# Pre-Lab Information

Purpose Explore the enthalpy of the combustion of magnesium using Hess’s law.

Time Approximately 45 minutes

Question How can you use Hess’s law to determine a reaction’s enthalpy when you can’t do so using a calorimeter?

**Summary** The combustion of magnesium has the equation Mg(*s*) + 1/2O2(*g*) MgO(*s*). This reaction gives off enough heat that it could melt a coffee cup calorimeter, making it difficult to compute the enthalpy of the reaction directly. However, you can do so indirectly using Hess’s law and the following three intermediate reactions:

**Reaction 1:** Mg(*s*) + 2HCl(*aq*) MgCl2(*aq*) + H2(*g*)

**Reaction 2:** MgO(*s*) + 2HCl(*aq*) MgCl2(*aq*) + H2O(*l*)

**Reaction 3:** H2(*g*) + 1/2O2(*g*) H2O(*l*)

You will compute the enthalpy of the Reactions 1 and 2 using a coffee cup calorimeter. The enthalpy of the third reaction is well known (–286 kJ/mol). With these three enthalpy values, you will use Hess’s law to compute the enthalpy of magnesium combustion.

# Safety

* Always wear a lab coat and safety goggles when performing an experiment.
* Check glassware, such as graduated cylinders and beakers, for cracks and chips prior to use.
* Use the right gear, such as chemically resistant gloves, when performing the experiment.
* Use caution when working with hydrochloric acid as it is corrosive and can cause burns. If it comes into contact with the skin, immediately rinse with water for 5-10 minutes.
* The magnesium ribbon is flammable and should not be placed near a flame.
* Report all accidents—no matter how big or small—to your teacher.

# Procedure

1. **Gather Materials**

|  |  |  |
| --- | --- | --- |
| * Two polystyrene coffee cups and a lid * Ring stand * Burette clamp * Thermometer | * Analytical balance * Weighing paper * 250-ml beaker * 100-ml graduated cylinder | * 200 ml of 1 M hydrochloric acid * Magnesium ribbon * Magnesium oxide * Steel wool |

1. **Prepare the Magnesium**

Using steel wool, polish a piece of magnesium ribbon to remove the oxide coating that   
prevents burning.

1. **Assemble a Coffee Cup Calorimeter**
   1. Place one coffee cup inside the other.
   2. Use scissors to punch the center of the lid and cut a small hole in it. (This will be for the thermometer.)
2. **Measure Masses of the Reactants**
   1. Put the calorimeter (lid off) on the balance, and tare the balance.
   2. Using a graduated cylinder, measure and pour 100 mL of 1 M HCl into the calorimeter.
   3. The mass shown is the mass of the HCl. Record it in the data table to the nearest 0.01 g.
   4. Remove the calorimeter from the balance. Put a piece of weighing paper on the balance, and tare the balance.
   5. On the weighing paper, add approximately 0.2 g of magnesium ribbon. Record the mass of the solid to the nearest 0.01 g in the data table. (For Reaction 2, weigh approximately 1.5 g of magnesium oxide instead.)
   6. Compute the mass of the reaction by adding the masses of the two reactants. Record the sum in the data table.
3. **Set the Calorimeter and Measure the Initial Temperature**
   1. Place the lid on the calorimeter. Without spilling acid, carefully put the calorimeter into the beaker.
   2. Clamp the thermometer in a burette holder on a ring stand. Gently insert the thermometer into the lid's hole until the tip of the thermometer is in the liquid.
   3. Unclamp the thermometer and gently swirl it to confirm that it is not touching the bottom of the cup. Reclamp it in place.
   4. After letting the temperature settle for one minute, record the initial temperature of the HCl   
      to the nearest 0.1°C.
4. **Carry out the Reaction and Measure the Temperature Change**
   1. Carefully raise the lid on the calorimeter and add the magnesium ribbon (magnesium oxide for Reaction 2) to the HCl solution. Quickly replace the lid and thermometer.
   2. Unclamp the thermometer, and swirl the reactants gently. Reclamp it in place.
   3. As the reaction occurs, identify the temperature furthest from the initial temperature. Record that temperature in the data table to the nearest 0.1°C.
   4. Compute *T*, the change in temperature, by subtracting the initial temperature from the temperature you just found.

**Steps 7–9:** Rinse and dry the coffee cup calorimeter and repeat steps 4–6 for Reaction 2, using magnesium oxide instead of magnesium.

1. **Perform Calculations to Complete the Data Table**
2. **Dispose of all Materials According to the Directions of Your Teacher**

# Data

Record data in the space below.

|  |  |  |
| --- | --- | --- |
| **Measurement** | **Reaction 1 (Mg + HCl)** | **Reaction 2 (MgO + HCl)** |
| Mass of HCl (g) |  |  |
| Mass of solid (g) |  |  |
| Total mass of reactants, *m* (g) (Add the masses above.) |  |  |
| Initial temperature (°C) |  |  |
| Temperature furthest from initial temperature (°C) |  |  |
| *T* (°C) (Subtract the two temperatures above.) |  |  |
| Heat released, *q* = *cm*∆*T* (J) (Use the specific heat of 1 M HCl, *c* = 4.18 J/g•°C.) |  |  |
| Moles of solid reactant (mol) (Moles = mass/molar mass) | (Mg: 24.3 g/mol) | (MgO: 40.3 g/mol) |
| Enthalpy of reaction,  (kJ/mol) |  |  |

Combination of ∆*H*1, ∆*H*2, and ∆*H*3 needed (using Hess’s law):

|  |  |
| --- | --- |
| **Reaction Equation** | ***H* (kJ/mol)** |
| **Reaction 1:** Mg(*s*) + 2HCl(*aq*) ⟶ MgCl2(*aq*) + H2(*g*) | (from row 9) |
| **Reaction 2:** MgO(*s*) + 2HCl(*aq*) ⟶ MgCl2(*aq*) + H2O(*l*) | (from row 9) |
| **Reaction 3:** H2(*g*) + ½O2(*g*) ⟶ H2O(*l*) | –286 (published value) |
| **Magnesium Combustion:** Mg(*s*) + ½O2(*g*) ⟶ MgO(*s*) |  |

The published value for this reaction is –603 kJ/mol. What is the percent error of your experimental value?