

Q1. Jack investigates magnesium and hydrochloric acid.

(a) Reaction type:

- Exothermic (1 mark)
[1 mark]

(b) Safe temperature measurement:

- Use a thermometer to measure initial and final temperature (1 mark)
- Place reaction mixture in insulated container / polystyrene cup to avoid burns & reduce heat loss (1 mark)
[2 marks]

Total: 3 marks

Q2. Tom studies energy transfers.

(a) Exothermic definition:

- A reaction that **transfers energy to the surroundings** (1 mark)
- Usually observed as a **temperature increase** (1 mark)
[2 marks]

(b) Everyday example:

- Combustion / burning fuels / respiration / neutralisation / hand warmers (any 1) (1 mark)
[1 mark]

Total: 3 marks

Q3. Harry and endothermic reactions.

(a) Energy in endothermic reaction:

- Energy is **taken in / absorbed from surroundings** (1 mark)
[1 mark]

(b) Everyday example:

- Photosynthesis / cold packs / dissolving ammonium salts (any 1) (1 mark)
[1 mark]

Total: 2 marks

Q4. Ben and neutralisation.

(a) Type of reaction:

- Exothermic (1 mark)
[1 mark]

(b) Recording temperature:

- Use a thermometer (1 mark)
- Record temperature before and after the reaction (1 mark)
[2 marks]

Total: 3 marks

Q5. Daniel and polystyrene cup.

(a) Why use polystyrene cup:

- Provides **insulation** (1 mark)
- Reduces heat loss compared to glass beaker (1 mark)
[2 marks]

(b) Accuracy improvement:

- Keeps more heat inside reaction (1 mark)

- Ensures temperature change measured is closer to true value (1 mark)
[2 marks]

Total: 4 marks

Q6. Oliver and bond energies.

(a) Bonds in reactants:

- They must be broken (1 mark)
[1 mark]

(b) Bond breaking:

- Energy absorbed (1 mark)
[1 mark]

(c) Bond making:

- Energy released (1 mark)
[1 mark]

Total: 3 marks

Q7. Ethan compares reactions.

(a) Exothermic recognition:

- Temperature increases (1 mark)
[1 mark]

(b) Endothermic recognition:

- Temperature decreases (1 mark)
[1 mark]

(c) Photosynthesis:

- Endothermic (1 mark)
[1 mark]

Total: 3 marks

Q8. Sam and hand warmers.

(a) Reaction type:

- Exothermic (1 mark)
[1 mark]

(b) Why useful:

- Release heat (1 mark)
- Keep hands/body warm in cold conditions (1 mark)
[2 marks]

Total: 3 marks

Q9. Charlie and cold packs.

(a) Reaction type:

- Endothermic (1 mark)
[1 mark]

(b) Why useful:

- Absorb heat (1 mark)
- Reduce swelling/pain at injury site (1 mark)
[2 marks]

Total: 3 marks

Q10. Noah and neutralisation energy.

(a) Equipment:

- Thermometer (1 mark)
[1 mark]

(b) Why measure before and after:

- To compare starting and final temperature (1 mark)
- Allows calculation of temperature change (1 mark)
[2 marks]

Total: 3 marks

Q11. William and reaction profiles.

(a) Y-axis:

- Energy (1 mark)
[1 mark]

(b) Difference between reactants and products:

- Shows **overall energy change** (1 mark)
- Indicates whether reaction is exothermic (products lower) or endothermic (products higher) (1 mark)
[2 marks]

Total: 3 marks

Q12. Alex and bond energies.

(a) Bond breaking:

- Energy absorbed (1 mark)
[1 mark]

(b) Bond making:

- Energy released (1 mark)
[1 mark]

(c) Exothermic explanation:

- More energy released when bonds form (1 mark)
- Than is absorbed when bonds break (1 mark)
[2 marks]

Total: 4 marks

Q13. Jacob and dissolving salts.

