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EDEXCEL INTERNATIONAL GCSE CHEMISTRY: QUESTIONS BY TOPIC

Inorganic Chemistry (2)

International GCSE Chemistry Topic 2

123 questions · 1226 marks · Mark schemes included

Pearson Edexcel International GCSE (9–1) Chemistry 4CH1, Papers 1C, 1CR, 2C & 2CR, June 2019 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic and run from the lowest mark tariff to the highest within each one.
Click any row below to jump straight to that sub-topic or question.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

123 questions · 1226 marks · 8 sub-topics

SUB-TOPIC 2a

GROUP 1 (ALKALI METALS)

Sub-topic 2a · 14 questions · 153 marks · lowest tariff first

2 This question is about some elements in Group 1 of the Periodic Table.

(a) The table gives some statements about the reaction of potassium with water.

Place ticks (✓) in three boxes to show which three statements are correct.

(3)

Statement	
potassium reacts more vigorously than sodium when added to water	
potassium sinks to the bottom of the water	
bubbles of oxygen gas are produced	
a lilac flame is seen	
potassium moves around	
a solution of potassium oxide is formed	

(b) After the reaction of potassium with water is complete, a few drops of universal indicator are added to the solution formed. The universal indicator turns purple.

(i) Suggest a value for the pH of the solution.

(1)

.....

(ii) Give the formula of the ion responsible for this pH value.

(1)

.....

(c) Sodium burns in oxygen to produce sodium oxide.

Complete the equation for this reaction.

(1)

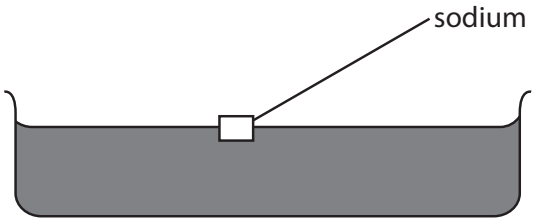
..... Na + ... O_2 → ..... Na_2O

(Total for Question 2 = 6 marks)

4 This question is about the alkali metals.

A teacher demonstrates the reaction between sodium and water.

The teacher fills a trough with water and then adds a piece of sodium.



(a) The sodium reacts with the water, forming bubbles of hydrogen gas and a colourless solution.

State two other observations that would be made.

(2)

1 .....

.....

2 .....

.....

(b) Give a test to show that, at the end of the reaction, the solution contains sodium ions.

(2)

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(c) Lithium, sodium and potassium react in a similar way when added to water.

(i) State, with reference to the electronic configurations of atoms, why these elements have similar reactions.

(1)

.....

.....

(ii) The table shows the atomic radius of a lithium atom, a sodium atom and a potassium atom.

Atom	Atomic radius in cm
lithium	1.82×10^{-12}
sodium	2.27×10^{-12}
potassium	2.80×10^{-12}

Deduce the relationship between the atomic radius and the reactivity of the metals.

(1)

.....

.....

(Total for Question 4 = 6 marks)

2 A small piece of lithium is added to a trough of water.

(a) State two observations made when lithium reacts with water.

(2)

1 .....

.....

2 .....

.....

(b) What are the products of the reaction?

(1)

- ☒ **A** lithium hydroxide and hydrogen
- ☒ **B** lithium hydroxide and oxygen
- ☒ **C** lithium oxide and hydrogen
- ☒ **D** lithium oxide and oxygen

(c) After the reaction is complete, a few drops of universal indicator are added to the solution in the trough.

(i) Explain the colour and pH of the solution in the trough.

(3)

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(ii) Give the formula of the ion responsible for this pH.

(1)

.....

(d) Lithium ions can be identified using a flame test.

What flame colour indicates the presence of lithium ions?

(1)

- ☒ **A** lilac
- ☒ **B** orange
- ☒ **C** red
- ☒ **D** yellow

(Total for Question 2 = 8 marks)

4 This question is about sodium and potassium.

A trough is filled with water and a few drops of phenolphthalein indicator are added.

(a) A small piece of sodium is dropped into the water. One of the products of the reaction is an alkali.

(i) Complete the chemical equation for the reaction of sodium with water.

(2)

_____Na(.....) + _____$H_2O(l)$ → _____NaOH(.....) + $H_2(g)$

(ii) Identify the ion that causes the solution to become alkaline.

(1)

.....

(iii) Give three observations that would be made when sodium reacts with water.

(3)

1 .....

.....

2 .....

.....

3 .....

.....

(b) Explain why potassium is more reactive than sodium.

Refer to the electronic configurations of the atoms in your answer.

(3)

(Total for Question 4 = 9 marks)

4 This question is about some of the alkali metals and their compounds.

(a) When a teacher drops a small piece of sodium into a trough of cold water, she observes bubbles of gas.

Give two other observations that would be made when sodium reacts with cold water.

(2)

1 .....

.....

2 .....

.....

(b) Lithium reacts with fluorine to form the compound lithium fluoride.

(i) Give a chemical equation for this reaction.

(1)

.....

(ii) Give a test to show that lithium fluoride contains lithium ions.

(2)

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.....

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.....

(iii) Draw diagrams to show the arrangement of the electrons in a lithium ion and in a fluoride ion.

Include the charge on each ion.

(3)

lithium ion	fluoride ion

(c) The table shows the electronic configurations of sodium and potassium.

Element	Electronic configuration
sodium	2.8.1
potassium	2.8.8.1

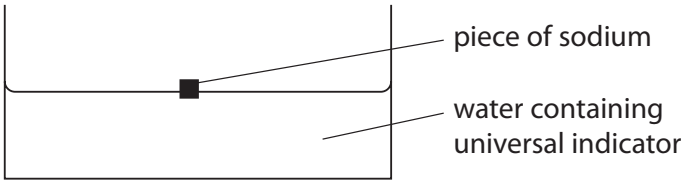
Explain, in terms of their electronic configurations, why potassium is more reactive than sodium.

(3)

(Total for Question 4 = 11 marks)

4 This question is about the reactions of Group 1 metals with water.

(a) A teacher adds a piece of sodium to some water containing universal indicator.



The equation for this reaction is

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

The sodium floats on the surface of the water and the universal indicator changes colour because an alkaline solution is formed.

(i) Give two other observations.

(2)

1 .....

.....

2 .....

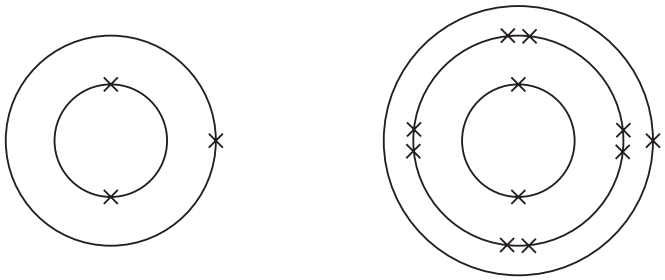
.....

(ii) Give the final colour of the universal indicator.

(1)

.....

(b) The diagram represents an atom of lithium and an atom of sodium.



lithium sodium

(i) Give a reason why lithium and sodium have similar reactions with water.

(1)

(ii) Explain why lithium is less reactive than sodium.

(3)

(c) The teacher adds 0.150 g of lithium to an excess of water and collects the hydrogen gas produced.

The equation for the reaction is

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

The teacher collects 254 cm^3 of hydrogen gas at room temperature and pressure (rtp).

Show by calculation that 1 mol of hydrogen gas has a volume of approximately 24 000 cm^3 at rtp.

(4)

(Total for Question 4 = 11 marks)

5 This question is about lithium and some of its compounds.

(a) A small piece of lithium is added to a trough containing water.

The lithium floats on the surface of the water and a vigorous reaction occurs.

(i) Give two other observations when lithium reacts with water.

(2)

1 .....

.....

2 .....

.....

(ii) A few drops of methyl orange are added to the solution in the trough.

Explain the final colour of the solution.

(2)

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(b) An unlabelled bottle containing a white powder is found in a laboratory.

Describe tests to show that the white powder in the bottle is lithium carbonate.

(5)

(c) Lithium carbonate has ionic bonding.

State what is meant by the term **ionic bonding**.

(2)

(Total for Question 5 = 11 marks)

4 A teacher adds a small piece of lithium to water and collects the gas produced.

(a) (i) Give two observations when lithium is added to water.

(2)

1 .....

.....

2 .....

.....

(ii) The teacher adds a few drops of universal indicator to the solution at the end of the reaction.

Explain the final colour of the universal indicator.

(2)

.....

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.....

(b) This is the equation for the reaction between lithium and water.

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

The teacher collects 550 cm^3 of hydrogen at rtp.

Calculate the mass, in grams, of lithium that the teacher added to the water.

[one mole of gas at rtp has a volume of 24 000 cm^3]

[for lithium, $A_r = 7$]

[for carbon $A_r = 12$ for hydrogen, $A_r = 1$ for oxygen $A_r = 16$]

(3)

mass = ... g

(c) The teacher then adds a small piece of potassium to water.

(i) Give one observation seen with potassium that is **not** seen with lithium.

(1)

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(ii) Explain why potassium is more reactive than lithium.

Refer to atomic structure in your answer.

(3)

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(Total for Question 4 = 11 marks)

4 This question is about Group 1 metals.

(a) A teacher adds a small piece of lithium metal to a trough containing water.

(i) Complete the equation for the reaction between lithium and water by adding the state symbols.

(2)

$$2Li(\ldots\ldots) + 2H_2O(\ldots\ldots) \rightarrow 2LiOH(\ldots\ldots) + H_2(\ldots\ldots)$$

(ii) Give two observations made when the lithium is added to the water.

(2)

1 .....

.....

2 .....

.....

(iii) The reaction produces 375 cm^3 of hydrogen gas at room temperature and pressure (rtp).

Show, by calculation, that the mass of lithium added is between 0.20 g and 0.30 g.

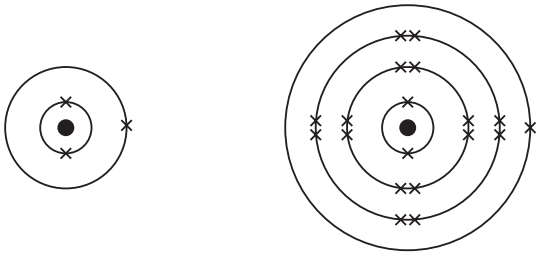
[1 mol of gas has a volume of 24 000 cm^3 at rtp]

[for lithium, $A_r = 7$]

(3)

(b) Potassium is more reactive than lithium.

The diagram shows the electronic structure of an atom of lithium and an atom of potassium.



Lithium Potassium

(i) Give one observation that is different when a small piece of potassium, instead of lithium, is added to water.

(1)

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.....

(ii) Explain why potassium is more reactive than lithium.

Refer to the electronic structure of lithium and of potassium in your answer.

(3)

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(Total for Question 4 = 11 marks)

5 This question is about Group 1 metals and their reactions.

(a) When lithium is added to water, bubbles of hydrogen gas are observed.

(i) Give two other observations that could be made.

(2)

1 .....

.....

2 .....

.....

(ii) Give the test for hydrogen gas.

(1)

.....

.....

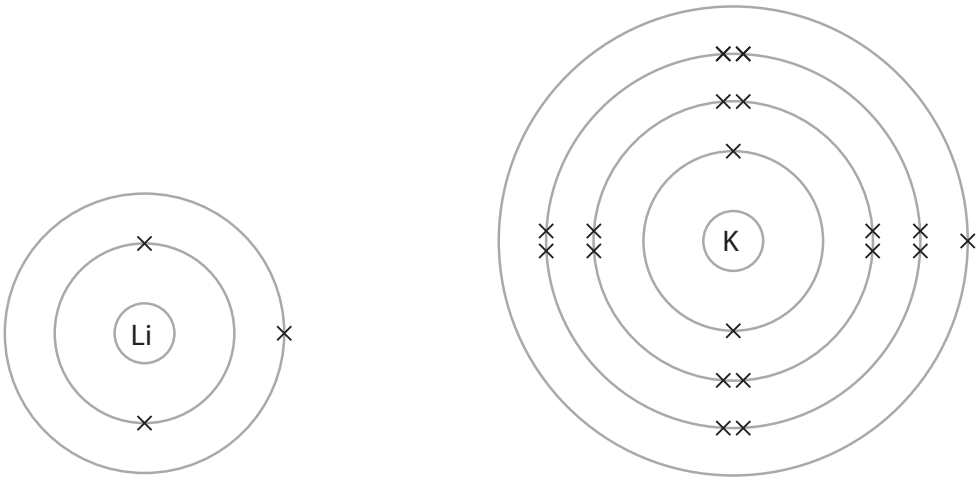
(b) (i) Give one observation that would be different if potassium is used instead of lithium.

(1)

.....

.....

(ii) The diagram represents an atom of lithium and an atom of potassium.



Explain why potassium is more reactive than lithium.

(3)

(c) The equation for the reaction between lithium and water is

$$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$$

(i) A mass of 0.500 g of lithium reacts with an excess of water.

Calculate the volume, in cm^3, of hydrogen gas produced at rtp.

[molar volume of a gas at rtp = 24 000 cm^3]

Give your answer to three significant figures.

(3)

volume = ... cm^3

(ii) In a reaction between lithium and water, 150 cm^3 of lithium hydroxide solution is formed.

The lithium hydroxide solution is then completely neutralised by 24.85 cm^3 of 0.100 mol/dm^3 sulfuric acid.

The equation for the neutralisation is

$$2LiOH(aq) + H_2SO_4(aq) \rightarrow Li_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration, in mol/dm^3, of the lithium hydroxide solution.

(3)

concentration = ... mol/dm^3

(Total for Question 5 = 13 marks)

9 Lithium, sodium and potassium are the first three elements in Group 1 of the Periodic Table.

(a) Suggest why these three elements are all stored in paraffin oil.

(1)

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.....

.....

(b) Caesium, Cs, is below potassium in Group 1.

(i) Give a similarity and a difference between the reactions of potassium with water and caesium with water.

(2)

similarity .....

.....

difference .....

.....

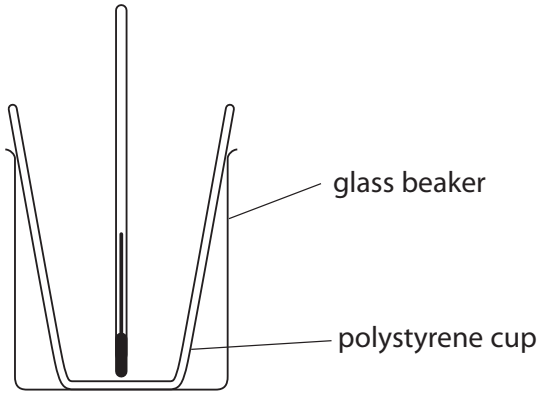
(ii) Give the chemical equation for the reaction between caesium and water.

(2)

.....

(c) A student investigates the temperature change in the reaction between dilute acids and solutions of Group 1 hydroxides.

He uses this apparatus.



This is the student's method.

- measure the temperature of 50 cm^3 of hydrochloric acid
- pour the acid into a polystyrene cup
- add 50 cm^3 of sodium hydroxide solution to the acid
- measure the maximum temperature of the mixture

(i) Suggest what could be added to the apparatus to improve the experiment.

(1)

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.....

(ii) Explain a change to the method that would improve the accuracy of the experiment.

(2)

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.....

(d) These are the student's results.

temperature of hydrochloric acid = 19.9 °C

maximum temperature of mixture = 26.5 °C

(i) Calculate the energy change, Q, in joules for this reaction.

[mass of 1.0 cm^3 of mixture = 1.0 g]

[for the mixture, c = 4.2 J/g/°C]

(3)

Q = ... J

(ii) In the student's reaction between hydrochloric acid and sodium hydroxide, 0.050 mol of water forms.

Calculate the molar enthalpy change, ΔH, in kJ/mol for this reaction.

(2)

ΔH = ... kJ/mol

(Total for Question 9 = 13 marks)

6 This question is about some Group 1 elements and their compounds.

(a) A teacher adds a small piece of sodium to a trough of water.

(i) Give two observations that are made when sodium reacts with water.

(2)

1 .....

2 .....

(ii) After the reaction has stopped, the teacher adds a few drops of phenolphthalein to the solution in the trough.

Explain the colour of the phenolphthalein after it is added to the solution.

(2)

.....

.....

.....

.....

(b) A student does a flame test to see if a white solid contains lithium ions.

They clean a platinum wire before using it for the flame test.

(i) Explain why the student needs to clean the platinum wire.

(2)

.....

.....

.....

.....

.....

(ii) What is the colour of the flame if the solid contains lithium ions?

(1)

☒ **A** lilac

☒ **B** orange

☒ **C** red

☒ **D** yellow

(c) Potassium aluminium sulfate can be used in baking.

Anhydrous potassium aluminium sulfate has the formula $KAl(SO_4)_2$

(i) Give the formula of each ion in potassium aluminium sulfate.

(2)

potassium ion

.....

aluminium ion

.....

sulfate ion

.....

(ii) Potassium aluminium sulfate is normally found as a hydrated salt, with the formula $KAl(SO_4)_2.xH_2O$

When 23.7 g of the hydrated salt is heated to remove all the water, 12.9 g of the anhydrous salt is formed.

Calculate the value of x.

[for $KAl(SO_4)_2$, $M_r = 258$ for H_2O, $M_r = 18$]

(4)

x = ...

(Total for Question 6 = 13 marks)

6 This question is about some of the Group 1 elements and their compounds.

(a) A teacher adds a small piece of lithium to water in a trough.

(i) Give three observations that are made when lithium reacts with water.

(3)

1 .....

2 .....

3 .....

(ii) After the reaction has finished, the teacher adds a few drops of universal indicator to the solution in the trough.

Explain the colour of the universal indicator after it is added to the solution.

(2)

.....

.....

.....

.....

(iii) Write a chemical equation for the reaction of lithium with water.

(2)

.....

(b) A student does a flame test to see if a white solid contains sodium ions.

She cleans a platinum wire before using it for the flame test.

(i) Explain why the student needs to clean the platinum wire.

(2)

.....

.....

.....

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.....

(ii) Which of these is the colour of the flame if the solid contains sodium ions? **(1)**

- ☒ **A** green
- ☒ **B** lilac
- ☒ **C** red
- ☒ **D** yellow

(c) Potassium sulfate (K_2SO_4) is an ionic compound.

(i) Give the formula of each ion in potassium sulfate. **(1)**

potassium ion ..... sulfate ion .....

(ii) The melting point of potassium sulfate is 1069 °C.

Explain why potassium sulfate has a high melting point.

Refer to structure and bonding in your answer. **(4)**

(Total for Question 6 = 15 marks)

6 (a) Describe the forces of attraction in metallic bonding.

(2)

(b) When a small piece of potassium is added to water, bubbles of hydrogen gas are observed.

(i) Give the test for hydrogen gas.

(1)

(ii) Give two other observations that would be made.

(2)

1

2

(c) Explain why lithium is less reactive than potassium.

Refer to atomic structure in your answer.

(3)

(d) This is the equation for the reaction between sodium and water.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

A mass of 0.750 g of sodium is reacted with an excess of water.

Calculate the volume of hydrogen gas produced, in cm^3, at room temperature.

[molar volume of hydrogen at rtp = 24 000 cm^3]

[for Na, A_r = 23]

Give your answer to three significant figures.

(4)

volume of hydrogen = ... cm^3

(e) This is the equation for the reaction between sodium hydroxide and sulfuric acid.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

A volume of 25.0 cm^3 of sodium hydroxide solution is completely neutralised by 16.3 cm^3 of 0.0500 mol / dm^3 sulfuric acid.

Calculate the concentration of the sodium hydroxide solution in mol / dm^3.

(3)

concentration = ... mol / dm^3

(Total for Question 6 = 15 marks)

SUB-TOPIC 2b

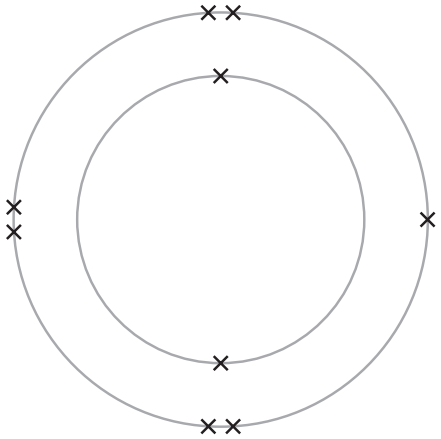
GROUP 7 (HALOGENS)

Sub-topic 2b · 14 questions · 145 marks · lowest tariff first

2 This question is about Group 7 elements and their reactions.

(a) Fluorine has the smallest atoms in Group 7.

The diagram shows the electronic configuration of a fluorine atom.



(i) State why fluorine has the smallest atoms in Group 7.

(1)

.....

.....

(ii) Which row gives the correct number of occupied electron shells and the correct number of outer shell electrons in an atom of iodine?

Use the Periodic Table on page 2 to help you.

(1)

		Number of occupied electron shells	Number of outer shell electrons
☒	**A**	4	5
☒	**B**	5	6
☒	**C**	5	7
☒	**D**	7	5

(b) (i) The table gives descriptions of the reactions of some Group 7 elements with iron wool.

Complete the table by giving a description of the reaction of fluorine with iron wool.

(2)

Element	Description of reaction with iron wool
fluorine	
chlorine	• does not need heating • reacts quickly
bromine	• needs heating • reacts slowly
iodine	• needs heating • reacts very slowly

(ii) State the relationship between the reactivity of the Group 7 elements and the size of their atoms.

(2)

.....

.....

.....

.....

(Total for Question 2 = 6 marks)

1 This question is about Group 7, the halogens.

(a) What is the total number of electrons in one fluorine atom?

(1)

- ☒ **A** 7
- ☒ **B** 9
- ☒ **C** 10
- ☒ **D** 19

(b) What is the charge on a bromide ion?

(1)

- ☒ **A** 1–
- ☒ **B** 1+
- ☒ **C** 2–
- ☒ **D** 2+

(c) Which of these describes the element iodine at room temperature?

(1)

- ☒ **A** brown liquid
- ☒ **B** brown solid
- ☒ **C** grey solid
- ☒ **D** purple gas

(d) When a halogen is added to a solution containing halide ions, a displacement reaction may occur.

The table shows whether a reaction occurs.

Halogen added	Chloride ion in solution	Bromide ion in solution	Iodide ion in solution
chlorine		reaction	reaction
bromine	no reaction		reaction
iodine	no reaction	no reaction	

Using information from the table, explain the order of reactivity of the three halogens.

(3)

(Total for Question 1 = 6 marks)

2 The table gives some information about the halogens, fluorine, chlorine, bromine and iodine.

Halogen	Physical state at room temperature	Colour	Colour of dilute aqueous solution of halogen
fluorine	gas		colourless
chlorine	gas	green	colourless
bromine		red-brown	orange
iodine	solid	grey	brown

(a) Complete the table by giving the missing information.

(2)

(b) Describe a test to show that a colourless liquid is an alkene.

(2)

.....

.....

.....

.....

(c) A student is given an aqueous solution of chlorine and an aqueous solution of sodium iodide.

The student mixes the two solutions.

Explain the colour change that occurs.

(3)

(Total for Question 2 = 7 marks)

2 The table gives some information about the halogens, chlorine, bromine and iodine.

Halogen	Physical state at room temperature	Colour
chlorine	gas	pale green
bromine		red-brown
iodine	solid	

(a) Complete the table.

(2)

(b) Chlorine has two isotopes of mass numbers 35 and 37

The relative percentage of each isotope in a sample of chlorine is

chlorine-35 77.78% chlorine-37 22.22%

Calculate the relative atomic mass of this sample of chlorine.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(c) A student is given an aqueous solution of chlorine and an aqueous solution of potassium bromide.

Explain how he can use these two solutions to compare the reactivity of chlorine with the reactivity of bromine.

(4)

.....

.....

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.....

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.....

(Total for Question 2 = 9 marks)

3 The Group 7 elements are called halogens.

Halogens form compounds called halides.

Three of the halogens are represented by the formulae X_2, Y_2 and Z_2

Solutions of these halogens are added separately to solutions of sodium halides, NaX, NaY and NaZ.

The table shows whether or not a reaction occurs.

	X_2	Y_2	Z_2
NaX	no	yes	yes
NaY	no	no	yes
NaZ	no	no	no

(a) Use the information in the table to deduce the order of reactivity of the halogens X_2, Y_2 and Z_2

(1)

most reactive .....

.....

least reactive .....

(b) An aqueous solution of halogen Y_2 is orange.

This solution is decolourised when it reacts with an alkene.

Deduce the identity of halogen Y_2

(1)

.....

(c) (i) The table shows some physical properties of the halogens.

Complete the table by predicting a boiling point for chlorine, the state of fluorine at room temperature and the colour of astatine.

(3)

Halogen	Boiling point in °C	State at room temperature	Colour
fluorine	−188		yellow
chlorine		gas	green
bromine	59	liquid	red-brown
iodine	sublimes	solid	grey
astatine	337	solid	

(ii) Why do the halogens have similar chemical properties?

(1)

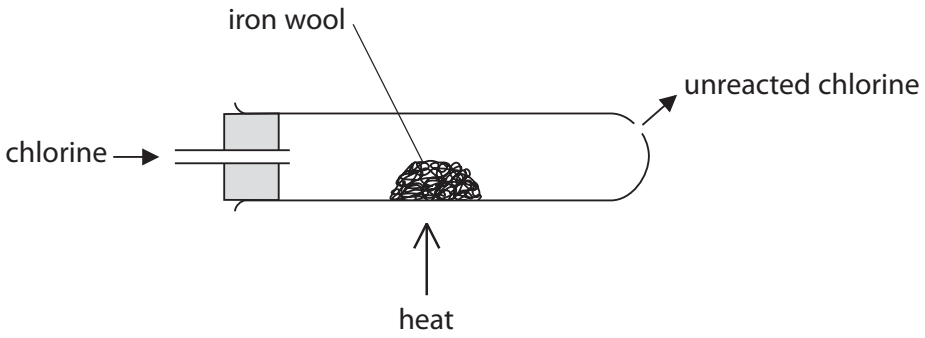
☒ **A** they are non-metals

☒ **B** they are molecules

☒ **C** they have the same number of outer shell electrons

☒ **D** they are in the same period of the Periodic Table

(d) A teacher uses this apparatus to demonstrate the reaction between chlorine gas and iron wool. The teacher does the reaction in a fume cupboard.



(i) Suggest why the teacher does the reaction in a fume cupboard.

(1)

.....

.....

(ii) The product of the reaction between iron and chlorine is iron(III) chloride.

The ions in iron(III) chloride are Fe^{3+} and Cl^-

Use this information to give the chemical equation for this reaction.

(2)

.....

(Total for Question 3 = 9 marks)

2 This question is about elements in Group 7 and their compounds.

The table gives information about some of these elements.

Element	Symbol	Melting point in °C	Boiling point in °C	Colour at room temperature (20 °C)
fluorine	F	−220	−188	
chlorine	Cl	−101	−35	pale green
bromine	Br	−7	59	red-brown
iodine	I	114	184	grey

(a) (i) Predict the colour of fluorine at room temperature.

(1)

.....

(ii) How many of the elements in the table are liquids at room temperature (20 °C)?

(1)

☒ **A** 0

☒ **B** 1

☒ **C** 2

☒ **D** 3

(iii) The element astatine is below iodine in Group 7.

Predict the formula of a molecule of astatine.

(1)

.....

(b) Sea water contains bromide ions.

Bromine can be obtained by bubbling chlorine through a sample of sea water.

The ionic equation for the reaction is

$$Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$$

(i) Explain which species acts as an oxidising agent in this reaction.

(2)

(ii) The reaction occurs because chlorine is more reactive than bromine.

Bromine is below chlorine in Group 7.

Explain the decrease in reactivity from chlorine to bromine.

(3)

(c) Elements in Group 7 react with elements in Group 1 to form ionic compounds.

Which pair of ions both have the electronic configuration 2.8.8?

(1)

☒ **A** Li^+ and Cl^-

☒ **B** K^+ and F^-

☒ **C** Li^+ and F^-

☒ **D** K^+ and Cl^-

(Total for Question 2 = 9 marks)

5 This question is about elements in Group 7 of the Periodic Table.

(a) Complete the table by giving the missing information.

(3)

Element	Colour	Physical state at room temperature
fluorine	pale yellow	gas
chlorine	pale green	
bromine		liquid
iodine	dark grey	solid
astatine	black	

(b) The order of reactivity of the Group 7 elements can be shown by using displacement reactions.

(i) When chlorine is added to sodium bromide solution, chlorine displaces bromine.

Give a chemical equation for this reaction.

(2)

.....

(ii) Explain whether a reaction takes place when bromine water is added to sodium chloride solution.

(2)

.....

.....

.....

.....

(iii) The displacement reaction between potassium astatide and bromine can be represented by this ionic equation.

$$2At^- + Br_2 \rightarrow At_2 + 2Br^-$$

Explain why this is described as a redox reaction.

(2)

.....

.....

.....

.....

(Total for Question 5 = 9 marks)

6 This question is about elements in Group 7 of the Periodic Table.

(a) (i) Which element is a liquid at room temperature?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** fluorine

(ii) What colour is solid iodine?

(1)

- ☒ **A** black
- ☒ **B** dark brown
- ☒ **C** dark grey
- ☒ **D** purple

(iii) Describe a test for chlorine gas.

(2)

.....

.....

.....

.....

(b) A sample of chlorine, containing two isotopes, has this percentage composition by mass.

chlorine-35 71.2% chlorine-37 28.8%

Calculate the relative atomic mass of this sample of chlorine.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(c) A student is given an aqueous solution of chlorine and an aqueous solution of sodium iodide.

Explain how the student can use these solutions to compare the reactivity of chlorine with the reactivity of iodine.

(4)

(Total for Question 6 = 11 marks)

8 This question is about the halogens.

(a) The table gives some information about the halogens.

