Mark schemes

Q1.

(a) flame emission spectroscopy

1

flame test

1

(b) white

1

(c) barium chloride (solution)

1

(d) (conversion)

(800 cm3 = $\frac{800}{1000}$ =) 0.8

1

(dm3)

allow correct use of incorrect / no volume conversion

1

(mass =) 0.8 × 258 (g)

1

= 206.4 (g)

= 206 (g)

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

1

alternative approach:
(conversion)

(258 g/dm3 = $\frac{258}{1000}$ =) 0.258

(g/cm3) (1)

(mass =) 0.258 × 800 (g) (1)

allow correct use of incorrect / no concentration conversion

= 206.4 (g) (1)

= 206 (g) (1)

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

[8]

Q2.

(a) the (minimum) energy needed for particles to react
or
the (minimum) energy needed for a reaction to occur

allow the (minimum) energy needed to start a reaction

1

(b) (*M*r of Fe_2O_3 =) 160

1

(moles Fe_2O_3 = $\frac{3000}{160}$ =)
18.75 (mol)

allow correct use of incorrectly calculated Mr

1

(moles Al = $\frac{1000}{27}$ =) 37.0 (mol)

allow 37.037037 (mol) correctly rounded to at least 2 significant figures

if both MP2 and MP3 are not awarded allow 1 mark for 0.01875 mol Fe_2O_3 and 0.037 mol Al

1

(aluminium is limiting because)
37.0 mol is less than the (2 x 18.75 =) 37.5 mol (aluminium needed)
or
iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2}$ =) 18.5 mol (iron oxide needed)

allow correct use of incorrect number of moles from steps 2 and/or 3

alternative approaches:

approach 1:

(finding required mass of aluminium by moles method)

(*M*r of Fe_2O_3 =) 160 (1)

(moles Fe_2O_3 = $\frac{3000}{160}$ =)
18.75 (mol) (1)

allow correct use of incorrectly calculated Mr

(moles Al needed =18.75 × 2 =) 37.5 (mol) and

(mass Al needed = 37.5 × 27 =) 1012.5 (g) or 1.0125 kg (1)

allow correct use of incorrectly calculated moles of iron oxide

allow correct use of incorrectly calculated moles of aluminium needed

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

approach 2:
(finding required mass of aluminium by proportion method)

(*M*r of Fe_2O_3 =) 160 (1)

(3.00 kg Fe_2O_3 needs)
$\frac{3.00}{160}$ × 2 × 27 (kg Al) (1)

allow correct use of incorrectly calculated Mr

(=) 1.0125 (kg) (1)

(so) 1.00 kg of aluminium is not enough (1)

dependent on calculated mass of aluminium needed being greater than 1.00 (kg)

alternative approaches:

approach 3:
(finding required mass of iron oxide by moles method)

*M*r of Fe_2O_3 =) 160 (1)

(moles Al = $\frac{1000}{27}$ =) 37.0 (mol) (1)

allow 37.037037 (mol) correctly rounded to at least 2 significant figures

(moles Fe_2O_3 needed) = $\frac{37.0}{2}$) = 18.5 (mol)
and
(mass Fe_2O_3 needed = 18.5 × 160 =) 2960 (g)or 2.96 (kg) (1)

allow correct use of incorrectly calculated moles of aluminium

allow correct use of incorrectly calculated moles of iron oxide needed
allow correct use of incorrectly calculated Mr

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

approach 4:
(finding required mass of iron oxide by proportion method)

(Mr of Fe2O3 =) 160 (1)

(1.00 kg Al needs) $\frac{1.00}{2 \times 27}$ (kg Fe2O3) (1)

allow correct use of incorrectly calculated Mr

(=) 2.96 (kg) (1)

(so) 3.00 kg of iron oxide is an excess (1)

dependent on calculated mass of iron oxide needed being less than 3.00 (kg)

1

(c) Mg(s) + Zn2+(aq) → Mg2+(aq) + Zn(s)

allow multiples

allow 1 mark for Mg2+ + Zn with missing or incorrect state symbols

2

(d) magnesium (atoms) are oxidised because they lose electrons

1

(and) zinc (ions) are reduced because they gain electrons

if no other marks awarded allow 1 mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons 1

1

[9]

Q3.

