GCSE Chemistry Topic 6 AQA: Rate and extent of chemical change

Mark Scheme

Q1. Jack – magnesium + HCl reaction

(a)

- Measure volume of gas produced (1 mark)
- Measure time taken for reaction to finish / how long until magnesium disappears (1 mark)
  (Allow: measure mass loss using balance – 1 mark)

(b)

- Rate increases / reaction happens faster (1 mark)

Total: 3 marks

Q2. Tom – $CaCO_3$ + HCl

(a)
Calcium carbonate + hydrochloric acid → calcium chloride + carbon dioxide + water (2 marks)

(b)

- Carbon dioxide (1 mark)

Total: 3 marks

Q3. Harry – surface area

(a)

- Powdered $CaCO_3$ has larger surface area (1 mark)
- More frequent collisions with acid particles (1 mark)

(b)

- Surface area (1 mark)

Total: 3 marks

Q4. Ben – mean rate

(a)
Rate = amount of product formed ÷ time (1 mark)
(Allow: reactant used ÷ time)

(b)
120 ÷ 60 = 2 cm^3/s (2 marks)

Total: 3 marks

Q5. Daniel – temperature

(a)

- Particles move faster at higher temperature (1 mark)
- More frequent successful collisions (1 mark)

(b)

- Example: food cooking faster / milk souring quicker / bread rising faster with yeast (1 mark)

Total: 3 marks

Q6. Oliver – catalysts

(a)

- Speeds up reaction (1 mark)

(b)

- Reduces energy costs (1 mark)

- Increases reaction speed → more product in less time (1 mark)

Total: 3 marks

Q7. Ethan – collecting gas

(a)

- Gas syringe / inverted measuring cylinder over water (1 mark)

(b)

- Repeat and average / ensure same acid volume and concentration / use precise measuring instruments (1 mark)

Total: 2 marks

Q8. Sam – concentration

(a)

- More particles in same volume (1 mark)
- Collisions happen more frequently (1 mark)

(b)

- Add more solute / use less water (1 mark)

Total: 3 marks

Q9. Charlie – reversible reactions

(a)

- Products can change back into reactants (1 mark)

(b)

- Example: ammonium chloride ⇌ ammonia + hydrogen chloride / hydrated copper sulfate ⇌ anhydrous copper sulfate + water (1 mark)

Total: 2 marks

Q10. Noah – equilibrium

(a)

- Forward and backward reactions occur at the same rate (1 mark)
- In a closed system (1 mark)

(b)

- Concentrations remain constant (1 mark)

Total: 3 marks

Q11. William – temperature and equilibrium

(a) Forward exothermic, ↑ temperature:

- Shifts equilibrium to favour endothermic (reverse) (1 mark)
- Less product from forward reaction (1 mark)

(b) ↓ temperature:

- Shifts equilibrium to exothermic (forward) (1 mark)
- More product formed (1 mark)

Total: 4 marks

Q12. Alex – pressure and equilibrium

(a) ↑ pressure with fewer molecules:

- Equilibrium shifts to side with fewer molecules (1 mark)
- More product (if products have fewer gas molecules) (1 mark)

(b)

- Because higher pressure favours fewer gas molecules (1 mark)
- To reduce pressure (1 mark)

Total: 4 marks

Q13. Jacob – catalysts

(a)

- Increase rate of reaction (1 mark)

(b)

- No effect on equilibrium position (1 mark)

Total: 2 marks

Q14. James – Haber process

(a)
Nitrogen + hydrogen → ammonia (2 marks)

(b)

- Nitrogen (from air) (1 mark)
- Hydrogen (from natural gas / methane / hydrocarbons) (1 mark)

Total: 4 marks

Q15. Luke – sodium thiosulfate experiment (6 marks)

Indicative points:

Apparatus (1 mark): conical flask, measuring cylinder, stopwatch, thermometer, paper with cross, beakers, safety goggles

Method (2 marks):

- Add fixed volume of sodium thiosulfate to flask
- Place flask on paper with cross
- Add hydrochloric acid, start timer
- Stop timing when cross is no longer visible

Measurements (2 marks):

- Record time for cross to disappear at different temperatures
- Repeat to improve accuracy