Complete the table by predicting the physical state of astatine at room temperature and the colour of astatine.

(2)

Halogen	Physical state at room temperature	Colour
fluorine	gas	yellow
chlorine	gas	pale green
bromine	liquid	red-brown
iodine	solid	grey
astatine		

(b) Bromine has two isotopes with mass numbers 79 and 81

(i) The relative percentages of each isotope in a sample of bromine are

bromine-79 = 51.0% bromine-81 = 49.0%

Calculate the relative atomic mass of this sample of bromine.

Give your answer to one decimal place.

(3)

relative atomic mass = ...

(ii) Give a reason why both isotopes of bromine have the same chemical properties.

(1)

.....

.....

(c) A student investigates the reactivity of some halogens.

She uses these solutions of halogens and their halides.

- bromine, chlorine and iodine
- sodium bromide, sodium chloride and sodium iodide

She adds each halogen solution to each halide solution.

The table shows her results.

	Sodium bromide	**Sodium chloride**	**Sodium iodide**
Bromine	no reaction	no reaction	reaction occurs
Chlorine	reaction occurs	no reaction	reaction occurs
Iodine	no reaction	no reaction	no reaction

(i) Explain how these results show the order of reactivity of bromine, chlorine and iodine.

(3)

.....

.....

.....

.....

.....

.....

(ii) Suggest why the student does not need to add bromine solution to sodium bromide solution.

(1)

.....

.....

.....

(iii) The ionic equation for the reaction between bromine and sodium iodide is

$$Br_2(aq) + 2I^-(aq) \rightarrow I_2(aq) + 2Br^-(aq)$$

Explain why this is a redox reaction.

(2)

.....

.....

.....

.....

(Total for Question 8 = 12 marks)

3 This question is about Group 7, the halogens.

(a) Which halogen has the palest colour?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** fluorine
- ☒ **D** iodine

(b) Which halogen is a solid at room temperature?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** fluorine

(c) The table shows the electronic configurations of a fluorine atom and a chlorine atom.

	Electronic configuration
fluorine	2.7
chlorine	2.8.7

Explain the relative reactivities of fluorine and chlorine using the information in the table.

(4)

(d) Lithium reacts with chlorine to form lithium chloride.

(i) Write a chemical equation for the reaction of lithium with chlorine.

(1)

(ii) Describe tests to show that the product of the reaction is lithium chloride.

(5)

(Total for Question 3 = 12 marks)

7 This question is about some of the halogens and their compounds.

(a) (i) Which element is a liquid at room temperature?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** iodine

(ii) Which element has the palest colour?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** iodine

(iii) Which element is the least reactive?

(1)

- ☒ **A** astatine
- ☒ **B** bromine
- ☒ **C** chlorine
- ☒ **D** iodine

(b) A teacher uses displacement reactions to demonstrate the reactivities of some halogens.

She adds solutions of chlorine, bromine and iodine separately to three different sodium halide solutions.

The table shows some of the teacher's results.

	sodium chloride	**sodium bromide**	**sodium iodide**
chlorine solution	not done	solution turns orange	
bromine solution	solution stays orange	not done	solution turns brown
iodine solution		solution stays brown	not done

A change in colour of the solution indicates that a reaction has occurred.

(i) Complete the table by predicting the missing results.

(2)

(ii) State why the teacher does not add bromine solution to sodium bromide solution.

(1)

.....

.....

(iii) The word equation for the reaction of bromine with sodium iodide is

bromine + sodium iodide → iodine + sodium bromide

Write a chemical equation for this reaction.

(1)

.....

(c) A technician sees an unlabelled bottle containing a liquid.

He knows that the liquid is a solution of one of these compounds.

- copper(II) chloride
- copper(II) bromide
- iron(II) chloride
- iron(II) bromide

Describe chemical tests that the technician could use to identify the compound in the solution.

(6)

(Total for Question 7 = 13 marks)

6 This question is about elements in Group 7 of the Periodic Table and their compounds.

(a) (i) Give the name of this group of elements.

(1)

.....

(ii) State the colour of chlorine gas.

(1)

.....

(iii) Give a test for chlorine gas.

(2)

.....

.....

.....

.....

(b) Give a test to show that a solution contains iodide ions.

(3)

test .....

.....

.....

.....

result .....

.....

.....

.....

(c) A student compares the reactivity of the elements bromine, chlorine and iodine.

He mixes these pairs of solutions and observes the reactions that occur.

- chlorine solution and potassium bromide solution
- bromine solution and potassium iodide solution

Explain how the reactions can be used to show the order of reactivity of the three elements.

Include the colour change that the student would observe in each reaction.

(6)

(Total for Question 6 = 13 marks)

7 This question is about the three halogens, bromine, chlorine and iodine.

(a) Give the number of protons and the number of neutrons in an atom of iodine–127

(2)

number of protons

.....

number of neutrons

.....

(b) A sample of bromine contains two isotopes.

- Br–79 with relative abundance 52.8 %
- Br–81 with relative abundance 47.2 %

Calculate the relative atomic mass (A_r) of this sample of bromine.

Give your answer to three significant figures.

(3)

A_r = ...

(c) Aluminium reacts with chlorine to form aluminium chloride.

This is the equation for the reaction.

$$2Al + 3Cl_2 \rightarrow 2AlCl_3$$

Calculate the minimum mass of chlorine needed to form 26.7 g of aluminium chloride.

[for Cl_2, $M_r = 71$ for $AlCl_3$, $M_r = 133.5$]

(3)

minimum mass of chlorine = ... g

(d) A student mixes the following pairs of solutions.

Pair 1 bromine solution and potassium chloride solution

Pair 2 bromine solution and potassium iodide solution

Explain how the student can use the results of these experiments to show the order of reactivity of the three halogens, bromine, chlorine and iodine.

Include observations in your answer.

(6)

(Total for Question 7 = 14 marks)

4 This question is about the halogens and their compounds.

(a) The table gives the colour and physical state at room temperature of the halogens.

Complete the table by predicting the colour of astatine and the physical state of fluorine at room temperature.

(2)

Halogen	Colour	Physical state at room temperature
fluorine	pale yellow	
chlorine	pale green	gas
bromine	red-brown	liquid
iodine	dark grey	solid
astatine		solid

(b) Chlorine gas is bubbled into a colourless solution of potassium bromide.

Explain why the solution turns orange.

(2)

.....

.....

.....

.....

(c) Potassium bromide is an ionic compound.

Draw diagrams to show the outer electrons in a potassium ion and in a bromide ion.

Include the charges on the ions.

(3)

potassium ion	bromide ion

(d) A student sets up a circuit to test the electrical conductivity of water, solid sodium chloride and aqueous sodium chloride.

The table shows the student's results.

Substance	Conducts electricity?
water	no
solid sodium chloride	no
aqueous sodium chloride	yes

Explain these results, with reference to the structure and bonding of the substances.

(5)

(e) A concentrated aqueous solution of sodium chloride is electrolysed using graphite electrodes.

Chlorine is formed at the positive electrode (anode).

(i) Give an ionic half-equation for the formation of chlorine at the positive electrode.

(1)

.....

(ii) State why this ionic half-equation represents an oxidation reaction.

(1)

.....

.....

(iii) Which substance is formed at the negative electrode (cathode)?

(1)

- ☒ **A** hydrogen
- ☒ **B** oxygen
- ☒ **C** sodium
- ☒ **D** water

(Total for Question 4 = 15 marks)

SUB-TOPIC 2c

GASES IN THE ATMOSPHERE

Sub-topic 2c · 20 questions · 161 marks · lowest tariff first

1 This question is about gases in the atmosphere.

(a) The box gives the names of some gases in the atmosphere.

argon	carbon dioxide	helium
nitrogen	oxygen	

Use gases from the box to answer the questions.

Each gas may be used once, more than once or not at all.

(i) Identify the two noble gases.

(1)

.....

(ii) Identify the gas that is a compound.

(1)

.....

(iii) Identify the most abundant gas in the atmosphere.

(1)

.....

(iv) Identify the greenhouse gas.

(1)

.....

(b) Describe the test for oxygen.

(1)

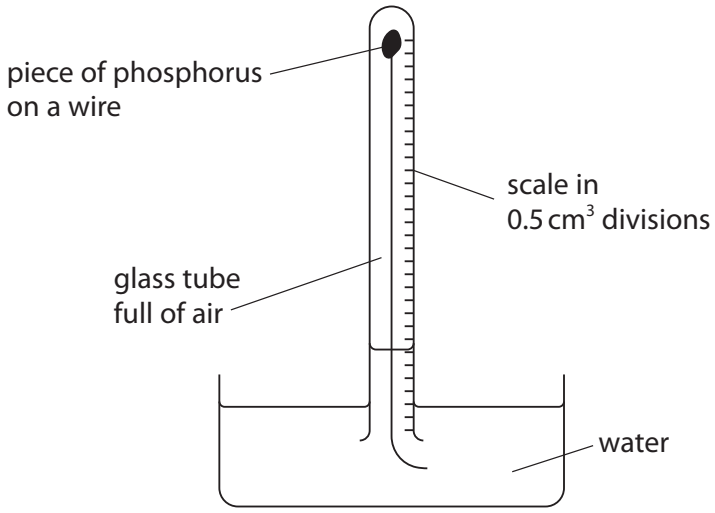
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(Total for Question 1 = 5 marks)

5 A teacher uses the reaction between phosphorus and oxygen to calculate the percentage of oxygen in air.

She uses this apparatus and excess phosphorus.



The volume of gas in the tube decreases as the phosphorus reacts with oxygen.

The teacher measures the volume of gas in the tube at one-minute intervals.

The table shows the teacher's results.

Time in minutes	Volume of gas in tube in cm^3
0	48.5
1	41.0
2	38.0
4	37.5
5	37.0
6	37.0
7	37.0

(a) State how the results show that all the oxygen has reacted.

(1)

.....

.....

(b) Give one change to this experiment that would make the results more accurate.

(1)

.....

.....

(c) Use the results to calculate the percentage of oxygen in air.

Give your answer to one decimal place.

(3)

percentage = ...%

(Total for Question 5 = 5 marks)

2 This question is about gases.

(a) The box gives the names of some gases.

argon	carbon dioxide	hydrogen	nitrogen	oxygen

Use gases from the box to answer these questions.

Each gas may be used once, more than once or not at all.

(i) Name the most abundant gas in the Earth's atmosphere.

(1)

.....

(ii) Name the gas that is a compound.

(1)

.....

(iii) Name the least reactive of the gases.

(1)

.....

(iv) Name the gas formed by the complete combustion of hydrocarbons.

(1)

.....

(b) Describe the test for hydrogen gas.

(1)

.....

.....

(Total for Question 2 = 5 marks)

1 This question is about gases in the atmosphere.

(a) The box gives the names of some gases in the atmosphere.

argon	carbon dioxide	helium	nitrogen	oxygen

Choose gases from the box to answer these questions.

Each gas may be used once, more than once or not at all.

(i) Identify a noble gas.

(1)

.....

(ii) Identify a gas that makes up about 78% of the atmosphere.

(1)

.....

(iii) Identify a greenhouse gas.

(1)

.....

(iv) Identify a gas produced by the thermal decomposition of calcium carbonate.

(1)

.....

(b) Sulfur reacts with oxygen to produce sulfur dioxide gas.

(i) Write a chemical equation for this reaction.

(1)

.....

(ii) State an environmental problem caused when sulfur dioxide gas dissolves in water in the atmosphere.

(1)

.....

.....

(Total for Question 1 = 6 marks)

1 This question is about gases in the atmosphere.

The box gives the names of some gases.

argon	carbon dioxide	hydrogen
nitrogen	oxygen	water vapour

(a) Choose gases from the box to answer these questions.

(i) Identify the least reactive gas in the atmosphere.

(1)

.....

(ii) Identify the most abundant gas in the atmosphere.

(1)

.....

(iii) Identify the gas that is not normally found in the atmosphere.

(1)

.....

(b) State an environmental problem caused by increasing amounts of carbon dioxide in the atmosphere.

(1)

.....

.....

(c) Describe a test for carbon dioxide.

(2)

.....

.....

.....

.....

(Total for Question 1 = 6 marks)

3 This question is about gases.

(a) (i) Name the gas that is about 1% of dry air by volume.

(1)

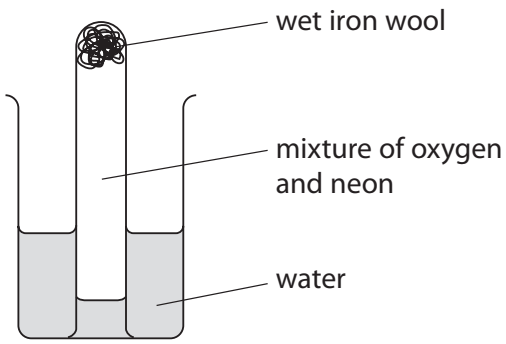
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(ii) Which is the most abundant gas in dry air by volume?

(1)

- ☒ **A** carbon dioxide
- ☒ **B** methane
- ☒ **C** nitrogen
- ☒ **D** oxygen

(b) A student uses this apparatus to find the percentage by volume of oxygen in a mixture of oxygen and neon.



This is the student's method.

- measure the initial length of the column of gas in the inverted test tube
- leave the test tube in the beaker for a week
- measure the final length of the column of gas in the test tube

(i) Some of the iron wool rusts.

Give the chemical name for rust.

(1)

.....

(ii) Give a reason why neon does not react with the iron wool.

(1)

.....

.....

(iii) The table shows the student's results.

initial length of column of gas	75 mm
final length of column of gas	30 mm

Use the results to calculate the percentage of oxygen in the mixture of oxygen and neon.

(2)

percentage of oxygen = ...%

(Total for Question 3 = 6 marks)

2 The table gives some information about five gases.

Name	Formula	Boiling point in °C
chlorine	Cl_2	–35
hydrogen chloride	HCl	–114
oxygen	O_2	–183
nitrogen	N_2	–196
hydrogen	H_2	–253

(a) Use gases from the table to answer these questions.

You may use each gas once, more than once or not at all.

(i) Name the gas needed for combustion.

(1)

.....

(ii) Name the gas that is most abundant in air.

(1)

.....

(iii) Name the gas that can bleach damp litmus paper.

(1)

.....

(b) Explain why hydrogen chloride is classified as a compound.

(2)

.....

.....

.....

.....

(c) Why does chlorine have the highest boiling point of the gases in the table?

(1)

- ☒ **A** chlorine has the strongest covalent bonds between its atoms
- ☒ **B** chlorine has the strongest covalent bonds between its molecules
- ☒ **C** chlorine has the strongest ionic bonds between its atoms
- ☒ **D** chlorine has the strongest forces of attraction between its molecules

(Total for Question 2 = 6 marks)

1 This question is about gases.

(a) The box gives the names of some gases.

carbon dioxide	carbon monoxide	helium
neon	nitrogen	oxygen

Choose gases from the box to answer questions (i) to (iv).

You may use each gas once, more than once or not at all.

(i) Identify **two** gases in Group 0 of the Periodic Table.

(1)

.....

(ii) Identify the gas that makes up about 21% of the atmosphere.

(1)

.....

(iii) Identify a greenhouse gas.

(1)

.....

(iv) Identify the toxic gas formed by incomplete combustion of a hydrocarbon.

(1)

.....

(b) Describe a test to show that a gas is carbon dioxide.

(2)

.....

.....

.....

.....

(Total for Question 1 = 6 marks)

2 This question is about gases in the atmosphere.

(a) (i) Name the most abundant gas in the atmosphere.

(1)

.....

(ii) Name the noble gas that makes up about 1% of the atmosphere.

(1)

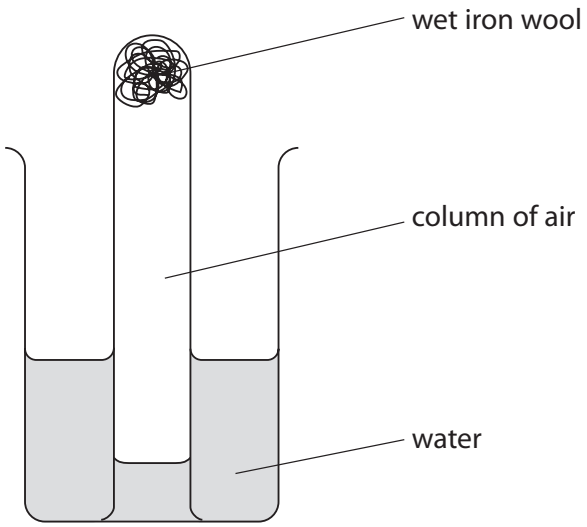
.....

(iii) Name a greenhouse gas in the atmosphere.

(1)

.....

(b) A student uses this apparatus to determine the percentage of oxygen in a sample of air.



This is the student's method.

- measure the initial length of the column of air in the tube
- leave the apparatus for one week
- measure the final length of the column of air

The table shows the student's results.

initial length of column of air in mm	84
final length of column of air in mm	69

(i) State the appearance of the iron wool after one week.

(1)

.....

(ii) Use the student's results to show that the percentage of oxygen in the sample of air is approximately 18%.

(2)

(iii) The actual percentage of oxygen in air is approximately 21%.

Give a reason why the percentage of air calculated from the student's results is less than 21%.

(1)

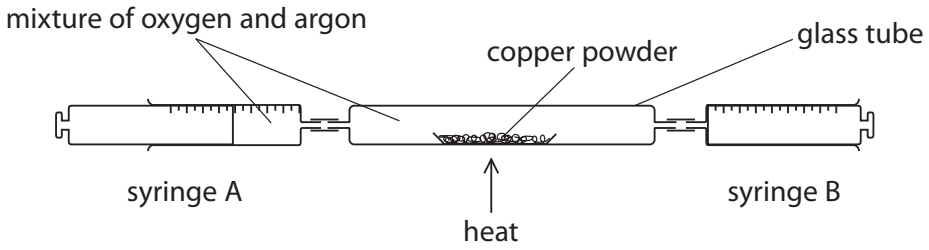
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(Total for Question 2 = 7 marks)

4 A teacher uses this apparatus to find the percentage of oxygen in a gaseous mixture of oxygen and argon.



This is the teacher's method.

Step 1 heat the copper powder

Step 2 push the plunger on syringe A to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe B

Step 3 push the plunger on syringe B to pass the mixture of oxygen and argon over the hot copper so that the mixture moves into syringe A

Step 4 record the reading on syringe A

Step 5 repeat Steps 2, 3 and 4 a number of times

The volume of gas decreases as the oxygen reacts with the copper.

Argon is unreactive so does not react with the copper.

The copper powder turns black.

(a) (i) Give a reason why the copper powder is heated.

(1)

.....

.....

(ii) State why argon is unreactive.

(1)

.....

.....

(iii) Give the name of the black powder that forms when the oxygen reacts with the copper.

(1)

.....

(b) The table shows the teacher's results.

Reading number	Reading on syringe A in cm^3
Start	78
1	70
2	67
3	65
4	63
5	61
6	60
7	59
8	58
9	58
10	58

(i) State how the results show that all the oxygen has reacted.

(1)

.....

.....

(ii) The volume of gas in the glass tube and connecting tubes is 175 cm^3.

Use this value and the results table to calculate the percentage of oxygen in the mixture of oxygen and argon.

(3)

percentage of oxygen = ... %

(iii) Suggest one reason why the calculated percentage of oxygen in the mixture may not be accurate.

(1)

.....

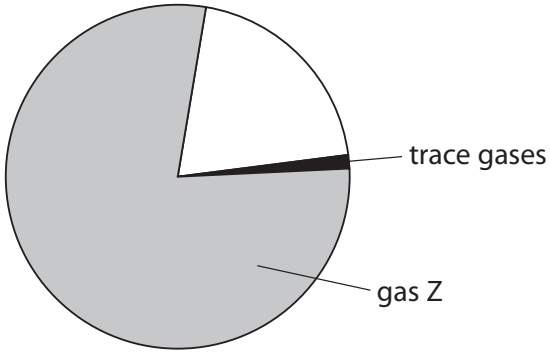
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(Total for Question 4 = 8 marks)

2 This question is about gases in the air.

The pie chart represents the percentages of gases in dry, unpolluted air.

Gases with percentages of less than 1% in air are called trace gases.



(a) (i) Which of these is gas Z?

(1)

- ☒ **A** hydrogen
- ☒ **B** methane
- ☒ **C** neon
- ☒ **D** nitrogen

(ii) Which of these is the approximate percentage of oxygen in dry, unpolluted air?

(1)

- ☒ **A** 0.04%
- ☒ **B** 0.9%
- ☒ **C** 21%
- ☒ **D** 35%

(b) One of the trace gases is carbon dioxide.

(i) Identify **two** reactions that produce carbon dioxide by placing a tick (✓) in two boxes.

(2)

cracking an alkane	
complete combustion of an alkane	
reaction between magnesium and hydrochloric acid	
rusting of iron	
thermal decomposition of copper(II) carbonate	

(ii) Name an environmental problem that is caused by the percentage of carbon dioxide increasing in the atmosphere.

(1)

.....

(iii) Name the trace gas with the highest percentage in dry, unpolluted air.

(1)

.....

(c) Rainwater is acidic because carbon dioxide dissolves in water to form carbonic acid.

Acid rain is more acidic than rainwater because acidic pollutant gases also dissolve in water.

(i) Give the name of the acid that forms when nitrogen dioxide dissolves in water.

(1)

.....

(ii) Name another pollutant gas that also forms acid rain.

(1)

.....

(Total for Question 2 = 8 marks)

4 This question is about gases.

(a) The table gives information about some gases.

Complete the table by choosing a gas from the box that matches the information.

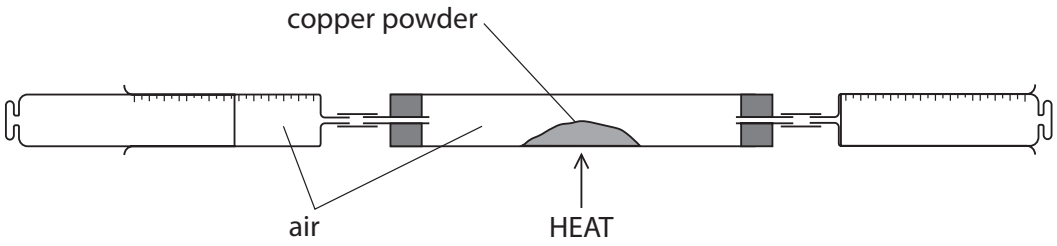
carbon dioxide	carbon monoxide	helium
methane	nitrogen	oxygen

You may use each gas once, more than once, or not at all.

(4)

Information	Gas
the most abundant gas in air	
a toxic gas that is a product of incomplete combustion of hydrocarbons	
an unreactive gas that exists as atoms	
a gas produced by the fractional distillation of crude oil	

(b) A teacher uses this apparatus to determine the percentage of oxygen in a sample of air.



This is the teacher's method.

- record the total volume of air in the apparatus
- heat the copper powder
- use the syringes to pass air over the heated copper powder several times
- allow the remaining gas to cool and record its volume

The copper powder turns black.

(i) State why the copper powder turns black.

(1)

.....

.....

(ii) Give a reason why the remaining gas is allowed to cool before its volume is recorded.

(1)

.....

.....

(iii) At the start of the experiment, the total volume of air in the apparatus is 138 cm^3.

At the end of the experiment, the volume of gas remaining is 108 cm^3.

Calculate the percentage of oxygen in the sample of air.

Assume that all the oxygen has reacted.

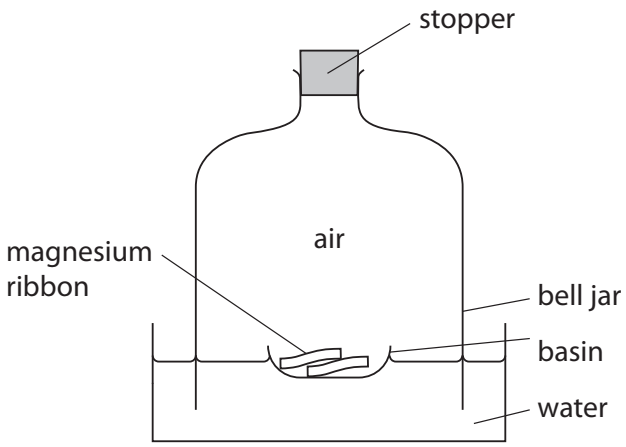
(2)

percentage of oxygen = ... %

(Total for Question 4 = 8 marks)

2 This question is about gases in the atmosphere.

A teacher uses this apparatus to determine the percentage of oxygen in air.



The teacher removes the stopper, ignites the magnesium ribbon and immediately replaces the stopper.

The magnesium reacts with oxygen to form magnesium oxide.

During the reaction the water level in the bell jar rises.

When the flame goes out, some magnesium remains in the basin.

(a) (i) Give the appearance of the magnesium oxide.

(1)

.....

.....

(ii) Give a chemical equation for the reaction of magnesium with oxygen.

(1)

.....

(iii) Explain why the water in the bell jar rises.

(2)

.....

.....

.....

.....

(b) The volume of air in the bell jar at the start of the reaction is 2000 cm^3.

When the reaction ends, the apparatus cools down to room temperature.

Calculate the expected volume of gas in the bell jar at room temperature.

(3)

volume of gas = ... cm^3

(c) State why the gas remaining in the bell jar at the end of the reaction is approximately 99% nitrogen.

(1)

.....

.....

(Total for Question 2 = 8 marks)

4 When iron is left in damp air, rust forms on its surface.

(a) (i) State the chemical name for rust.

(1)

.....

(ii) Explain how a barrier method prevents rusting.

(2)

.....

.....

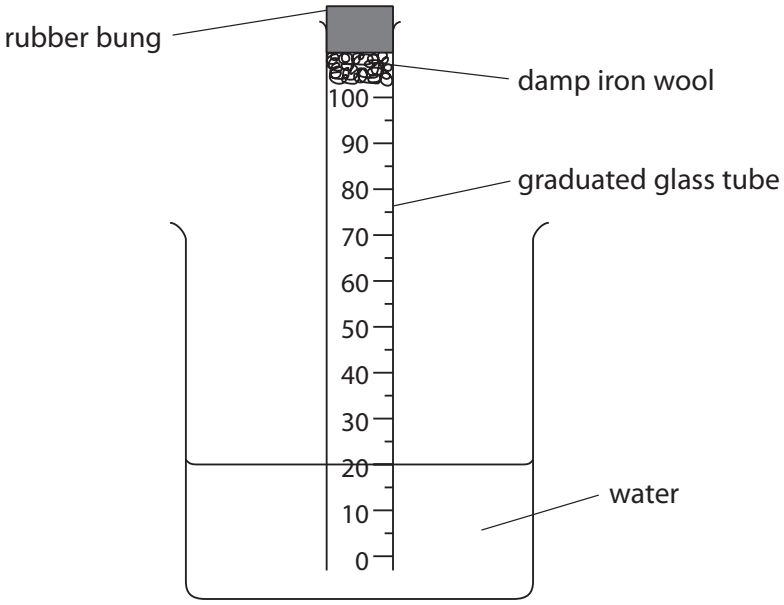
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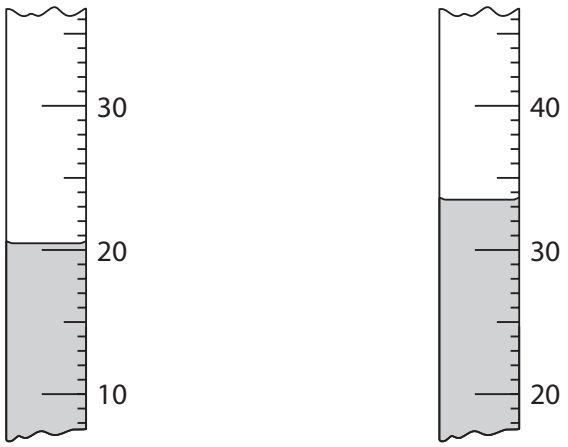
(b) A student uses this apparatus to find the approximate percentage by volume of oxygen in air.



This is the student's method.

- place a graduated glass tube in a beaker of water
- place some damp iron wool and a rubber bung in the top of the tube
- record the reading of the water level in the tube
- leave the apparatus for a few days
- record the reading of the water level again

The diagram shows the readings at the start and at the end of the experiment.



start end

(i) Use the readings to complete the table, giving all values to the nearest 0.5 cm^3.

(2)

reading at start in cm^3	20.5
reading at end in cm^3	
volume of oxygen used in cm^3	

(ii) The student uses these results to calculate the percentage by volume of oxygen in air.

Suggest why her calculated value is lower than the expected value.

(1)

.....

.....

.....

(c) The student repeats the experiment using the same apparatus.

These are her results for the second experiment.

volume of air in tube at start = 80.0 cm^3

reading at start = 20.0

reading at end = 35.5

Use the results to calculate the percentage by volume of oxygen in air.