(a) liquid gas

1

(b) (boiling point) increases (down the table / group)

1

(because) the relative formula / molecular mass increases
or
(because) the size of the molecule increases

1

(so) the intermolecular forces increase (in strength)

allow (so) the forces between molecules increase (in strength)

1

(so) more energy is needed to overcome the intermolecular forces

allow (so) more energy is needed to separate the molecules

do not accept a reference to breaking bonds unless specifically between molecules

1

(c) boiling point is a bulk property

allow boiling point is related to intermolecular forces (so more than one molecule is involved)

1

(d) the gas / halogen is toxic

allow the gas / halogen is poisonous / harmful allow to prevent inhalation of the gas / halogen

ignore deadly / lethal

1

(e) (going down the group) the outer electrons / shell become further from the nucleus

allow energy level for shell throughout

allow the atoms become larger

allow the number of shells increases

ignore the number of outer shells increases

1

(so) the nucleus has less attraction for the outer electrons / shell

allow (so) the nucleus has less attraction for the incoming electron

allow (so) increased shielding between the nucleus and the outer electrons / shell

allow (so) increased shielding between the nucleus and the incoming electron

1

(so) an electron is gained less easily

1

(f) 4.48 (g iron) and 8.52 (g chlorine)

1

(moles Fe = $\frac{4.48}{56}$ =) 0.08

allow correct calculation using incorrectly calculated mass of iron

1

(moles Cl = $\frac{8.52}{35.5}$ =) 0.24

allow correct calculation using incorrectly calculated mass of chlorine

allow (moles Cl_2 = $\frac{8.52}{71}$ =) 0.12

1

(Fe : Cl = 0.08 : 0.24 =) 1 : 3

allow correct calculation using incorrectly calculated moles of iron and / or chlorine

$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$

allow multiples / fractions

allow a correctly balanced equation including Fe and Cl_2 from an incorrect ratio of Fe : Cl

allow 1 mark for Fe and Cl_2 (reactants) and $FeCl_3$ (product)
or
allow 1 mark for Fe and Cl_2 (reactants) and a formula for iron chloride correctly derived from an incorrect ratio of Fe : Cl (product)

2

[16]

Q4.

(a) to make sure all of the oxide (of copper) has reacted

or

to make sure all water (produced) is removed

ignore to ensure complete reaction unqualified
ignore to make sure all of the hydrogen has reacted

1

(b) to prevent hydrogen escaping (into the air)

1

(because) hydrogen is explosive

ignore hydrogen is flammable

1

(c) (mass of copper) 8.66 (g)

1

(mass of water) 2.45 (g)

1

(d) moles Cu = 0.04
or
$\frac{2.54}{63.5} = 0.04$

1

moles H2O = 0.04
or
$\frac{0.72}{18} = 0.04$

1

ratio = 1:1 so equation 2 is correct

1

alternative approach A
(calculating mass of water from copper)

moles Cu= 0.04 **or** $\frac{2.54}{63.5} = 0.04$(1)

0.02 x 18 = 0.36 (g of water for equation 1) (1)

0.04 x 18 = 0.72 (g of water) so equation 2 is correct (1)

alternative approach B

calculating mass of copper from water)

moles H_2O=0.04 **or** $\frac{0.72}{18}$=0.04 (1)

0.08 x 63.5 = 5.08 (g of copper for equation 1) (1)

0.04 x 63.5 = 2.54 (g of copper) so equation 2 is correct (1)

alternative approach C
(mass ratio)
(copper : water for equation 1)
127 : 18 = 7.06 : 1 (1)
(copper : water for equation 2)
63.5 : 18 = 3.53 : 1 (1)
2.54 : 0.72 = 3.53 : 1 = 63.5 : 18
so equation 2 is correct (1)

[8]

Q5.

