Mark schemes

(a) endothermic

(b) 82 (%)

- correct answer with working gains 3 marks
- if 17 or 34 not shown in working max 2 marks
- accept 82.4
- accept 82.35 to full calculator display (82.35294...) correctly rounded to at least 2 sf
- if no answer or incorrect answer, then
  - $(M_r =) \text{ 17 gains 1 mark or }$
  - 14/17 gains 2 marks
  - OR
  - $(2M_r =) \text{ 34 gains 1 mark or }$
  - 28/34 gains 2 marks
  - OR
  - 14/their $M_r$ shown gains 1 mark or
  - correct calculation of 14/their $M_r$ gains 2 marks

(c) (i) 7 / seven

(ii) $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

(iii) ammonium chloride

- allow $\text{NH}_4\text{Cl}$
- ignore an incorrect formula
(d) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a ‘best-fit’ approach to the marking.

**Level 3 (5 – 6 marks):**
Suggestion with reasons from all three graphs, and linking of ideas which may explain a compromise.

**Level 2 (3 – 4 marks):**
Suggestion with reasons referring to more than one graph.

**Level 1 (1 – 2 marks):**
Suggestion with a reference to a graph.

**0 marks:**
No relevant content.

**Examples of chemistry points made in response:**
A reasonable suggested amount of fertiliser would be in the region of 200 kg (per ha).
Accept any suggestion from about 180 kg (per ha) to 500 kg (per ha).

**Yield:**
- Using fertiliser improves yield.
- Yield improved most up to about 200 kg (per ha) of fertiliser.
- Yield only increased slightly above about 200 kg (per ha).

**Profit:**
- About 200 kg of fertiliser gives the most profit.
- Above about 200 kg (per ha) of fertiliser profit declines.

**Run off:**
- Run off is at low levels until about 300 kg (per ha) of fertiliser.
- Above about 300 kg (per ha) of fertiliser, run off increases.

**Examples of linking of ideas:**
- Overall 200 kg gives high crop yield and most profit.
- In conclusion 200 kg gives high crop yield and low run off.
- 200 kg gives most profit and low run off.

**Examples of compromise:**
- Profits go down after about 200 kg (per ha) of fertiliser because cost of fertiliser is not covered by increased yield.
- 200 kg gives the highest profit although it is not the highest yield.
- 500 kg gives the best yield but has the most runoff.
(so electrons) can move through the structure/metal
accept (so electrons) can carry charge through the structure/metal
accept (so electrons) can form a current

reference to incorrect particles or incorrect bonding or incorrect structure = max 1

(b) giant structure
accept lattice
accept each atom forms four bonds (with other carbon atoms)
ignore macromolecular

strong bonds
accept covalent
do not accept ionic

reference to intermolecular forces/bonds or incorrect particles = max 1

(c) thermosetting polymers do not melt (when heated)
accept thermosetting polymers do not change shape (when heated)
accept thermosetting polymers have high(er) melting points
ignore thermosetting polymers do not soften (when heated)

due to cross-links (between chains)
accept due to bonds between chains

reference to smart polymers = max 1
accept converse argument

[6]

(a) (i) nitrogen: air

hydrogen: natural gas

(ii) as a catalyst

so the reaction speeds up
allow lowers activation energy or so a lower temperature can be used
(iii) cooled

ammonia condenses / liquefies

*allow nitrogen and hydrogen remain in the gaseous state*

(iv) recycled

*allow reused or returned to the reactor*

(b) reversible arrows

hydrogen and ammonia

(a) (i) natural gas

*allow fossil fuels / biogas generator*

(ii) air contains oxygen

this would react with / oxidise the hydrogen

*allow this would react with / oxidise the iron*

ignore nitrogen

(iii) cooled

ammonia condenses / liquefies (so can be separated)

nitrogen and hydrogen (remain as gases and) are returned to the reactor

*allow recycled*

(b) (i) 200 °C and 1000 atmospheres

(ii) the reaction is reversible

*allow stated as equilibrium or forward / backward reaction anywhere in answer*

forward reaction is exothermic so increased temperature lowers the yield of ammonia

*allow converse*

a lower temperature would decrease rate of reaction

*allow converse*
a higher pressure would increase the yield of ammonia because the forward reaction produces the least number of (gaseous) molecules / moles

allow converse

higher pressures would involve high cost / energy

ignore risk / explosion

(a) (i) Filtration

(ii) Chlorine

(b) (i) nanoparticles are small / smaller / much smaller / tiny

allow any in range 1−100 nm or 1 × 10⁻⁹ m − 1 × 10⁻⁷ m or a few hundred atoms in size

ignore numbers if stated smaller

(ii) they have a high surface area to volume ratio

reference to surface area without volume ratio is insufficient

allow nanoparticles are very reactive or nanoparticles are more reactive than normal particles.