(3)

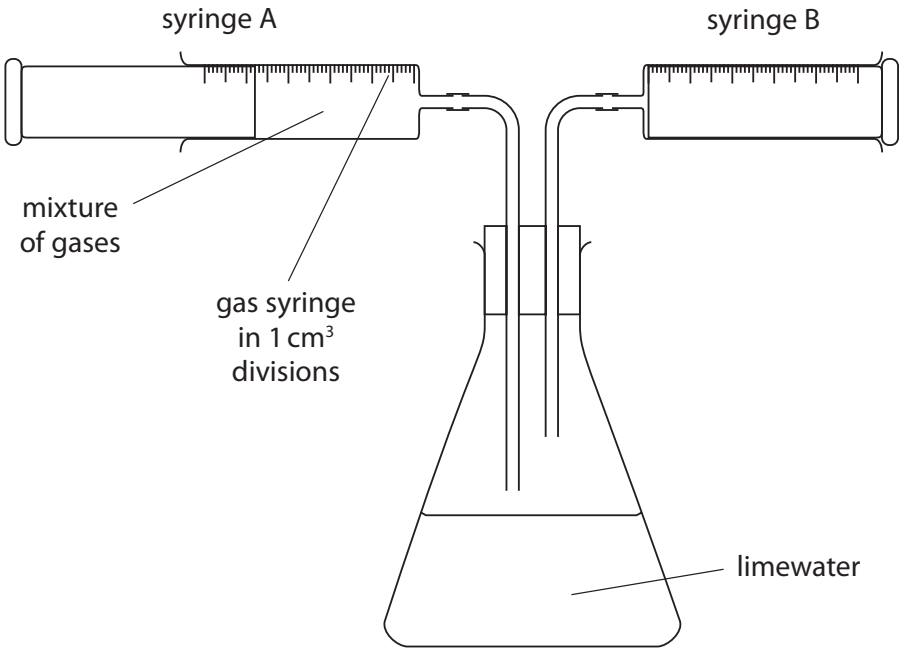
percentage = ... %

(Total for Question 4 = 9 marks)

5 Two experiments are done to determine the percentage composition by volume of a mixture of three gases, carbon dioxide, oxygen and argon.

(a) In experiment 1, a student bubbles the mixture of gases through limewater. Carbon dioxide reacts with limewater.

The diagram shows the apparatus the student uses.



The student pushes the mixture of gases out of syringe A, but no gas bubbles appear in the limewater.

Give one change the student needs to make to the apparatus for gas bubbles to appear in the limewater.

(1)

.....

.....

(b) When the apparatus in experiment 1 is set up correctly, the mixture of gases is bubbled gently through the limewater so that all the carbon dioxide is removed.

The volume of the mixture of gases in syringe A at the start is 76 cm^3.

The volume of the mixture of gases in syringe B at the end is 66 cm^3.

(i) Calculate the percentage by volume of carbon dioxide in the mixture of gases in syringe A.

(2)

percentage of carbon dioxide = ... %

(ii) Give the change in the appearance of the limewater.

(1)

.....

.....

(iii) Explain why the gas syringes in experiment 1 cannot be used to find the percentage of carbon dioxide in a typical sample of air.

(2)

.....

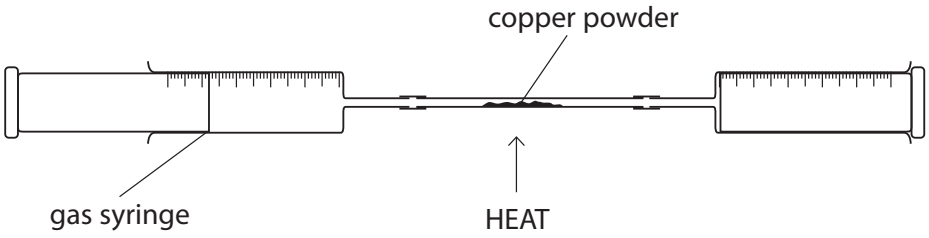
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(c) In experiment 2, a teacher pushes the remaining gases over hot copper powder.

The diagram shows the apparatus the teacher uses.



The copper powder turns black as it reacts with oxygen.

Argon is extremely unreactive, so it does not react with copper.

(i) Name the black substance that forms on the copper powder.

(1)

.....

(ii) Suggest why the teacher uses copper powder instead of the same mass of large pieces of copper.

(1)

.....

.....

.....

(iii) Explain why argon is extremely unreactive.

(2)

.....

.....

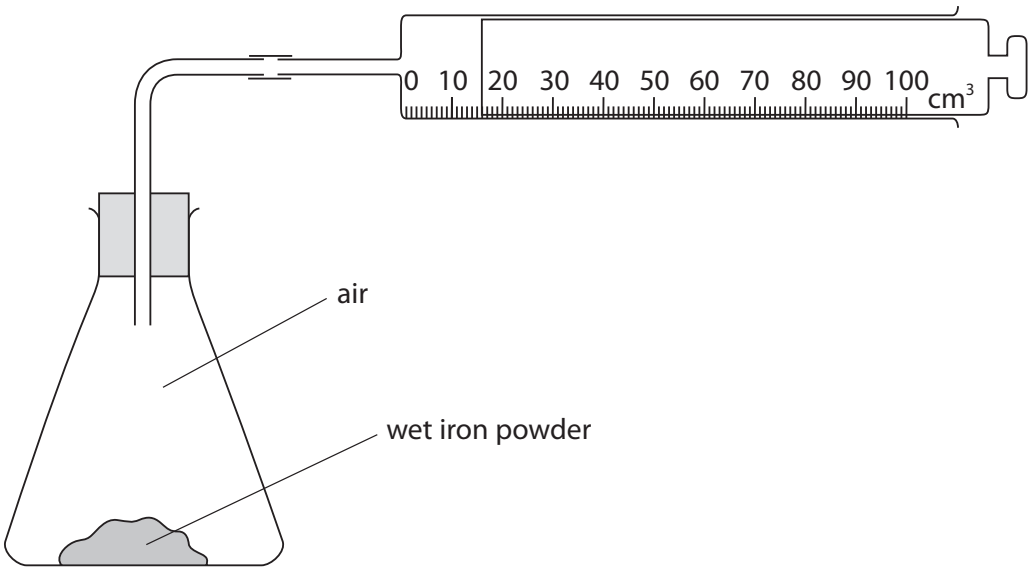
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(Total for Question 5 = 10 marks)

4 A student uses the reaction between iron and oxygen to find the percentage of oxygen in air.

The diagram shows the apparatus the student uses.



(a) (i) State why the iron powder needs to be wet.

(1)

(ii) State the colour of the compound formed in the reaction between iron and oxygen.

(1)

(iii) Give the formula of the compound formed.

(1)

(iv) Explain the advantage of using iron powder rather than pieces of iron.

(2)

(b) The syringe in the diagram shows the reading at the end of the experiment.

Complete table 1 to show the readings on the syringe.

Give both values to the nearest 1 cm^3.

(2)

syringe reading at start	
syringe reading at end	
change in volume in cm^3	65

Table 1

(c) The student repeats the experiment and obtains a different set of results.

Table 2 shows these results.

volume of air in conical flask and glass tube in cm^3	260
syringe reading at start	90
syringe reading at end	22

Table 2

Use the results from table 2 to calculate the percentage by volume of oxygen in the air.

(3)

percentage by volume of oxygen in air = ... %

(Total for Question 4 = 10 marks)

2 This question is about gases in the atmosphere.

(a) Which of these gases has the lowest percentage by volume in the atmosphere?

(1)

- ☒ **A** argon
- ☒ **B** carbon dioxide
- ☒ **C** nitrogen
- ☒ **D** oxygen

(b) When copper(II) carbonate is heated, copper(II) oxide and carbon dioxide form.

(i) What is the name of this type of reaction?

(1)

- ☒ **A** addition
- ☒ **B** decomposition
- ☒ **C** oxidation
- ☒ **D** substitution

(ii) Which colour change occurs when copper(II) carbonate is heated?

(1)

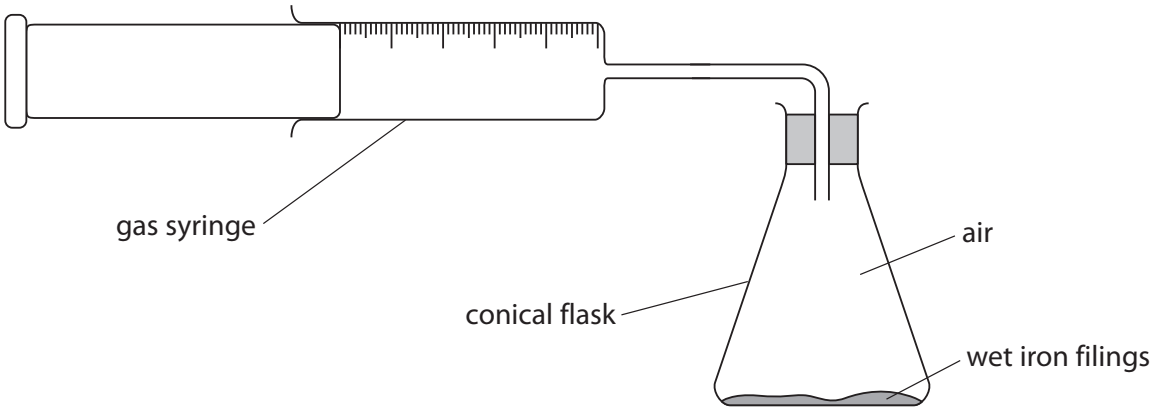
- ☒ **A** blue to black
- ☒ **B** blue to orange
- ☒ **C** green to black
- ☒ **D** green to orange

(iii) Give the chemical equation for this reaction.

(1)

.....

(c) A student uses this apparatus to find the percentage of oxygen in a sample of air.



The student leaves the apparatus until there is no further change in volume of gas in the syringe.

These are the student's results.

volume of gas in flask and connecting tube in cm^3	280
volume of gas in syringe at start in cm^3	100
volume of gas in syringe at end in cm^3	27

Calculate the percentage of oxygen in the sample of air.

Give your answer to two significant figures.

(4)

percentage of oxygen = ...%

(d) Explain why an increasing amount of carbon dioxide in the atmosphere is likely to cause a problem for the environment.

(2)

.....

.....

.....

.....

(Total for Question 2 = 10 marks)

4 This question is about gases.

(a) The table gives information about five gases.

Name of gas	argon	carbon dioxide	hydrogen	oxygen	nitrogen
Formula of gas	Ar	CO_2	H_2	O_2	N_2
M_r of gas	40		2	32	28

Use information from the table to answer these questions.
Each gas may be used once, more than once or not at all.

(i) Give the name of the gas that is about 79% of the atmosphere by volume.

(1)

.....

(ii) Give the name of the gas that is a compound.

(1)

.....

(iii) Give the name of the least reactive gas.

(1)

.....

(iv) Give the name of the gas that is not normally found in the atmosphere.

(1)

.....

(v) Give the name of the gas that affects global warming.

(1)

.....

(vi) Calculate the M_r for carbon dioxide.

(1)

M_r = ...

(vii) Give a reason why it is not possible to give information for air in the table.

(1)

.....

.....

(b) When copper(II) carbonate is heated, the products are copper(II) oxide and carbon dioxide.

(i) Give the name for this type of reaction.

(1)

.....

(ii) Give the colour change that occurs during this reaction.

(2)

..... to .....

(iii) Give a chemical equation for this reaction.

(1)

.....

(Total for Question 4 = 11 marks)

7 This question is about nitrogen and its compounds.

(a) What is the approximate percentage by volume of nitrogen in the atmosphere?

(1)

- ☒ **A** 1%
- ☒ **B** 20%
- ☒ **C** 70%
- ☒ **D** 80%

(b) Complete the dot-and-cross diagram for a molecule of nitrogen.

Show outer electrons only.

(2)

N N

(c) Nitrogen dioxide produced in car engines reacts with water vapour and oxygen in the atmosphere to form nitric acid.

(i) Give a chemical equation for this reaction.

(2)

.....

(ii) Nitric acid forms acid rain.

State one environmental effect of acid rain.

(1)

.....

.....

(d) Ammonium carbonate contains nitrogen.

(i) What is the formula of ammonium carbonate?

(1)

- ☒ **A** NH_3CO_3
- ☒ **B** $(NH_3)_2CO_3$
- ☒ **C** NH_4CO_3
- ☒ **D** $(NH_4)_2CO_3$

(ii) A technician finds an unlabelled bottle on a shelf that could be ammonium carbonate solution.

Describe tests that the technician should do to confirm that the solution contains ammonium ions and carbonate ions.

(6)

(Total for Question 7 = 13 marks)

7 This question is about nitrogen and some of its compounds.

(a) Nitrogen and oxygen do not react together at room temperature.

At the high temperatures in a car engine, nitrogen and oxygen react to form nitrogen monoxide, NO

(i) Give a chemical equation for this reaction.

(1)

.....

(ii) Give a reason why this reaction only occurs at high temperatures.

(1)

.....

.....

(iii) State why it is important that oxides of nitrogen are not released into the atmosphere.

(1)

.....

.....

(b) Nitrogen monoxide gas can be removed from car exhaust fumes when it reacts with carbon monoxide gas.

(i) The rate of the reaction is increased by passing the gases over a catalyst.

Explain how a catalyst increases the rate of a reaction.

(2)

.....

.....

.....

.....

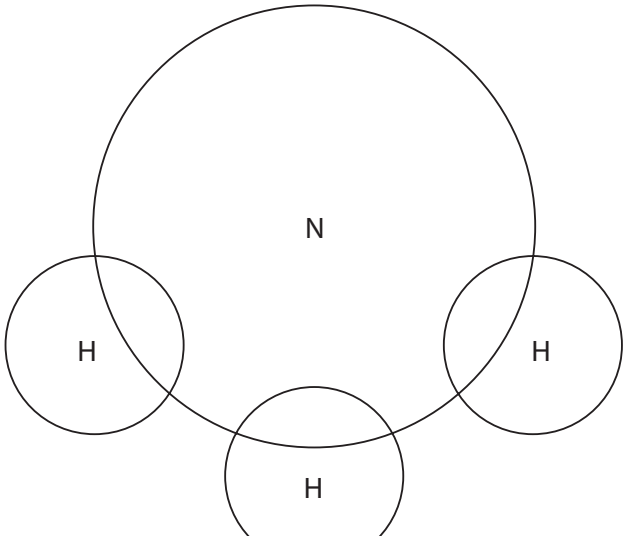
(ii) Explain how increasing the pressure of gases increases the rate of reaction.

(3)

(c) Ammonia is a simple molecule with the formula NH_3

(i) Complete the diagram to show the outer shell electrons in ammonia.

(2)



(ii) The bonds in ammonia are covalent.

Describe the forces of attraction in a covalent bond.

(2)

(iii) Explain why ammonia has a low boiling point.

(2)

(Total for Question 7 = 14 marks)

SUB-TOPIC 2d

REACTIVITY SERIES

Sub-topic 2d · 10 questions · 91 marks · lowest tariff first

6 The reactions of metals with water and with dilute sulfuric acid can be used to determine the order of reactivity of the metals.

The table shows the reactions of four metals, W, X, Y and Z, with water and with dilute sulfuric acid.

Metal	Reaction with water	Reaction with dilute sulfuric acid
W	no reaction	no reaction
X	very slow reaction	reacts quickly
Y	no reaction	reacts slowly
Z	reacts quickly	reacts violently

(a) What is the order of reactivity of these metals?

(1)

	most reactive →			least reactive
☒ **A**	W	X	Y	Z
☒ **B**	Z	X	Y	W
☒ **C**	W	Y	X	Z
☒ **D**	Z	Y	X	W

(b) (i) State which metal, W, X, Y or Z, could be copper.

(1)

.....

(ii) State which metal, W, X, Y or Z, could be magnesium.

(1)

.....

(c) A displacement reaction can also be used to decide the order of reactivity of two metals.

State two observations made when an excess of magnesium powder is added to an aqueous solution of copper(II) sulfate.

(2)

1 .....

.....

2 .....

.....

(Total for Question 6 = 5 marks)

5 A student investigates the reactivities of four metals, aluminium, magnesium, copper and metal X.

(a) The student adds pieces of magnesium ribbon to aqueous solutions of the sulfates of each metal.

After a few minutes the student removes the pieces of magnesium ribbon and records the appearance of each piece of magnesium.

Table 1 shows the student's results.

Solution	Appearance
aluminium sulfate	grey coating on magnesium
magnesium sulfate	no change
copper(II) sulfate	brown coating on magnesium
sulfate of metal X	grey coating on magnesium

Table 1

(i) Name the substance that causes the brown coating on the magnesium.

(1)

.....

(ii) State why there is no change with magnesium sulfate solution.

(1)

.....

.....

(b) The student repeats the experiment with pieces of metal X instead of pieces of magnesium.

Table 2 shows the student's results.

Solution	Appearance
aluminium sulfate	no change
magnesium sulfate	no change
copper(II) sulfate	brown coating on metal X
sulfate of metal X	no change

Table 2

(i) Use the information from both tables to deduce the order of reactivity of aluminium, magnesium, copper and metal X.

(2)

most reactive .....

.....

.....

least reactive .....

(ii) Give a possible identity for metal X.

(1)

.....

(c) This ionic equation represents the reaction between magnesium and aluminium nitrate.

$$3Mg(s) + 2Al^{3+}(aq) \rightarrow 3Mg^{2+}(aq) + 2Al(s)$$

Explain, in terms of electrons, which species acts as a reducing agent in this reaction.

(2)

.....

.....

.....

.....

(Total for Question 5 = 7 marks)

3 This question is about metals.

(a) Metals can be arranged in a reactivity series based on their reactions with water and their reactions with dilute hydrochloric acid.

The table shows how four metals, P, Q, R and S, react with water and with dilute hydrochloric acid.

Metal	Reaction with water	Reaction with dilute hydrochloric acid
P	no reaction	hydrogen gas forms very slowly
Q	no reaction	no reaction
R	hydrogen gas forms very quickly	not done
S	hydrogen gas forms quickly	hydrogen gas forms very quickly

(i) Identify which of the metals P, Q, R or S could be gold.

(1)

.....

(ii) Suggest why the reaction between metal R and dilute hydrochloric acid was not done.

(1)

.....

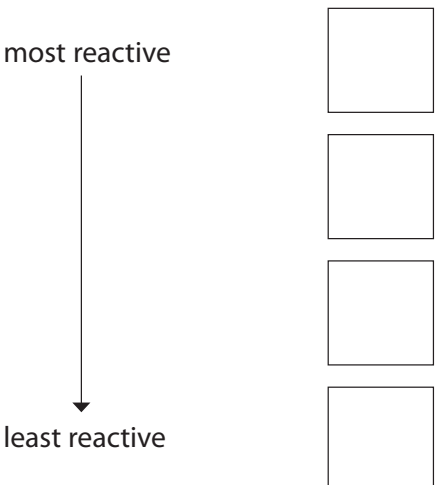
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(iii) Use the information in the table to place the metals in order of reactivity from most reactive to least reactive.

(1)

most reactive



least reactive

(b) Zinc is used to coat iron gates to prevent the iron from rusting.

(i) State the name of this method of preventing iron from rusting.

(1)

.....

(ii) State another method of preventing iron from rusting.

(1)

.....

(c) A mixture of zinc powder and copper(II) oxide is heated.

The chemical equation for the reaction that takes place is

$$Zn + CuO \rightarrow ZnO + Cu$$

(i) State how the reaction shows that zinc is more reactive than copper.

(1)

.....

.....

(ii) Explain which substance is the oxidising agent.

(2)

.....

.....

.....

.....

(Total for Question 3 = 8 marks)

2 This question is about the reactions of iron.

(a) Iron rusts when exposed to water and oxygen.

(i) Give the chemical name of the compound that forms when iron rusts.

(1)

.....

(ii) What type of reaction occurs when iron rusts?

(1)

☒ **A** combustion

☒ **B** decomposition

☒ **C** neutralisation

☒ **D** oxidation

(iii) Galvanising is a method used to prevent iron from rusting.

Give the name of the metal used to galvanise iron.

(1)

.....

(b) When iron reacts with dilute sulfuric acid, the products are iron(II) sulfate and hydrogen.

(i) Give a chemical equation for the reaction between iron and sulfuric acid.

(1)

.....

(ii) Give a test for hydrogen.

(1)

.....

.....

(c) An excess of iron is added to copper(II) sulfate solution.

(i) Name the type of reaction that occurs.

(1)

.....

(ii) State the appearance of the solid that forms in the reaction.

(1)

.....

(d) Give the reason why no reaction occurs when iron is added to magnesium sulfate solution.

(1)

.....

.....

(Total for Question 2 = 8 marks)

2 This question is about the reactivities of metals.

(a) The table shows the reactions of four metals, P, Q, R and S, with water and with dilute hydrochloric acid.

The letters are not the symbols of the elements.

Metal	Reaction with water	Reaction with dilute hydrochloric acid
P	no reaction	no reaction
Q	very fast reaction	(not done)
R	no reaction	slow reaction
S	slow reaction	fast reaction

(i) Deduce the order of reactivity of the metals.

(1)

most reactive .....

.....

.....

least reactive .....

(ii) Give the letter of the metal that could be zinc.

(1)

.....

(iii) Give a word equation for the reaction between aluminium and hydrochloric acid.

(1)

.....

(iv) Give the name of a metal that could be P.

(1)

.....

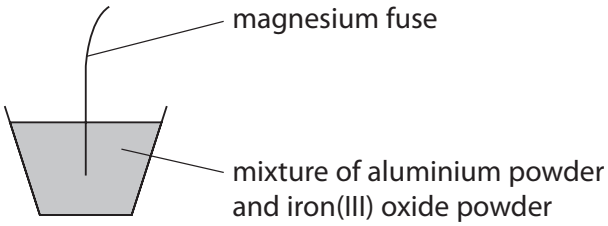
(v) Give a reason why the reaction of Q with dilute hydrochloric acid is not done.

(1)

.....

.....

(b) The diagram shows the apparatus used to demonstrate the reaction between aluminium and iron(III) oxide.



When the magnesium fuse is lit, a very exothermic reaction occurs.

This is the equation for the reaction.

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$$

(i) State what is meant by the term **exothermic**.

(1)

.....

.....

(ii) State why aluminium displaces iron.

(1)

.....

.....

(iii) Explain why this reaction is a redox reaction.

(2)

.....

.....

.....

.....

(Total for Question 2 = 9 marks)

8 (a) A piece of magnesium ribbon is ignited and placed in a gas jar of oxygen.

The equation for the reaction is

$$2Mg + O_2 \rightarrow 2MgO$$

(i) Give two observations that would be made in this reaction.

(2)

1 .....

.....

2 .....

.....

(ii) State why this is an oxidation reaction.

(1)

.....

.....

(b) A second piece of magnesium ribbon is ignited and placed in a gas jar of carbon dioxide.

A very exothermic reaction occurs, forming magnesium oxide and carbon.

(i) State what is meant by the term **exothermic**.

(1)

.....

.....

(ii) Give the chemical equation for this reaction.

(1)

.....

(iii) A fire starts in a warehouse where magnesium is stored.

Suggest why it would **not** be suitable to use a carbon dioxide fire extinguisher to put out this fire.

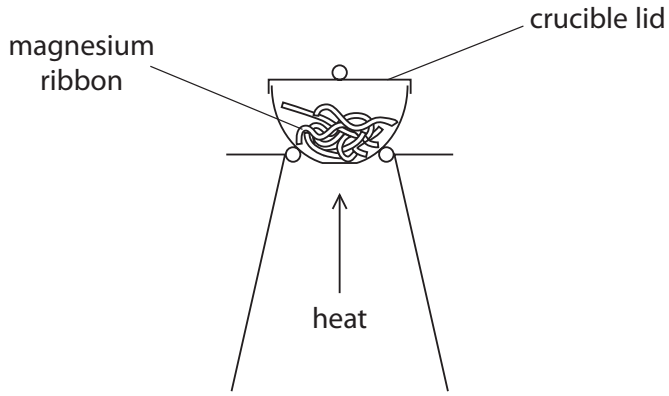
(1)

.....

.....

.....

(c) A student uses this apparatus to find the mass of magnesium oxide that forms when a known mass of magnesium is heated.



This is his method.

- find the mass of the crucible and lid
- place some magnesium ribbon in the crucible
- find the mass of the crucible, lid and magnesium
- heat the crucible with the lid on for a few minutes
- find the mass of the crucible, lid and magnesium oxide

Using this method, the mass of magnesium oxide formed is less than expected.

Explain two changes that the student should make to his method to obtain a mass of magnesium oxide closer to the expected mass.

(4)

1 .....

.....

.....

.....

2 .....

.....

.....

.....

(Total for Question 8 = 10 marks)

3 (a) The box gives the names of some metals.

calcium	copper	iron	magnesium	silver	zinc

(i) Identify the metal from the box that burns with a bright white flame.

(1)

.....

(ii) In the Earth, metals are found either in ores or as uncombined elements.

Explain which metal from the box is most likely to be found as an uncombined element.

(2)

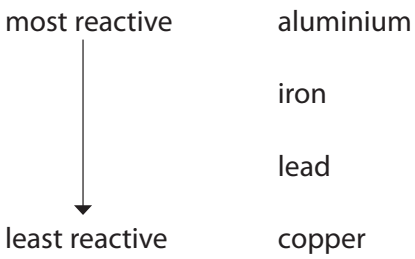
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(b) This is the order of reactivity of four metals.



The method used to obtain a metal from its oxide depends on the reactivity of the metal.

Two possible methods are

Method 1 heating the metal oxide with carbon

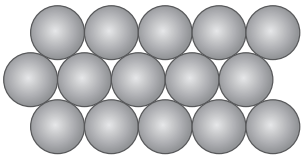
Method 2 electrolysis

Explain which method should be used to obtain lead from lead(II) oxide, PbO

Include an equation for the formation of lead in your answer.

(3)

(c) The diagram shows the arrangement of the particles in a pure metal.



Metals are often made into alloys to make them harder.

Explain why alloys are harder than pure metals.

Draw a diagram to support your answer.

(4)

(Total for Question 3 = 10 marks)

7 (a) A teacher ignites a piece of magnesium ribbon and places it in a gas jar of oxygen.

This is the equation for the reaction.

$$2Mg + O_2 \rightarrow 2MgO$$

Give two observations that would be made during this reaction.

(2)

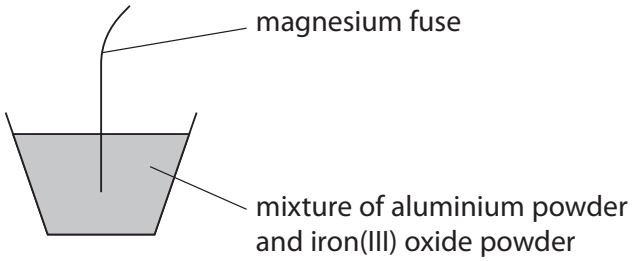
1 .....

.....

2 .....

.....

(b) The teacher demonstrates the reaction between aluminium and iron(III) oxide.



The teacher ignites the magnesium fuse. A very exothermic reaction then occurs between aluminium powder and iron(III) oxide.

The products of the reaction are iron and aluminium oxide.

(i) State what is meant by the term **exothermic**.

(1)

.....

.....

(ii) Give a chemical equation for the reaction between aluminium and iron(III) oxide.

(1)

.....

(iii) Explain why this reaction is a redox reaction.

(2)

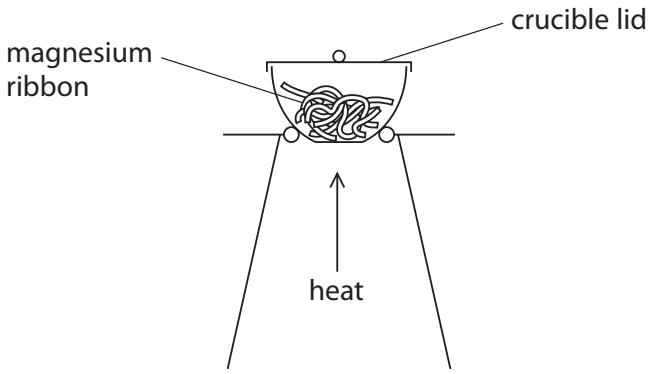
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(c) A student uses this apparatus to determine the formula of magnesium oxide.



This is the student's method.

- find mass of empty crucible and lid
- place some magnesium ribbon in crucible
- find mass of crucible, lid and magnesium ribbon
- heat crucible, lifting lid occasionally
- after five minutes, find mass of crucible, lid and magnesium oxide

(i) Explain why the student lifts the lid.

(2)

.....

.....

.....

.....

(ii) The mass of magnesium oxide formed is less than expected.

Describe what the student should do next to obtain a more accurate value for the mass of magnesium oxide.

(2)

.....

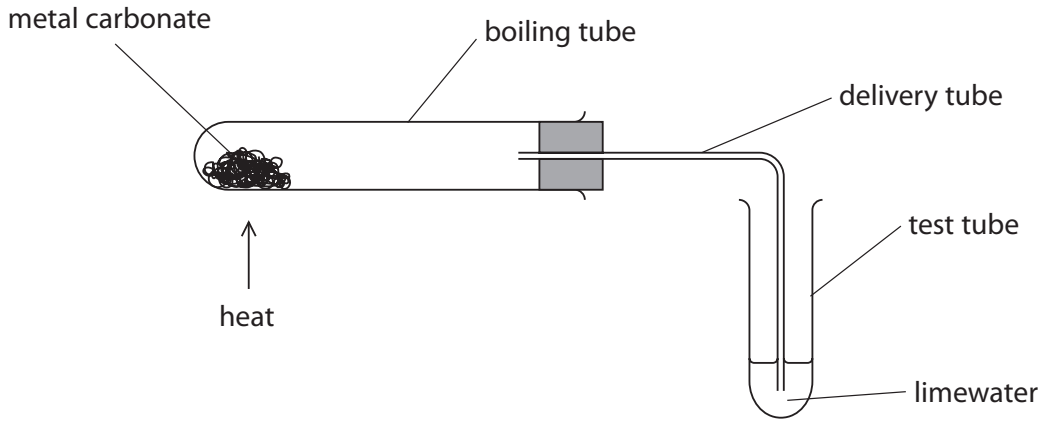
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(Total for Question 7 = 10 marks)

5 A student uses this apparatus to investigate the effect of heat on different solid metal carbonates.



This is the student's method.

- use a spatula to put some metal carbonate in the boiling tube
- fit the delivery tube into position
- pour some limewater into the test tube
- start a timer and immediately begin to heat the metal carbonate
- record the time when a change first occurs in the limewater

The student repeats the method using different metal carbonates.

When a metal carbonate is heated a reaction sometimes occurs.

The equation for the reaction is

$$\text{metal carbonate} \rightarrow \text{metal oxide} + \text{carbon dioxide}$$

(a) State the name given to this type of reaction.