(a) Exo vs endo salts:

- Exothermic: release heat when dissolving (1 mark)
- Endothermic: absorb heat when dissolving (1 mark)
[2 marks]

(b) Measuring energy change:

- Dissolve salt in water in polystyrene cup (1 mark)
- Measure temperature before and after with thermometer (1 mark)
[2 marks]

Total: 4 marks

Q14. James and reaction profiles.

(a) Exothermic profile:

- Products lower in energy than reactants (1 mark)
- Energy difference shown as released to surroundings (1 mark)
[2 marks]

(b) Endothermic profile:

- Products higher in energy than reactants (1 mark)
- Energy difference shown as absorbed from surroundings (1 mark)
[2 marks]

Total: 4 marks

Q15. Luke's experiment (6-mark practical Q).

Indicative content – allow **1 mark per valid point**:

- Apparatus: polystyrene cup, thermometer, measuring cylinder, acids/alkalis (1 mark)
- Measure set volume of acid into cup (1 mark)
- Record initial temperature (1 mark)
- Add measured volume of alkali (1 mark)
- Stir gently and record highest/lowest temperature reached (1 mark)
- Calculate temperature change (final – initial) (1 mark)

[6 marks]

Q16. Jack and neutralisation.

(a) Reaction type:

- Exothermic (1 mark)
[1 mark]

(b) Improving accuracy:

- Use a polystyrene cup/insulated container to reduce heat loss (1 mark)
- Place lid or use thermometer with finer scale/digital thermometer (1 mark)
[2 marks]

Total: 3 marks

Q17. Tom and bonds.

(a) Bond breaking:

- Energy absorbed (1 mark)
[1 mark]

(b) Bond making:

- Energy released (1 mark)
[1 mark]

(c) Balance explanation:

- If more energy released in bond formation (1 mark)
- Than absorbed in bond breaking, reaction is exothermic (1 mark)
[2 marks]

Total: 4 marks

Q18. Harry and profiles.

(a) Difference in energy:

- Represents **overall energy change** (1 mark)
- Shows whether reaction is exothermic (negative) or endothermic (positive) (1 mark)
[2 marks]

(b) Endothermic shown if:

- Products higher in energy than reactants (1 mark)
- Energy absorbed from surroundings (1 mark)
[2 marks]

Total: 4 marks

Q19. Ben and bond energy calcs.

(a) Equation:

- Energy change = bonds broken – bonds formed (1 mark each part)
[2 marks]

(b) Approximations:

- Bond energy values are averages (1 mark)
- Actual bond energies vary depending on molecule/environment (1 mark)
[2 marks]

Total: 4 marks

Q20. Daniel compares reactions.

(a) Exothermic:

- Products have lower energy than reactants (1 mark)
- Difference released to surroundings as heat (1 mark)
[2 marks]

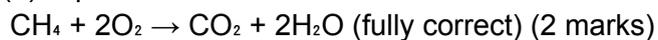
(b) Endothermic:

- Products higher energy than reactants (1 mark)
- Energy absorbed from surroundings (1 mark)
[2 marks]

Total: 4 marks

Q21. Oliver and combustion.

(a) Equation:



[2 marks]

(b) Why exothermic:

- More energy released making CO₂/H₂O bonds (1 mark)

- Than absorbed breaking CH₄/O₂ bonds (1 mark)
[2 marks]

Total: 4 marks

Q22. Ethan and neutralisation.

(a) Ionic equation:



[2 marks]

(b) Always exothermic:

- Energy released when water molecules form (1 mark)
- More released than absorbed in breaking bonds (1 mark)
[2 marks]

Total: 4 marks

Q23. Sam and hand warmers.

(a) Why exothermic:

- Release energy to surroundings (1 mark)
- Causes temperature increase (1 mark)
[2 marks]

(b) Advantage/disadvantage:

- Advantage: provide heat in cold conditions (1 mark)
- Disadvantage: wasteful / single-use / creates waste (1 mark)
[2 marks]

Total: 4 marks

Q24. Charlie and cold packs.