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

Total: 6 marks

Q16. Jack – mean rate of reaction

(a)

- Mean rate = amount of reactant used ÷ time OR amount of product formed ÷ time (1 mark)

(b)

- Substitution: 240 ÷ 120 (1 mark)
- Answer: 2 cm^3/s (1 mark)

Total: 3 marks

Q17. Tom – surface area

(a)

- Powder has larger surface area (1 mark)
- More frequent collisions between acid and $CaCO_3$ particles (1 mark)

(b)

- Sketch with: Powder curve steeper at start (1 mark)
- Both curves level off at same final volume (1 mark)

Total: 4 marks

Q18. Harry – collision theory

(a)
Any two:

- Increase concentration (1 mark)
- Increase pressure (for gases) (1 mark)
- Increase surface area (1 mark)

(b)

- Increase temperature (1 mark)

Total: 3 marks

Q19. Ben – temperature

(a)

- Particles move faster → more collisions per second (1 mark)
- Higher proportion of particles with energy ≥ activation energy (1 mark)

(b)

- Gas produced faster / steeper curve on graph / reaction finishes quicker (1 mark)

Total: 3 marks

Q20. Daniel – catalysts

(a)

- Provide an alternative reaction pathway (1 mark)
- With lower activation energy (1 mark)

(b)

- Reduces energy costs / speeds up production (1 mark)

Total: 3 marks

Q21. Oliver – rate graphs

(a)

- Steeper gradient = faster rate (1 mark)
- Gradient = rate at that point in time (1 mark)

(b)

- Horizontal curve means reaction has finished (1 mark)
- Reactants completely used up / no further product formed (1 mark)

Total: 4 marks

Q22. Ethan – concentration

(a)

- Higher concentration = more particles in same volume (1 mark)
- More frequent successful collisions (1 mark)

(b)

- Sketch: High conc = steeper line, levels off higher volume (1 mark)
- Both curves level off (same max volume only if same limiting reactant given) (1 mark)

Total: 4 marks

Q23. Sam – gas syringe

(a)

- More accurate measurement (1 mark)
- Allows continuous recording / avoids gas loss in water displacement (1 mark)

(b)

- Plunger may stick / leaks in syringe / gas may escape (1 mark)

Total: 3 marks

Q24. Charlie – reversible

(a)

- A reaction where products can react to form reactants again (1 mark)

(b)

- Example: ammonium chloride ⇌ ammonia + hydrogen chloride (1 mark)

(c)

- Forward is exothermic, reverse is endothermic (1 mark)
- Same energy magnitude, opposite direction (1 mark)

Total: 4 marks

Q25. Noah – equilibrium

(a)

- Forward and reverse reactions occur at the same rate (1 mark)
- In a closed system (1 mark)

(b)

- Because rates are equal (1 mark)
- So concentrations remain constant (1 mark)

Total: 4 marks

Q26. William – Le Chatelier

(a)

- If a change is made to a system at equilibrium (1 mark)
- The system shifts to oppose the change (1 mark)

(b)

- ↑ pressure → equilibrium shifts to side with fewer gas molecules (1 mark)
- More products formed (if products have fewer molecules) (1 mark)

Total: 4 marks

Q27. Alex – temperature

(a) Forward exothermic, ↑ temp:

- Equilibrium shifts to favour endothermic (reverse) (1 mark)
- Yield of product decreases (1 mark)

(b) ↓ temp:

- Equilibrium shifts to exothermic (forward) (1 mark)
- Yield of product increases (1 mark)

Total: 4 marks

Q28. Jacob – catalysts in equilibrium

(a)

- Speeds up both forward and reverse reactions (1 mark)
- Equilibrium reached faster (1 mark)

(b)

- Does not change relative rates at equilibrium (1 mark)
- So position / yield is unchanged (1 mark)

Total: 4 marks

Q29. James – Haber

(a)
$N_2 + 3H_2 \rightleftharpoons 2NH_3$ (2 marks: correct formulae + balanced)

(b)

- Temperature ~450 °C (1 mark)
- Pressure ~200 atm (1 mark)

(c)

- Iron catalyst (1 mark)