(1)

.....

(b) State two variables that the student should control in this investigation.

(2)

1 .....

.....

2 .....

.....

(c) Suggest why bubbles appear in the limewater immediately after heating has started but before there is any change to the metal carbonate.

(1)

.....

.....

.....

(d) Explain the purpose of limewater in this investigation.

(2)

.....

.....

.....

.....

(e) The table shows some of the results for the student's investigation.

Metal carbonate	Colour change of solid	Time taken for any change in limewater
calcium carbonate	remains white	90 seconds
sodium carbonate	remains white	no change
copper(II) carbonate		50 seconds

(i) State the colour change that occurs for copper(II) carbonate.

(2)

from ..... to .....

(ii) Give a chemical equation for this reaction of copper(II) carbonate.

(1)

.....

(f) (i) There is a relationship between the position of a metal in the reactivity series and how easily the metal carbonate reacts when heated.

Use the student's results and your own knowledge to deduce this relationship.

(2)

.....

.....

.....

.....

(ii) State how you should extend the investigation to see if your deduction is correct.

(1)

.....

.....

(Total for Question 5 = 12 marks)

11 This question is about the reactivity of metals.

(a) Table 1 shows whether a reaction occurs between a metal and an aqueous solution of a metal sulfate.

Metal	Metal sulfate	Does a reaction occur?
manganese	chromium sulfate	yes
tin	cadmium sulfate	no
chromium	cadmium sulfate	yes

Table 1

(i) Name the type of reaction that occurs between manganese and chromium sulfate.

(1)

.....

(ii) Use the information in Table 1 to complete the order of reactivity.

(1)

most reactive — manganese

↓

.....

.....

least reactive .....

(b) Table 2 shows the colours of four metals and the colours of their metal sulfate solutions.

Metal	Colour of metal	Colour of metal sulfate solution
copper	brown	blue
iron	dark grey	green
magnesium	silvery	colourless
zinc	light grey	colourless

Table 2

When a metal is added to a metal sulfate solution there may be a colour change on the surface of the metal and in the solution.

Use the information in Table 2 and your knowledge of the reactivity series to explain any colour changes in these two experiments.

(5)

copper added to magnesium sulfate solution.....

.....

.....

.....

.....

zinc added to iron sulfate solution.....

.....

.....

.....

.....

(c) A different experiment can be used to place metals in order of reactivity.

This is the method.

Step 1 add 1 g of a metal to 25 cm^3 of dilute sulfuric acid

Step 2 measure the volume of gas produced in one minute

(i) Give two variables that should be controlled in this experiment.

(2)

1 .....

.....

2 .....

.....

(ii) A small piece of calcium is added to some dilute sulfuric acid in a beaker.

One of the products of the reaction, calcium sulfate, is insoluble in water.

Suggest why the reaction stops after a short time, even though the beaker still contains calcium and dilute sulfuric acid.

(1)

.....

.....

(d) 1.00 g of aluminium is added to 0.0600 mol of dilute sulfuric acid.

The equation for the reaction is

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Show by calculation that the sulfuric acid is in excess.

(2)

(Total for Question 11 = 12 marks)

SUB-TOPIC 2e

EXTRACTION AND USES OF METALS

Sub-topic 2e · 19 questions · 169 marks · lowest tariff first

1 (a) Two substances are needed to cause iron to rust.

Name these two substances.

(2)

1 .....

2 .....

(b) The box gives the names of some substances.

calcium	copper	gold
iodine	methane	zinc

Use words from the box to answer these questions.

(i) Give the name of a non-metallic element.

(1)

.....

(ii) Give the name of a compound.

(1)

.....

(iii) Give the name of the metal that is lowest in the reactivity series.

(1)

.....

(Total for Question 1 = 5 marks)

2 Structures made of iron can rust.

(a) (i) Name the two substances that cause iron to rust.

(2)

1 .....

2 .....

(ii) State a barrier method that prevents rusting.

(1)

.....

(b) Explain how sacrificial protection prevents the rusting of iron.

(2)

.....

.....

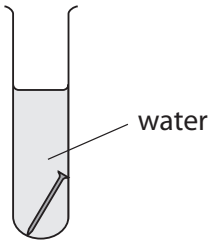
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(Total for Question 2 = 5 marks)

2 A student investigates the rusting of iron.

(a) She places an iron nail in a test tube of water and leaves it for several days.



(i) Predict the appearance of the iron nail after several days.

(1)

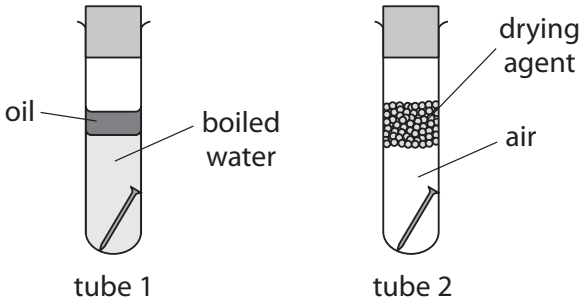
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(ii) Name the main compound in rust.

(1)

.....

(b) The student then sets up two more test tubes containing iron nails.



Explain why the iron nail in tube 1 and the iron nail in tube 2 do not rust.

(4)

tube 1 .....

.....

.....

.....

tube 2 .....

.....

.....

.....

(Total for Question 2 = 6 marks)

3 (a) The box gives the names of some metals.

aluminium	calcium	gold	magnesium	silver	zinc

Use words from the box to answer these questions.

(i) Identify the metal that burns with a bright white flame.

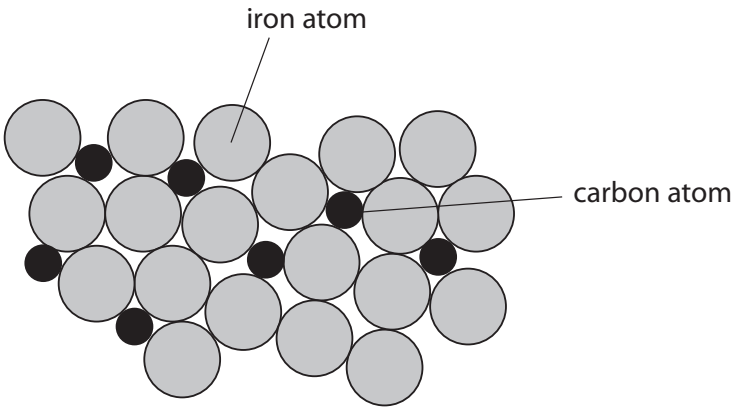
(1)

(ii) Explain which metal is most likely to be found in the Earth as an uncombined element.

(2)

(b) Steel is an alloy of iron and carbon.

The diagram shows how the particles are arranged in steel.



(i) State what is meant by the term **alloy**.

(1)

(ii) Explain why an alloy is less malleable than a pure metal.

(2)

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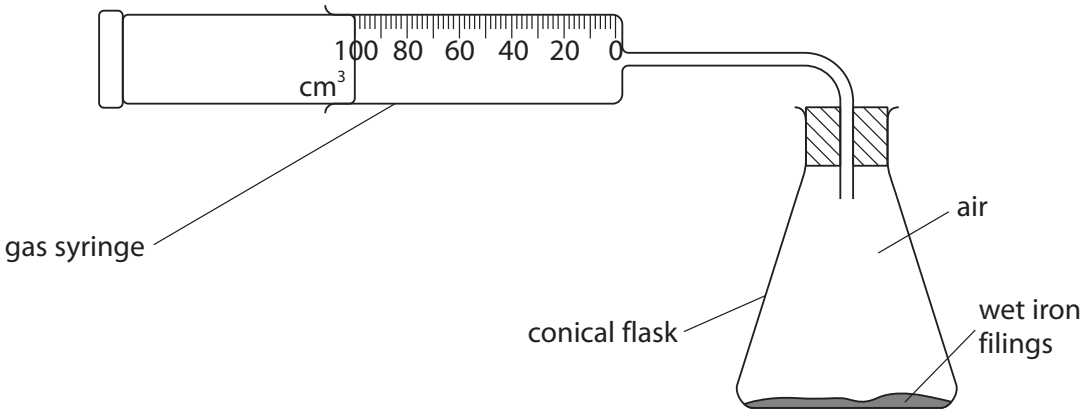
(Total for Question 3 = 6 marks)

4 This question is about rusting.

(a) When iron rusts, it reacts with oxygen in the air.

A student uses the rusting of iron to find the percentage of oxygen in a sample of air.

The diagram shows the apparatus.



These are the student's results.

volume of air in conical flask and connecting tube = 265 cm^3

volume of air in gas syringe at start = 100 cm^3

volume of air in gas syringe at end = 25 cm^3

Calculate the percentage of oxygen in the sample of air using the student's results.

(3)

percentage of oxygen = ... %

(b) (i) Cars are painted to prevent the iron in car bodies from rusting.

Explain how painting prevents the iron in car bodies from rusting.

(2)

.....

.....

.....

.....

(ii) Some car manufacturers use paint containing tiny particles of zinc.

Explain how particles of zinc prevent iron in car bodies from rusting even when this paint is scratched.

(2)

.....

.....

.....

.....

(Total for Question 4 = 7 marks)

3 This question is about the rusting of iron.

(a) Water is needed for iron to rust.

(i) Name one other substance needed for iron to rust.

(1)

.....

(ii) Give the chemical name for rust.

(1)

.....

(b) The diagram shows two methods used to prevent iron from rusting.



Method A Method B

Method A will only work if the plastic coating is not damaged.

Method B will work even when the zinc coating is damaged.

(i) Explain how method A prevents iron from rusting.

(2)

.....

.....

.....

.....

(ii) Give the name of method B.

(1)

.....

(iii) Explain how method B prevents iron from rusting even when the zinc coating is damaged.

(2)

.....

.....

.....

.....

(Total for Question 3 = 7 marks)

2 This question is about the rusting of iron.

(a) Oxygen is needed for iron to rust.

(i) Name one other substance needed for iron to rust.

(1)

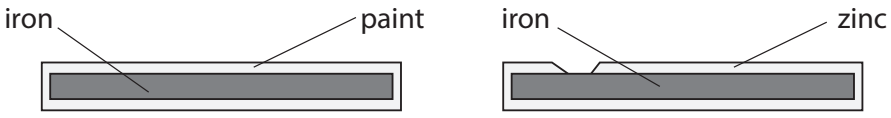
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(ii) Give the chemical name for rust.

(1)

.....

(b) The diagram shows method A and method B, which are both used to prevent iron from rusting.



Method A **Method B**

(i) Describe how method A prevents iron from rusting.

(2)

.....

.....

.....

.....

(ii) Name method B.

(1)

.....

(iii) Explain how method B prevents iron from rusting even when the zinc layer is damaged.

(2)

.....

.....

.....

.....

(Total for Question 2 = 7 marks)

3 This question is about aluminium.

(a) State why aluminium cannot be extracted by heating aluminium oxide with carbon.

(1)

.....

.....

(b) Aluminium is a metal with many uses.

Aluminium is malleable, a good conductor of heat and electricity, and has a low density compared to most other metals.

Explain two uses of aluminium that are related to its properties.

(4)

1 .....

.....

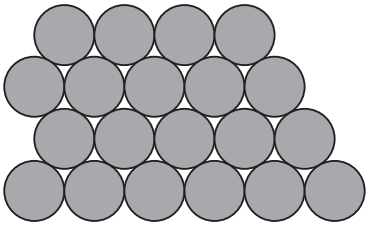
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2 .....

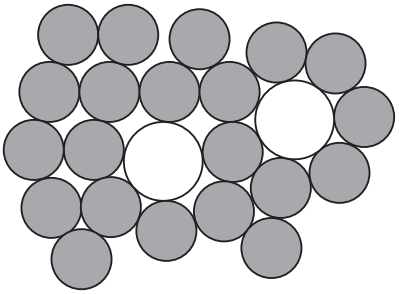
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(c) The diagram represents the structure of pure aluminium, and the structure of an alloy of aluminium.



Pure aluminium



Alloy of aluminium

Use the diagram to explain why the alloy is harder than pure aluminium.

(3)

(Total for Question 3 = 8 marks)

3 This question is about the rusting of iron.

(a) (i) Name the two substances needed for iron to rust.

(2)

1 .....

2 .....

(ii) Give the chemical name for rust.

(1)

.....

(b) The diagram shows two methods used to prevent iron from rusting.



Method A **Method B**

Method A will work only if the paint coating is **not** scratched.

Method B will work even if the zinc coating is scratched.

(i) Explain how method A prevents iron from rusting.

(2)

.....

.....

.....

.....

(ii) Give the name of method B.

(1)

.....

(iii) Explain how method B prevents iron from rusting even when the zinc coating is scratched.

(2)

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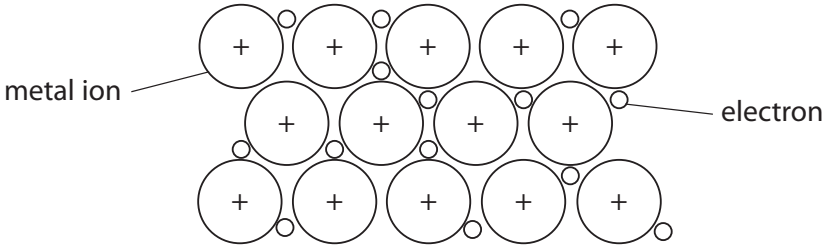
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(Total for Question 3 = 8 marks)

2 This question is about metals and metal compounds.

(a) All metals are malleable and good conductors of electricity.

The diagram shows the structure of a metal.



(i) Explain why metals are malleable.

(2)

(ii) Explain why metals are good conductors of electricity.

(2)

(b) Two methods of obtaining a metal from a compound are electrolysis and extraction using carbon.

Explain, without giving practical details, which method is most suitable for extracting iron from iron(III) oxide.

(2)

(c) A student has a solution of iron(II) sulfate and a solution of iron(III) sulfate.

Describe a chemical test the student could use to identify which solution is iron(II) sulfate.

(2)

(Total for Question 2 = 8 marks)

2 This question is about rusting.

(a) A simplified formula for rust is Fe_2O_3

(i) Name the two substances needed for iron to rust.

(2)

1 .....

2 .....

(ii) Give the chemical name for rust.

(1)

.....

(iii) What type of reaction occurs in the rusting of iron?

(1)

☒ **A** combustion

☒ **B** neutralisation

☒ **C** oxidation

☒ **D** thermal decomposition

(b) Some iron objects are coated with a layer of zinc to prevent rusting.

(i) Name this type of rust prevention.

(1)

.....

(ii) Explain how this type of rust prevention continues to protect iron when the layer of zinc is damaged.

(2)

.....

.....

.....

.....

.....

(iii) Give two other methods used to prevent iron from rusting.

(2)

1 .....

.....

2 .....

.....

(Total for Question 2 = 9 marks)

6 Titanium is an important metal in industry.

Titanium dioxide (TiO_2) can be converted into titanium metal in two stages.

Stage 1 titanium dioxide is converted into titanium(IV) chloride ($TiCl_4$)

Stage 2 titanium(IV) chloride is converted into titanium

(a) This is the equation for the reaction in stage 1.

$$TiO_2 + 2Cl_2 + C \rightarrow TiCl_4 + CO_2$$

Calculate the volume, in dm^3, of chlorine gas at rtp needed to react completely with 20 tonnes of titanium dioxide.

Give your answer in standard form.

[1 tonne = 10^6 g M_r of TiO_2 = 80]

[molar volume of chlorine gas at rtp = 24 dm^3]

(4)

volume of chlorine gas = ... dm^3

(b) In stage 2, titanium(IV) chloride vapour is passed through molten magnesium in a container filled with argon.

This is the equation for the reaction in stage 2.

$$TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$$

Explain why the container is filled with argon rather than air.

(2)

(c) Aeroplanes are made of an alloy containing aluminium and titanium.

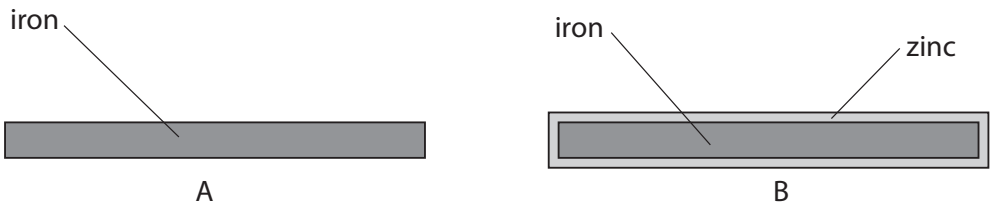
Explain why the alloy is stronger than pure titanium metal.

You may include diagrams in your answer.

(3)

(Total for Question 6 = 9 marks)

3 The diagram shows two samples of iron, A and B.



Sample B is coated with a thin layer of zinc.

(a) Name the process used to coat iron with zinc.

(1)

.....

(b) The two samples of iron are left outside for several weeks.

A brown solid containing hydrated iron(III) oxide forms on sample A.

(i) Give the common name for the brown solid.

(1)

.....

(ii) Give the names of the two substances that react with the iron to form the brown solid.

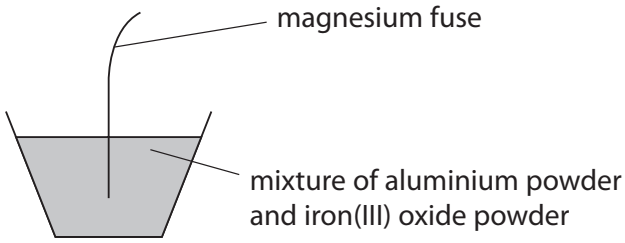
(2)

1 .....

2 .....

(c) Iron can be formed by reacting aluminium powder with iron(III) oxide.

The diagram shows how this reaction can be demonstrated.



When the magnesium fuse is lit, a very exothermic reaction occurs.

(i) State the meaning of the term **exothermic**.

(1)

(ii) The equation for the reaction between aluminium and iron(III) oxide is

$$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$$

Explain what this reaction shows about the relative reactivities of aluminium and iron.

(2)

(iii) Explain why the reaction between aluminium and iron(III) oxide is a redox reaction.

(3)

(Total for Question 3 = 10 marks)

5 This question is about the metal aluminium.

(a) (i) Draw a labelled diagram to represent the structure and bonding in a metal.

(2)

(ii) Explain why a metal conducts electricity.

(2)

.....

.....

.....

.....

(b) Aluminium is used to make cans for drinks.



Give two properties of aluminium that make it suitable for this use.

(2)

1 .....

.....

2 .....

.....

(c) Aluminium is extracted from aluminium oxide (Al_2O_3) by electrolysis.

The electrolyte is aluminium oxide dissolved in molten cryolite.

(i) State why aluminium cannot be extracted by heating aluminium oxide with carbon.

(1)

.....

.....

(ii) Aluminium is produced at the negative electrode.

The ionic half-equation for the reaction is

$$Al^{3+} + 3e^- \rightarrow Al$$

State why this is a reduction reaction.

(1)

.....

.....

(iii) Complete the ionic half-equation for the reaction at the positive electrode.

(2)

..... $O^{2-} \rightarrow$ ..... + ...

(Total for Question 5 = 10 marks)

5 Metals are found in the Earth's crust either as uncombined elements or in metal compounds in rocks.

The method of extraction of a metal is related to its position in the reactivity series.

The table shows the positions of some metals and carbon in the reactivity series.

most reactive	potassium
↑	sodium
	lithium
	calcium
	magnesium
	aluminium
	carbon
	zinc
	iron
	lead
	copper
	silver
	gold
least reactive	platinum

(a) (i) State the name given to rocks that contain metal compounds used in the extraction of metals.

(1)

.....

(ii) Name a metal that is found as an uncombined element in the Earth's crust.

(1)

.....

(b) Carbon extraction and electrolysis are two methods of obtaining a metal from a compound.

(i) Explain, without giving practical details, which method is most suitable to obtain calcium from calcium chloride.

(2)

(ii) Explain, without giving practical details, which method is most suitable to obtain lead from lead oxide.

(2)

(c) Explain, using a labelled diagram, why lead metal is malleable.

(3)

(d) Aluminium is extracted from aluminium oxide.

The overall equation for the process is

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Calculate the maximum mass, in grams, of aluminium that could be obtained from 1.275 kg of aluminium oxide.

(3)

mass = ... g

(Total for Question 5 = 12 marks)

5 This question is about iron.

(a) One problem with iron is that it rusts.

(i) Name the two substances that iron reacts with when it rusts.

(2)

1 .....

2 .....

(ii) State what type of reaction occurs when iron rusts.

(1)

.....

(b) Iron can be prevented from rusting by painting or by coating with zinc.

(i) Explain how painting prevents iron from rusting.

(2)

.....

.....

.....

.....

(ii) Name the process used to coat iron with zinc.

(1)

.....

(iii) Explain why a layer of zinc protects iron from rusting, even if the layer of zinc is scratched.

(2)

(c) Iron is formed when aluminium reacts with iron(III) oxide.

This is the equation for the reaction.

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$

(i) Explain what this reaction shows about the relative reactivities of aluminium and iron.

(2)

(ii) Explain which substance acts as an oxidising agent in this reaction.

(2)

(Total for Question 5 = 12 marks)

6 Iron metal was discovered several thousand years ago. Iron is produced industrially from iron(III) oxide by extraction using carbon.

Sodium is a metal in Group 1 of the Periodic Table. Sodium was discovered by Sir Humphrey Davy in 1807. It is produced industrially by the electrolysis of sodium chloride.

(a) (i) Explain, using the reactivity series, why carbon can be used to extract iron from iron(III) oxide.

(2)

.....

.....

.....

.....

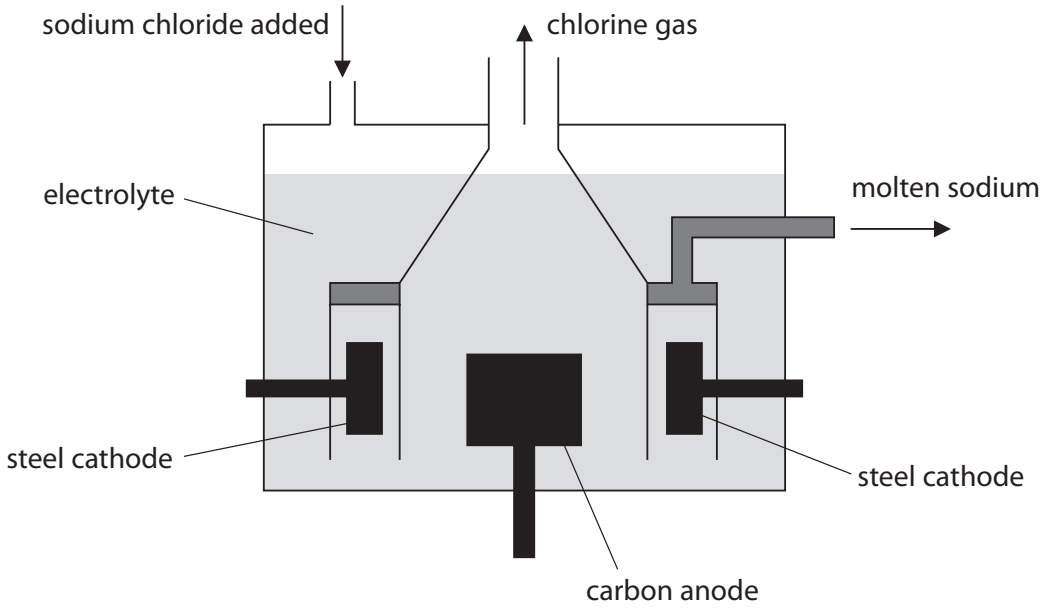
(ii) Suggest why sodium was not discovered until 1807.

(1)

.....

.....

(b) The diagram shows a simplified version of the Downs cell, which can be used to produce sodium industrially. The electrolyte is molten sodium chloride.



(i) Explain why the molten electrolyte conducts electricity.

(2)

.....

.....

.....

.....

(ii) What is the formula of the cation in the electrolyte?

(1)

☒ **A** H^+

☒ **B** Cl^-

☒ **C** Na^+

☒ **D** OH^-

(iii) During the production of sodium, small explosions can be heard.

Explain why using sodium chloride that is not completely dry could cause these small explosions.

(2)

.....

.....

.....

.....

(iv) Give ionic half-equations for the reactions at the anode and cathode.

(2)

anode .....

cathode .....

(c) Explain why the reactivity of metals in Group 1 increases from lithium to potassium.

(3)

(Total for Question 6 = 13 marks)

6 (a) When iron rusts, iron(III) oxide forms.

State two conditions needed for iron to rust.

(2)

1 .....

2 .....

(b) What is the name of the process used to coat iron with zinc?

(1)

☒ **A** galvanisation

☒ **B** oxidation

☒ **C** reduction

☒ **D** sacrificial protection

(c) What is the correct order of reactivity of these four metals?

(1)

		most reactive →			**least reactive**
☒	**A**	aluminium	copper	iron	zinc
☒	**B**	aluminium	iron	zinc	copper
☒	**C**	aluminium	zinc	iron	copper
☒	**D**	zinc	aluminium	iron	copper

(d) Describe a test to show that a solution contains Fe^{3+} ions.

(2)

test

.....

.....

result

.....

.....

(e) A sample of iron(III) oxide reacts with excess carbon monoxide.

This is the equation for the reaction.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(i) Explain why this is a redox reaction.

(2)

.....

.....

.....

.....

(ii) Calculate the minimum mass of iron(III) oxide needed to produce a theoretical yield of 28 g of iron.

[for Fe_2O_3 $M_r = 160$]

(3)

minimum mass of iron(III) oxide = ... g

(iii) The actual yield of iron from this sample is 21 g.

Calculate the percentage yield of iron.

(2)

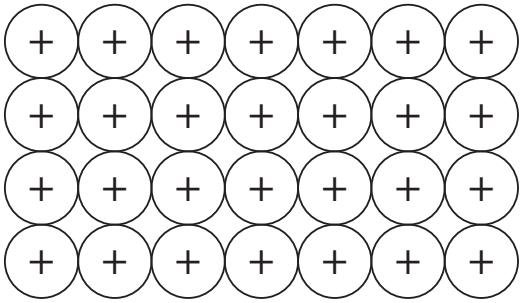
percentage yield = ... %

(Total for Question 6 = 13 marks)

5 This question is about the metal aluminium.

(a) Aluminium is malleable and conducts electricity.

The diagram shows the arrangement of the ions in aluminium metal.



(i) Explain why aluminium is malleable.

(2)

(ii) Explain why aluminium conducts electricity.

(2)

(b) Aluminium cannot be extracted by heating a mixture of carbon and aluminium oxide.

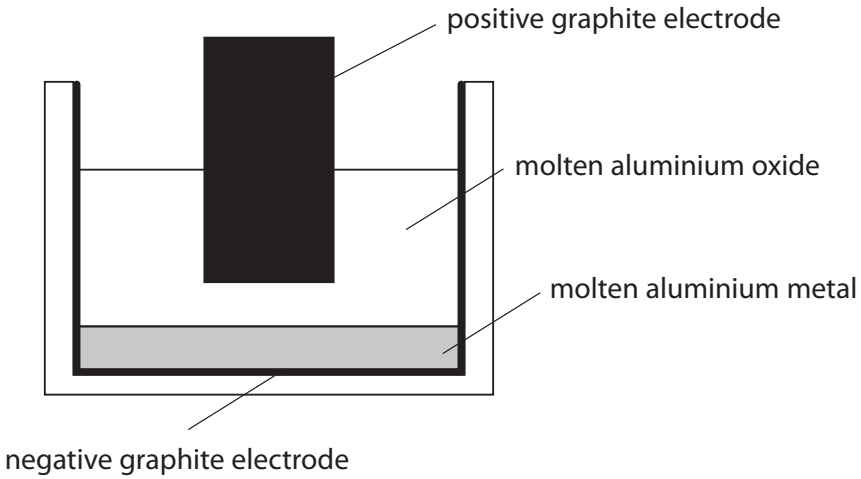
Give a reason why heating a mixture of aluminium oxide and carbon does not produce aluminium.

(1)

(c) Aluminium is extracted industrially by the electrolysis of molten aluminium oxide Al_2O_3 at a temperature of about 950 °C.

Aluminium metal forms at the negative electrode and oxygen gas forms at the positive electrode. The positive and negative electrodes are made of graphite.

The diagram shows the apparatus used.



(i) Explain how aluminium metal forms at the negative electrode.

(2)

.....

.....

.....

.....

(ii) Write an ionic half-equation for the formation of oxygen gas at the positive electrode.

(1)

..... → .....

(iii) Suggest why carbon dioxide gas is also produced at the positive electrode.

(2)

.....

.....

.....

.....

(d) Aluminium reacts with iron(III) oxide. The reaction is exothermic.

The equation for the reaction is

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe$$

(i) State how the equation shows that iron(III) oxide is reduced.

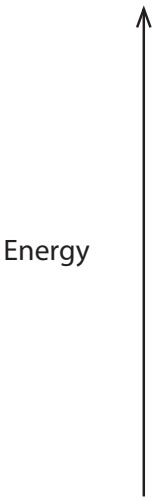
(1)

.....

.....

(ii) Draw an energy level diagram for the reaction between aluminium and iron(III) oxide.

(3)



(Total for Question 5 = 14 marks)

SUB-TOPIC 2f

ACIDS, ALKALIS AND TITRATIONS

Sub-topic 2f · 21 questions · 237 marks · lowest tariff first

1 This question is about acids, alkalis and indicators.

(a) Which of these is the colour of litmus indicator in an acidic solution?

(1)

- ☒ **A** blue
- ☒ **B** orange
- ☒ **C** red
- ☒ **D** yellow

(b) Which of these is the pH value of a neutral solution?

(1)

- ☒ **A** 0
- ☒ **B** 4
- ☒ **C** 7
- ☒ **D** 14

(c) Which of these describes a solution with a pH value of 9?

