Mark schemes

Q1.

(a) ($3 \times M_r$ H_2O = 3 × (2 + 16) =) 54

(A_r **R** = 150 – 54 =) 96

ignore units

1

alternative approach:
(M_r **R**O_3 = 150 – 6 =) 144 (1)

(A_r **R** = 144 – (3 × 16) =) 96 (1)

ignore units

1

(b) **(R** =) molybdenum / Mo

*allow ecf from question **(a)***

1

(c) (total M_r of reactants) = 163

1

(% atom economy =) $\frac{119}{163}$ (×100)

allow correct use of an incorrectly calculated value of total M_r

1

= 73 (%)

allow 73.00613 (%) correctly rounded to at least 2 significant figures

1

(d) **Level 2:** Some logically linked reasons are given. There may also be a simple judgement.

3–4

Level 1: Relevant points are made. They are not logically linked.

1–2

No relevant content

0

Indicative content

- carbon and iron are the cheapest reactants
- hydrogen is the most expensive reactant

- separating solid products is expensive
- separating solid products is time consuming

- in method 1, tungsten needs to be separated from tungsten carbide

- in method 1, some tungsten is lost as tungsten carbide
- in method 1, the carbon dioxide produced will escape

- in method 2, the water vapour produced will escape
- in method 2, no separation of solids is needed

- in method 3, tungsten needs to be separated from iron oxide

[10]

Q2.

(a) fuel

1

(b) propene

1

(c) (percentage yield =)

$$\frac{380}{400} \times 100$$

1

= 95 (%)

1

(d) some ethanol changes back into ethene and steam

1

some ethanol escapes from the apparatus

1

(e) $C_2H_5OH + \mathbf{3}\ O_2 \rightarrow$
$3\ H_2O + 2\ CO_2$

allow multiples

1

(f) (advantages)

(fermentation) low energy usage

1

(fermentation) uses renewable raw materials

1

(disadvantages)

(fermentation) produces impure ethanol

1

(fermentation) slow rate of reaction

1

[11]

Q3.

(total) mass before = 156.76 (g)
and

(total) mass after = 156.76 (g)

allow 78.26 + 78.50 = 156.76
and
108.22 + 48.54 = 156.76

or

increase in mass of beaker **A** and contents = 29.96 (g)
and
decrease in mass of beaker **B** and contents = 29.96 (g)

allow 108.22 – 78.26 = 29.96
and
48.54 – 78.50 = – 29.96

1

(so) the mass of products equals the mass of the reactants
or
(so) there is no change in mass during the reaction

allow (so) no atoms were lost or made during the reaction

1

(b) filter / filtration

allow a description of filtration

1

(c) sodium nitrate (solution)
or
silver nitrate (solution)
or
sodium iodide (solution)

allow correct formulae

allow sodium / nitrate / silver / iodide ions

1

(d) to remove / evaporate the water

allow to dry (the solid)

1

(e) (total M_r = 170 + 150) = 320

allow (235 + 85) = 320

1

(% atom economy =) 235

$$\frac{235}{320} \times 100$$

allow correct use of incorrectly calculated total M_r

1

= 73.4375 (%)

1

= 73.4 (%)

allow an answer correctly calculated to 3 significant figures from an incorrect percentage calculation which uses the values in the question

1

(f) any **one** from:

- for sustainable development
- for economic reasons
- to produce a high(er) percentage of useful product

allow to reduce waste

1

[10]

Q4.

(a)

*an answer of 77 (%) scores **2** marks*
*an answer of 78.63247863 (%) correctly rounded to at least 2 significant figures scores **1** mark*

$$\frac{184}{(232 + 6)} \times 100$$

1

= 77 (%)

allow 77.31092437 (%) correctly rounded to at least 2 significant figures

1

(b)

*an answer of 15 (kg) scores **2** marks*

$$\frac{38}{100} \times 40$$

1

= 15 (kg)

allow 15.2 (kg)

1

(c)

*an answer of 102 scores **2** marks*

(2 x 27) + (3 x 16)

1

= 102

ignore units

1

(d)

*an answer of 89.3 (%) scores **3** marks*

$\frac{28.4}{31.8} \times 100$

1

= 89.3081761 (%)

allow 89.3081761(%) correctly rounded to at least 2 significant figures

1

= 89.3 (%)

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the masses in the question

1

(e) aluminium is more reactive than carbon

allow aluminium is above carbon in the reactivity series

1

(so) carbon cannot displace aluminium

allow (so) carbon cannot replace aluminium

or

(so) carbon cannot reduce aluminium oxide

allow (so) carbon cannot remove oxygen from aluminium oxide
allow (so) carbon will not react with aluminium oxide

1

[11]

Q5.