(a) Why endothermic:

- Reaction absorbs energy from surroundings (1 mark)
- Causes temperature drop (1 mark)
[2 marks]

(b) Use:

- Sports injuries / reduce swelling (1 mark)
[1 mark]

Total: 3 marks

Q25. Noah and exothermic profile.

Diagram must show:

- Reactants at higher energy than products (1 mark)
 - Labelled reactants and products (1 mark)
 - Activation energy arrow (1 mark)
 - Overall energy change arrow (1 mark)
[4 marks]
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Q26. William compares.

(a) Exothermic example: combustion / neutralisation / respiration (1 mark)

(b) Endothermic example: photosynthesis / thermal decomposition (1 mark)

(c) Difference:

- Exothermic releases energy to surroundings (1 mark)
 - Endothermic absorbs energy from surroundings (1 mark)
[4 marks]
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Q27. Alex and bond energies.

(a) Calculation:

- Bonds broken: H-H (436) + Cl-Cl (242) = 678 (1 mark)
- Bonds formed: $2 \times \text{H-Cl}$ ($431 \times 2 = 862$) (1 mark)
- Energy change = $678 - 862 = -184$ kJ/mol (1 mark)
[3 marks]

(b) Reaction type:

- Exothermic (1 mark)
[1 mark]

Total: 4 marks

Q28. Jacob and neutralisation.

(a) Ionic equation: $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ (2 marks)
[2 marks]

(b) Why exothermic:

- Formation of water releases energy (1 mark)
- More released than absorbed (1 mark)
[2 marks]

Total: 4 marks

Q29. James and ammonium nitrate.

(a) Endothermic because:

- Dissolving absorbs energy from surroundings (1 mark)
- Temperature of solution decreases (1 mark)
[2 marks]

(b) Measuring method:

- Use thermometer in insulated container (1 mark)
- Record temperature before and after dissolving (1 mark)
[2 marks]

Total: 4 marks

Q30. Luke's practical (6 marks).

Indicative points:

- Apparatus: polystyrene cup, thermometer, measuring cylinder, balance (1 mark)
 - Measure acid into cup (1 mark)
 - Record initial temperature (1 mark)
 - Add weighed magnesium (1 mark)
 - Stir gently and record highest temperature reached (1 mark)
 - Calculate temperature change (final – initial) (1 mark)
[6 marks]
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Q31. Jack and activation energy.

(a) Definition:

- Minimum energy needed (1 mark)
- To start a reaction by breaking bonds in reactants (1 mark)
[2 marks]

(b) Why needed in exothermic:

- Energy needed to break bonds initially (1 mark)
- Even though more energy released later (1 mark)
[2 marks]

Total: 4 marks

Q32. Tom and respiration/photosynthesis.

(a) Respiration: exothermic (1 mark)

(b) Photosynthesis: endothermic (1 mark)

(c) Link:

- Respiration releases energy stored in glucose (1 mark)
 - Photosynthesis absorbs energy to produce glucose (1 mark)
- [2 marks]**

Total: 4 marks

Q33. Harry and endothermic profile.

(a) Diagram:

- Products higher than reactants (1 mark)
 - Labels: reactants/products (1 mark)
 - Activation energy arrow (1 mark)
 - Overall energy change arrow (1 mark)
- [4 marks]**

(b) Why higher:

- Reaction absorbs energy from surroundings (1 mark)
 - Stored in products as chemical energy (1 mark)
- [2 marks]**

Total: 6 marks

Q34. Ben and hydrogen fuel cells.

(a) Word equation: hydrogen + oxygen → water (2 marks)
[2 marks]

(b) Why exothermic:

- Energy released when bonds form in water (1 mark)
- More than energy absorbed breaking H₂ and O₂ bonds (1 mark)
[2 marks]

Total: 4 marks

Q35. Daniel – evaluation Q.