(1)

- ☒ **A** strongly acidic
- ☒ **B** strongly alkaline
- ☒ **C** weakly acidic
- ☒ **D** weakly alkaline

(d) Which of these is the chemical formula of an acid?

(1)

- ☒ **A** HNO_3
- ☒ **B** H_2O
- ☒ **C** NaCl
- ☒ **D** NaOH

(e) Name the type of reaction that occurs when an acid reacts with an alkali.

(1)

.....

(f) Name the two products of the reaction between hydrochloric acid and potassium hydroxide.

(2)

1 .....

2 .....

(Total for Question 1 = 7 marks)

7 A student investigates the reaction between sodium hydroxide solution and hydrochloric acid.

He uses this method.

Step 1 add 50 cm^3 of dilute hydrochloric acid to a conical flask

Step 2 add a 5 cm^3 portion of sodium hydroxide solution to the conical flask

Step 3 test the pH of the mixture using both universal indicator paper and a pH meter

The student repeats step 2 and step 3 until a total of 50 cm^3 of sodium hydroxide solution has been added.

(a) (i) State the piece of apparatus that should be used to measure 50 cm^3 of hydrochloric acid.

(1)

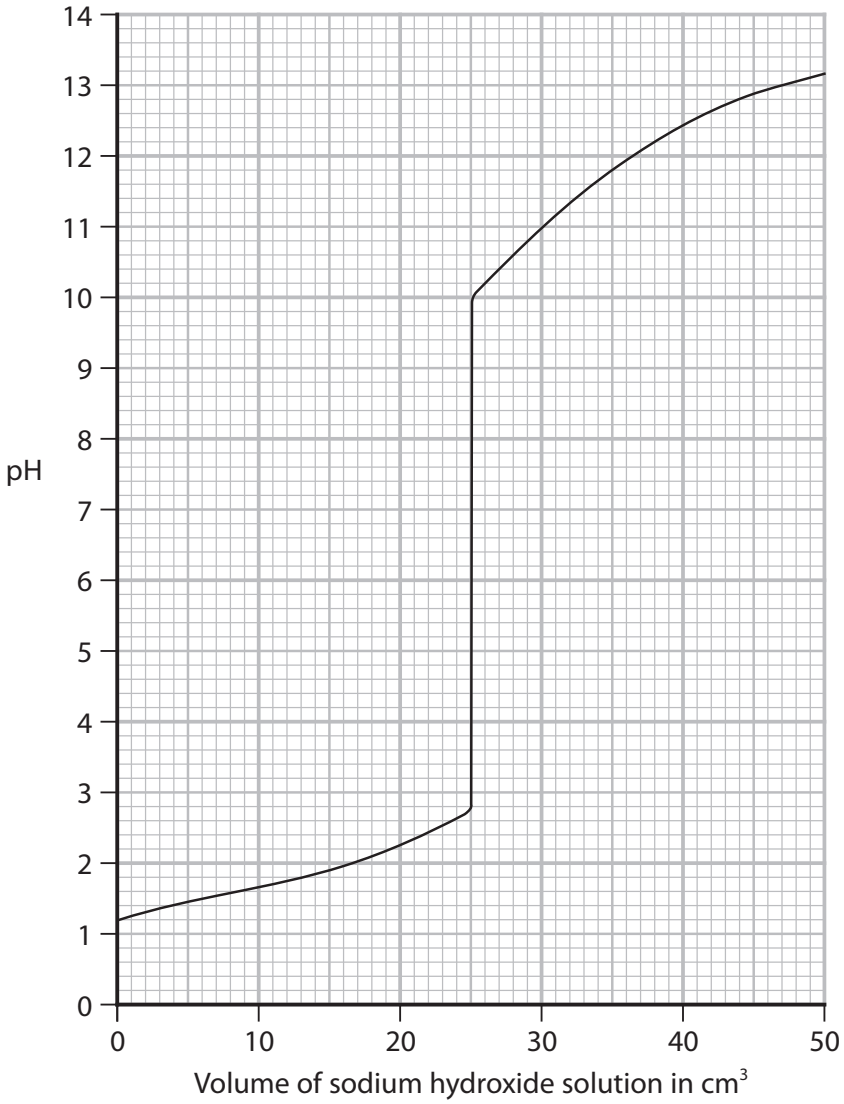
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(ii) Name the type of reaction that occurs between hydrochloric acid and sodium hydroxide.

(1)

.....

(b) Graph 1 shows how the pH of the mixture changes as the sodium hydroxide solution is added.



Graph 1

(i) Determine the pH after 40 cm^3 of sodium hydroxide solution has been added.

(1)

.....

(ii) Suggest the colour of the universal indicator paper when these volumes of sodium hydroxide solution have been added.

(2)

15 cm^3 .....

30 cm^3 .....

(iii) Give the formula of the ion that causes sodium hydroxide to be alkaline.

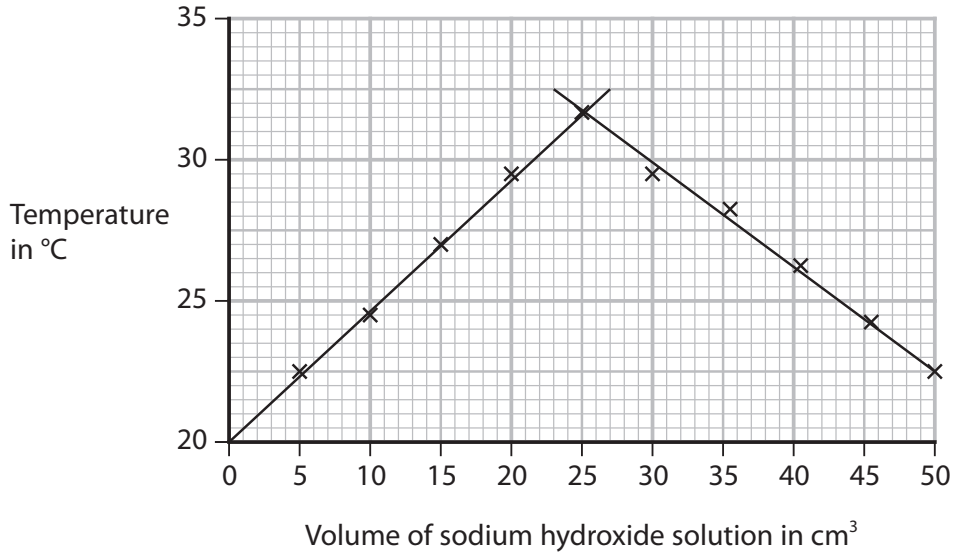
(1)

(c) Another student investigates how the temperature changes when the sodium hydroxide solution is added to the hydrochloric acid.

The hydrochloric acid and the sodium hydroxide solution are at the same temperature at the start of the investigation.

The student records the temperature of the mixture after adding each 5 cm^3 portion of sodium hydroxide solution.

Graph 2 shows her results.



Graph 2

Explain the shape of graph 2.

(3)

(Total for Question 7 = 9 marks)

4 A student investigates the reaction between sodium hydroxide solution and dilute sulfuric acid.

He does a titration to find the concentration of the sulfuric acid.

This is his plan for the titration. There are some mistakes and omissions in his plan.

- rinse a conical flask with the sodium hydroxide solution
- use a measuring cylinder to measure out 25 cm^3 of the sodium hydroxide solution and add it to the conical flask
- add a few drops of methyl orange indicator to the conical flask
- rinse a burette with water and then fill it with the sulfuric acid
- add the acid from the burette to the conical flask until the indicator changes colour at the end-point of the titration
- record the final burette reading

(a) Give the colour change of the methyl orange indicator at the end-point.

(2)

from ..... to .....

(b) Describe four changes that the student could make to improve his plan.

(4)

1 .....

.....

.....

2 .....

.....

.....

3 .....

.....

.....

4 .....

.....

.....

(c) The student then does the titration correctly.

He finds that 16.70 cm^3 of the dilute sulfuric acid neutralises 25.0 cm^3 of sodium hydroxide solution of concentration 0.200 mol/dm^3

The equation for the reaction is

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

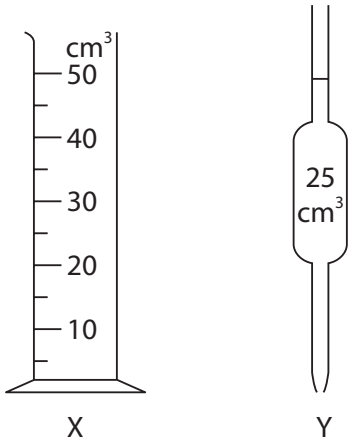
Calculate the concentration, in mol/dm^3, of the sulfuric acid.

(3)

concentration of sulfuric acid = ... mol/dm^3

(Total for Question 4 = 9 marks)

2 (a) The diagram shows two pieces of apparatus, X and Y.



(i) Give the name of each piece of apparatus.

(2)

X .....

Y .....

(ii) In a titration, a student adds 25.0 cm^3 of barium hydroxide solution to a conical flask.

Give a reason why it is better to use Y rather than X.

(1)

.....

.....

(b) The student uses methyl orange indicator in the titration.

(i) State the colour of methyl orange in barium hydroxide solution.

(1)

.....

(ii) Give a reason why universal indicator is **not** suitable for use in a titration.

(1)

.....

.....

.....

(c) The student adds some dilute nitric acid to a burette and does the titration.

The equation for the reaction is

$$Ba(OH)_2 + 2HNO_3 \rightarrow Ba(NO_3)_2 + 2H_2O$$

The student finds that 21.50 cm^3 of nitric acid of concentration 0.600 mol/dm^3 neutralises 25.0 cm^3 of barium hydroxide solution.

Calculate the concentration, in mol/dm^3, of the barium hydroxide solution.

(3)

concentration = ... mol/dm^3

(d) State why sulfuric acid would not be a suitable acid to use in this titration.

(1)

.....

.....

(Total for Question 2 = 9 marks)

4 Sodium hydroxide dissolves in water, forming a strongly alkaline solution.

Ammonia dissolves in water, forming a slightly less alkaline solution.

(a) (i) Identify the ion that makes the sodium hydroxide solution alkaline.

(1)

.....

(ii) What is a possible pH of ammonia solution?

(1)

☒ **A** 3

☒ **B** 6

☒ **C** 11

☒ **D** 14

(b) When ammonia solution reacts with sulfuric acid, a neutralisation reaction occurs and ammonium sulfate forms.

(i) How does the sulfuric acid act in this reaction?

(1)

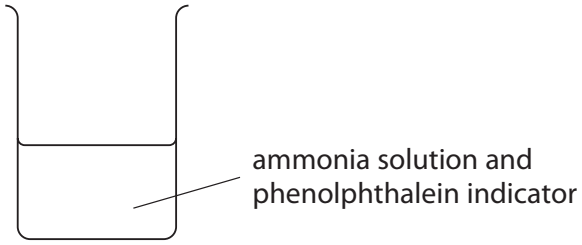
☒ **A** as a neutron donor

☒ **B** as a neutron acceptor

☒ **C** as a proton donor

☒ **D** as a proton acceptor

(ii) The diagram shows a beaker containing some ammonia solution and a few drops of phenolphthalein indicator.



Dilute sulfuric acid is added to the beaker until it is in excess.

What are the colours of the phenolphthalein indicator before and after adding excess sulfuric acid?

(1)

	Before	After
☒ **A**	orange	red
☒ **B**	yellow	red
☒ **C**	pink	colourless
☒ **D**	colourless	pink

(c) Ammonium sulfate is used by gardeners as a fertiliser because it contains nitrogen.

(i) Explain why the chemical formula of ammonium sulfate is $(NH_4)_2SO_4$

Refer to the charges on the ions in your answer.

(2)

.....

.....

.....

.....

(ii) Calculate the relative formula mass of ammonium sulfate, $(NH_4)_2SO_4$

(1)

relative formula mass = ...

(iii) Calculate the mass, in grams, of nitrogen in 1.0 kg of ammonium sulfate.

(3)

mass = ... g

(Total for Question 4 = 10 marks)

6 A student does a titration using dilute sulfuric acid to find the concentration of a solution of potassium hydroxide.

The student adds 25.0 cm^3 of the potassium hydroxide solution to a conical flask. He then adds a few drops of methyl orange indicator.

The student does the titration four times.

(a) (i) Name the piece of apparatus the student should use to add the potassium hydroxide solution.

(1)

.....

(ii) What is the colour of methyl orange in an alkaline solution?

(1)

- ☒ **A** blue
- ☒ **B** orange
- ☒ **C** red
- ☒ **D** yellow

(b) The table shows the student's results.

titration	1	2	3	4
volume of acid added in cm^3	20.65	20.60	20.90	20.55
concordant results				

Concordant results are those within 0.20 cm^3 of each other.

(i) Place ticks (✓) in the table to show which results are concordant.

(1)

(ii) Use the concordant results to calculate the mean (average) volume of acid added.

(2)

mean volume = ... cm^3

(c) This table shows the student's results for another titration.

volume of potassium hydroxide solution used in cm^3	25.0
concentration of potassium hydroxide solution in mol/dm^3	0.0370
mean volume of sulfuric acid added in cm^3	21.20

The equation for the reaction is

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

(i) Calculate the amount, in moles, of KOH in 25.0 cm^3 of the potassium hydroxide solution.

(2)

amount of KOH = ... mol

(ii) Calculate the amount, in moles, of H_2SO_4 in 21.20 cm^3 of sulfuric acid.

(1)

amount of H_2SO_4 = ... mol

(iii) Calculate the concentration, in mol/dm^3, of the sulfuric acid.

(2)

concentration of sulfuric acid = ... mol/dm^3

(Total for Question 6 = 10 marks)

10 A student investigates how the electrical conductivity changes as dilute sulfuric acid is added to barium hydroxide solution.

This is the student's method.

Step 1 add 50.0 cm^3 of barium hydroxide solution to a beaker

Step 2 measure the electrical conductivity of the solution

Step 3 add 10.0 cm^3 of dilute sulfuric acid to the beaker

Step 4 stir the mixture

Step 5 measure the electrical conductivity of the mixture

Step 6 repeat steps 3 to 5 until a total of 100 cm^3 of dilute sulfuric acid has been added

The table shows the student's results.

Total volume of acid added in cm^3	Electrical conductivity in arbitrary units
0.0	10.0
10.0	8.0
20.0	7.2
30.0	4.0
40.0	2.0
50.0	0.0
60.0	1.4
70.0	2.8
80.0	4.2
90.0	5.6
100.0	7.0

(a) (i) Name a piece of apparatus the student could use to add 10.0 cm^3 of dilute sulfuric acid to the beaker.

(1)

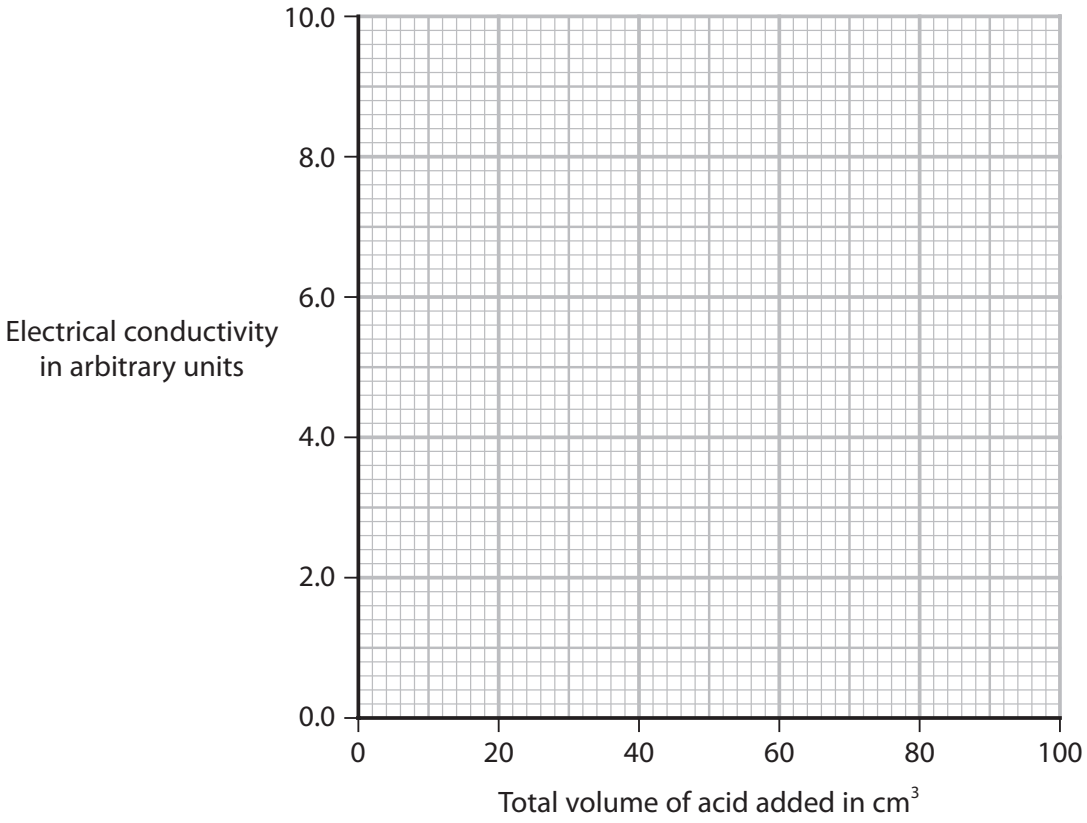
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(ii) Plot the student's results.

(2)

(iii) Ignoring the anomalous result, draw two lines of best fit, making sure that the two lines cross.

(1)



(iv) Give the trend shown on the graph for the first 50 cm^3 of acid added.

(1)

.....

.....

(v) Suggest a mistake the student could have made to cause the anomalous result.

(1)

.....

.....

(b) This is the equation for the reaction.

$$Ba(OH)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H_2O(l)$$

(i) When 50 cm^3 of dilute sulfuric acid have been added, only barium sulfate and water are present in the mixture.

Explain why this mixture does not conduct electricity.
Refer to the type of bonding in barium sulfate and in water in your answer.

(3)

(ii) Name a technique the student could use to separate barium sulfate from the mixture after 100 cm^3 of dilute sulfuric acid has been added.

(1)

(Total for Question 10 = 10 marks)

9 This question is about some compounds of the elements in Group 4 of the Periodic Table.

(a) When carbon dioxide dissolves in water, a weak acid forms.

(i) Which of these could be the pH of this weak acid?

(1)

☒ **A** 1

☒ **B** 5

☒ **C** 7

☒ **D** 9

(ii) Which of these is a correct statement about acids?

(1)

☒ **A** acids contain OH^- ions

☒ **B** acids are electron donors

☒ **C** acids are proton acceptors

☒ **D** acids are proton donors

(b) When lead(II) carbonate is heated, lead(II) oxide and carbon dioxide form.

(i) Give the name of this type of reaction.

(1)

.....

(ii) Complete the equation for this reaction.

(1)

$PbCO_3 \rightarrow$ ..... + ...

(c) Silicon dioxide, SiO_2, and silicon(IV) chloride, $SiCl_4$, are both covalently bonded compounds.

The table shows the melting and boiling points of these two compounds, and the physical state of silicon dioxide at room temperature.

Compound	Melting point in °C	Boiling point in °C	Physical state at room temperature
SiO_2	1710	2230	solid
$SiCl_4$	–69	58	

(i) Complete the table by giving the physical state of silicon(IV) chloride at room temperature.

(1)

(ii) Explain, in terms of structure and bonding, why silicon dioxide has a much higher melting point than silicon(IV) chloride.

(6)

(Total for Question 9 = 11 marks)

6 A student is provided with a bottle containing a colourless solution X.

Solution X is thought to be dilute sulfuric acid of concentration 0.10 mol/dm^3.

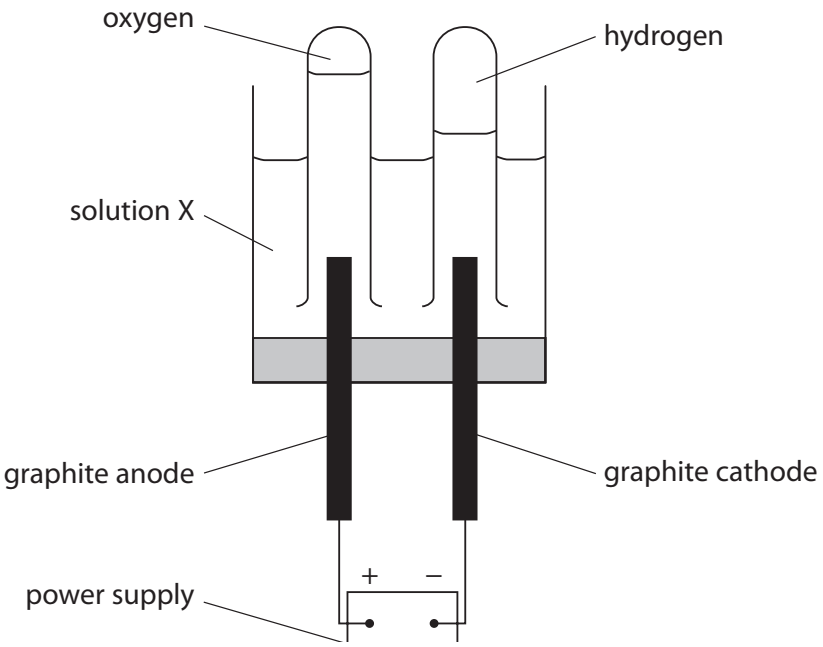
The student does some experiments on samples of solution X to try to show that it is dilute sulfuric acid.

The student adds a few drops of litmus to a sample of solution X.

The litmus turns red.

(a) The student knows that the products of the electrolysis of dilute sulfuric acid are hydrogen and oxygen.

She carries out the electrolysis using this apparatus.



(i) Suggest why the student does not use zinc electrodes in her experiment.

(1)

.....

.....

(ii) State what is observed at both the anode and the cathode during the electrolysis.

(1)

.....

(iii) Which of these tests shows that the gas formed at the cathode is hydrogen?

(1)

- ☒ **A** a glowing splint relights
- ☒ **B** a burning splint gives a squeaky pop
- ☒ **C** a burning splint goes out
- ☒ **D** limewater turns cloudy

(b) Describe a test to show that solution X contains sulfate ions.

(2)

.....

.....

.....

.....

(c) The student then does a titration to see if the concentration of the dilute sulfuric acid is 0.10 mol/dm^3.

She measures 25.0 cm^3 of potassium hydroxide solution into a conical flask, and then adds a few drops of indicator solution.

(i) Name the piece of apparatus the student should use to measure 25.0 cm^3 of the potassium hydroxide solution.

(1)

.....

(ii) The concentration of potassium hydroxide in the solution is 0.125 mol/dm^3.

Calculate the amount, in mol, of KOH in 25.0 cm^3 of this solution.

(2)

amount = ... mol

(iii) The equation for the reaction in the titration is

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

Calculate the volume, in cm^3, of 0.10 mol/dm^3 sulfuric acid needed to neutralise 25.0 cm^3 of the potassium hydroxide solution.

(3)

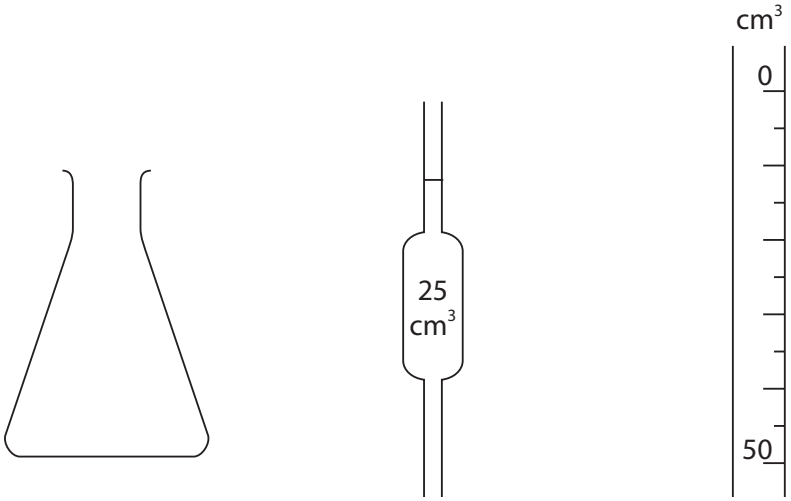
volume of sulfuric acid = ... cm^3

(Total for Question 6 = 11 marks)

3 A student does a titration to find the concentration of a solution of dilute sulfuric acid.

The student uses these solutions and this apparatus.

- dilute sulfuric acid
- potassium hydroxide solution of concentration 0.240 mol / dm^3
- methyl orange indicator



(a) The student wants to find the volume of sulfuric acid needed to neutralise 25.0 cm^3 of the potassium hydroxide solution.

Describe how the student should do this titration.

Assume that all pieces of apparatus are clean and dry.

(6)

(b) The student needs 15.00 cm^3 of sulfuric acid to neutralise 25.0 cm^3 of the potassium hydroxide solution.

This is the equation for the reaction.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

(i) Calculate the amount, in moles, of KOH in 25.0 cm^3 of potassium hydroxide solution of concentration 0.240 mol / dm^3.

(2)

amount of KOH = ... mol

(ii) Calculate the amount, in moles, of H_2SO_4 in 15.00 cm^3 of the sulfuric acid.

(1)

amount of H_2SO_4 = ... mol

(iii) Calculate the concentration, in mol / dm^3, of the sulfuric acid.

(2)

concentration of sulfuric acid = ... mol / dm^3

(Total for Question 3 = 11 marks)

7 A student is asked to find the concentration of a solution of nitric acid by doing a titration.

The student is provided with sodium hydroxide solution with a concentration of 0.350 mol/dm^3

These are the first four steps in the student's method.

- use a pipette to add exactly 25.0 cm^3 of the nitric acid solution to a conical flask placed on a white tile
- add a few drops of indicator to the flask
- use a burette to add sodium hydroxide solution to the flask until the indicator has changed colour
- record the volume needed for the indicator to change colour

(a) Give the reason for using the white tile.

(1)

.....

.....

(b) Universal indicator is not a suitable indicator to use in a titration.

Complete the table to show the name of a suitable indicator and its final colour in this titration.

(2)

Indicator	Final colour in titration

(c) The student wants to obtain an accurate value for the volume of sodium hydroxide solution needed to neutralise the 25.0 cm^3 of nitric acid.

Describe all the further steps the student should take.

(5)

(d) This is a summary of the student's results.

volume of HNO_3 used = 25.0 cm^3

concentration of NaOH solution = 0.350 mol/dm^3

volume of NaOH solution needed for neutralisation = 18.80 cm^3

The equation for the reaction is

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

(i) Calculate the amount, in moles, of NaOH that reacts.

(1)

amount of NaOH = ... mol

(ii) Determine the amount, in moles, of HNO_3 that reacts.

(1)

amount of HNO_3 = ... mol

(iii) Calculate the concentration, in mol/dm^3, of the HNO_3

(1)

concentration = ... mol/dm^3

(Total for Question 7 = 11 marks)

4 A student does a titration to find the concentration of potassium hydroxide solution.

This is the student's method.

- add 25.0 cm^3 of the potassium hydroxide solution to a conical flask
- add a few drops of methyl orange indicator to the conical flask
- fill a burette with dilute sulfuric acid and record the initial burette reading
- place the conical flask on a white tile
- add the acid from the burette to the mixture in the conical flask, swirling the flask continuously
- when the indicator changes colour at the end point, record the final burette reading

Repeat the titration to obtain concordant results.

(a) Give the name of the most suitable piece of apparatus to measure out 25.0 cm^3 of potassium hydroxide solution.

(1)

(b) Give the colour of methyl orange in potassium hydroxide solution and in dilute sulfuric acid.

(2)

colour in potassium hydroxide solution

colour in dilute sulfuric acid

(c) State why the student places the conical flask on a white tile.

(1)

(d) State why the student swirls the flask continuously.

(1)

(e) State what is meant by the term **concordant results**.

(1)

.....

.....

(f) The student finds that 15.00 cm^3 of sulfuric acid of concentration 0.180 mol/dm^3 neutralises 25.0 cm^3 of potassium hydroxide solution.

This is the equation for the reaction.

$$2KOH + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O$$

Calculate the concentration of the potassium hydroxide solution.

(3)

concentration = ... mol/dm^3

(g) This is the ionic equation for the reaction between an acid and an alkali.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

Explain why the OH^- ion is a proton acceptor in this reaction.

(2)

.....

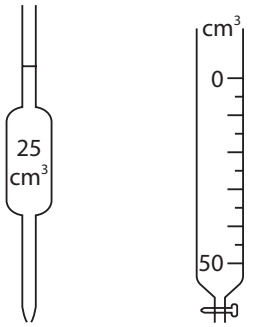
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.....

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(Total for Question 4 = 11 marks)

6 (a) The diagram shows two pieces of apparatus used in a titration.



X Y

Not to scale

Give the names of these pieces of apparatus.

(2)

X .....

Y .....

(b) Give the name of a suitable indicator that can be used in an acid-alkali titration.

(1)

.....

(c) A student does a titration using sodium carbonate solution and dilute nitric acid.

This is the equation for the reaction.

$$Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + CO_2 + H_2O$$

The table shows the concentrations of the two solutions and the volume of sodium carbonate used in the titration.

Concentration of nitric acid in mol / dm^3	0.350
Concentration of sodium carbonate solution in mol / dm^3	0.220
Volume of sodium carbonate solution in cm^3	25.0

Use the equation and the data in the table to answer these questions.

(i) Calculate the volume of dilute nitric acid that the student would need to neutralise the sodium carbonate solution.

(3)

volume of nitric acid = ... cm^3

(ii) Calculate the volume, in cm^3, of carbon dioxide gas at rtp that would be produced from the 25.0 cm^3 of the sodium carbonate solution.

