Core practical: displacement energy and diagrams

Student activity • practical and reasoning

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The question

How does a displacement temperature rise relate to an energy diagram?

Measure the temperature change when zinc displaces copper from solution. Calculate an approximate energy transfer; Chemistry learners add an energy-level diagram.

Equipment

- Eye protection, insulated cup with support/lid, probe, stirrer and 25 cm^3 measuring cylinder
- Staff-issued 20.0 cm^3 0.100 mol dm^{-3} $CuSO_4$ and 0.20 g fine zinc granules; no powder
- Calculator and timer

Wear eye protection, avoid copper-salt contact and zinc dust. No flames or acid. Keep the cup vented and collect all metal-containing residues.

Course coverage: Shared core: 3.2–3.4 and 3.8, steps 1–5/questions 1–4. Chemistry-only 3.5C: step 6/questions 5–6 energy-level diagrams.

Plan, model or apparatus sketch

Draw the insulated cup, supported probe and loose lid; label energy transfer between reaction and surroundings.

Method and reasoning

Read the whole sequence before starting

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1. Wear eye protection and place 20.0 cm^3 copper(II) sulfate solution in a supported insulated cup. Record its starting temperature.

2. Add the staff-issued zinc granules, fit the loose lid and stir gently. Record temperature every 15 seconds for up to five minutes on a separate table.

3. Record the highest temperature, colour change and solid appearance. Do not invent an endpoint if zinc reacts slowly or the change is unresolved.

4. Use the solution mass approximation 20.0 g and c=4.18 J g^{-1} $°C^{-1}$ to estimate q=mcΔT. Identify copper(II) ions as the limiting reactant if reaction is complete.

5. Calculate approximate ΔH for Zn + $CuSO_4$ → $ZnSO_4$ + Cu using n($CuSO_4$)=0.00200 mol. Explain heat loss and incomplete-reaction limitations.

6. Chemistry only: draw an energy-level diagram with products lower than reactants, labelled reaction progress/enthalpy axes and a downward ΔH arrow; distinguish activation energy from overall ΔH.

Cleanup

- Staff collect solution, zinc and copper residues in labelled metal waste; rinse as directed and wash hands.

Record your evidence

Blank spaces are for your own work

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Reference and task data

Invented calculation example only: 20.0 cm^3 0.100 M $CuSO_4$, 0.20 g Zn, initial 21.0 °C and maximum 25.0 °C. Assume 20.0 g solution, c=4.18 J g^{-1} $°C^{-1}$ and complete Cu^{2+} reaction. M(Zn)=65.4 g mol^{-1}. Zinc and apparatus heat capacities are neglected; use actual data separately.

Quantity / evidence	Actual reading / working	Interpretation
Temperature / appearance		
q / amount / ΔH		
Chemistry-only diagram		

Show your calculations, labelled model or correction here.

Explain and evaluate

Use evidence and show calculation steps where relevant

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1. Describe your actual observations and classify the energy change.

2. Calculate q for the invented example or your labelled actual results.

3. Show that $CuSO_4$ is limiting in the example.

4. Calculate approximate ΔH and explain one limitation.

5. Chemistry only: draw and label the exothermic energy-level diagram.

6. Chemistry only: explain why activation energy is not the same as ΔH.