Mark schemes

Q1.

(a) potassium chloride

allow KCl

1

(b) $H^+ + OH^- \rightarrow H_2O$

ignore state symbols

1

(c) copper carbonate and copper oxide only

1

(d) (Step 2) to speed up the reaction

1

(Step 5) to make sure all the (hydrochloric) acid reacts

1

(Step 6) to remove the excess magnesium oxide

ignore to remove impurities

1

(e) using a (boiling) water bath
or
using an electric heater

1

(f) (moles Fe = $\frac{14}{56}$ =) 0.25 (mol)

1

(moles Cl_2 = $\frac{3}{2}$ $_2$ × 0.25 =) 0.375 (mol)

allow correct use of an incorrectly calculated number of moles of Fe

1

(volume Cl_2 = 24 × 0.375) = 9.0 (dm^3)

allow correct use of an incorrectly calculated number of moles of Cl_2

1

[10]

Q2.

(a) water vapour

allow steam

allow gaseous water

1

(b) 75 (cm^3)

1

(c) product level below reactants

ignore labelling of products

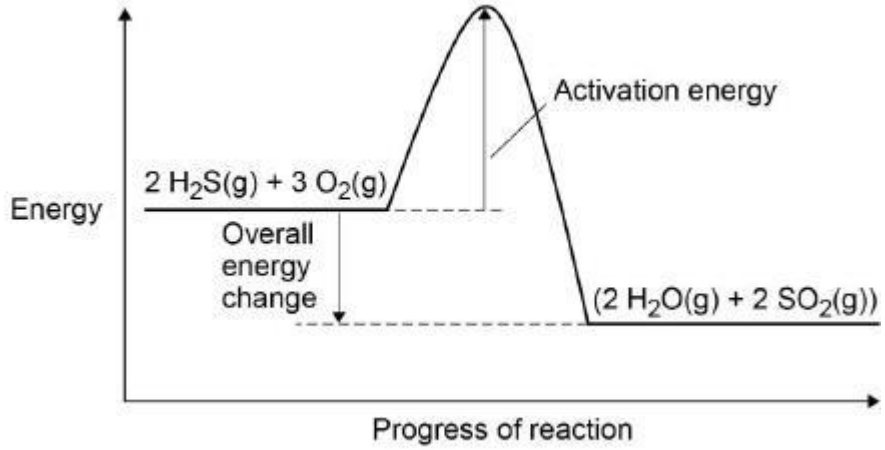
1

activation energy drawn and labelled

1

overall energy change drawn and labelled

if endothermic profile drawn allow corresponding overall energy change



scores **3** marks

1

(d) (bonds broken = 4(364) + 3(498) =) 2950

1

(bonds formed = 2950 + 1034 =) 3984

allow correct use of incorrectly calculated values of bonds broken

1

4**X** + 4(464) = 3984

allow correct use of incorrectly calculated values of bonds formed

1

4**X** = **(**3984 – 1856 =) 2128

1

X = 532 (kJ/mol)

1

alternative approach:

(bonds broken = 4(364) + 3(498) =) 2950 (1)

(bonds formed = 4(464) + 4**X** =) 1856 + 4**X** (1)

(1856 + 4**X**) – 2950 = 1034 (1)

allow correct use of incorrectly calculated values of bonds broken

and/or bonds formed

4**X** = (1034 + 2950 – 1856 =) 2128 (1)

X = 532 (kJ/mol) (1)

[10]

Q3.

(a) the activation energy should be from the reactants (line to the peak)

ignore description of where the activation energy is on the diagram

1

the products (line) should be below the reactants (line)
or
the products should have less energy than the reactants

allow the product (line) is above the reactants (line)

allow the products have more energy than the reactants allow the profile shows an endothermic reaction

ignore the arrow for the overall energy change should point downwards

1

(b) any **two** from: (hydrogen fuel cells)

allow converse arguments for a rechargeable cell

- no toxic chemicals to dispose of at the end of the cell's life
- take less time to refuel (than to recharge rechargeable cells)
- travel further before refuelling (than before recharging rechargeable cells)

  allow has a greater range

- no loss of efficiency (over time)

  allow does not lose capacity / range in cold weather 2

2

(c) any **one** from:

allow multiples

- $H_2 \longrightarrow 2\ H^+ + 2\ e^-$

  allow H_2 - 2 e^- $\longrightarrow$ 2 H^+

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

  allow H_2 + 2 OH^- - 2 e^- $\longrightarrow$ 2 H_2O

- $H_2 + 2\ OH^- \longrightarrow 2\ H_2O + 2\ e^-$

- $O_2 + 2\ H_2O + 4\ e^- \longrightarrow 4\ OH^-$

1

(d) any **two** from:
- hydrogen is not shown as H_2 / molecules
- particles are shown as spheres
- particles are shown as solid
- does not show the (weak) forces (between particles)
- does not show the movement / speed (of particles)
- is only two-dimensional

