

Standard Enthalpy of an Ion

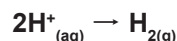
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INTRODUCTION

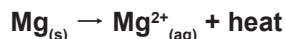
Exothermic reactions, symbolized by a (-) ΔH , release heat to the environment and form products with less potential energy than the reactants. Endothermic reactions, symbolized by (+) ΔH , form products with more potential energy. In this experiment, we will measure the heat produced in an exothermic reaction. Because heat can be lost easily to the air and the surrounding environment, we will use a calorimeter to contain the heat produced in the reaction. The equation below shows the reaction we will measure. Magnesium metal reacts with hydrogen ions in hydrochloric acid according to the following reaction:



The heat released is a direct measure of the heat of formation (ΔH_f) of the magnesium ion, $\text{Mg}^{2+}(\text{aq})$. This is because the heats of formation of all the other products are zero. In other words, the half-reaction



has a heat of formation, $\Delta H_f = 0$. Since Cl^- does not change, it does not add or absorb energy. The only reaction which produces heat is the following part of the reaction:



The heat released by this reaction can be calculated by following the directions outlined in the procedure below.

Activity Overview

In this activity we will

- explore exothermic and endothermic reactions
- create a classroom calorimeter to measure energy of a reaction

Approximate Total Time: 35 minutes

Science Objective

Using a simple calorimeter constructed in class, students explore exothermic and endothermic reactions. The Vernier Temperature Probe is used to determine the heat produced in the reaction.

MATERIALS

- magnesium metal ribbon/turnings
- 1 M HCl solution
- plastic calorimeter (two 1 oz condiment cups with lids, rubber band)
- 10 mL graduated cylinder
- 1/4 in. hole punch

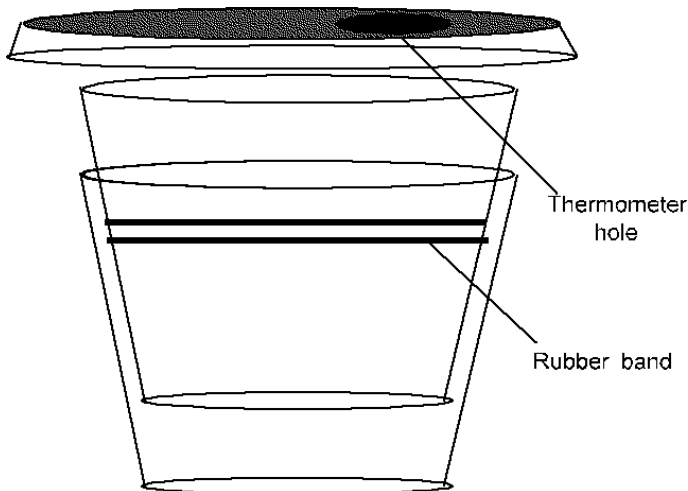
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PROCEDURE

1

Assemble a microcalorimeter by following the diagram and instructions below.

Place a thick rubber band around the center of a 1 oz condiment cup. Insert the cup with the band into another cup of the same size, creating an airtight seal between the two cups. Use a 1/4 in. hole punch to make an opening in the lid of the cup. This opening will serve as a hole for the insertion of the EasyTemp thermometer probe.



Calorimeter

Measure the mass of the calorimeter, and record it in the data table.

2

Add approximately 20 mL of 1.0 M HCl to the calorimeter. Assume that $d = 1 \text{ g/mL}$ for HCl solution.

3

Record the mass of your sample of magnesium ribbon in the data table.

4

Plug the Vernier EasyTemp probe directly into the USB port on the calculator.

5

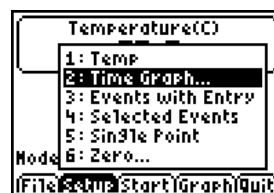
The calculator should automatically turn on, and the EasyData program should start. The temperature should be displayed at the top of the screen.

6

Insert the probe into the HCl solution inside the calorimeter. Wait until the temperature is stable, and record this temperature in the data table as the starting temperature of the HCl (T_1).

7

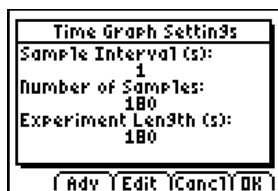
Press **WINDOW** to select SETUP, and then press **2** to select TIME GRAPH.



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8

The screen should display the settings for the time graph. Press **ZOOM** to select EDIT. Enter the number 1 for the time between samples, and press **ZOOM** to select NEXT. Enter the number 180 for number of samples to collect, and select NEXT. Data will be collected for 3 min.



9

Press **GRAPH** to select OK. Add the sample of Mg metal to the calorimeter all at once. Quickly insert the temperature probe, and swirl the contents for the entire duration of the experiment, to ensure even mixing. Then press **ZOOM** to start collecting the data. If you get a message saying the selected function will overwrite the latest run, select OK.

10

A graph will appear plotting temperature vs. time. A digital readout of the temperature will appear in the upper right corner of the display.

11

When 3 min have passed, the calculator will adjust the graph so you can see it more clearly. Use the **←** and **→** keys to scroll across the graph. The x value is the time in seconds, and the y value is the temperature in degrees Celsius. Find the point(s) on the graph with the highest temperature, and record that temperature in the data table as the ending temperature of the HCl solution and Mg (T2).

12

Discard the solution in the calorimeter as instructed by your teacher.

13

Repeat the experiment. Press **TRACE** to select MAIN, then press **GRAPH** to select QUIT. Perform the necessary calculations to fill the data table and answer the questions that follow.

DATA TABLE

	Trial 1	Trial 2
1. Mass of magnesium	g	g
2. Moles of magnesium (Data 1 ÷ 24 g/mol)	mol	mol
3. Starting temperature of HCl solution (T1)	°C	°C
4. Ending temperature of HCl solution and Mg (T2)	°C	°C
5. Change in temperature (T2 – T1)	°C	°C
6. Mass of calorimeter	g	g
7. Mass of calorimeter and HCl solution	g	g
8. Mass of solution (Data 7 – Data 6)	g	g

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DATA ANALYSIS AND QUESTIONS

Trial 1

a) Joules for reaction = mass of solution \times change in temperature \times Cp (4.18 j/g water), = _____ joules

b) Joules/mole of magnesium = $\frac{\text{joules (A)}}{\text{moles of magnesium}}$ = _____ j/mole

Trial 2

a) Joules for reaction = mass of solution (Data 8) \times change in temperature (Data 5) \times Cp(4.18 j/g water) so joules for reaction = _____ joules

b) Joules/mole of magnesium = $\frac{\text{joules (A)}}{\text{moles of magnesium}}$ = _____ j/mole

Average joules/moles as joules/mole of magnesium, for the two trials:

(Trial 1 + Trial 2) \div 2 = _____ j/mole

This activity comes courtesy of Theta Technologies.

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