HESS'S LAW LAB

Pre lab assignment: You will need to complete the following parts prior to doing the lab: **Title, Purpose, and Storyboard of the procedures for each part, Blank Data tables, and the Prelab questions (below).**

Chemical Background Information:

Magnesium reacts with oxygen in air to for magnesium oxide, according to equation 1.

$$Mg(s) + \tfrac{1}{2}\, O_2\,(g) \rightarrow MgO(s) + heat \qquad \textbf{Equation 1}$$

In the reaction above, a great deal of heat and light are produced – the temperature of the flame can reach as high as 2400 ^{o}C. The amount of heat energy produced in this reaction cannot be measured directly using standard methods in the high school lab. It is possible, however, to determine the amount of heat produced by an indirect method, using Hess's Law.

The heat or enthalpy change for a chemical reaction is called the $\Delta H_{reaction}$. The enthalpy change – defined as the difference in enthalpy between the products and reactants – is equal to the amount of heat transferred at a constant pressure and does not depend on how the transformation occurs. This definition of enthalpy makes it possible to determine the heats of reaction for reactions that cannot be measured directly. According to Hess's Law, if the same overall reaction is achieved in a series of steps, rather than in one step, the enthalpy change for the overall reaction is equal to the sum of the enthalpy changes for each step in the reaction series. Consider the following three reactions:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$		**Equation**
$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$		**Equation B**
$H_2(g) + \tfrac{1}{2}\, O_2(g) \rightarrow H_2O(l)$	$\Delta H = -285.8$ kJ	**Equation C**

It is possible to express the combustion of magnesium (Equation 1 above) as an sum of Equations A, B, and C.

Purpose

The purpose of this experiment is to use Hess's Law to determine the heat of reaction for the combustion of magnesium (Equation 1).

Materials

Hydrochloric acid, HCl, 1 M, 60 mL
Magnesium ribbon, Mg, 7-cm strip
Magnesium oxide, MgO, 0.04 g
Balance, centigram (0.01 g precision)
Calorimeter, small-scale
Digital thermometer or temperature sensor
Forceps
Graduated Cylinder, 25- or 50-mL
Metric ruler, marked in mm
Scissors
Spatula
Stirring rod
Wash bottle and water
Weighing dish

Safety Precautions *Hydrochloric acid is toxic by ingestion and inhalation and is corrosive to skin and eyes. Magnesium metal is a flammable solid. Keep away from flames. Wash hands thoroughly with soap and water before leaving the lab.*

Procedure
Part A. Reaction of Magnesium with Hydrochloric Acid

1. Obtain a small strip of magnesium ribbon.
2. Measure the exact length of each piece of magnesium ribbon to the nearest 0.1 cm.
3. Multiply the length of each piece of Mg ribbon by the conversion factor 0.0124 g/cm to obtain the mass of each piece of Mg in cm…**record this in your data table**.
4. Mass a clean, dry calorimeter …**record this in your data table**.
5. Using a graduated cylinder, add 15 mL of 1 M hydrochloric acid to the calorimeter and measure the combined mass of the calorimeter and acid… **record this in your data table**.
6. Using a digital thermometer or temperature sensor, measure the initial temperature of the hydrochloric acid solution … **record this in your data table**.
7. Add the piece of magnesium ribbon to the acid and stir the solution until the magnesium has dissolved and the temperature of the solution remains constant.
8. Measure the final temperature of the solution … **record this in your data table**.
9. Rinse the contents of the calorimeter down the drain with excess water.

Part B. Reaction of Magnesium Oxide with Hydrochloric Acid

10. Mass a clean, dry calorimeter … **record this in your data table**.
13. Using a graduated cylinder, add 15 mL of 1 M HCl to the calorimeter and measure the combined mass of the calorimeter and hydrochloric acid… **record this in your data table**.
14. Using a small weighing dish measure about 0.20 g of magnesium oxide. Measure the exact mass of magnesium oxide … **record this in your data table**.
15. Using a digital thermometer or a temperature sensor, measure the initial temperature of the hydrochloric acid solution … **record this in your data table**.
16. Using a stirring rod, add the magnesium oxide to the acid. Stir the reaction mixture until the temperature remains constant. Measure the final temperature of the solution… **record this in your data table**.
17. Pour the reaction mixture down the drain with excess water. Rinse and dry the calorimeter.