[at rtp, molar volume = 24 000 cm^3]

(2)

volume of carbon dioxide = ... cm^3

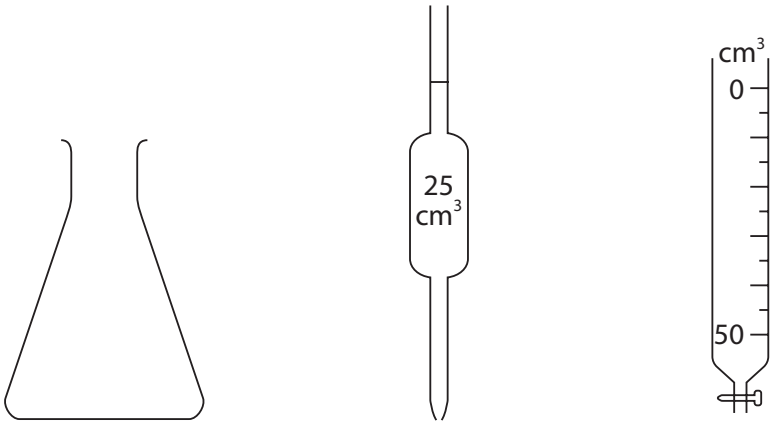
(d) Describe a test to show that sodium carbonate solution contains carbonate ions.

(3)

(Total for Question 6 = 11 marks)

7 A student does a titration to find the concentration of a solution of phosphoric acid.

He uses these pieces of apparatus X, Y and Z in his titration.



X Y Z

Diagrams are not to scale.

(a) Give the names of X, Y and Z.

(3)

X .....

Y .....

Z .....

(b) What is the colour of phenolphthalein in phosphoric acid?

(1)

- ☒ **A** blue
- ☒ **B** colourless
- ☒ **C** pink
- ☒ **D** red

(c) The student titrates 25.0 cm^3 of phosphoric acid with a solution of sodium hydroxide (NaOH).

Table 1 shows the student's results.

titration number	1	2	3	4
volume of NaOH added in cm^3	30.35	30.25	30.00	30.30
concordant results				

Table 1

Concordant results are those within 0.20 cm^3 of each other.

(i) Add ticks (✓) to table 1 to show the concordant results.

(1)

(ii) Use your ticked results to calculate the mean (average) volume of NaOH added.

(2)

mean volume = ... cm^3

(d) Table 2 shows the titration results of another student.

volume of phosphoric acid used in cm^3	25.0
concentration of sodium hydroxide solution in mol/dm^3	0.525
mean volume of sodium hydroxide added in cm^3	30.40

Table 2

The equation for the reaction is

$$3NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3H_2O$$

(i) Calculate the amount, in moles, of NaOH in 30.40 cm^3 of sodium hydroxide solution.

(2)

amount = ... mol

(ii) Calculate the amount, in moles, of H_3PO_4 in 25.0 cm^3 of phosphoric acid.

(1)

amount = ... mol

(iii) Calculate the concentration, in mol/dm^3, of the phosphoric acid.

(2)

concentration = ... mol/dm^3

(Total for Question 7 = 12 marks)

6 A student uses this method to do a titration.

- use a measuring cylinder to obtain 25 cm^3 of sodium hydroxide solution
- transfer the solution to a conical flask
- add a few drops of universal indicator to the flask
- fill a burette with dilute sulfuric acid and record the initial burette reading
- add the acid to the flask, swirling the flask continuously
- add the acid slowly near the end-point
- record the final burette reading at the end-point

The student repeats the titration until at least two concordant results are obtained.

(a) State what is meant by concordant results.

(1)

(b) Explain two improvements to the student's method so that more accurate results are obtained.

(4)

(c) The student makes the improvements and repeats the titration.

The sulfuric acid has a concentration of 0.600 mol/dm^3.

The sodium hydroxide solution has a concentration of 1.50 mol/dm^3.

This is the equation for the reaction.

$$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$$

Calculate the volume, in cm^3, of sulfuric acid that the student needs to completely react with 25.0 cm^3 of the sodium hydroxide solution.

(3)

volume of sulfuric acid = ... cm^3

(d) The student plans to obtain pure dry crystals of hydrated sodium sulfate.

They add the calculated volume of sulfuric acid to 25.0 cm^3 of the sodium hydroxide solution to form sodium sulfate solution.

Describe what the student should do to obtain pure dry crystals of hydrated sodium sulfate from the solution.

(4)

(Total for Question 6 = 12 marks)

6 A student wants to prepare sodium chloride crystals from sodium hydroxide solution and dilute hydrochloric acid.

He does a titration to find the volume of dilute hydrochloric acid needed to neutralise the sodium hydroxide solution.

This is his method.

- add 25.0 cm^3 of sodium hydroxide solution to a conical flask
- add a few drops of phenolphthalein indicator to the conical flask
- titrate the solution with the hydrochloric acid

(a) Name a suitable piece of apparatus that the student should use to measure 25.0 cm^3 of sodium hydroxide solution.

(1)

.....

(b) (i) Give the colour of the phenolphthalein indicator in sodium hydroxide solution and in hydrochloric acid.

(2)

colour in sodium hydroxide solution .....

colour in hydrochloric acid .....

(ii) Suggest why universal indicator is never used in a titration.

(1)

.....

.....

(c) The student finds that 21.50 cm^3 of hydrochloric acid is needed to neutralise 25.0 cm^3 of sodium hydroxide solution.

(i) Describe what the student should do next to prepare a pure solution of sodium chloride.

(2)

.....

.....

.....

.....

(ii) Describe how the student could obtain dry crystals of sodium chloride from the pure sodium chloride solution.

(4)

(d) The student needs 21.50 cm^3 of hydrochloric acid to neutralise 25.0 cm^3 of sodium hydroxide solution of concentration 0.800 mol/dm^3.

The equation for the reaction is

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Calculate the concentration, in mol/dm^3, of the hydrochloric acid.

(3)

concentration = ... mol/dm^3

(Total for Question 6 = 13 marks)

5 A student does some titrations to find the volume of dilute nitric acid needed to exactly neutralise 25.0 cm^3 of sodium hydroxide solution.

This is the student's method.

Step 1 add 25.0 cm^3 of sodium hydroxide solution to a conical flask

Step 2 add three drops of methyl orange indicator

Step 3 fill a burette with the acid

Step 4 add acid from the burette until the indicator changes colour

Step 5 record the volume of acid added

(a) (i) Give the name of the apparatus that the student should use to measure the volume of sodium hydroxide solution in step 1.

(1)

.....

(ii) Give the colour change seen in step 4.

(1)

.....

(iii) Give a reason why the student does not use universal indicator in this titration.

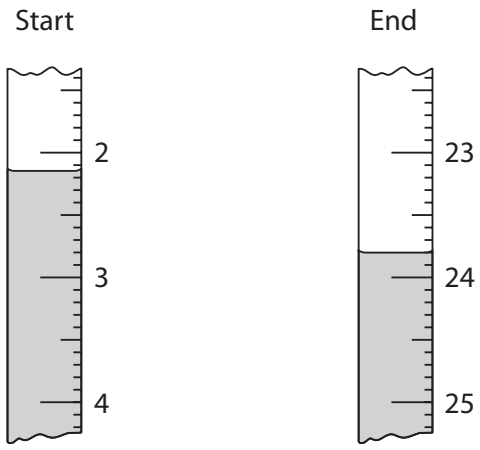
(1)

.....

.....

(b) The student completes a rough titration and four accurate titrations.

The diagram shows the burette readings from the rough titration.



The table shows the student's results.

	Rough titration	Titration 1	Titration 2	Titration 3	Titration 4
Burette reading at end in cm^3		21.80	22.85	21.75	24.10
Burette reading at start in cm^3		0.50	0.15	0.25	0.10
Volume added in cm^3		21.30	22.70	21.50	24.00

(i) Complete the table by adding the results from the rough titration.

Record the volumes to the nearest 0.05 cm^3

(2)

(ii) Concordant results are results within 0.20 cm^3 of each other.

Use the concordant results from the table to calculate the mean volume of acid added.

(3)

mean volume of acid = ... cm^3

(c) This is the equation for the reaction between dilute nitric acid and sodium hydroxide solution.

$$HNO_3(aq) + NaOH(aq) \rightarrow NaNO_3(aq) + H_2O(l)$$

After the titration, the student knows the volume of acid needed to neutralise 25.0 cm^3 of the sodium hydroxide solution.

Sodium nitrate decomposes at high temperatures.

Describe how the student could obtain pure, dry crystals of sodium nitrate from dilute nitric acid and sodium hydroxide solution.

(5)

(Total for Question 5 = 13 marks)

5 A student does a titration to find the concentration of a solution of sulfuric acid.

This is the student's method.

- fill a burette with sulfuric acid and record the reading
- transfer 25.0 cm^3 of potassium hydroxide solution to a conical flask
- add a few drops of methyl orange to the conical flask
- place the conical flask on a white tile
- swirl the flask continuously while adding sulfuric acid from the burette
- keep adding sulfuric acid until the end-point has been reached
- record the rough reading at the end-point

(a) (i) Name the most suitable piece of apparatus for measuring 25.0 cm^3 of potassium hydroxide solution.

(1)

.....

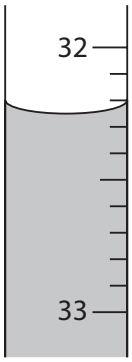
(ii) State why the student places the conical flask on a white tile.

(1)

.....

.....

(b) The diagram shows the final burette reading.



The initial burette reading is given in the table.

Complete the table, giving both values to the nearest 0.05 cm^3.

(2)

final burette reading	
initial burette reading	4.15
volume of sulfuric acid added in cm^3	

(c) The student repeats the titration more accurately four times.

The table shows their results.

titration number	1	2	3	4
volume of sulfuric acid added in cm^3	27.40	27.65	27.30	27.35
concordant results				

Concordant results are those within 0.20 cm^3 of each other.

(i) Place ticks (✓) in the table to show which results are concordant.

(1)

(ii) Use the concordant results to calculate the mean volume of sulfuric acid added.

(1)

mean volume of sulfuric acid = ... cm^3

(d) Another student also does the titration.

(i) The student uses 25.0 cm^3 of potassium hydroxide solution with a concentration of 0.500 mol/dm^3.

The mean volume of sulfuric acid added is 26.50 cm^3.

This is the equation for the reaction.

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration of the sulfuric acid.

(3)

concentration of sulfuric acid = ... mol/dm^3

(ii) The student repeats the titration without the methyl orange indicator.

They add exactly 26.50 cm^3 of sulfuric acid to the potassium hydroxide solution.

Describe how the student could obtain pure, dry potassium sulfate crystals from the reaction mixture.

(4)

.....

.....

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.....

.....

.....

(Total for Question 5 = 13 marks)

5 Sodium sulfate can be prepared by the reaction between sodium hydroxide solution and sodium hydrogensulfate ($NaHSO_4$) solution.

This is the equation for the reaction.

$$NaOH(aq) + NaHSO_4(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

Sodium hydrogensulfate solution is acidic.

A student adds 25.0 cm^3 of sodium hydroxide solution to a conical flask and adds two drops of indicator.

The student does a titration.

(a) (i) Name a piece of apparatus that should be used to add 25.0 cm^3 of sodium hydroxide solution to the conical flask.

(1)

(ii) Describe the method the student should use to find the accurate volume of sodium hydrogensulfate solution needed to neutralise the 25.0 cm^3 of sodium hydroxide solution.

(5)

(b) The student repeats the titration without the indicator and forms a solution of sodium sulfate.

Describe how the student can obtain pure, dry crystals of hydrated sodium sulfate from the solution.

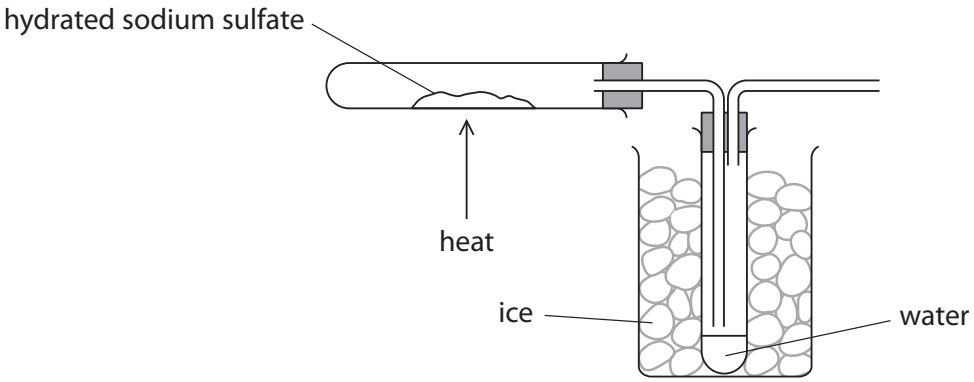
(4)

(c) Crystals of hydrated sodium sulfate decompose when heated.

This is the equation for the decomposition.

$$Na_2SO_4.xH_2O \rightarrow Na_2SO_4 + xH_2O$$

A student uses this apparatus to find the value of x.



The student heats the crystals until the decomposition is complete.

The table shows the student's results.

mass of empty test tube in g	25.12
mass of test tube and $Na_2SO_4.xH_2O$ in g	31.56
mass of test tube and Na_2SO_4 in g	27.96

Use the results to calculate the value of x.

[for Na_2SO_4, $M_r = 142$ for H_2O, $M_r = 18$]

(4)

value of x = ...

(Total for Question 5 = 14 marks)

6 When a bottle of wine is left open for several days, some of the ethanol in the wine turns to ethanoic acid, CH_3COOH

(a) A scientist uses a titration method to investigate how much ethanoic acid is formed if a bottle of white wine is left open for one week.

She uses this method.

- fill a burette with the white wine and record the reading
- add 25.0 cm^3 of sodium hydroxide solution to a conical flask
- add a few drops of phenolphthalein indicator to the flask
- swirl the flask continuously while adding wine from the burette
- add the wine drop by drop near the end point
- record the reading at the end point

(i) Name the piece of apparatus that would be most suitable for measuring the 25.0 cm^3 of sodium hydroxide solution.

(1)

.....

(ii) Suggest why red wine would not be suitable to use for this investigation.

(1)

.....

.....

.....

(iii) State why she swirls the flask continuously.

(1)

.....

.....

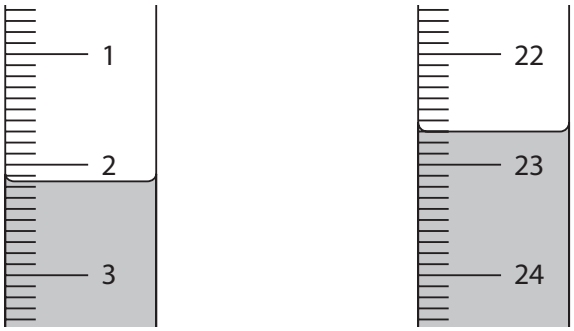
(iv) State why she adds the wine drop by drop near the end point.

(1)

.....

.....

(b) The diagram shows the burette readings at the start and end of one of the titrations.



Use the readings to complete the table.

Give your values to the nearest 0.05 cm^3.

(3)

burette reading at end	
burette reading at start	
volume of wine added in cm^3	

(c) The scientist repeats the titration four more times.

The table shows her results for these four titrations.

titration number	1	2	3	4
volume of wine added in cm^3	20.40	20.10	20.35	20.45
concordant results				

Concordant results are those within 0.20 cm^3 of each other.

(i) Add ticks (✓) to the table to show the concordant results.

(1)

(ii) Use your ticked results to calculate the mean (average) volume of wine added.

(2)

mean volume of wine added = ... cm^3

(d) Another scientist repeats the titration with a different bottle of white wine that has been left open for a week.

The equation for the reaction that occurs in this titration is

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

The mean volume of wine added is 19.50 cm^3.

(i) The concentration of the sodium hydroxide solution is 0.0500 mol/dm^3.

Calculate the amount, in moles, of NaOH in 25.0 cm^3 of sodium hydroxide solution.

(2)

amount of NaOH = ... mol

(ii) Deduce the amount, in moles, of CH_3COOH in 19.50 cm^3 of the wine.

(1)

amount of CH_3COOH = ... mol

(iii) Calculate the concentration, in mol/dm^3, of CH_3COOH in the wine.

(2)

concentration of CH_3COOH = ... mol/dm^3

(Total for Question 6 = 15 marks)

6 A student does a titration to find the volume of phosphoric acid solution (H_3PO_4) needed to neutralise a sample of potassium hydroxide solution (KOH).

One of the products of the reaction is potassium phosphate.

This is the student's method.

- use a measuring cylinder to transfer 25 cm^3 of potassium hydroxide solution to a conical flask
- add two drops of an indicator
- fill a burette with phosphoric acid solution and record the initial reading on the burette
- add the acid to the conical flask
- record the final burette reading when the indicator changes colour

This is the equation for the reaction.

$$H_3PO_4(aq) + 3KOH(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$$

(a) Explain two improvements to the student's method that would give more accurate results.

(4)

1 .....

.....

.....

.....

.....

2 .....

.....

.....

.....

.....

(b) The student repeats the titration correctly.

The potassium hydroxide solution has a concentration of 0.150 mol / dm^3.

The phosphoric acid solution has a concentration of 0.0400 mol / dm^3.

Calculate the volume, in cm^3, of phosphoric acid solution needed to neutralise 25.0 cm^3 of 0.150 mol / dm^3 potassium hydroxide solution.

Give your answer to **three** significant figures.

(4)

volume of phosphoric acid solution = ... cm^3

(c) Potassium phosphate solution reacts with calcium chloride solution.

One of the products is the insoluble solid, calcium phosphate.

(i) Complete the equation for the reaction.

(1)

$$2K_3PO_4(aq) + \text{.....} CaCl_2(aq) \rightarrow Ca_3(PO_4)_2(s) + \text{.....} KCl(aq)$$

(ii) The student reacts a solution containing 0.0400 mol of potassium phosphate with an excess of calcium chloride solution.

The student obtains 5.70 g of calcium phosphate.

Show that the percentage yield for the reaction is about 90%

[for $Ca_3(PO_4)_2$ $M_r = 310$]

(3)

(iii) Describe how the student can obtain a pure, dry sample of calcium phosphate from the mixture at the end of the reaction.

(3)

(Total for Question 6 = 15 marks)

SUB-TOPIC 2g

ACIDS, BASES AND SALT PREPARATIONS

Sub-topic 2g · 17 questions · 190 marks · lowest tariff first

3 Solutions of silver nitrate and potassium chloride react together to make the insoluble salt, silver chloride.

A student uses this method to prepare a sample of silver chloride.

Step 1 add 25 cm^3 of silver nitrate solution to a conical flask

Step 2 add potassium chloride solution to the flask

Step 3 filter off the silver chloride

(a) What term is used for this reaction?

(1)

☒ **A** neutralisation

☒ **B** precipitation

☒ **C** redox

☒ **D** thermal decomposition

(b) Give two more steps that will produce a pure, dry sample of silver chloride.

(2)

Step 4 .....

.....

Step 5 .....

.....

(c) Acidified silver nitrate solution is used to test for chloride ions.

Give a reason why hydrochloric acid is not used to acidify silver nitrate solution.

(1)

.....

.....

.....

(d) The chemical equation for the reaction between solutions of silver nitrate and potassium chloride is

$$AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$$

A student adds an excess of potassium chloride solution to 25.0 cm^3 of 0.100 mol/dm^3 silver nitrate solution.

Calculate the maximum mass of silver chloride, in grams, that can be produced.

[M_r of AgCl = 143.5]

(2)

mass = ... g

(Total for Question 3 = 6 marks)

8 This question is about barium chloride.

(a) Barium chloride can be made by reacting barium carbonate with dilute hydrochloric acid.

The chemical equation for the reaction is

$$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + H_2O(l) + CO_2(g)$$

Describe a method to produce dry crystals of hydrated barium chloride, starting with barium carbonate powder and dilute hydrochloric acid.

(6)

(b) A colourless solution contains sodium carbonate and sodium sulfate.

Describe a test using barium chloride to show that the colourless solution contains sulfate ions.

(2)

.....

.....

.....

.....

(Total for Question 8 = 8 marks)

7 This question is about soluble and insoluble compounds.

A precipitate is an insoluble compound formed when solutions of soluble compounds react after mixing.

(a) Different solutions are mixed in separate test tubes.

Tube 1 copper(II) sulfate solution and calcium chloride solution

Tube 2 magnesium nitrate solution and potassium sulfate solution

Tube 3 sodium carbonate solution and copper(II) sulfate solution

In which of the tubes will a precipitate form?

(1)

☒ **A** 1 and 2 only

☒ **B** 2 and 3 only

☒ **C** 1 and 3 only

☒ **D** 1, 2 and 3

(b) A student mixes solutions, containing equal amounts in moles, of silver nitrate and sodium chloride.

The equation for the reaction between silver nitrate solution and sodium chloride solution is

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

(i) State the colour of the precipitate of silver chloride.

(1)

.....

.....

(ii) The student wants to obtain pure, dry crystals of sodium nitrate.

Crystals of sodium nitrate decompose at temperatures above 300 °C.

Describe a method the student could use to obtain pure, dry crystals of sodium nitrate.

(5)

(iii) Give an advantage of mixing solutions containing equal amounts, in moles, of silver nitrate and sodium chloride.

(1)

(Total for Question 7 = 8 marks)

3 This question is about soluble salts and insoluble salts.

(a) Which pair of solutions produces an insoluble salt when mixed?

(1)

- ☒ **A** sodium sulfate and potassium nitrate
- ☒ **B** potassium carbonate and calcium nitrate
- ☒ **C** sodium chloride and ammonium nitrate
- ☒ **D** sodium hydroxide and potassium sulfate

(b) When solutions of lead nitrate and sodium sulfate are mixed, one product is solid lead sulfate.

This is the equation for the reaction.

$$Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4(s) + 2NaNO_3(aq)$$

Describe how a pure, dry sample of solid lead sulfate can be obtained from the mixture.

(3)

(c) The table gives the solubility of a salt in water at six different temperatures.

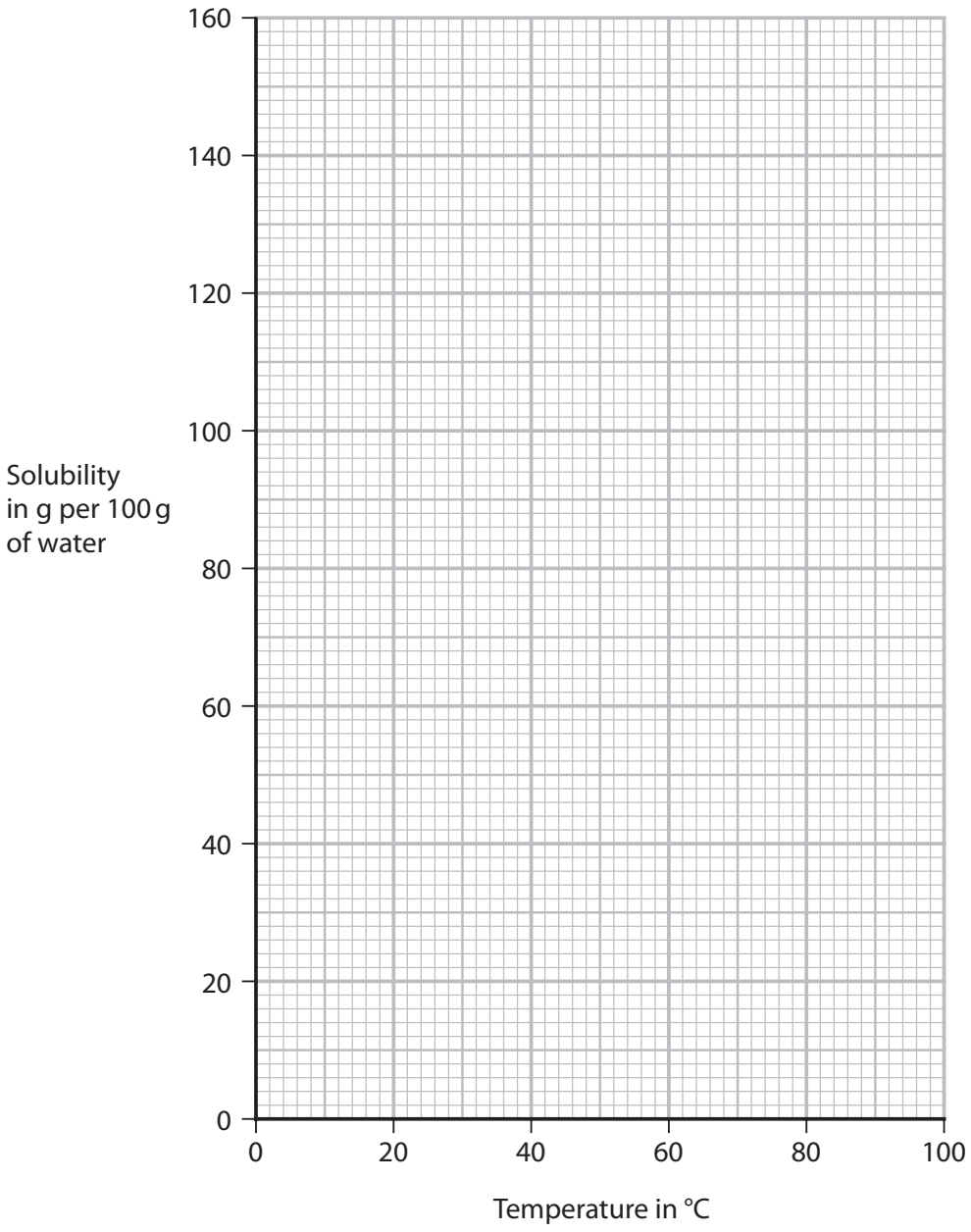
Temperature in °C	0	20	40	60	80	100
Solubility in g per 100 g of water	18	34	54	77	104	142

(i) Plot the points on the grid.

(1)

(ii) Draw a curve of best fit.

(1)



(iii) A saturated solution of the salt in 100 g of water is cooled from 90 °C to 30 °C.

Use your graph to determine the mass of salt that will crystallise.

Show your working on the graph.

(2)

mass of salt = ... g

(Total for Question 3 = 8 marks)

6 A student uses the reaction between magnesium and dilute hydrochloric acid to prepare crystals of hydrated magnesium chloride.

The student adds excess magnesium powder to hydrochloric acid.
This is the equation for the reaction.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(a) How does hydrochloric acid behave when acting as an acid?

(1)

- ☒ **A** as an electron acceptor
- ☒ **B** as an electron donor
- ☒ **C** as a proton acceptor
- ☒ **D** as a proton donor

(b) State one observation made during this reaction.

(1)

.....

.....

(c) Give a reason why the student adds an excess of magnesium to the dilute hydrochloric acid.

(1)

.....

.....

(d) Describe what the student should do to the mixture formed in (c) to produce pure, dry crystals of hydrated magnesium chloride.

(5)

(Total for Question 6 = 8 marks)

6 This question is about salts.

(a) When solutions of salts are mixed together, precipitates sometimes form.

The insoluble salt barium carbonate forms as a precipitate when solutions of the soluble salts ammonium carbonate and barium chloride react together.

When solutions of the soluble salts potassium chloride and magnesium sulfate are mixed, no precipitate forms.

Complete the table to show the results of mixing solutions of some soluble salts.

(3)

	ammonium carbonate solution	**magnesium sulfate solution**
barium chloride solution	precipitate of barium carbonate	
potassium chloride solution		no precipitate
calcium chloride solution		precipitate of calcium sulfate

(b) A student has four unlabelled beakers, each containing a colourless solution of a different salt.

The four solutions are

- potassium carbonate
- potassium chloride
- potassium iodide
- sodium chloride

Describe a method to identify each solution.

Do not refer to safety in your answer.

(6)

(Total for Question 6 = 9 marks)

10 This method is used in an experiment to produce hydrated zinc nitrate crystals.

- pour 50 cm^3 of dilute nitric acid into a beaker
- add a spatula of zinc powder to the acid
- add more zinc until it is in excess
- filter the mixture
- obtain crystals of zinc nitrate from the filtrate

(a) State why the mixture is filtered.

(1)

(b) Describe how a pure, dry sample of hydrated zinc nitrate crystals could be obtained from the filtrate.

(4)

(c) This equation represents the formation of hydrated zinc nitrate in the experiment.

$$Zn(s) + 2HNO_3(aq) + 6H_2O(l) \rightarrow Zn(NO_3)_2.6H_2O(aq) + H_2(g)$$

(i) In another experiment, 9.75 g of zinc is completely reacted with nitric acid.

Show that the maximum possible mass of hydrated zinc nitrate crystals that could be formed is approximately 45 g.

[for $Zn(NO_3)_2.6H_2O$, $M_r = 297$]

(2)

(ii) The actual yield of hydrated zinc nitrate crystals is 36.4 g.

Calculate the percentage yield of hydrated zinc nitrate crystals.

(2)

percentage yield = ... %

(Total for Question 10 = 9 marks)

9 A student uses the reaction between zinc powder and dilute nitric acid to prepare some zinc nitrate crystals.

(a) (i) Complete the equation for the reaction by adding the state symbols.

(1)

$$Zn\ (\ldots\ldots) + 2HNO_3\ (\ldots\ldots) \rightarrow Zn(NO_3)_2\ (\ldots\ldots) + H_2\ (\ldots\ldots)$$

(ii) State what the student would observe during this reaction.

(1)

.....

.....

(b) In the preparation, the student adds an excess of zinc powder to some dilute nitric acid.

(i) State why the student uses an excess of zinc powder.

(1)

.....

.....

(ii) Describe what the student should do next to obtain pure, dry crystals of zinc nitrate.

(5)

(c) The formula for the zinc nitrate crystals is $Zn(NO_3)_2.6H_2O$

When zinc nitrate crystals are heated, the products are zinc oxide, nitrogen dioxide (NO_2), oxygen and water.

Complete the equation for this reaction.

