

Heat changes, energy cycles and bond enthalpies

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab

Name: _____ Date: _____ Class: _____

This lab uses two simple calorimetry experiments and Hess's law to find the enthalpy of formation of magnesium oxide. You will measure temperature rises, calculate two enthalpy changes, combine them in a cycle, and judge how accurate the final value is.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB R1.1-R1.2

Aim

Use Hess's law with two calorimetry experiments to find the enthalpy of formation of magnesium oxide, which cannot be measured directly.

Equipment

- two polystyrene cups with lids, one placed inside a beaker
- thermometer (0.1 °C divisions) and stirrer
- 100 cm³ measuring cylinder
- 1.0 mol/dm³ hydrochloric acid, in excess
- magnesium ribbon (0.30 g) and magnesium oxide powder (1.00 g)
- balance reading to 0.01 g, stopwatch, safety goggles

Safety

Safety

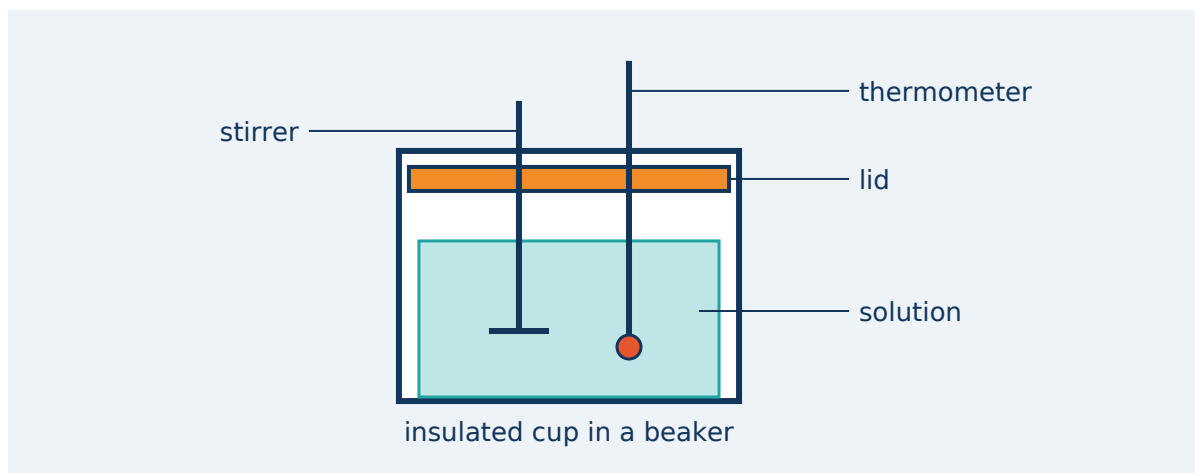
Wear safety goggles. Dilute hydrochloric acid is an irritant: wipe spills at once. Hydrogen gas is given off in experiment 1, so keep flames away and do not put a tight stopper on the cup. Magnesium oxide powder irritates the lungs, so do not breathe it in.

Method

1. Measure 100 cm³ of hydrochloric acid into the cup, put the lid on and record the temperature every 30 seconds for 2 minutes.
2. At 2 minutes add the weighed magnesium ribbon (experiment 1), replace the lid and stir gently.
3. Keep recording every 30 seconds until the temperature has fallen steadily for 2 minutes.

Note the highest temperature.

- Repeat steps 1 to 3 with 1.00 g of magnesium oxide (experiment 2).
- Use the data book value $\Delta H_f(\text{H}_2\text{O}, \text{l}) = -285.8 \text{ kJ/mol}$.



Set-up used in both experiments: the acid is stirred while the temperature is recorded.

Results

	Experiment 1: Mg	Experiment 2: MgO
Mass of solid (g)	0.30	1.00
Volume of acid (cm ³)	100	100
Initial temperature (°C)	21.0	21.2
Highest temperature (°C)	34.6	29.6
Temperature rise ΔT (°C)	13.6	8.4

Analysis questions

Question 1 Experiment 1

Calculate the enthalpy change for $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$ in kJ/mol (Ar of Mg = 24.3; assume 100 g of solution, $c = 4.18 \text{ J/(g K)}$).

Question 2 Experiment 2

Calculate the enthalpy change for $\text{MgO(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{O(l)}$ (M of MgO = 40.3 g/mol).

Question 3 Hess cycle

Draw the energy cycle (in words) and calculate ΔH_f of MgO using ΔH_1 , ΔH_2 and $\Delta H_f(\text{H}_2\text{O}, \text{l}) = -285.8 \text{ kJ/mol}$.

Question 4 Percentage difference

The data-book value is -601.6 kJ/mol. Calculate the percentage difference.

Question 5 Uncertainty

The thermometer has an uncertainty of ± 0.1 °C per reading and the balance ± 0.01 g. Calculate the percentage uncertainty in the mass of Mg and in each ΔT , and identify the largest.

Question 6 Heat loss

Explain how heat loss affects the results and describe two ways to reduce its effect.

Question 7 Excess acid

Explain why the acid must be in excess in both experiments.

Question 8 Assumptions

State two assumptions made in the calculations.