(a) polystyrene is a better (thermal) insulator
allow polystyrene is a poorer (thermal) conductor

1

(so) reduces energy exchange (with the surroundings)
allow (so) reduces energy / heat loss (to the surroundings)

1

(b) all six points plotted correctly
allow a tolerance of ± ½ a small square
allow 1 mark for at least 3 points plotted correctly

2

line of best fit through points plotted from the table 1

both lines of best fit extrapolated correctly until they cross 1

(c) 11 (cm^3)

allow ecf from part (b)

allow answers in the range 10.75 to 11.25 (cm^3)

allow a tolerance of ± ½ a small square

1

(d) (27.5 − 18.9) = 8.6 (°C)

allow ecf from part (b)

allow answers in the range 8.5 to 8.7 (°C)

allow a tolerance of ± ½ a small square

1

(e)

an answer of 0.62 (mol/dm^3) for concentration in mol/dm^3 scores 4 marks

an answer of 0.31 (mol/dm^3) for concentration in mol/dm^3 scores 3 marks

(moles H_2SO_4 = $0.500 \times \frac{15.5}{1000}$) = 0.00775 1

(moles KOH = 2 x moles H_2SO_4 = 2 x 0.00775) = 0.0155

allow correct calculation using incorrectly calculated value of moles of H_2SO_4

1

(conc KOH = moles KOH x $\frac{1000}{25.0}$) = 0.0155 x $\frac{1000}{25.0}$)

allow correct calculation using incorrectly calculated value of moles of KOH

1

= 0.62 (mol/dm^3)

allow correct answer using incorrectly calculated value of moles of KOH

1

(M_r KOH =) 56 1

(conc = M_r x conc in mol/dm^3 = 56 x 0.62) = 34.7 (g/dm^3)

allow 35 or 34.72 (g/dm3)
allow correct answer using incorrectly calculated value of concentration in mol/dm3 and/or incorrect Mr

1

alternative approach for step 1 to step 4

$\frac{2}{1} = \frac{25 \times \text{conc KOH}}{15.5 \times 0.500}$ (2)

(conc KOH) = $\frac{2 \times 15.5 \times 0.500}{25.0}$ (1)

= 0.62 (mol/dm3) (1)

allow 1 mark if mole ratio is incorrect

1

[14]

Q6.

(a) sodium oxide

allow Na2O

1

(b) oxidation

1

(c) 13

1

(d) sodium hydroxide

1

(e) OH−

1

(f) (volume =) $\frac{250}{1000}$ or $\frac{1}{4}$

or 0.25 (dm3)

1

or

(mass per cm^3 =) $\frac{40}{1000}$ (g)

or 0.04 (g)

$(\frac{250}{1000} \times 40 =)$ 10 (g)

1

an answer of 10 (g) scores 2 marks

(g) all points correct

allow a tolerance of ±½ a small square
allow 1 mark for 3 points correct
ignore any attempt at a line of best fit

2

(h) 39 °C

allow any value from 34 to 46 (°C)

1

[10]

Q7.

(a) chlorine is toxic

allow carbon monoxide is toxic
allow poisonous for toxic
ignore harmful / deadly / dangerous
allow a poisonous gas is used / produced
allow titanium chloride is corrosive

1

(b) any one from:

- very exothermic reaction

  allow explosive
  allow violent reaction
  ignore vigorous reaction
  ignore sodium is very reactive

- produces a corrosive solution

  allow caustic for corrosive
  ignore alkaline

- produces hydrogen, which is explosive / flammable

  allow flames produced
  ignore sodium burns

1

(c) argon is unreactive / inert

allow argon will not react (with reactants / products / elements)

1

oxygen (from air) would react with sodium / titanium
or
water vapour (from air) would react with sodium / titanium

allow elements / reactants / products for sodium / titanium

1

(d) metal chlorides are usually ionic

allow titanium chloride is ionic

1

(so)(metal chlorides) are solid at room temperature

or
(so)(metal chlorides) have high melting points

allow titanium chloride for metal chlorides

1

(because) they have strong (electrostatic) forces between the ions

ignore strong ionic bonds

or
(but) must be a small molecule or covalent

allow molecular

1

allow alternative approach:
titanium chloride must be covalent or has small molecules (1)
with weak forces between molecules do not accept bonds unless intermolecular bonds(1)
(but) metal chlorides are usually ionic (1)

(e) sodium (atoms) lose electrons

do not accept references to oxygen

1

(f) Na → Na+ + e−

do not accept e for e−

1

(g) (*M*r of TiCl4 =) 190

(moles Na = $\frac{20\,000}{23}$ =) 870 (mol) *

1

(moles $TiCl_4$ = $\frac{40\,000}{190}$ =) 211 (mol) *

1

**allow 1 mark for 0.870 mol Na and 0.211 mol TiCl4*
allow use of incorrectly calculated Mr from step 1

either
(sodium is in excess because) 870 mol Na is more than the 844 mol needed
or
(because) 211 mol TiCl4 is less than the 217.5 mol needed

the mark is for correct application of the factor of 4
other correct reasoning showing, with

values of moles or mass, an excess of sodium or insufficient TiCl4 is acceptable

allow use of incorrect number of moles from steps 2 and / or 3

1

alternative approaches:

approach 1:

