead, you will determine the enthalpy changes for two other reactions (equations (2) and (3) below). You will use these enthalpy changes, along with the known enthalpy change for another reaction (equation (4) below), to determine the enthalpy change for the combustion of magnesium.

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

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

(4) $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(\ell) + 285.8\ kJ$

Notice that equations (2) and (3) occur in aqueous solution. You can use a simple calorimeter to determine the enthalpy changes for these reactions. Equation (4) represents the formation of water directly from its elements in their standard state.

Question

What is the molar enthalpy of formation of magnesium oxide?

Predictions

• Predict the molar enthalpy of formation of magnesium oxide.

• Predict whether reactions (2) and (3) will be exothermic or endothermic.

Safety Precautions

• Hydrochloric acid is corrosive. Use care when handling it.
• Be careful not to inhale the magnesium oxide powder.

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Materials

- 1.00 mol/L HCl(aq)
- MgO(s) powder
- Mg ribbon (or Mg turnings)
- simple calorimeter
- 100 mL graduated cylinder
- scoopula
- electronic balance
- thermometer (alcohol or digital)
- sandpaper or emery paper

Procedure

Part 1: Determining ΔH of Reaction (2)

1. Read the Procedure for Part 1. Prepare a data table to record mass and temperature data.

2. Set up the simple calorimeter (refer to Investigation 9.B on page 358). Using a graduated cylinder, add 100 mL of 1.00 mol/L HCl(aq) to the calorimeter. **Caution:** Hydrochloric acid can burn your skin.

3. Record the initial temperature, t_i, of the HCl(aq), to the nearest tenth of a degree.

4. Find the mass of no more than 0.80 g of MgO(s) powder. Record the exact mass.

5. Add the MgO(s) powder to the calorimeter containing the HCl(aq). Swirl the solution gently, recording the highest temperature, t_f, reached.

6. Dispose of the reaction solution as directed by your teacher.

Part 2: Determining ΔH of Reaction (3)

1. Read the Procedure for Part 2. Prepare a data table to record mass and temperature data.

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2. Using a graduated cylinder, add 100 mL of 1.00 mol/L HCl(aq) to the calorimeter.

3. Record the initial temperature, t_i, of the HCl(aq) to the nearest tenth of a degree.

4. If you are using magnesium ribbon (as opposed to turnings), sand the ribbon. Accurately determine the mass of no more than 0.50 g of magnesium. Record the exact mass.

5. Add the Mg(s) to the calorimeter containing the HCl(aq). Swirl the solution gently, recording the highest temperature, t_f, reached.

6. Dispose of the solution as directed by your teacher.

Analysis

1. Determine the enthalpy change of reactions (2) and (3). List any assumptions you make and explain why they are valid assumptions.

2. Write thermochemical equations for reactions (2) and (3) using ΔH notation. Ensure the signs you use are correct.

3. (a) Algebraically combine equations (2), (3), and (4), and their corresponding ΔH values, to arrive at equation (1) and the molar enthalpy of combustion of magnesium.

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(b) Draw a potential energy diagram to represent the combining of equations (2), (3), and (4) to obtain equation (1) and the molar enthalpy of combustion of magnesium.

4. (a) Compare your result with the accepted value of $\Delta_c H$ for magnesium. Calculate your percent error.

(b) Suggest some sources of error in the procedure. In what ways could you improve the procedure?

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Conclusion

5. Explain how you used Hess's law to determine ΔH for the combustion of magnesium. State the result you obtained for the thermochemical equation that corresponds to chemical equation (1).

Application

6. Design an investigation to test Hess's law by using the following equations:

(1) $NaOH(s) \rightarrow NaOH(aq)$

(2) $NaOH(s) + HCl(aq) \rightarrow NaCl(aq) + H_2O(\ell)$

(3) $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(\ell)$

Assume you have a simple calorimeter, NaOH(s), 1.00 mol/L HCl(aq), 1.00 mol/L NaOH(aq), and standard laboratory equipment. Write a step-by-step procedure for the investigation. Then outline a plan for analyzing your data. Be sure to include appropriate safety precautions. If time permits, obtain your teacher's approval and carry out the investigation.