(a)

an answer of 17.6470588 (%) correctly rounded to at least 2 significant figures scores 2 marks

$\frac{6}{34} \times 100$

1

= 17.6 (%)

allow 17.6470588 (%) correctly rounded to at least 2 significant figures

1

(b)

allow converse arguments in terms of higher pressure
ignore references to rate

higher yield (of hydrogen or carbon monoxide or product)

allow more hydrogen or more carbon monoxide or more product
allow equilibrium moves to the right
allow equilibrium moves in the forward direction

1

(because) fewer moles / molecules / particles on left hand side
or
(because) more moles / molecules / particles on right hand side

allow (because) the reverse reaction produces fewer moles / molecules / particles
or
allow (because) the forward reaction produces more moles / molecules / particles
*do **not** accept fewer / more atoms*

1

(c) no effect (on yield of hydrogen)

allow position of equilibrium unaffected by pressure
ignore references to rate of reaction

1

(d)

*an answer of 2.25 scores **3** marks*

350 (°C) and 285 (atmospheres) = 63 (%)
and
450 (°C) and 200 (atmospheres) = 28 (%)

allow a value between 62 (%) and 64 (%) inclusive

1

$\frac{63}{28}$

allow a correct expression using incorrectly determined value(s) for percentage yield

1

= 2.25 (times greater)

allow a correct calculation using incorrectly determined value(s) for percentage yield correctly evaluated and rounded to at least 2 significant figures

1

(e)

allow converse arguments in terms of low(er) pressure

any **one** from:

- the energy costs would be high(er)
  ignore energy / cost unqualified
- the equipment would need to be strong(er)
  allow the equipment would be (more) expensive (to build / maintain)
- high(er) pressures are (more) dangerous
  allow (more) dangerous because (greater) risk of explosion

1

(f) higher temperatures produce a lower (percentage) yield (of ammonia)

allow converse
allow correct reference to shift in equilibrium
ignore references to pressure

1

(g) world population has increased

1

any **one** from:
- demand for fertiliser has increased
  allow more food needed
- increased demand for other specified ammonia-based products e.g. nitric acid, drugs, dyes, explosives

1

[12]

Q6.

(a) FeS_2

*do **not** accept equations*

1

(b) 26

1

30

1

26

1

must be this order

(c) any **two** from:
- iron has a high(er) melting / boiling point
- iron is dense(r)
- iron is hard(er)
  allow iron is less malleable / ductile
- iron is strong(er)
- iron is less reactive
  allow specific reactions showing

difference in reactivity

- iron has ions with different charges
- iron forms coloured compounds
- iron can be a catalyst

allow iron is magnetic

allow the converse statements for sodium
allow transition metal for iron
allow Group 1 metal for sodium

ignore references to atomic structure

ignore iron rusts

2

(d) carbon is more reactive (than nickel)

allow converse

1

(so) carbon will displace / replace nickel (from nickel oxide)

allow (so) nickel ions gain electrons

or

(so) carbon will remove oxygen (from nickel oxide)

allow (so) carbon transfers electrons to nickel (ions)

1

(e) (total M_r of reactants =) 87

1

(percentage atom economy)

$$= \frac{59}{87} \times 100$$

allow (percentage atom economy)

$$= \frac{59}{\text{incorrectly calculated } M_r} \times 100$$

1

= 67.8 (%)

allow an answer from an incorrect calculation to 3 sig figs

1

*an answer of 67.8 (%) scores **3** marks*

*an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks*

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

[11]

Q7.

(a) lithium (atom) loses (one) electron(s)

1

chlorine (atom) gains (one) electron(s)

1

reference to transfer of one electron

1

to form positive and negative ions

allow to form noble gas electronic structures
or
allow to form stable electron arrangements
or
allow to form full outer shells
or
allow reference to ionic bonding

1

(b) $\frac{161}{81+98} \times 100$

1

= 89.944134

1

= 89.9 (%)

1

*an answer of 89.9 (%) scores **3** marks*

(c) more sustainable **or** less waste

allow any sensible economic or environmental reason but not 'cheaper' without qualification

1

(d) 50 / 1000 (dm^3) or 0.05 dm^3
or
80 / 1000 (g / cm^3) or 0.08 g / cm^3

1

= 4(.00) (g)

1

*an answer of 4(.00) (g) scores **2** marks*

[10]

Q8.