Total: 5 marks

Q30. Luke – Haber compromise (6 marks)

Indicative points:

- High pressure gives higher yield but expensive / dangerous equipment (1 mark)
- Lower pressure is cheaper but yield too low (1 mark)
- High temp increases rate (1 mark)
- High temp decreases yield (equilibrium shifts backwards) (1 mark)
- Compromise: 200 atm and 450 °C chosen (1 mark)
- Catalyst reduces costs further (1 mark)

Total: 6 marks

Q31. Jack – pressure with more gas

- If forward produces more molecules, ↑ pressure → equilibrium shifts to side with fewer molecules (reverse) (1 mark)
- Yield of product decreases (1 mark)

Total: 2 marks

Q32. Tom – rate graphs

(a)

- Steepest line at start = fastest reaction (1 mark)

(b)

- More frequent collisions (1 mark)
- With enough energy to react (1 mark)

Total: 3 marks

Q33. Harry – temperature & energies

(a)

- More particles have energy ≥ activation energy (1 mark)
- Higher proportion of successful collisions (1 mark)

(b)

- Sketch Maxwell–Boltzmann distribution:
    - Higher temp curve lower and shifted right (1 mark)
    - Both curves start at origin; higher temp has more area above Ea (1 mark)

Total: 4 marks

Q34. Ben – concentration

(a)

- More particles in same volume (1 mark)
- More frequent successful collisions (1 mark)

(b)

- Add more solute / evaporate solvent (1 mark)

Total: 3 marks

Q35. Daniel – catalyst vs temp

- Catalyst lowers activation energy (1 mark)
- Increases rate without needing extra energy (1 mark)
- High temperature is costly / energy-intensive (1 mark)

- Catalyst reduces costs and environmental impact (1 mark)

Total: 4 marks

Q36. Oliver – rate graphs

(a)

- Steepest part = fastest rate (1 mark)

(b)

- Curve levels off because reactants are used up (1 mark)
- Reaction has stopped / no further product made (1 mark)

Total: 3 marks

Q37. Ethan – activation energy

(a)

- Minimum energy particles need to react (1 mark)
- To break bonds / start reaction (1 mark)

(b)

- Catalyst provides alternative pathway (1 mark)
- With lower activation energy (1 mark)

Total: 4 marks

Q38. Sam – Haber equilibrium

(a)

- High pressure → favours side with fewer gas molecules (products) (1 mark)
- Increases yield of ammonia (1 mark)

(b)

- High temperature favours reverse reaction (endothermic) (1 mark)
- So yield decreases, despite faster rate (1 mark)

Total: 4 marks

Q39. Charlie – reversible vs irreversible

(a)

- Example: hydrated copper sulfate ⇌ anhydrous copper sulfate + water (1 mark)

(b)

- Example: combustion (1 mark)

(c)

- Reversible: products can change back into reactants (1 mark)
- Irreversible: products cannot return to reactants (1 mark)

Total: 4 marks

Q40. Noah – concentration experiment (6 marks)

Indicative points:

Apparatus (1 mark): conical flask, stopwatch, thermometer, measuring cylinder, paper with cross, safety goggles

Method (2 marks):

- Add fixed volume sodium thiosulfate into flask on paper with cross

- Add hydrochloric acid of varying concentrations, start timer
- Stop when cross not visible

Measurements (2 marks):

- Time for cross to disappear at different concentrations
- Repeat for reliability, average times

Accuracy (1 mark): keep temperature constant / use same volumes / repeat & average

Total: 6 marks

Q41. William – initial rate methods

(a)

- The rate of reaction **right at the start** (1 mark)
- Before concentration of reactants changes significantly (1 mark)

(b)

- Draw a tangent to the curve at time = 0 (1 mark)
- Calculate the gradient of the tangent (1 mark)

Total: 4 marks

Q42. Alex – Maxwell–Boltzmann distributions

- Curve for **low temperature**: taller, peak to the left (1 mark)
- Curve for **high temperature**: lower, broader, peak to the right (1 mark)
- Both curves start at origin and approach x-axis but never touch (1 mark)
- **Activation energy** marked with line; high-T curve shows more particles above Ea (1 mark)