2

(e) any **one** from:
- under (higher) pressure

  allow increase concentration
- cool

  allow condense
- absorb / adsorb in a solid

  allow store as a liquid / solid

  allow develop more efficient engines

1

(f) (58 MJ =) 58 000 kJ

or

(290 kJ =) 0.290 MJ

allow (58 MJ =) 58 000 000 J

and

(290 kJ =) 290 000 J

1

(moles = $\frac{58000}{290}$ **or** $\frac{58}{0.290}$

allow correct use of an incorrectly converted or unconverted value of energy

1

(volume =) 200 × 24

allow correct use of an incorrectly calculated number of moles of hydrogen

1

= 4800 (dm^3)

1

alternative approach:

(58 MJ =) 58 000 kJ (1)

(energy released per dm^3 = $\frac{290}{24}$ =) 12.08333 (kJ/dm^3) (1)

(volume =) $\frac{58000}{12.08333}$ (1)

allow correct use of an incorrectly

converted or unconverted value of energy

allow correct use of an incorrectly calculated energy released per dm^3

= 4800 (dm^3) (1)

[12]

Q4.

(a) mixture has a lower melting point (than aluminium oxide)

allow cryolite lowers melting point (of aluminium oxide)

ignore boiling point

*do **not** accept cryolite is a catalyst*

1

(so) less energy needed

ignore cost

1

(b) aluminium ions gain electrons

1

(c) $2\ O^{2-} \rightarrow O_2 + 4\ e^-$

allow multiples

*allow **1** mark for an unbalanced equation containing correct species*

2

(d) the electrode reacts with oxygen

1

the electrode is carbon / graphite

1

(so) carbon dioxide is produced

allow (so) the electrode / carbon / graphite is used up

allow (so) the electrode / carbon / graphite is burned away

ignore (so) the electrode / carbon / graphite is worn away ignore (so) the electrode / carbon / graphite is corroded

1

(e)

*an answer of 941 (kg) scores **4** marks*

(M_r of Al_2O_3 =) 102

$\left(\frac{2\,000\,000}{102} =\right)$ 19 608 (mol Al_2O_3)

allow correct calculation using incorrectly calculated value of M_r of

Al_2O_3

1

$\left(19\,608 \times \frac{3}{2} =\right)\ 29\,412\ (\text{mol } O_2)$

allow correct calculation using incorrectly calculated value of moles of Al_2O_3

1

$\left(\frac{29\,412 \times 32}{1000} =\right)\ 941\ (\text{kg})$

allow 941.1764706 (kg) correctly rounded to at least 2 significant figures

allow correct answer using incorrectly calculated value of moles of O_2

1

alternative approach:

(2 M_r of Al_2O_3 =) 204 (1)

204 (kg of Al_2O_3) gives 96 (kg of O_2) (1)

(2000 kg of Al_2O_3 gives)

$\frac{2000}{204} \times 96$ (kg of O_2)

or

$\frac{2000000}{204} \times 96$ (g of O_2) (1)

= 941 (kg) (1)

(f) hydrogen (gas) would be produced (instead of sodium)

1

(because) sodium is more reactive than hydrogen

1

(g)

*an answer of 50700 (dm^3) scores **2** marks*
*an answer of 50.7 (dm^3) scores **1** mark*

$\left(\frac{150\,000}{71} =\right)\ 2113\ (\text{mol of } Cl_2)$

1

or

(volume of 1 g of $Cl_2 = \frac{24}{71}$ =) 0.34 (dm^3)

$(\frac{150\,000}{71} \times 24) = 50700\ (dm^3)$

allow 50704.22535 (dm^3) correctly rounded to at least 2 significant figures

allow correct calculation using their calculated number of moles and/or calculated volume of 1 g

1

[16]

Q5.