(c) (sodium hydroxide) produces a white precipitate

accept solid / suspension or ppt or ppte for precipitate.

ignore cloudy / milky

which (then) dissolves / disappears (in excess sodium hydroxide)

M2 cannot be awarded unless a solid of some sort has been made

ignore names or formulae of compounds

(a) because sulfur dioxide causes acid rain

which kills fish / aquatic life or dissolves / damages statues / stonework or kills / stunts growth of trees

if no other mark awarded then award 1 mark for sulfur dioxide is toxic or causes breathing difficulties.
(b) (i) electrons are lost

(ii) $\text{Cu}^{2+} + 2e^- \rightarrow \text{Cu}$

allow $\text{Cu}^{2+} \rightarrow \text{Cu} - 2e^-$

ignore state symbols

(iii) copper sulfate

allow any ionic copper compound

(c) (lattice of) positive ions

delocalised electrons

accept sea of electrons

(electrostatic) attraction between the positive ions and the electrons

electrons can move through the metal / structure or can flow

allow electrons can carry charge through the metal / structure

if wrong bonding named or described or attraction between oppositely charged ions then do not award M1 or M3 − MAX 2

(d) (copper compounds are absorbed / taken up by) plants

allow crops

which are burned

the ash contains the copper compounds

do not award M3 if the ash contains copper (metal)

(e)

<table>
<thead>
<tr>
<th>/ $A_r$</th>
<th>55.6 / 63.5</th>
<th>16.4 / 56</th>
<th>28.0 / 32</th>
</tr>
</thead>
<tbody>
<tr>
<td>moles</td>
<td>0.876</td>
<td>0.293</td>
<td>0.875</td>
</tr>
<tr>
<td>ratio</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>formula</td>
<td>Cu$_3$FeS$_3$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
award 4 marks for \( \text{Cu}_3\text{FeS}_3 \) with some correct working
award 3 marks for \( \text{Cu}_3\text{FeS}_3 \) with no working
if the answer is not \( \text{Cu}_3\text{FeS}_3 \) award up to 3 marks for correct steps from the table apply ecf
if the student has inverted the fractions award 3 marks for an answer of \( \text{CuFe}_3\text{S} \)

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(a) gold
(b) atom (s)

(c) (i) protons
   any order
   allow proton

   neutrons
   allow neutron

(ii) 3 / three

(d) (i) Al
   ignore any numbers / charges

(ii) any two from:
   • limited resource
   • expensive in terms of energy / mining
   • effects on the environment, such as, landfill, atmospheric pollution, quarrying
   allow uses a lot of energy to extract.

(e) resistant to corrosion

   does not react (with water or food)
   allow one mark for low density with a suitable reason given

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(a) (i) central block

(ii) conducts electricity
(b) any two from:
• visual pollution
• noise pollution
• dust pollution
• habitat destruction.

(c) (i) to concentrate the ore / copper carbonate
or
to remove / separate the rock

(ii) 12 (tonnes)

*If answer is incorrect allow one mark for (127 + 132) – 247 or 259 - 247*

(iii) any one from:
• so no reactant is wasted / left unreacted
• so they know how much product they will make
• need to record / compensate for the carbon dioxide produced

*allow so they can work out their carbon footprint.*

(a) The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound

*allow to concentrate the metal or metal compound*

rock / other compounds need to be removed / separated

(b) (i) (cast iron is) brittle

*allow not strong*

*ignore weak*

(ii) the oxygen reacts with carbon

*allow carbon burns in oxygen or is oxidised*

reducing the percentage of carbon in the mixture
or producing carbon dioxide

(c) (i) aluminium has a low density

(ii) (because copper) is in the central / middle (block of the periodic table)

whereas aluminium is in Group 3 (of the periodic table)
(iii) iron is more reactive (than copper)

 ignored cost

 so copper is displaced / reduced