Total: 4 marks

Q43. Jacob – pressure and equilibrium

(a)

- Yield of ammonia increases (1 mark)

(b)

- Increasing pressure shifts equilibrium to side with fewer gas molecules (1 mark)
- Forward reaction has fewer molecules (4 vs 2) so more ammonia formed (1 mark)

Total: 3 marks

Q44. James – exothermic reversible reactions

(a)

- Decreasing temperature shifts equilibrium to exothermic direction (1 mark)
- Forward reaction favoured → yield of products increases (1 mark)

(b)

- Reaction profile drawn showing reactants higher than products (1 mark)
- Activation energy arrow clearly labelled (1 mark)

Total: 4 marks

Q45. Luke – catalysts

(a)

- Provide alternative pathway (1 mark)
- Pathway has lower activation energy (1 mark)

(b)

- So particles need less energy to react (1 mark)

Total: 3 marks

Q46. Jack – rate equations

(a)

- First order with respect to A (1 mark)

(b)

- First order with respect to B (1 mark)

(c)

- Overall order = 2 (1 mark)

Total: 3 marks

Q47. Tom – catalysts in equilibrium

(a)

- Catalyst speeds up forward and reverse reactions equally (1 mark)
- So equilibrium is reached faster but yield is unchanged (1 mark)

(b)

- Example: Haber process (1 mark)
  (Allow: Contact process, hydrogenation of alkenes)

Total: 3 marks

Q48. Harry – concentration and equilibrium

(a)

- Yield of SO_3 increases (1 mark)

(b)

- Increasing SO_2 shifts equilibrium to oppose change (1 mark)
- More SO_3 formed (1 mark)

Total: 3 marks

Q49. Ben – mean rate

(a)

- Substitution: 100 ÷ 25 (1 mark)
- Answer: 4 cm^3/s (1 mark)

(b)

- Units = cm^3/s (1 mark)

Total: 3 marks

Q50. Daniel – Haber process compromise (6 marks)

Indicative points:

- High pressure → high yield but expensive and dangerous (1 mark)
- Lower pressure → cheaper, but yield reduced (1 mark)
- High temperature → faster rate (1 mark)
- High temperature → lower yield (favours reverse endothermic) (1 mark)
- Compromise at 200 atm, 450 °C (1 mark)
- Iron catalyst reduces energy costs further (1 mark)

Total: 6 marks

Q51. Oliver – equilibrium shifts

(a) Forward endothermic, ↑ temp:

- Equilibrium shifts to forward (1 mark)
- Yield increases (1 mark)

(b) ↓ temp:

- Equilibrium shifts to exothermic reverse (1 mark)
- Yield decreases (1 mark)

Total: 4 marks

Q52. Ethan – energy diagram with catalyst

- Reactants higher than products (exothermic) or appropriate curve (1 mark)
- Curve with catalyst lower peak than without (1 mark)
- Both activation energies labelled (1 mark)

Total: 3 marks

Q53. Sam – particle collisions

(a)

- Minimum energy needed for particles to react (1 mark)
- To break bonds/start reaction (1 mark)

(b)

- Not all collisions have energy ≥ activation energy (1 mark)
- Orientation may be incorrect (1 mark)

Total: 4 marks

Q54. Charlie – dynamic equilibrium

(a)

- Reactions are continuous, both forward and reverse occurring (1 mark)
- At the same rate (1 mark)

(b)

- Closed system prevents loss of reactants/products (1 mark)
- Allows equilibrium to be maintained (1 mark)

Total: 4 marks

Q55. Noah – sodium thiosulfate experiment

Indicative points:

Apparatus (1 mark): conical flask, stopwatch, measuring cylinder, paper with cross, thermometer, safety goggles

Method (2 marks):

- Place flask on paper with cross
- Add fixed volume sodium thiosulfate, then add hydrochloric acid
- Start timer, measure time until cross no longer visible

Variables (2 marks):

- Control acid concentration, volumes, same concentration of thiosulfate, same person observing, room temp controlled

Safety (1 mark):

- Wear goggles, avoid inhaling SO_2 gas, well-ventilated room

Total: 6 marks