(2)

$2Zn(NO_3)_2.6H_2O \rightarrow$ ..... + ... + ... + ...

(Total for Question 9 = 10 marks)

6 When solutions of lead(II) nitrate and potassium chloride are mixed, a precipitate of lead(II) chloride forms.

(a) (i) Complete the equation for the reaction by adding the state symbols.

(1)

$$Pb(NO_3)_2(\ldots\ldots) + 2KCl(\ldots\ldots) \rightarrow PbCl_2(\ldots\ldots) + 2KNO_3(\ldots\ldots)$$

(ii) Give the formula of each ion in lead(II) nitrate.

(1)

lead ion

.....

nitrate ion

.....

(iii) Calculate the relative formula mass (M_r) of lead(II) nitrate, $Pb(NO_3)_2$

(2)

M_r = ...

(b) A student investigates the height of the precipitate formed when lead(II) nitrate solution is added to potassium chloride solution.

This is the student's method.

Step 1 pour 15.0 cm^3 of potassium chloride solution into a boiling tube

Step 2 add 2.0 cm^3 of lead(II) nitrate solution and allow the precipitate to settle

Step 3 measure the height of the precipitate

Repeat steps 2 and 3 until a total of 14.0 cm^3 of lead(II) nitrate solution has been added.

The table shows the student's results.

Volume of lead(II) nitrate in cm^3	2.0	4.0	6.0	8.0	10.0	12.0	14.0
Height of precipitate in cm	0.8	1.6	2.9	3.2	3.6	3.6	3.6

(i) Plot the results on the grid.

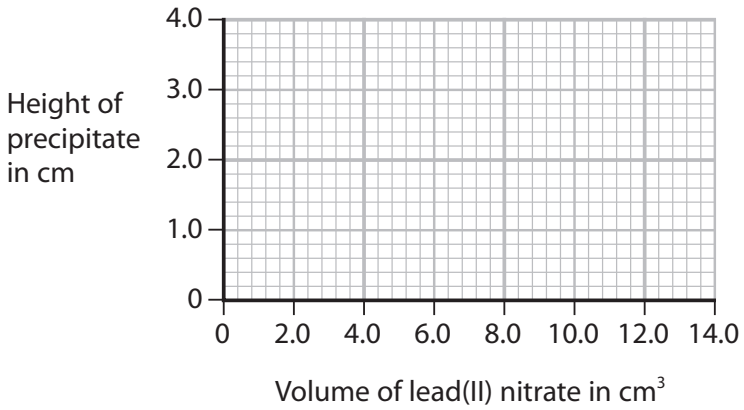
(1)

(ii) Draw a circle around the anomalous result.

(1)

(iii) Draw a line of best fit through the first four points and another line of best fit through the last three points. Make sure that the lines cross.

(2)



(iv) Give two possible mistakes the student could have made to cause the anomalous result.

(2)

1 .....

.....

2 .....

.....

(v) State why the first line of best fit should pass through the origin.

(1)

.....

.....

(vi) Use your graph to determine the volume of lead(II) nitrate solution needed to react completely with 15.0 cm^3 of potassium chloride solution.

(1)

volume = ... cm^3

(Total for Question 6 = 12 marks)

7 A student uses the reaction between zinc and dilute sulfuric acid to prepare some zinc sulfate crystals.

(a) (i) Complete the equation for this reaction by giving the correct state symbols.

(1)

$$Zn\ (\ldots\ldots) + H_2SO_4\ (\ldots\ldots) \rightarrow ZnSO_4\ (\ldots\ldots) + H_2\ (\ldots\ldots)$$

(ii) State what would be observed during this reaction.

(1)

.....

.....

(b) The student adds excess zinc to a beaker of dilute sulfuric acid.

(i) Explain why it is necessary to add excess zinc.

(2)

.....

.....

.....

.....

(ii) Draw a diagram of the apparatus the student should use to remove the unreacted zinc and collect the zinc sulfate solution.

(2)

(c) The student obtains a pure, dry sample of zinc sulfate crystals.

The formula of zinc sulfate crystals is $ZnSO_4.7H_2O$

(i) Calculate the relative molecular mass (M_r) of zinc sulfate crystals.

(2)

M_r = ...

(ii) The student uses 0.0200 mol of dilute sulfuric acid in her preparation.

Show that the maximum mass of zinc sulfate crystals that the student could obtain is about 6 g.

(2)

(iii) The student obtains a mass of 4.28 g of zinc sulfate crystals.

Calculate the percentage yield of the zinc sulfate crystals.

Give your answer to three significant figures.

(3)

percentage yield = ...%

(Total for Question 7 = 13 marks)

11 This question is about the reaction between magnesium and dilute nitric acid.

(a) A student reacts dilute nitric acid with an excess of magnesium powder as a first step in the preparation of dry crystals of hydrated magnesium nitrate.

This is the equation for the reaction.

$$Mg(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2(g)$$

(i) Explain why it is important that magnesium is in excess.

(2)

.....

.....

.....

.....

(ii) The student adds 0.75 g of magnesium to 0.025 mol of nitric acid.

Calculate the mass of magnesium, in grams, that remains at the end of the reaction.

[for magnesium, $A_r = 24$]

(3)

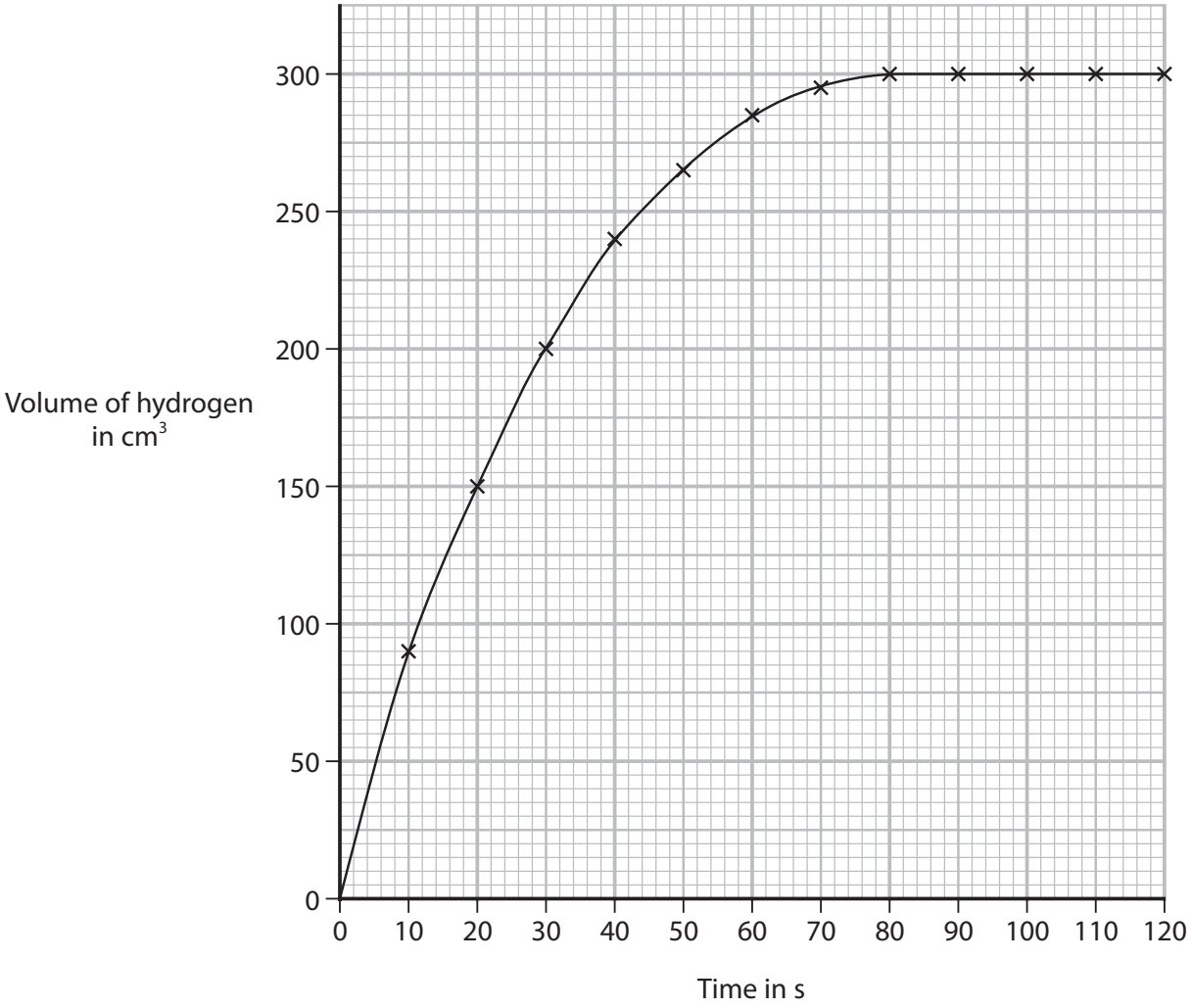
mass of magnesium = ... g

(iii) Describe how the student can obtain dry crystals of hydrated magnesium nitrate from the mixture at the end of the reaction.

(5)

(b) The student repeats the experiment and records the volume of hydrogen gas collected.

The graph shows the student's results.



Use the graph to calculate the rate of reaction, in cm^3/s, at t = 40 s.

Show your working on the graph.

(3)

rate of reaction = ... cm^3/s

(Total for Question 11 = 13 marks)

5 This question is about the insoluble salt, lead(II) bromide.

Lead(II) bromide can be made by a precipitation reaction.

This is the equation for the reaction.

$$Pb(NO_3)_2(aq) + 2KBr(aq) \rightarrow PbBr_2(s) + 2KNO_3(aq)$$

(a) Describe how solutions of lead nitrate and potassium bromide can be used to make a pure, dry sample of lead(II) bromide.

(4)

(b) A solution containing 0.150 mol of lead(II) nitrate is reacted with an excess of potassium bromide solution.

A mass of 49.6 g of pure, dry lead(II) bromide is produced.

Show, by calculation, that the percentage yield of lead(II) bromide is 90.1%.

[for $PbBr_2$, $M_r = 367$]

(2)

(c) A student investigates the change in electrical conductivity as dilute lead(II) nitrate solution is added to dilute potassium bromide solution.

This is the student's method.

Step 1 add 50 cm^3 of potassium bromide solution to a beaker

Step 2 measure the electrical conductivity of the solution

Step 3 add 10 cm^3 of lead(II) nitrate solution to the beaker

Step 4 stir the mixture

Step 5 measure the electrical conductivity of the mixture

Repeat steps 3, 4 and 5 until a total of 50 cm^3 of lead(II) nitrate solution has been added.

The table shows the student's results.

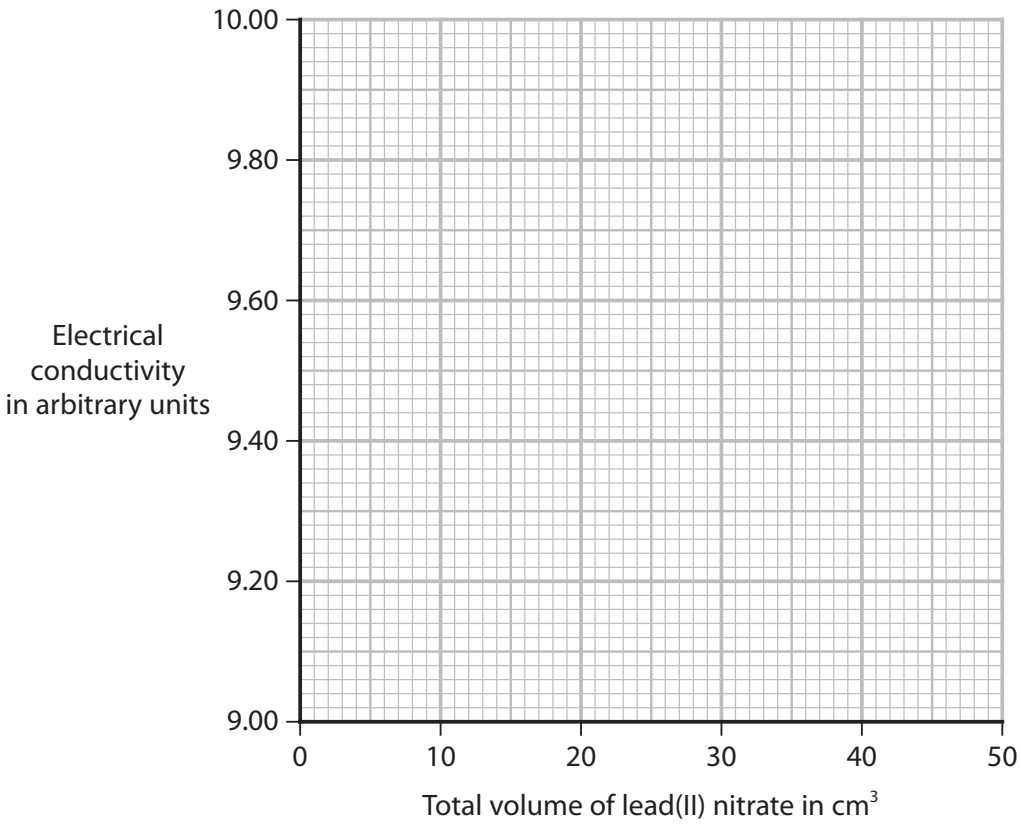
Total volume of lead(II) nitrate solution added in cm^3	Electrical conductivity in arbitrary units
0	10.00
10	9.80
20	9.77
30	9.40
40	9.20
50	9.00

(i) Plot the student's results on the grid.

(1)

(ii) Draw a line of best fit, ignoring the anomalous result.

(1)



(iii) Explain the shape of the graph.

(2)

(iv) Suggest a mistake the student could have made to cause the anomalous result.

(1)

(v) Further 10 cm^3 volumes of lead(II) nitrate are added to the beaker so the lead(II) nitrate is in excess.

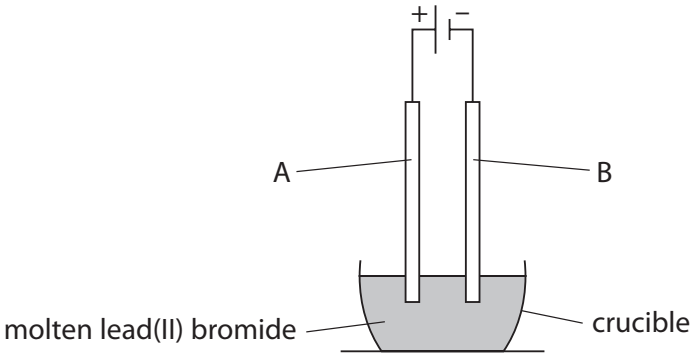
Predict what will happen to the conductivity of the mixture when the lead(II) nitrate is in excess.

(1)

.....

.....

(d) The diagram shows the electrolysis of molten lead(II) bromide, $PbBr_2$



This is the ionic half-equation for the formation of bromine at electrode A.

$$2Br^- \rightarrow Br_2 + 2e^-$$

Give a reason why this half-equation shows oxidation.

(1)

.....

.....

(Total for Question 5 = 13 marks)

14 A salt can be made by reacting an acid with an insoluble base.

A student has a sample of copper(II) oxide.

The student uses this method.

Stage 1 pour 50 cm^3 of dilute sulfuric acid into a beaker

Stage 2 warm the acid using a Bunsen burner

Stage 3 add a small amount of copper(II) oxide to the warm acid and stir the mixture

Stage 4 add further amounts of copper(II) oxide until copper(II) oxide is in excess

Stage 5 filter the mixture

Stage 6 obtain crystals from the filtrate

(a) State why the acid is warmed in stage 2.

(1)

.....

.....

(b) State how the student would know that the copper(II) oxide is in excess in stage 4.

(1)

.....

.....

(c) State why the mixture is filtered in stage 5.

(1)

.....

.....

(d) State the colour of the filtrate obtained in stage 5.

(1)

.....

(e) Describe how the student could obtain a pure, dry sample of hydrated copper(II) sulfate crystals from the filtrate in stage 6.

(5)

(f) The overall equation for the formation of hydrated copper(II) sulfate crystals from copper(II) oxide is

$$CuO(s) + H_2SO_4(aq) + 4H_2O(l) \rightarrow CuSO_4.5H_2O(s)$$

(i) In an experiment, a student completely reacts 9.54 g copper(II) oxide.

Show that the maximum possible mass of $CuSO_4.5H_2O$ crystals that can be obtained is about 30 g.

[M_r of CuO = 79.5 M_r of $CuSO_4.5H_2O$ = 249.5]

Give your answer to an appropriate number of significant figures.

(3)

mass = ... g

(ii) In this experiment, the actual yield of $CuSO_4.5H_2O$ crystals is 23.92 g.

Calculate the percentage yield of $CuSO_4.5H_2O$

(2)

percentage yield = ... %

(Total for Question 14 = 14 marks)

7 A student makes some magnesium nitrate crystals from magnesium oxide and dilute nitric acid.

The equation for the reaction is

$$MgO(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + H_2O(l)$$

(a) (i) Give the formula of each ion in magnesium nitrate.

(2)

..... and .....

(ii) A student has a beaker containing dilute nitric acid.

Describe a method that she could use to prepare a pure, dry sample of magnesium nitrate crystals from magnesium oxide.

(6)

(b) Magnesium nitrate crystals contain water of crystallisation with the formula $Mg(NO_3)_2.6H_2O$

(i) Show by calculation that the relative formula mass of $Mg(NO_3)_2.6H_2O$ is 256.

(1)

(ii) Show that the maximum mass of $Mg(NO_3)_2.6H_2O$ that could be made from 0.050 mol of nitric acid is about 6 g.

(3)

(iii) The actual mass of crystals that the student obtains is 4.8 g.

Calculate the percentage yield of $Mg(NO_3)_2.6H_2O$ in this experiment.

(2)

percentage yield = ... %

(Total for Question 7 = 14 marks)

7 This question is about some Group 2 elements and their compounds.

(a) Calcium reacts with water to produce calcium hydroxide and hydrogen gas.

(i) Give the word equation for this reaction.

(1)

.....

(ii) State two observations that would be made during this reaction.

(2)

1 .....

2 .....

(b) (i) Describe how a pure, dry sample of the insoluble salt, barium sulfate, could be made from the two solids sodium sulfate and barium chloride.

(5)

.....

.....

.....

.....

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.....

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.....

.....

.....

(ii) Give an ionic equation for the reaction that occurs.

Include state symbols in your equation.

(2)

.....

(c) When magnesium nitrate is heated, magnesium oxide, nitrogen dioxide and oxygen form.

The equation for the reaction is

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

(i) What is the name for this type of reaction?

(1)

- ☒ **A** addition
- ☒ **B** combustion
- ☒ **C** decomposition
- ☒ **D** neutralisation

(ii) Calculate the **total** volume, in dm^3, of gas produced at rtp when 7.7 g of magnesium nitrate completely reacts.

[Assume that the molar volume of a gas at rtp is 24 dm^3]

[M_r of $Mg(NO_3)_2$ = 148]

Give your answer to two significant figures.

(4)

total volume of gas = ... dm^3

(Total for Question 7 = 15 marks)

10 This question is about salts.

(a) Soluble salts can be prepared by the reaction between a metal oxide and an acid.

The equation for this type of reaction is

metal oxide + acid → salt + water

(i) State the name given to this type of reaction.

(1)

(ii) State, in terms of protons, what happens in this reaction.

(1)

(b) (i) A student is given 50 cm^3 of dilute sulfuric acid and a bottle of solid copper(II) carbonate.

Describe the method that the student should use to prepare a saturated solution of copper(II) sulfate.

In your answer, refer to the pieces of apparatus that the student should use.

(5)

(ii) The student produces dry crystals of hydrated copper(II) sulfate from the saturated solution.

He calculates that 6.40 g of dry crystals should be formed.

The mass of dry crystals he actually obtains is 1.80 g less than he calculated.

Calculate the student's percentage yield.

Give your answer to one decimal place.

(3)

percentage yield = ... %

(c) (i) Gypsum is hydrated calcium sulfate.

A sample of gypsum contains 79% of calcium sulfate by mass.

Calculate the value of x in $CaSO_4.xH_2O$

[M_r of $CaSO_4$ = 136 M_r of H_2O = 18]

(3)

x = ...

(ii) Describe a test for calcium ions in the sample of gypsum.

(2)

.....

.....

.....

.....

(Total for Question 10 = 15 marks)

6 This question is about the insoluble salt silver chloride (AgCl).

Silver chloride can be made by the reaction between copper(II) chloride and silver nitrate.

(a) Describe how a student could prepare a pure, dry sample of silver chloride starting with copper(II) chloride solution and silver nitrate solution.

(4)

(b) A student investigates the quantity of silver chloride produced when different volumes of silver nitrate solution are added to copper(II) chloride solution.

This is the student's method.

- pour 5.0 cm^3 of copper(II) chloride solution into a test tube
- add 1.0 cm^3 of silver nitrate solution to the test tube
- allow the silver chloride precipitate to settle
- measure the height of the precipitate

The student repeats the method using different volumes of silver nitrate solution.

The table shows the student's results.

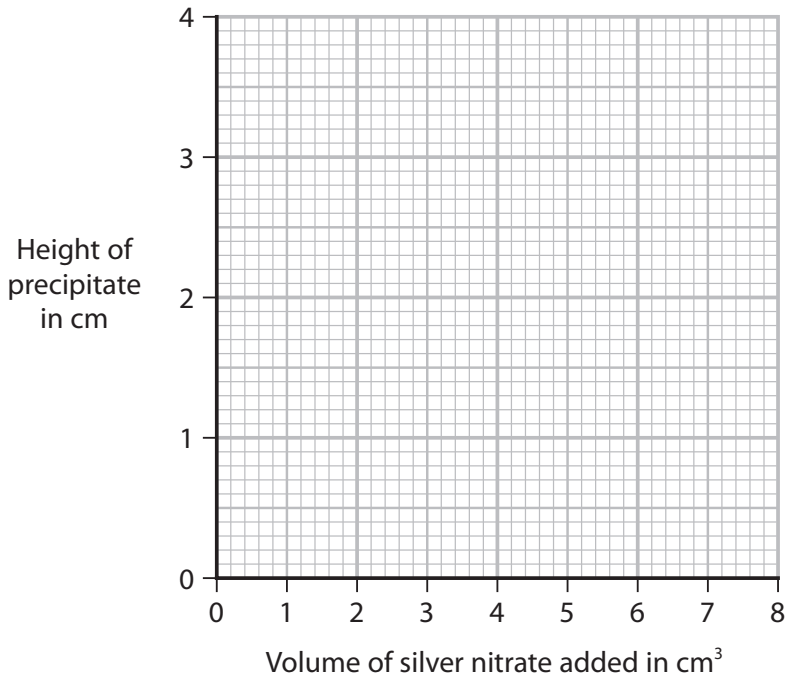
Volume of silver nitrate added in cm^3	Height of precipitate in cm
0.0	0.0
1.0	0.5
2.0	1.0
3.0	1.2
4.0	2.0
5.0	2.5
6.0	3.0
7.0	3.0
8.0	3.0

(i) Plot the student's results.

(2)

(ii) Draw two straight lines of best fit, ignoring the anomalous result.

(1)



(iii) Suggest a mistake the student made to cause the anomalous result.

(1)

.....

.....

(iv) Give a reason why the last three heights are the same.

(1)

.....

.....

(c) The equation for the reaction between copper(II) chloride and silver nitrate is

$$CuCl_2(aq) + 2AgNO_3(aq) \rightarrow 2AgCl(s) + Cu(NO_3)_2(aq)$$

A student measures 25.0 cm^3 of 0.500 mol/dm^3 copper(II) chloride solution and reacts it with silver nitrate solution.

(i) Name a piece of apparatus suitable for measuring 25.0 cm^3 of copper(II) chloride solution.

(1)

.....

(ii) Calculate the maximum mass, in grams, of silver chloride that could be produced.

[M_r of AgCl = 143.5]

(3)

maximum mass = ... g

(iii) In an experiment using different solutions, the mass of silver chloride produced is 0.744 g.

The maximum mass of silver chloride that could be produced is 0.850 g.

Calculate the percentage yield.

(2)

percentage yield = ... %

(Total for Question 6 = 15 marks)

SUB-TOPIC 2h

CHEMICAL TESTS

Sub-topic 2h · 8 questions · 80 marks · lowest tariff first

3 A student does these two tests on a solution made from a white solid.

- flame test
- add acidified silver nitrate solution

The table shows his results.

Test	Result
flame test	red flame
add acidified silver nitrate solution	cream precipitate

(a) Give the formula of the ion that produces the red flame.

(1)

(b) Name the cream precipitate.

(1)

(c) Identify the white solid.

(1)

(d) The student uses a clean metal wire in the flame test.

(i) State why the wire should be clean when used in the flame test.

(1)

(ii) The table lists properties of some metals.

Add ticks (✓) to the table to show the two properties needed in a metal wire used in a flame test.

(2)

Property	
good conductor of electricity	
high density	
high melting point	
unreactive	

(Total for Question 3 = 6 marks)

9 A student is given a mixture of two white solid compounds, and a colourless solution containing the same two compounds.

The student is told that one of the compounds is a halide and that the other compound is a carbonate.

(a) Give two reasons why the student should know, without doing any tests, that one of the compounds **cannot** be copper(II) carbonate.

(2)

1 .....

.....

2 .....

.....

(b) Describe tests the student could do to show that the mixture contains potassium carbonate and potassium iodide.

(6)

.....

.....

.....

.....

.....

.....

.....

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.....

.....

.....

(Total for Question 9 = 8 marks)

15 Hydrated ammonium iron(III) sulfate is a violet solid that has the formula $(NH_4)_2SO_4.Fe_2(SO_4)_3.xH_2O$

The table shows some tests done on three separate samples of the solid.

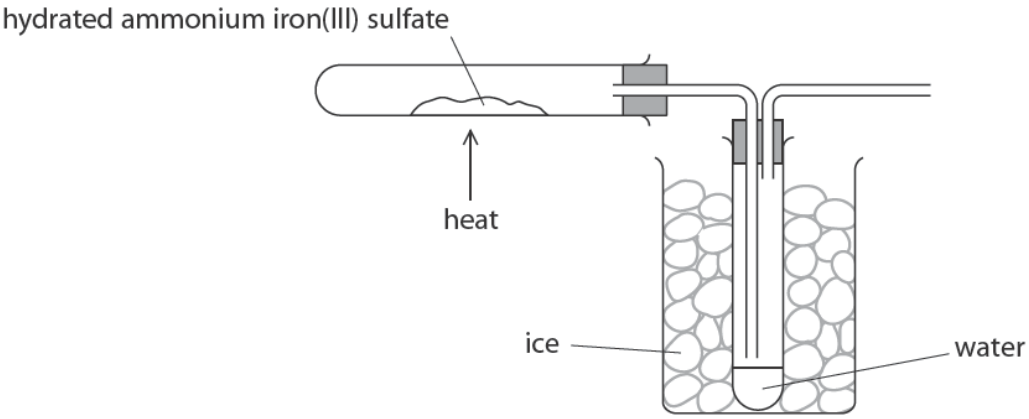
Test	Observation
Dissolve the solid in water and add acidified barium chloride solution.	
Dissolve the solid in water and add sodium hydroxide solution.	
Add sodium hydroxide solution to the solid and warm the mixture. Test the gas given off with moist universal indicator paper.	

(a) Complete the table to show the observation made in each test.

(3)

(b) A student needs to find the value of x in the formula $(NH_4)_2SO_4.Fe_2(SO_4)_3.xH_2O$

He uses this apparatus.



The hydrated solid decomposes when heated gently.

The equation for the reaction is

$$(NH_4)_2SO_4.Fe_2(SO_4)_3.xH_2O \rightarrow (NH_4)_2SO_4.Fe_2(SO_4)_3 + xH_2O$$

The table shows the student's results.

mass of empty test tube in g	22.04
mass of test tube and $(NH_4)_2SO_4.Fe_2(SO_4)_3.xH_2O$ in g	34.09
mass of test tube and $(NH_4)_2SO_4.Fe_2(SO_4)_3$ in g	28.69

(i) Calculate the mass of $(NH_4)_2SO_4.Fe_2(SO_4)_3$ produced by heating.

(1)

mass of $(NH_4)_2SO_4.Fe_2(SO_4)_3$ = ... g

(ii) Calculate the mass of water produced.

(1)

mass of water = ... g

(iii) Calculate the value of x.

[M_r of $(NH_4)_2SO_4.Fe_2(SO_4)_3$ = 532 and M_r of H_2O = 18]

Give your answer to the nearest whole number.

(4)

value of x = ...

(Total for Question 15 = 9 marks)

4 This question is about ammonium chloride.

(a) Give the formula of the ammonium ion.

(1)

.....

(b) Describe a test to show that ammonium chloride contains ammonium ions.

(3)

.....

.....

.....

.....

.....

.....

(c) The equation shows the thermal decomposition of ammonium chloride.

$$NH_4Cl(s) \rightleftharpoons NH_3(g) + HCl(g)$$

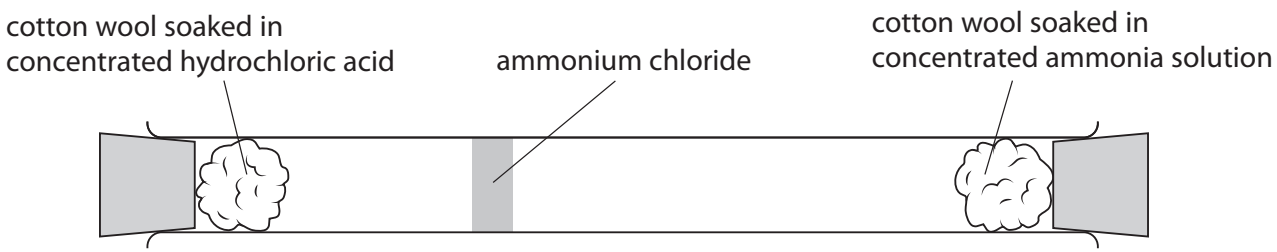
State what the $\rightleftharpoons$ symbol indicates about this reaction.