Pre-Lab Questions

1. Review the *Backround* section. Arrange Equations A, B, and C in such a way that they add up to Equation 1.
2. Use Hess's Law to express the heat of the reaction for Equation 1 as the appropriate algebraic sum of the heats of reaction for Equations A, B, and C.

Calculations: Be sure to give a word equation first and then a number equation for each calculation.

1. Calculate $q_{solution}$ for each of the trials of each of the reactions (remember the mass of the solution is the mass of the reactants). Use the specific heat of water for c.
2. Determine $q_{reaction}$ for each trial of each reaction (remember $q_{reaction} = -q_{solution}$).
3. Determine $\Delta H_{reaction}$ (q/mole of limiting reactant) for each trial of each reaction (LR is Mg or MgO).
4. Convert each of the $\Delta H_{reaction}$ to kJ/mol.
5. Use your $\Delta H_{reaction}$ above, and Hess's law to determine the $\Delta H_{reaction}$ for equation #1.
6. The actual value for $\Delta H_{reaction}$ for equation # 1 is -601.5 kJ/mol. Calculate your percent error.

Conclusions: Write a conclusion which summarizes what you learned and valid sources of error.

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Digital thermometer or temperature sensor
Forceps
Graduated Cylinder, 25- or 50-mL
Metric ruler, marked in mm
Scissors
Spatula
Stirring rod
Wash bottle and water
Weighing dish

Safety Precautions *Hydrochloric acid is toxic by ingestion and inhalation and is corrosive to skin and eyes. Magnesium metal is a flammable solid. Keep away from flames. Wash hands thoroughly with soap and water before leaving the lab.*

Procedure

Part A. Reaction of Magnesium with Hydrochloric Acid

1. Obtain a 7-cm strip of magnesium ribbon and cut it into two pieces of unequal length, roughly 3- and 4-cm each. *Note:* Handle the magnesium ribbon using the forceps.
2. Measure the exact length of each piece of magnesium ribbon to the nearest 0.1 cm.
3. Multiply the length of each piece of Mg ribbon by the conversion factor (g/cm) provided by your teacher to obtain the mass of each piece of Mg.
4. Mass a clean, dry calorimeter to the nearest 0.01 g.
5. Using a graduated cylinder, add 15 mL of 1 M hydrochloric acid to the calorimeter and measure the combined mass of the calorimeter and acid.
6. Using a digital thermometer or temperature sensor, measure the initial temperature of the hydrochloric acid solution to the nearest 0.1°C.
7. Add the first (shorter) piece of magnesium ribbon to the acid and stir the solution until the magnesium has dissolved and the temperature of the solution remains constant.
8. Record the final temperature of the solution to the nearest 0.1°C.
9. Rinse the contents of the calorimeter down the drain with excess water.
10. Dry the calorimeter and mass it again to the nearest 0.01 g.
11. Repeat steps 5-9 using the second (larger) piece of magnesium ribbon.

Part B. Reaction of Magnesium Oxide with Hydrochloric Acid

12. Mass a clean, dry calorimeter to the nearest 0.01 g.

13. Using a graduated cylinder, add 15 mL of 1 M HCl to the calorimeter and measure the combined mass of the calorimeter and hydrochloric acid.
14. Mass a small weighing dish and add about 0.20 g of magnesium oxide. Measure the exact mass of magnesium oxide and the dish to the nearest 0.01 g.
15. Using a digital thermometer or a temperature sensor, measure the initial temperature of the hydrochloric acid solution to the nearest 0.1°C.
16. Using a stirring rod, add the magnesium oxide to the acid. Stir the reaction mixture until the temperature remains constant for several five-second intervals. Record the final temperature of the solution to the nearest 0.1°C.
17. Pour the reaction mixture down the drain with excess water. Rinse and dry the calorimeter.
18. Repeat steps 12-16 using a second sample of magnesium oxide.