Indicative points (max 6):

- Hydrogen fuel cells advantages: only water produced (1), renewable fuel (1), lightweight/continuous supply (1)
- Disadvantages: hydrogen difficult to store/transport (1), safety issues (flammable gas) (1), expensive technology (1)
- Batteries: convenient, existing infrastructure (1), but need recharging, limited lifespan, contain toxic metals (1).

Levelled marking (AO3):

- 1–2: basic description, little comparison.
- 3–4: some comparison with advantages/disadvantages.
- 5–6: detailed, balanced evaluation.

[6 marks]

Q36. Oliver and catalysts.

(a) Profile:

- Curve with lower activation energy shown (1 mark)
- Both with same overall energy change (1 mark)

[2 marks]

(b) Explanation:

- Catalyst provides alternative reaction pathway with lower activation energy (1 mark)
- Does not change energy of reactants/products (1 mark)
[2 marks]

Total: 4 marks

Q37. Ethan compares A and B.

(a) Exothermic: A (temperature rises) (1 mark)

(b) Why B is endothermic:

- Absorbs energy from surroundings (1 mark)
- Causes temperature drop (1 mark)
[2 marks]

Total: 3 marks

Q38. Sam and fuels.

(a) Equation:

Energy released (J) = mass of water (g) × 4.2 (J/g°C) × temperature change (°C) (2 marks)

[2 marks]

(b) Heat loss explanation:

- Some energy escapes to surroundings instead of heating water (1 mark)
- Means calculated value is less than true energy released (1 mark)
[2 marks]

Total: 4 marks

Q39. Charlie and exothermic examples.

- Combustion (1 mark)

- Neutralisation / respiration (1 mark)
[2 marks]
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Q40. Noah – 6 mark plan.

Indicative content:

- Apparatus: polystyrene cup, thermometer, measuring cylinder, balance (1 mark)
- Measure fixed volume of acid into cup (1 mark)
- Record initial temperature (1 mark)
- Add measured alkali/solid carbonate (1 mark)
- Stir gently and record highest temperature reached (1 mark)
- Calculate temperature change (1 mark)

[6 marks]

Q41. William – methane combustion bond energy calculation

Equation: $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$

Bond energies (kJ/mol): C–H = 412, O=O = 498, C=O = 805, O–H = 463

- Bonds broken: $4 \times \text{C–H} = 1648$ (1 mark)
- Bonds broken: $2 \times \text{O=O} = 996$ (1 mark)
- Total bonds broken = 2644 (1 mark)
- Bonds formed: $2 \times \text{C=O} = 1610$, $4 \times \text{O–H} = 1852 \rightarrow 3462$ (1 mark)
- Overall energy change = $2644 - 3462 = -818$ kJ/mol (exothermic) (1 mark)

Total: 5 marks

Q42. Alex – activation energy

(a) Definition:

- Minimum energy required (1 mark)
- To start a reaction by breaking bonds in reactants (1 mark)
[2 marks]

(b) Reaction profile:

- Diagram with reactants higher than products (exothermic) (1 mark)
- Activation energy arrow labelled correctly (1 mark)
[2 marks]

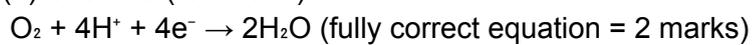
Total: 4 marks

Q43. Jacob – fuel cell electrolysis equations

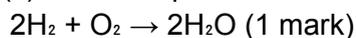
(a) Anode (oxidation):



(b) Cathode (reduction):



(c) Overall equation:



Total: 5 marks

Q44. James – hydrogen fuel cells vs batteries

(a) Advantage: can run continuously if supplied with H_2 / quicker refuelling / higher energy density (1 mark)

(b) Disadvantage: hydrogen storage difficulties / explosive / expensive infrastructure (1 mark)

(c) Environmentally friendly:

- Only water produced, no CO_2 emissions (1 mark)
- Renewable if hydrogen from electrolysis using renewable electricity (1 mark)

