3.2.2 Calorimetry and evaluation

Name: _____ Class: _____ Date: _____ **Total: 21 marks**

KEY WORDS heat loss • extrapolation • insulated container

Objective

Master the calorimetry calculation and its evaluation: prove the excess, convert a temperature change to an enthalpy change per mole of the limiting reagent, diagnose heat loss, and know which improvements the scheme credits – and which it ignores. Original practice for WCH13 Q5 (Summer 2025) and CP2.

1 Key knowledge and worked examples

■ The four-step enthalpy calculation

1. Which reagent limits? Compare amounts: $n = cV$ for solution, $n = m/A_r$ for solid.
2. Energy: $q = mc\Delta T$ with the **solution's** mass (g), $c = 4.18$ J g^{-1} °C^{-1}, ΔT in °C.
3. Per mole: $\Delta H = -q/n$ using the **limiting reagent's** moles.
4. Sign and unit: exothermic reaction, negative, kJ mol^{-1}.

Worked check (2025 paper). 50.0 cm^3 of 1.00 mol dm^{-3} $ZnSO_4$ ($n = 0.0500$ mol) + 2.20 g Mg (0.0905 mol – excess). T: 19.4 → 55.2 °C.

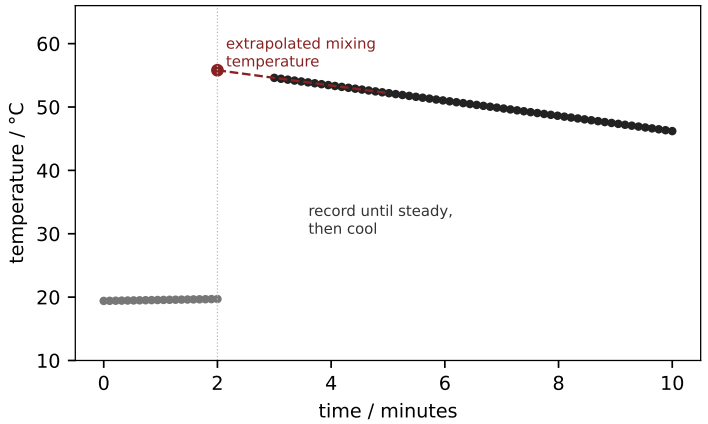
$$\Delta T = 55.2 - 19.4 = 35.8 \text{ °C}$$

$$q = 50.0 \times 4.18 \times 35.8 = 7482 \text{ J}$$

$$\Delta H = -7.482 \text{ kJ} \div 0.0500 \text{ mol} = -150 \text{ kJ mol}^{-1}$$

■ Why values come out low, and what fixes them

An experimental value well below the data book means **heat loss to the surroundings** – the standard one-mark answer. Credited improvements: an insulated container (polystyrene cup); a lid; temperature every 30 s or a data logger; a **lower concentration** (slower, less intense heating, less loss); a temperature–time graph with the cooling extrapolated back to mixing (below). The scheme *ignores* more accurate glassware (pipette/burette), a better balance, and repeats.



2 Practice

2.1 25.0 cm^3 of 0.800 mol dm^{-3} copper(II) sulfate is mixed with 1.50 g of zinc powder. Show which reagent is in excess. (A_r Zn = 65.4.) [3]

2.2 For that mixture, the temperature rises from 21.5 °C to 34.3 °C. Calculate q. [2]

2.3 Using your answers, calculate ΔH with sign and unit. [2]

2.4 State the most likely reason an experimental value is much less exothermic than the data-book value. [1]

3 Exam-style questions

3.1 A student measures the enthalpy of displacement between magnesium and 50.0 cm^3 of 1.00 mol dm^{-3} zinc sulfate using a glass beaker, a thermometer read at the start and once after stirring, and 2.20 g of magnesium powder. The temperatures were 19.4 °C and 55.2 °C. Calculate the enthalpy change (mass of solution 50.0 g; c = 4.18 J g^{-1} $°C^{-1}$), and justify four improvements to equipment or procedure. [8]

3.2 A second student's value is considerably less exothermic than the data book's. Give the most likely reason, and explain why repeating and averaging would not close the gap. [3]

3.3 Explain why the enthalpy change is divided by the moles of zinc ions rather than the moles of magnesium added, in the 2025 calculation. [2]