(a) heat with a water bath
or
heat with an electric heater
or
allow to evaporate / crystallise at room temperature

1

(b) to make sure that all the iodine reacts

allow so can see the reaction is complete

1

(as) excess iodine would remain in solution

1

(so) iodine could not be filtered off

allow (whereas) excess zinc could be filtered off

or

(so) the zinc iodide would not be pure

allow (so) would have to separate iodine from zinc iodide

1

(c) $\text{moles } I_2 = \frac{0.5(00)}{254} = (0.00197)$

allow moles I_2 = 0.00197

allow 65 g Zn: 254 g I_2

1

mass Zn = 0.00197 × 65 (g)

1

mass = 0.128 (g)

1

allow an expression $\frac{0.5(00) \times 65}{254}$ *(g) for the first **2** marks*

(d) $92.0 = \frac{12.5}{\text{maximum mass}} \times 100$

1

$(\text{maximum mass}=) \ \frac{100}{92.0} \times 12.5$

1

= 13.6 (g)

allow 13.5869... (g)

1

(e) some product lost on separation

allow incomplete reaction

1

(f) M_r ZnI_2 = 319

1

moles needed

$\left(= 0.1 \times \frac{250}{1000}\right) = 0.025$

or

mass per dm^3 = 31.9 (g)

1

(mass) = 7.98 (g)

allow 7.975 / 8.0 (g)

1

*an answer of 7.975, 7.98 or 8.0 (g) scores **3** marks*

[14]

Q9.

(a) s

1

l

*Answers **must** be in the correct order.*

1

(b) A gas was lost from the flask

1

(c) **Level 3 (5–6 marks):**
A coherent method is described with relevant detail, and in correct sequence which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered. The method would lead to the production of valid results.

Level 2 (3–4 marks):
The bulk of the method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content.

Indicative content

- sulfuric acid in beaker (or similar)
- add copper carbonate one spatula at a time
- until copper carbonate is in excess or until no more effervescence occurs *
- filter using filter paper and funnel
- filter excess copper carbonate
- pour solution into evaporating basin / dish
- heat using Bunsen burner
- leave to crystallise / leave for water to evaporate / boil off water
- decant solution
- pat dry (using filter paper)
- wear safety spectacles / goggles

*Students. may choose to use a named indicator until it turns a neutral colour, record the number of spatulas of copper carbonate added then repeat without the indicator.

6

(d) Total mass of reactants = 221.5

1

159.5

221.5

allow ecf from step 1

1

72.0 (%)

1

*allow 72.0 with no working shown for **3** marks*

(e) any **one** from:

- Important for sustainable development
- Economic reasons
- Waste products may be pollutants / greenhouse gases

1

[13]

Q10.

(a) add excess copper carbonate (to dilute hydrochloric acid)

accept alternatives to excess, such as 'until no more reacts'

1

filter (to remove excess copper carbonate)

reject heat until dry

1

heat filtrate to evaporate some water **or** heat to point of crystallisation

accept leave to evaporate or leave in evaporating basin

1

leave to cool (so crystals form)

until crystals form

1

*must be in correct order to gain **4** marks*

(b) M_r $CuCl_2$ = 134.5

*correct answer scores **4** marks*

1

moles copper chloride = (mass / M_r = 11 / 134.5) = 0.0817843866

1

M_r $CuCO_3$= 123.5

1

Mass $CuCO_3$ (=moles × M_2= 0.08178 × 123.5) = 10.1(00)

1

*accept 10.1 with no working shown for **4** marks*

(c) $\frac{79.1}{100} \times 11.0$

or

11.0 × 0.791

1

8.70 (g)

1

*accept 8.70(g) with no working shown for **2** marks*

(d) Total mass of reactants = 152.5

1

134.5

152.5

allow ecf from step 1

1

88.20 (%)

1

*allow 88.20 with no working shown for **3** marks*

(e) atom economy using carbonate lower because an additional product is made **or** carbon dioxide is made as well

allow ecf

1

[14]

Q11.

(a) $N_2 + 3\ H_2 \rightarrow 2\ NH_3$

1

(b) catalyst

1

(c) as pressure increases percentage yield increases

1

(d) 32−23

both readings correct

1

= 9 (%)

1

[5]