(Mr of TiCl4 =) 190(1)

(40 kg TiClr needs)

$$\frac{40}{190} \times 4 \times 23 \text{ (kg Na) (1)}$$

(=) 19.4 (kg) (1)

so 20 kg is an excess (1)

approach 2:

(Mr of TiCl4 =) 190(1)

(20 kg Na needs)

$$\frac{20}{4 \times 23} \times 190 \text{ (kg } TiCl_4\text{) (1)}$$

(=) 41.3 (kg) (1)

so 40 kg is not enough (1)

(h) (actual mass =) $\frac{92.3}{100} \times 13.5$

or

(actual mass =) 0.923 × 13.5

1

= 12.5 (kg)

allow 12 / 12.46 / 12.461 / 12.4605 (kg)

1

an answer 12.5 (kg) scores 2 marks

[15]

Q8.

(a) enzyme

1

(b) 2.0 × 103 moles

1

(c) smaller yield

allow less methanol is produced

1

(because) favours endothermic reaction

allow (because) favours reverse reaction

allow equilibrium / reaction shifts to the left
allow equilibrium / reaction shifts to reduce the temperature

ignore reference to forward reaction is exothermic
ignore references to rate

1

(d) (yield)
equilibrium position moves to the product side

allow equilibrium / reaction moves to the right
allow equilibrium / reaction shifts to reduce the pressure

1

(because) fewer molecules / moles / particles on product side

allow (because) fewer molecules / moles / particles on the right
allow (because) smaller volume on product side

1

(rate)
more collisions per unit time

allow increases collision frequency / rate

ignore more collisions alone
ignore faster collisions
do not accept any indication of more energetic / forceful collisions

1

(because) more molecules / particles per unit volume

allow (gas) molecules / particles closer together

ignore more molecules / particles alone

1

allow converse arguments

(e) provides different reaction pathway

allow provides a different mechanism / route

1

(which has a) lower activation energy

1

ignore references to collisions

(f) less energy is needed

allow reduces the temperature required
allow reduces costs

ignore references to pressure
ignore references to rate or time

1

(g) no effect / change

1

[12]

Q9.

(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 (dm3) or 0.05 dm3
or
80 / 1000 (g / cm3) or 0.08 g / cm3

1

= 4(.00) (g)

1

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

[10]

Q10.

(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 I2 = 0.00197

allow 65g Zn: 254g I2

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

(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 ZnI2 = 319
1

moles needed

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

or
mass per dm3 = 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]

Q11.

(a) sodium chloride
or

salt

allow dissolved salts
1

(b) expensive
1

(c) to remove solids
1

(d) to sterilise the water

allow to kill microorganisms
1

(e) test: (damp) litmus paper
1

result: bleached
or

turns white
1

(f) pH: 7.0
1

mass of dissolved solid: 0.0 (g)
1

(g) 0.05 g
1

(h) did not immerse the thermometer (bulb)

1

[10]

Q12.

(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 × M2= 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]

Q13.

(a) (delivery) tube sticks into the acid

1

the acid would go into the water or the acid would leave the flask or go up the delivery tube

ignore no gas collected

1

(b) any one from:

- bung not put in firmly / properly
- gas lost before bung put in
- leak from tube

1

(c) all of the acid has reacted

1

(d) take more readings in range 0.34 g to 0.54 g

1

take more readings is insufficient
ignore repeat

(e) $\frac{95}{24000}$

1

0.00396 or 3.96×10^{-3}

1

accept 0.00396 or 3.96 × 10−3 with no working shown for 2 marks

(f) use a pipette / burette to measure the acid

1

because it is more accurate volume than a measuring cylinder
or
greater precision than a measuring cylinder
or
use a gas syringe to collect the gas

so it will not dissolve in water

or

use a flask with a divider

accept description of tube suspended inside flask

so no gas escapes when bung removed

1

(g) they should be collected because carbon dioxide is left in flask at end

1

and it has the same volume as the air collected / displaced

1

[11]