Mark schemes

(a) any one from:
- there was a flame
- energy was given out
- a new substance was formed
- the magnesium turned into a (white) powder

answers must be from the figure

(b) Magnesium oxide

(c) The reaction has a high activation energy

(d) 9

(e) They have a high surface area to volume ratio

(f) any one from:
- Better coverage
- More protection from the Sun’s ultraviolet rays

(g) any one from:
- Potential cell damage to the body
- Harmful effects on the environment

(h) indication of $\frac{1}{1.6} = 0.625$

and

use of indices $10^{-9} - 10^{-6} = 10^3$

Both steps must be seen to score first mark

$0.625 \times 1000 = 625$ (times bigger)

2

(a) (zinc has) lost electron(s)

accept loss of electrons

(b) copper is the least reactive
because it gave the most negative voltage when it was metal 2
or
it gave the biggest voltage with chromium
or
it gave the most positive voltage when it was metal 1

(c) $-0.7 \text{ V}$

The voltage with chromium and copper is 1.2

accept use of other cell pairings such as tin with copper and tin with iron

The voltage with chromium and iron is 0.5 and copper is less reactive (than iron)

(d) hydrogen + oxygen = water

e) $H_2 \rightarrow 2H^+ + 2e^-

O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$

(a) line goes up before it goes down

energy given out correctly labelled

activation energy labelled correctly

(b) electrostatic force of attraction between shared pair of negatively charged electrons

and both positively charged nuclei

(c) bonds formed = 348 + 4(412) + 2(276) = 2548 kJ / mol

bonds broken − bonds formed = 612 + 4(412) + (Br-Br) − 2548 = 95 kJ / mol

Alternative approach without using C-H bonds

For step 1 allow = 348 + 2(276) = 900 kJ / mol

Then for step 2 allow 612 + (Br-Br) − 900 = 95 kJ / mol

193 (kJ / mol)
accept (+)193 (kJ / mol) with no working shown for 3 marks
−193(kJ / mol) scores 2 marks
allow ecf from step 1 and step 2

(d) **Level 3 (5–6 marks):**
A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links. A conclusion is reached.

**Level 2 (3–4 marks):**
An explanation is given which demonstrates a reasonable understanding of the key scientific ideas. A conclusion may be reached but the logic used may not be clear or linked to bond energies.

**Level 1 (1–2 marks):**
Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.

**0 marks:**
No relevant content.

**Indicative content**

**Size and strength**
- chlorine atoms have fewer electron energy levels/shells
- chlorine atoms form stronger bonds
- Cl–Cl bond stronger than Br–Br
- C–Cl bond stronger than C–Br

**Energies required**
- more energy required to break bonds with chlorine
- more energy given out when making bonds with chlorine
- overall energy change depends on sizes of energy changes

**Conclusions**
- if C–Cl bond changes less, then less exothermic
- if C–Cl bond changes more, then more exothermic
- can’t tell how overall energy change will differ as do not know which changes more.

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(a) (i) high temperature
   *allow heating / hot / 250-900 °C*

catalyst or steam
   *allow named catalyst eg zeolite, Al₂O₃, silica, ceramic*
   *allow in the absence of air / oxygen*

*ignore any references to pressure*
(ii) colourless
   
   allow decolourised
   
   ignore clear / discoloured

(iii)

\[ \begin{array}{cccccc}
  & H & H & H & H \\
  & C & C & C & C & H \\
  & H & H & H & H \\
\end{array} \]

(b) (i) 20.3(0) (kJ)
   if answer incorrect allow 1 mark for 24.36/1.2

(ii) use a lid
   
   allow insulate beaker or use draught shield

   reduce energy / heat loss
   
   ignore references to thermometer or repeats or distance of flame or loss of water vapour

   allow stir (1) to distribute energy / heat (1)
   
   allow use a metal can (1) as it’s a better conductor (1)

(iii) carbon/soot
   
   ignore tar, smoke

   (produced by) incomplete combustion
   
   allow from a limited supply of oxygen/air

(iv) hexane gives out the greatest energy (per 1.0 g)
   
   ignore more energy

   hexane produces the least smoke / carbon / soot
   
   allow has the cleanest flame
   
   ignore less smoke / carbon / soot
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):
Descriptions of advantages and disadvantages that are linked to their own knowledge.

Level 2 (3 – 4 marks):
Descriptions of an advantage and a disadvantage with some use of their knowledge to add value.

Level 1 (1 – 2 marks):
Statements made from the information that indicate whether at least one statement is an advantage or a disadvantage or a linked advantage or disadvantage

0 marks:
No relevant content

Examples of the added value statements and links made in the response could include:
Note that link words are in bold; links can be either way round. Accept reverse arguments and ignore cost throughout.