Total: 4 marks

Q45. Luke – reversible ammonium chloride decomposition

(a) Endothermic forward:

- Energy absorbed (1 mark)
- To break bonds and separate NH_4Cl into $\text{NH}_3 + \text{HCl}$ (1 mark)

(b) Exothermic reverse:

- Energy released (1 mark)
- When NH_3 and HCl recombine to form NH_4Cl (1 mark)

Total: 4 marks

Q46. Jack – reaction profiles

(a) Endothermic profile:

- Products higher than reactants (1 mark)
- Activation energy arrow labelled (1 mark)

(b) Catalysts:

- Lower activation energy (alternative pathway) (1 mark)
- But same reactant/product energy levels, so overall energy change unchanged (1 mark)

Total: 4 marks

Q47. Tom – $\text{H}_2 + \text{Br}_2$ bond energy calculation

Bond energies: $\text{H-H} = 436$, $\text{Br-Br} = 193$, $\text{H-Br} = 366$

- Bonds broken: $436 + 193 = 629$ (1 mark)
- Bonds formed: $2 \times 366 = 732$ (1 mark)
- Energy change = $629 - 732 = -103$ kJ/mol (1 mark)

Total: 3 marks

Q48. Harry – platinum catalyst

(a) Platinum:

- Speeds up redox reactions in fuel cell (1 mark)
- Provides large surface area for hydrogen/oxygen to react (1 mark)
(b) Disadvantage: very expensive / scarce metal / can be poisoned by impurities (1 mark)

Total: 3 marks

Q49. Ben – photosynthesis

(a) Endothermic because:

- Requires energy input from sunlight (1 mark)
- Energy stored in glucose molecules (1 mark)
(b) Equation:
 $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ (fully correct = 2 marks)

Total: 4 marks

Q50. Daniel – reversible reaction energy

(a) Forward/reverse:

- If forward is exothermic, energy released (1 mark)
- Reverse must absorb same energy (endothermic) (1 mark)
(b) Profile:
- Two-way arrow showing forward drop (exothermic) (1 mark)
- Reverse rise (endothermic) (1 mark)

Total: 4 marks

Q51. Oliver – ethanol combustion calc

Energy = mass \times 4.2 \times ΔT

- Correct substitution: $200 \times 4.2 \times 15 = 12,600 \text{ J}$ (1 mark)
- Correct units J (1 mark)
- Conversion to kJ if given: 12.6 kJ (1 mark)

Total: 3 marks

Q52. Ethan – exothermic energy release

(a) Explanation:

- Energy released as heat from bond formation (1 mark)
 - Energy can also excite atoms, producing light (1 mark)
- (b) Example: combustion / fireworks / magnesium burning (1 mark)

Total: 3 marks

Q53. Sam – hydrogen fuel

(a) Renewable: produced by electrolysis of water using renewable energy (1 mark)

(b) Safety issue: flammable/explosive gas (1 mark)

(c) Energy density:

- Hydrogen has low relative mass (1 mark)
- Bonds release large amounts of energy per gram when forming water (1 mark)

Total: 4 marks

Q54. Charlie – experimental error

(a) Less energy measured because:

- Heat lost to surroundings (1 mark)
- Incomplete combustion / evaporation losses (1 mark)
(b) Reduce error:
- Use insulated container (1 mark)
- Reduce heat loss with lid / draught shield (1 mark)

Total: 4 marks

Q55. Noah – 6 mark practical plan

Indicative points:

Apparatus (1 mark): polystyrene cups, thermometer, measuring cylinders, balance, safety goggles

Method (2 marks):

- Measure fixed volume of HCl, record initial temperature
- Add NaOH, stir, record highest temperature
- Repeat with ammonium nitrate, record lowest temperature

Safety (1 mark): goggles, handle acids carefully, wash spills

Measurements (2 marks): initial + final temperatures, calculate ΔT for both reactions

Total: 6 marks