(a) wood is renewable
or
(natural) gas is finite

1

(burning) wood produces the same amount of carbon dioxide as the trees absorbed

allow wood is carbon-neutral allow wood does not add to global warming

or

(burning natural) gas increases the amount of carbon dioxide (in the atmosphere)

allow (burning natural) gas adds to global warming
allow (burning natural) gas adds greenhouse gases (to the atmosphere)

ignore references to energy / cost

1

(b) not enough oxygen

allow not enough air

*do **not** accept no oxygen / air*

1

(so) incomplete combustion

1

(c) $\mathbf{2}CH_4(g) + \mathbf{3}O_2(g) \rightarrow \mathbf{2}CO(g) + \mathbf{4}H_2O(g)$

allow correct multiples / fractions

1

(d)

*an answer of 1250 (cm^3 oxygen unreacted) scores **4** marks*

ratio of $O_2 : CO_2 = 5 : 3$

1

$\left(\text{oxygen needed} = \frac{3.60 \times 5}{3}\right)$
$= 6.0\ (dm^3)$

allow correct calculation using an incorrectly determined mole ratio

1

(oxygen unreacted = 7.25 − 6.0) = 1.25 (dm^3)

allow correct subtraction of an incorrectly calculated volume of oxygen

1

(oxygen unreacted = 1.25 × 1000)
= 1250 (cm^3)

allow correct conversion to cm^3 anywhere in response

1

alternative approach for MP1 and MP2

moles CO_2 = 0.15
and
moles O_2 = 0.25 (1)

(0.25 x 24 =) 6.0 (dm^3 oxygen needed) (1)

[9]

Q6.

(a) solid (zinc chloride) does not conduct (electricity)
or
zinc chloride needs to be in solution **or** molten

allow liquid / aqueous

1

(because) ions cannot move in the solid
or
(as) ions can (only) move in liquid / solution

*do **not** accept references to movement of electrons in zinc chloride*

1

(b) each carbon / atom forms 3 (covalent) bonds

1

one electron per carbon / atom is delocalised

1

(so) these electrons carry charge through the graphite
or
(so) these electrons move through the structure

ignore carry current / electricity

1

*if no other mark scored, allow **1** mark for delocalised / free electrons*

allow free electrons for delocalised electrons

(c) use measuring cylinders (instead of test tubes)

allow use burettes
allow use (gas) syringes
allow Hoffmann voltameter

1

(because) test tubes cannot measure volume
or
(because) test tubes have no graduations / scale

allow (so that) volume can be measured

1

(d) any **three** from:

- the volume of hydrogen collected is directly proportional to the time

  allow the (volume of) hydrogen is collected at a constant / steady rate

- the rate of collection of hydrogen is 0.45 (cm^3/min)

- up to 8 minutes chlorine is collected at an increasing rate

  allow any value from 6 to 8 minutes

  allow initially chlorine is collected at an increasing rate

- after 8 minutes the rate of collection of chlorine is the same as that of hydrogen

  allow any value from 6 to 8 minutes

  or
  after 8 minutes the rate of collection of chlorine is 0.45 (cm^3/min)

  allow after 8 minutes the (volume of) chlorine is collected at a constant / steady rate

  *if neither bullet point 3 nor bullet point 4 is awarded allow **1** mark for chlorine is collected slowly up to 8 minutes and then more quickly*

  allow any value from 6 to 8 minutes

3

(e) chlorine reacts with water
or
chlorine dissolves (in the solution).

1

(f) $(\text{volume} =) \frac{6.6}{1000}\ (dm^3)$

or 0.0066 (dm^3)

allow 6.5 (cm^3) for 6.6 (cm^3)

1

$(\text{moles} =) \frac{0.0066}{24}$

allow use of incorrect volume from step

1

1

= 2.75 × 10^{-4} (mol)

allow 2.8 × 10^{-4} (mol)

allow answer from incorrect calculation given in standard form

alternative approach for marking points 1 and 2

24 dm^3 = 24 000 cm^3 (1)

$(moles =) \frac{6.6}{24\,000}$ *(1)*

1

*an answer of 2.75 × 10^{-4} (mol) or 2.8 × 10^{-4} (mol) scores **3** marks*

*an answer of 0.000275 / 0.00028 / 2.75 × 10^{-1} / 2.8 × 10^{-1} (mol) / scores **2** marks*

*an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps*

[10]

Q7.

(a) cool

1

to −34 °C

allow temperatures below −34 °C but above −196 °C

1

(b) recycled (to the reactor)

1

(c) $825 \times \frac{2}{3}$

1

= 550 (dm^3)

1

*an answer of 550 (dm^3) scores **2** marks*

(d) a lower pressure would decrease the equilibrium yield

1

a lower temperature would make the reaction too slow

1

(e) nitrogen / N

1

(f) **B** and **C**

1

contain nitrogen, phosphorus and potassium

1

(g) (**B**)

any **two** from:
- more stages
- uses more energy
- uses more raw materials
- takes longer

*allow converse for **C***

2

[12]