

Heat changes, energy cycles and bond enthalpies

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

The model answers use the sample results in the table. Check each calculation, the construction of the cycle and the discussion of uncertainty, and compare your own measurements with the sample data when you carry out the lab.

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

Question 1 Experiment 1

$n(\text{Mg}) = 0.30 / 24.3 = 0.01235 \text{ mol}$. $q = 100 \times 4.18 \times 13.6 = 5685 \text{ J}$. $\Delta H_1 = -5685 / 0.01235 = -460\,500 \text{ J/mol} = \mathbf{-460.5 \text{ kJ/mol}}$.

Question 2 Experiment 2

$n(\text{MgO}) = 1.00 / 40.3 = 0.02481 \text{ mol}$. $q = 100 \times 4.18 \times 8.4 = 3511 \text{ J}$. $\Delta H_2 = -3511 / 0.02481 = -141\,500 \text{ J/mol} = \mathbf{-141.5 \text{ kJ/mol}}$.

Question 3 Hess cycle

Route 1: $\text{Mg} + \frac{1}{2}\text{O}_2 \rightarrow \text{MgO}$ (ΔH_f), then $\text{MgO} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2\text{O}$ (ΔH_2). Route 2: $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ (ΔH_1), then $\text{H}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{H}_2\text{O}$ (-285.8). So $\Delta H_f + \Delta H_2 = \Delta H_1 + (-285.8)$ and $\Delta H_f = -460.5 + 141.5 - 285.8 = \mathbf{-604.8 \text{ kJ/mol}}$.

Question 4 Percentage difference

Difference = $604.8 - 601.6 = 3.2 \text{ kJ/mol}$. Percentage = $3.2 / 601.6 \times 100 = \mathbf{0.53 \%}$.

Question 5 Uncertainty

Mass of Mg: $0.01 / 0.30 = 3.3 \%$. ΔT_1 : $0.2 / 13.6 = 1.5 \%$. ΔT_2 : $0.2 / 8.4 = 2.4 \%$. **The mass of magnesium (3.3 %) is the largest**, so using 0.60 g would halve it.

Question 6 Heat loss

Heat lost to the surroundings makes ΔT too small, so each ΔH is **less exothermic** than the true value. Use a lid and insulation, and plot temperature against time and extrapolate the cooling line back to the time of mixing.

Question 7 Excess acid

Excess acid ensures that all the magnesium or magnesium oxide reacts, so the moles used to calculate ΔH are the moles of the solid weighed. **The solid is the limiting reactant.**

Question 8 Assumptions

The solution has density 1.00 g/cm^3 and specific heat capacity 4.18 J/(g K) , and the heat absorbed by the cup and thermometer is negligible. **Both assumptions introduce small errors.**