Advantages of using hydrogen:
• Combustion only produces water so causes no pollution
• Combustion does not produce carbon dioxide so this does not contribute to global warming or climate change
• Combustion does not produce sulfur dioxide so this does not contribute to acid rain
• Incomplete combustion of petrol produces carbon monoxide that is toxic
• Incomplete combustion of petrol produces particulates that contribute to global dimming
• Petrol comes from a non-renewable resource but there are renewable/other methods of producing hydrogen
• Hydrogen releases more energy so less fuel needed or more efficient

Disadvantages of using hydrogen:
• Hydrogen is a gas so is difficult to store or transfer to vehicles
• Hydrogen gas is very flammable so leaks cause a greater risk of explosion
• Most hydrogen is produced from fossil fuels which are running out
• Cannot be used in existing car engines so modification / development or replacement is needed
• Lack of filling stations so difficult to refuel your vehicle

5
(a) (i) 5.75 or 5.8

*correct answer with or without working gains 2 marks

*correct working showing addition of any four results and division by 4 gains 1 mark

OR

6(.04) for 1 mark
(ii) use a polystyrene cup or lid  
accept insulate the beaker  

to prevent energy/heat gain  
accept to prevent energy/heat transfer  
do not accept energy/heat loss  

OR  

use a digital thermometer  
allow use a data logger  
easier to read (to 0.1°C)  

(b) (as mass increases) the final temperature increases  
then stays constant  
correct reference to a value above 8 g up to and including 10 g as mass when the trend changes  

(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 =) 17 gains 1 mark or  
14/17 gains 2 marks  

OR  
(2M_r =) 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) H^+ + OH^- → H_2O  

[7]
(iii) ammonium chloride

\[ \text{allow } \text{NH}_4\text{Cl} \]

\[ \text{ignore an incorrect formula} \]

(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.
(a) water / H₂O

*allow steam or hydrogen oxide*

(b) (i) A

(ii) exothermic

*products (energy) lower than reactants (energy)*

(iii) 1860 (kJ)

(c) (i) 22.5

38.7

16.2

*allow ecf for correct subtraction*

(ii) 50 (g)

(iii) 20.1 (kJ)

*allow propanol*

*ignore 3*

(iv) as the number of carbon atoms (in one molecule of alcohol) increases the heat energy given out increases (when the alcohol is burned)

(v) any two from:
  - no lid
  - no insulation
  - no draught shield
  
  *Allow heat / energy loss to surroundings for any one of these marks*
  
  - incomplete combustion
  - inaccurate measurement
  - no repeats (to calculate a mean)

(iv) -O-H

(a) CH₄ + 2O₂ → CO₂ + 2H₂O

*allow multiples*
(b) 3444 J

if answer incorrect:
one mark for temperature increase = 16.4 °C
one mark for mass of water = 50 g
ecf for one incorrect value gains two marks for correct calculation
no ecf for two incorrect values

(c) (i) 1276 (kJ per mole)
ignore + or -
if answer incorrect:
\[(5 \times 413) + 347 + 358 + 467\] + \[(3 \times 495)\] = 4722 (1 mark)
\[(4 \times 799) + (6 \times 467)\] = 5998 (1 mark)
correct subtraction of calculated energy values (1 mark)

(ii) because energy released when bonds form is greater than energy used when bonds broken
allow converse
if no mark awarded allow one mark for energy is used to break bonds
or
one mark for energy is released when bonds form

(iii) products line lower than reactants
activation energy labelled
overall energy change labelled
(a)  
(i)  the products are at a lower energy level than the reactants

    accept products have less energy / less energy at the end than the beginning

(ii) because a catalyst provides an alternative / different pathway / mechanism / reaction route

    accept adsorption or ‘increases concentration at the surface’
    ignore absorption

    (that has) lower activation energy

    allow weakens bonds

    allow idea of increased successful collisions.

    DO NOT ALLOW answers stating catalysts provide energy for M1 and M2

(b) one pair of electrons in each overlap (8 pairs in total)

    allow any combination of dots, crosses or other symbols

    the rest of the diagram correct with four non-bonding electrons on the oxygen giving a total of eight electrons in oxygen outer energy level.

    gains 2 marks
(c)  
(i)  $\pm 3024 \text{ (J)}$

Correct answer with or without working gains 3 marks
if the answer is incorrect, award up to 2 marks for the following steps:
- $\Delta T = 14.4(\degree \text{C})$
- $50 \times 4.2 \times 14.4$

Allow ecf for incorrect $\Delta T$

3 marks

(ii) 0.015213913

Correct answer with or without working gains 3 marks
if answer is incorrect, allow 1 mark each for any of the following steps up to a max of 2.
- 0.70g
- $M_r$ of ethanol = 46
- $0.70 / 46$

Allow ecf in final answer for arithmetical errors

3 marks

(iii) $\pm 198,720 \text{ (J / mole)}$

c(i) ÷ c(ii)

Allow ecf from (c)(i) and (c)(ii)
0.015 gives 201,600
0.0152 gives 198,947
0.01522 gives 198,686

1 mark

(d) (as the molecules get bigger or the number of carbon atoms increases) the intermolecular forces

allow intermolecular bonds

1 mark

(intermolecular forces) increase

allow more / stronger (intermolecular forces)

1 mark

and therefore require more (heat) energy to overcome

breaking covalent bonds or unspecified bonds max 1 mark (M3)

1 mark

[15]