(1)

.....

.....

(d) The diagram shows the formation of ammonium chloride in a glass tube.



(i) Explain how the mean speed of ammonia molecules compares with the mean speed of hydrogen chloride molecules.

(2)

.....

.....

.....

.....

(ii) Gas particles travel very quickly.

Give two reasons why it takes several minutes for the ammonium chloride to form.

(2)

1 .....

.....

2 .....

.....

(Total for Question 4 = 9 marks)

8 (a) A scientist finds an unlabelled bottle on a shelf.

She thinks the bottle contains a solution of ammonium sulfate, $(NH_4)_2SO_4$

Describe tests the scientist could do to show that the solution is ammonium sulfate.

(6)

(b) Ammonium sulfate is often used as a fertiliser.

It is prepared by reacting ammonia (NH_3) with sulfuric acid (H_2SO_4).

(i) Name the type of reaction that occurs between ammonia and sulfuric acid.

(1)

.....

(ii) Write a chemical equation for the reaction of ammonia with sulfuric acid.

(1)

.....

(iii) Draw a dot-and-cross diagram to show the bonding in a molecule of ammonia.

Show outer electrons only.

(2)

(Total for Question 8 = 10 marks)

7 (a) A technician needs to identify the solution in an unlabelled bottle.

The technician knows that the solution contains one of these compounds.

- iron(II) bromide
- iron(II) chloride
- iron(III) bromide
- iron(III) chloride

Describe how the technician can use chemical tests to identify the compound.

(6)

(b) When chlorine gas is passed over heated iron powder, iron(III) chloride forms.

This is the equation for the reaction.

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

0.060 mol of chlorine gas is passed over 2.8 g of iron powder.

Show by calculation that the iron powder is in excess.

(3)

(c) When iron(III) chloride dissolves in water, an acidic solution forms.

(i) Give the colour of litmus in this solution.

(1)

.....

(ii) Give the formula of the ion that causes the solution to be acidic.

(1)

.....

(Total for Question 7 = 11 marks)

9 This question is about ionic compounds.

(a) Calcium nitrate has the formula $Ca(NO_3)_2$

(i) Give the formula of each ion in calcium nitrate.

(2)

calcium ion

.....

nitrate ion

.....

(ii) Explain why calcium nitrate has a high melting point.

Refer to structure and bonding in your answer.

(4)

.....

.....

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(iii) Calcium nitrate decomposes when heated.

Complete the chemical equation for the decomposition of calcium nitrate.

(1)

..... $Ca(NO_3)_2$ → ..... CaO + ... NO_2 + ... O_2

(b) A student has four unlabelled beakers, each containing a colourless solution of a different salt.

These are the four salt solutions.

- calcium bromide
- calcium chloride
- sodium chloride
- sodium sulfate

Describe a series of tests to identify each solution.

Do not refer to safety precautions in your answer.

(6)

(Total for Question 9 = 13 marks)

10 This question is about ammonia and ammonium compounds.

(a) Ammonia (NH_3) is a simple covalent molecule.

Draw a dot-and-cross diagram to show the bonding in a molecule of ammonia.

(2)

(b) The table shows the names and formulae of some ammonium compounds.

Name	ammonium sulfate		ammonium carbonate
Formula	$(NH_4)_2SO_4$	NH_4Cl	

(i) Complete the table by giving the missing information.

(2)

(ii) When ammonia reacts with sulfuric acid, ammonium sulfate is formed.

Write a chemical equation for this reaction.

(1)

(iii) Describe a test for ammonium ions.

(3)

(c) The table gives some information about ammonia and ammonium compounds.

Name	Formula	Percentage of nitrogen (%)	Approximate pH in solution
ammonia	$NH_3(g)$	82	11
ammonium nitrate	$NH_4NO_3(s)$		5.5
ammonium sulfate	$(NH_4)_2SO_4(s)$	21	5.5

(i) Calculate the percentage of nitrogen in ammonium nitrate.

[M_r of NH_4NO_3 = 80]

(2)

percentage of nitrogen = ... %

(ii) Fertilisers add nitrogen to the soil to help plants grow.

Ammonia and ammonium sulfate can both be used as fertilisers.

Discuss the advantages and disadvantages of using each of these compounds as fertilisers.

Use information from the table in your answer.

[pH of rainwater is approximately 5.6]

(4)

(Total for Question 10 = 14 marks)

MARK SCHEMES

official Pearson Edexcel mark schemes

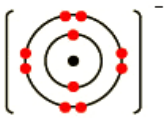
<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 a l</td><td>
<table>
<tr><td>potassium reacts more vigorously with water than sodium</td><td>✓</td></tr>
<tr><td>potassium sinks to the bottom of the water</td><td></td></tr>
<tr><td>bubbles of oxygen gas are produced</td><td></td></tr>
<tr><td>a lilac flame is seen</td><td>✓</td></tr>
<tr><td>potassium moves around</td><td>✓</td></tr>
<tr><td>potassium oxide solution is formed</td><td></td></tr>
</table>
</td><td></td><td>3</td></tr>
<tr><td>b (i)</td><td>any value or range between 11 and 14</td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>OH^-</td><td>ACCEPT HO^-

IGNORE any name</td><td>1</td></tr>
<tr><td>c</td><td>4Na + (1)O_2 → 2Na_2O</td><td>ACCEPT multiples or fractions</td><td>1</td></tr>
<tr><td></td><td></td><td></td><td>Total 6</td></tr>
</table>

Question number	Answer	Notes	Marks
4 (a)	any two from: M1 floats M2 moves M3 melts / turns into a ball /sphere M4 gets smaller / disappears M5 white trail	 M1 and M2 moves on the surface ALLOW sodium dissolves IGNORE effervescence / bubbling / fizzing	2
(b)	M1 do a flame test M2 yellow (flame)	ALLOW a description of the flame test ALLOW orange (flame)	2
(c) (i)	(they have the) same number of outer shell electrons / one outer shell electron		1
(ii)	as the atomic radius increases they get more reactive OWTTE		1
			total for question = 6

Question number	Answer	Notes	Marks
2 (a)	Any 2 from **M1** effervescence /fizzing /bubbles **M2** moves **M3** floats **M4** gets smaller / disappears	 **IGNORE** gas given off moves on the surface scores **M2** and **M3** **ALLOW** dissolves **IGNORE** heat produced **IGNORE** colour change	2
(b)	**A (lithium hydroxide and hydrogen)** B is incorrect as lithium hydroxide and oxygen are not the products C is incorrect as lithium oxide and hydrogen are not the products D is incorrect as lithium oxide and oxygen are not the products		1
(c) (i)	An explanation that links the following three points **M1** (colour of solution is) blue/purple **M2** (pH value or range between) 10 and 14 **M3** (as the solution is) alkaline /an alkali	 **ALLOW** indigo/violet **ACCEPT** (the solution is) basic	3
(ii)	OH^-	**ACCEPT** HO^-	1
(d)	**C (red)** A is incorrect as it is not lilac B is incorrect as it is not orange D is incorrect as it is not yellow		1
			Total 8

Question number	Answer	Notes	Marks
4 (a) (i)	$2\ Na\mathbf{(s)} + 2\ H_2O(l) \rightarrow 2\ NaOH\mathbf{(aq)} + H_2(g)$ M1 correct balancing numbers M2 (s) and (aq) for state symbols	**ALLOW** multiples or fractions.	2
(ii)	hydroxide or OH^-	**REJECT** OH	1
(iii)	Any **three** from: M1 the sodium moves (on the surface) M2 effervescence or bubbles (of gas) M3 (indicator or phenolphthalein or water) turns pink M4 the sodium gets smaller M5 the sodium melts or turns into a ball	**ALLOW** sodium floats **IGNORE** gas or hydrogen produced **IGNORE** initial colour of indicator **ALLOW** the sodium disappears / (appears to) dissolve	3
(b)	M1 electron configuration of sodium is 2,8,1 and electron configuration of potassium is 2,8,8,1 M2 outer electron less attracted (to the nucleus of potassium) M3 therefore (outer shell electron) is more easily lost	**ALLOW** the outer shell is further from the nucleus **ALLOW** potassium has more shells **ALLOW** larger atom / larger atomic radius **ALLOW** reverse argument for sodium	3
			9 marks

Question number	Answer	Notes	Marks
4 (a)	Any two of the following observations. **M1** (sodium) floats/moves on surface (of water) **M2** (sodium) melts/forms a ball **M3** (sodium) gets smaller/disappears **M4** (sodium forms) white trail	 **ALLOW** dissolves **IGNORE** references to flame/heat released /temperature increases **IGNORE** fizzing /effervescence	2 Exp
(b) (i)	$2Li + F_2 \rightarrow 2LiF$	**ALLOW** multiples or fractions **IGNORE** state symbols even if incorrect	1 Exp
(ii)	**M1** flame test **M2** red (flame)	**ALLOW** description of flame test **ALLOW** crimson /scarlet **REJECT** orange-red/ brick red	2 Exp
(iii)	**M1** correct electron arrangement of lithium ion  lithium ion Li^+ $[2]^+$ **M2** correct electron arrangement of fluoride ion  fluoride ion F^- [2,8]$^-$ **M3** correct charges on both ions (with or without brackets)	**ACCEPT** any combination of dots and crosses **IGNORE** empty second shell Inner electron shell required to score M2 **M3** not dep on **M1** and **M2** correct	3 Exp

Question number	Answer	Notes	Marks
4 (c)	An explanation that links three of the following four points **M1** the outer electron is further from the nucleus in potassium / potassium has more shells/ potassium has larger atomic radius ORA **M2** there is more shielding (by the inner shells) in potassium ORA **M3** there is less attraction between the outer electron and the nucleus in potassium ORA **M4** (so outer) electron (in potassium) more easily lost ORA	**ALLOW** potassium atom is bigger than a sodium atom outer electron needs to be mentioned at least once in the answer for full marks Max 2 if no mention of outer electron in the answer	3 Exp **Total 11**

Question number	Answer	Notes	Marks
4 (a) (i)	Any two from: M1 sodium moves (on the surface) M2 sodium turns into a sphere/ball M3 effervescence M4 sodium gets smaller M5 white trail seen	 ALLOW sodium melts ALLOW fizzing / bubbles ALLOW sodium disappears / dissolves IGNORE references to a flame	2
(ii)	blue / purple	IGNORE qualifiers ALLOW violet/lilac	1
(b) (i)	same number of electrons/one electron in the outer shell.	ALLOW same number of valence electrons/one valence electron	1
(ii)	M1 lithium (atom) has a smaller atomic radius M2 the outer shell electron is more strongly attracted to the nucleus OWTTE M3 so is less easily lost	ALLOW lithium is smaller (atom)/lithium (atom) has fewer shells /energy levels ALLOW outer electron in lithium (atom) is closer to the nucleus ALLOW reverse argument for sodium	3
(c)	M1 amount lithium = 0.150 ÷ 7 **OR** 0.0214 mol M2 amount hydrogen = 0.0107 mol M3 254 ÷ 0.0107 M4 23,738	penalise 1 sig fig in M1 ALLOW M1÷2 ALLOW 2 or more sig figs in answers to M1 and M2 ALLOW 2 or more sig figs if all working shown correct answers in the range 23,707 to 24,910 cm^3 to 3 or more significant figures, without working scores 4 marks.	4
			Total for question = 11

Question number	Answer	Notes	Marks
5 (a) (i)	Any two from:		2
	M1 effervescence/fizzing/bubbles	**IGNORE** hydrogen / gas formed	
	M2 lithium becomes smaller/disappears	**ALLOW** lithium dissolves	
	M3 moves (across the surface)	**IGNORE** melts / forms a ball / flame	
(ii)	**M1** (solution turns) yellow		2
	M2 (solution is) an alkali/alkaline	**ACCEPT** lithium hydroxide / hydroxide ions / OH^- ions formed **ALLOW** basic	
(b)	A description that refers to the following five points		5
	M1 flame test	**ACCEPT** description of flame test **IGNORE** 'burning'	
	M2 red (flame)	**ACCEPT** crimson **REJECT** brick-red	
	M3 add (dilute hydrochloric) acid	**ACCEPT** nitric or sulfuric acid **REJECT** if additional incorrect reagent given eg silver nitrate	
	M4 (pass/bubble) gas/carbon dioxide into limewater	**M4** dep on acid in **M3**	
	M5 (limewater) turns cloudy/milky / white ppt forms	**M5** dep on use of limewater No **M4** or **M5** if limewater added directly to the solution	
(c)	**M1** <u>electrostatic</u> attraction		2
	M2 between oppositely charged ions	**ACCEPT** between anions/negative ions and cations/positive ions **REJECT** implication of covalent bonding for M2	
			Total 11

Question number	Answer	Notes	Marks
4 (a) (i)	any two from: M1 effervescence / bubbles / fizzing (of hydrogen) M2 (the piece of lithium) gets smaller / disappears M3 (the piece of lithium) moves on the surface M4 white trail	 ALLOW dissolves ALLOW (the piece of lithium) floats (on the surface) any mention of a flame MAX = 1	2
(ii)	M1 blue/purple M2 hydroxide ions / lithium hydroxide / an alkaline solution / an alkali / OH^- (ions) is produced / formed		2
(b)	M1 (moles of H_2) = 550÷24000 OR 0.0229 M2 (moles of Li) = 0.0229×2 OR 0.0458 M3 (mass of Li) 0.321 (g)	0.321g scores 3 ALLOW M1×2 ALLOW M2×7 ALLOW 0.32 / 0.3206 /0.32088 /0.32083 /0.322 minimum 2 sig. figs.	3
(c) (i)	any one from: M1 (lilac) flame M2 melts / turns into a ball	 REJECT an incorrect colour of the flame ALLOW faster effervescence / moves faster / can explode	1
(ii)	M1 (atoms of potassium) are bigger / have more shells (of electrons) / larger atomic radius / the outer shell electron is further from the nucleus M2 (therefore) the outer shell electron is less attracted to the nucleus M3 (and therefore the outer shell) electron is more easily lost	ALLOW / more shielding from the nucleus / Li 2,1 K 2,8,8,1 lose 1 mark if outer shell electron is not mentioned lose 1 mark in M2 or M3 if electron**s** are mentioned	3
		Total = 11	

Question number	Answer	Notes	Marks
4 (a) (i)	$2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$	All four correct scores 2 2 or 3 correct scores 1	2
(ii)	any two from:		2
	M1 effervescence	ALLOW fizzing / bubbling IGNORE hydrogen/gas produced	
	M2 gets smaller	ALLOW disappears / dissolves	
	M3 floats	moves on the surface scores **M3** and **M4**	
	M4 moves	REJECT melts/molten sphere REJECT flame/burning	
(iii)	M1 (amount of hydrogen) = 375÷24000 **OR** 0.015625 (mol)		3
	M2 (amount of lithium) = 0.03125 (mol))	ALLOW M1 × 2	
	M3 (mass of lithium) 0.21875 (g)	ALLOW M2 × 7 ALLOW any number of significant figures apart from 1 REJECT incorrect rounding ALLOW any answer that rounds to 0.22g Answer with no working scores M3 only	

(b)	(i)	any one from: potassium melts / turns into a ball / potassium moves faster / faster effervescence/ (lilac/purple/pink) flame	 ALLOW disappears/dissolves faster	1
	(ii)	M1 potassium has a bigger atom / potassium has more shells / outer electron is further from the nucleus M2 the <u>outer</u> (shell) electron is less attracted to the nucleus **OR** the <u>outer</u> (shell) electron is more shielded (from the nuclear attraction) M3 (so outer) electron (in potassium) more easily lost	REJECT more outer shells for M1 Should be comparative for M3 IGNORE electrons (plural) in M1 and M2 but do not allow electrons in M3 ALLOW reverse argument throughout for lithium	3
				Total = 11

Question number	Answer	Notes	Marks
5 (a) (i)	Any two from: **M1** (lithium) moves (on the surface) **M2** (lithium) gets smaller/disappears **M3** colourless solution forms	 **ALLOW** floats **ALLOW** dissolves **IGNORE** white trail forms **REJECT** melts / turns into a ball **ALLOW** temperature increases/heat given off	2
(ii)	(when mixed with air) lit spill/splint or flame gives (squeaky) pop	must refer to test and result **IGNORE** squeaky pop test alone **ALLOW** burns with (squeaky) pop **REJECT** glowing spill/splint and pop	1
5 (b) (i)	Any one from: **M1** more rapid bubbles/fizzing/effervescence **M2** turns into a ball **M3** moves more quickly **M4** catches alight / burns / produces a flame	 **ALLOW** potassium melts **ALLOW** gets smaller/disappears more quickly **IGNORE** flame colour	1
(ii)	**M1** potassium has more shells than lithium **M2** (therefore) there is less attraction between the outer shell/electron and the nucleus **M3** so the electron in the outer shell is more easily lost	**ALLOW** potassium atom is bigger than lithium **ALLOW** outer shell/electron is further from nucleus **ALLOW** more repulsion (from inner shells) or more shielding (from the nuclear attraction) **ALLOW** nuclear pull for the outer shell/electron is weaker **ACCEPT** answers in terms of lithium for **M1**, **M2** and **M3**	3

Question number	Answer	Notes	Marks
5 (c) (i)	**M1** n(Li) = $\frac{0.500}{7}$ **OR** 0.0714 **M2** n(H_2) = $\frac{0.0714}{2}$ **OR** 0.0357 **M3** volume of H_2 (= 0.0357 x 24000) = 857 (cm^3)	**ALLOW** ECF from **M1** **ALLOW** ECF **M2** x 24 000 **M3** must be to 3 sig fig Correct answer to 3 sig fig without working scores 3 marks.	3
(ii)	**M1** n(H_2SO_4)= 0.02485 x 0.1 **OR** 0.002485 **M2** n(LiOH) = 2 x 0.002485 **OR** 0.00497 **M3** concentration of LiOH = 0.0331 (mol/dm^3)	**ALLOW** ECF from **M1** **ALLOW** ECF from **M2** (**M2** ÷ 0.150) **ALLOW** any number of sig fig except one for **M1 M2** and **M3** Correct answer without working scores 3 marks.	3

Question number	Answer	Notes	Marks
9 (a)	to keep out of contact/prevent reaction with air/oxygen/water/moisture	ALLOW they react with air/oxygen/water/moisture	1
(b) (i)	similarity: both fizz/move on surface/ produce flame	ALLOW both melt/form a ball/produce a gas/ produce hydrogen/form an alkaline solution	2
	difference caesium: faster/more violent reaction	ACCEPT reverse argument for potassium ALLOW caesium explodes	
(ii)	$2Cs + 2H_2O \rightarrow 2CsOH + H_2$ M1 all symbols/formulae correct M2 correctly balanced	ACCEPT fractions and multiples M2 DEP M1	2
(c) (i)	a lid/cover		1
(ii)	explanation linking either M1 stir solution M2 to obtain more accurate (maximum) temperature OR M1 measure temperature of sodium hydroxide M2 to check if different to/same as temperature of (hydrochloric) acid	ALLOW reference to even temperature throughout/ heat evenly distributed OWTTE ALLOW take an average of temperature of sodium hydroxide and temperature of (hydrochloric) acid for 2 marks	2

Question number	Answer	Notes	Marks
9 (d) (i)	M1 correct temperature change/△T M2 correct substitution into Q = m x c x △T M3 correct evaluation Example calculation: M1 △T = (26.5 – 19.9) OR 6.6 M2 Q = 100 x 4.2 x 6.6 M3 = 2800 (J)	 M2 ECF M1 M3 ECF M2 IGNORE any sign ALLOW 2770, 2772 correct answer without working scores 3	3
(ii)	M1 answer to M3 from (i) ÷ 0.05 M2 correct evaluation in kJ/mol with negative sign expected answer M1 2800 ÷ 0.05 OR 56000 (J) M2 - 56 (kJ/mol)	 2770 gives 55400 2772 gives 55440 negative sign required ACCEPT -55.4 ACCEPT -55.44 ACCEPT -55 correct answer without working scores 2	2

(Total for Question 9 = 13)

Question number	Answer	Notes	Marks
6 (a) (i)	Any 2 from **M1** effervescence/bubbles/fizzing **M2** moves **M3** floats **M4** disappears/ gets smaller **M5** melts/forms a ball/forms a sphere **M6** white trail	 moves on surface scores **M2** and **M3** **ALLOW** dissolves **IGNORE** heat produced **IGNORE** flame	2
(ii)	An explanation that links the following two points **M1** (the phenolphthalein) turns pink **M2** (because) OH^- ions/hydroxide ions are present	Mark independently **ALLOW** an alkaline solution /an alkali is produced **REJECT** red or purple **IGNORE** metal oxide forms	2
(b) (i)	An explanation that links the following two points **M1** (to remove) any other ions/chemicals/ impurities/substances/elements (that may be on the wire) **M2** (so that) they do not interfere with/mask the colour of the flame/change the flame colour		2
(ii)	**C** (red) A is incorrect as lithium ions do not give a lilac flame B is incorrect as lithium ions do not give an orange flame D is incorrect as lithium ions do not give a yellow flame		1
(c) (i)	**M1** potassium ion K^+ **M2** aluminium ion Al^{3+} **M3** sulfate ion SO_4^{2-} All three correct 2 marks Any two correct 1 mark	 **ALLOW** Al^{+3} **ALLOW** SO_4^{-2}	2

(c) (ii)	**M1** (mass of water =) 23.7 – 12.9 **OR** 10.8 **M2** (moles of $KAl(SO_4)_2$ =) 12.9 ÷ 258 **OR** 0.05(00) **M3** (moles of water =) 10.8 ÷ 18 **OR** 0.6(00) **M4** (x = 0.6 ÷ 0.05 =) 12	correct answer of 12 without working scores 4 **ALLOW** ecf on incorrect mass of water answer to **M4** must be a whole number **ACCEPT** alternative methods	4 **Total 13**

Question number	Answer	Notes	Marks
6 (a) (i)	Any 3 from **M1** effervescence/bubbles/fizzing **M2** moves **M3** floats **M4** disappears/gets smaller **M5** vapour trail/steam	 moves on surface scores **M2** and **M3** **ALLOW** dissolves **IGNORE** melts/heat produced **IGNORE** any reference to indicators	3
(ii)	An explanation that links the following two points **M1** the universal indicator turns purple/blue **M2** (because) OH^-/hydroxide ions are present	 **ALLOW** an alkaline solution /an alkali is produced / a solution of high pH is formed	2
(iii)	$2Li + 2H_2O \rightarrow 2LiOH + H_2$ **M1** all formulae correct **M2** balancing of correct formulae	**ALLOW** multiples and fractions **M2** dep on **M1**	2
(b) (i)	An explanation that links the following two points **M1** to remove any other ions/chemicals/ impurities/ contaminants/ compounds/substances (that may be on the wire) **M2** (so that) they do not interfere with/mask the colour of the flame	 **ALLOW** (so that) they do not affect the result (of the test) **ALLOW** (remove substances) that could colour the flame	2

(ii)	**D** yellow A is incorrect as sodium ions do not give a green flame B is incorrect as sodium ions do not give a lilac flame C is incorrect as sodium ions do not give a red flame		1

Question number	Answer	Notes	Marks
6 (c) (i)	K^+ and SO_4^{2-}		1
(ii)	An explanation that links the following four points **M1** (potassium sulfate) has a giant (ionic) structure /lattice **M2** electrostatic attraction between oppositely charged ions **M3** (ionic bonds or forces / attractions between ions) are strong **M4** a large amount of energy is needed to overcome the forces/break the bonds	ionic bonds are strong scores M3	4
			Total 15

Question number	Answer	Notes	Marks
6 (a)	**M1** (electrostatic attraction between) positive ions **M2** (and) delocalised electrons	ACCEPT (electrostatic attraction between positive) nuclei of (metal) atoms REJECT any references to ionic bonding / sharing of electrons / intermolecular forces for both marks	2
(b) (i)	(squeaky) pop with lighted splint/lit with a (Bunsen) flame	IGNORE just 'burns with a squeaky pop' REJECT use of glowing splint	1
(ii)	any two from: **M1** lilac / purple flame **M2** potassium melts / turns into a ball **M3** potassium moves on the surface **M4** potassium gets smaller	ALLOW flame REJECT other colours ALLOW floats ALLOW potassium disappears / dissolves IGNORE fizzing / bubbles etc	2
(c)	an explanation linking the following points: **M1** lithium has fewer shells than potassium **M2** outer shell / outer electron in lithium is more strongly attracted to the nucleus **M3** (so in lithium the outer shell) electron is less easily lost	 ALLOW lithium has smaller atoms than potassium ALLOW (outer shell) electron in lithium is closer to the nucleus ALLOW correct electron configurations REJECT 'fewer outer shells' ALLOW outer shell / outer electron in lithium is less shielded (by inner shells) ACCEPT valence electron ALLOW reverse argument throughout for potassium	3

(d)	**M1** (moles of sodium) 0.75 ÷ 23 **OR** 0.0326 moles **M2** (moles of hydrogen) 0.0326 ÷ 2 **M3** (volume of hydrogen) 391.304 (cm^3) **M4** 391 (cm^3)	 ALLOW **M1** ÷ 2 ALLOW **M2** × 24 000 REJECT incorrect rounding / use of 1SF once in **M1** – **M3** ALLOW **M3** to 3 significant figures, provided some attempt at calculation 391 (cm^3) scores 4 marks If **M1** is rounded to 0.033 moles, final answer of 396 (cm^3) scores 4 marks If **M2** is absent, final answer of 782 / 783 (cm^3) scores 3 marks If x 2 instead of ÷ 2 in **M2** , final answer of 1560 (cm^3) scores 3 marks	4
(e)	**M1** (moles of sulfuric acid) (16.3 × 0.0500) ÷ 1000 **OR** 0.000815 **M2** (moles of sodium hydroxide) = 0.00163 **M3** 0.0652 (mol/dm^3)	 ALLOW 8.15 x 10^{-4} (moles) ALLOW **M1** × 2 ALLOW **M2** ÷ 0.025 0.0652 (mol/dm^3) scores 3 marks ALLOW any SF except 1SF If **M2** is absent, final answer of 0.0326 (mol/dm^3) scores 2 marks If ÷ 2 instead of x 2 in **M2** , final answer of 0.0163 (mol/dm^3) scores 2 marks REJECT 16.3 / 25.0 = 0.652 (mol/dm^3) for all 3 marks	3
			Total 15

Question number	Answer	Notes	Marks
2 (a) (i)	fluorine has the fewest number of shells / energy levels	**ALLOW** fluorine has the fewest number of electrons **IGNORE** references to protons, neutrons, atomic number and mass number	1
(ii)	**C** **C** is the correct answer because iodine is in period 5 therefore has 5 shells and group 7 therefore has 7 electrons in its outer shell. A is incorrect because arsenic has 5 shells and 4 electrons in its outer shell. B is incorrect because selenium has 4 shells and 6 electrons in its outer shell. D is incorrect because the number of shells and number of electrons in the outer shell in iodine have been reversed.		1
(b) (i)	**M1** does not need heating **M2** reacts very quickly	 must imply quicker reaction than chlorine	2
(ii)	**M1** as the atoms get bigger **M2** the reactivity decreases	 **ACCEPT** reverse argument	2
			6

Question number	Answer	Notes	Marks
1 (a)	**B (9)** A is incorrect as there are not 7 electrons in total C is incorrect as there are not 10 electrons in total D is incorrect as there are not 19 electrons in total		1
(b)	**A (1–)** B is incorrect as the charge on a bromide ion is not 1+ C is incorrect as the charge on a bromide ion is not 2– D is incorrect as the charge on a bromide ion is not 2+		1
(c)	**C (grey solid)** A is not correct as iodine is not a brown liquid at room temperature B is not correct as iodine is not a brown solid at room temperature D is not correct as iodine is not a purple gas at room temperature		1
(d)	An explanation that links the following three points **M1** chlorine displaces bromine and iodine/chlorine reacts with bromide and iodide (ions) **M2** bromine displaces iodine/iodine doesn't displace chlorine or bromine /bromine reacts with iodide (ions) /iodine doesn't react with chloride or bromide (ions) **M3** most reactive chlorine bromine least reactive iodine	**ALLOW** chlorine has two reactions **ALLOW** iodine has no reactions **ACCEPT** chlorine is most reactive and iodine is least reactive **ALLOW** reactivity decreases down the group Deduct 1 mark only for incorrect use of **ide** or **ine**	3
			Total 6

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td>
<table>
<tr><th>Physical state at room temperature</th><th>Colour</th></tr>
<tr><td>gas</td><td>pale green / yellow</td></tr>
<tr><td>gas</td><td>green</td></tr>
<tr><td>liquid</td><td>red-brown</td></tr>
<tr><td>solid</td><td>grey</td></tr>
</table>
</td><td></td><td>2</td></tr>
<tr><td>(b)</td><td>M1 bromine <u>water</u> / bromine <u>solution</u>

M2 turns colourless / decolourised</td><td>ALLOW <u>aqueous</u> bromine

IGNORE any starting colour

M2 is dep on mention of bromine in M1</td><td>2</td></tr>
<tr><td>(c)</td><td>M1 (mixture) turns (from colourless) to brown

M2 iodine / I_2 is displaced

OR

(chlorine reacts with iodide ions) to produce / form iodine

M3 (because) chlorine is more reactive (than iodine)</td><td>ALLOW red-brown / orange-brown

REJECT iodide

IGNORE a displacement reaction occurs

M2 can be scored by I_2 as a product in a balanced equation or by a word equation

ALLOW reverse argument

REJECT iodide, except if already penalised in M2</td><td>3</td></tr>
<tr><td></td><td></td><td></td><td>Total 7</td></tr>
</table>

<table>
<tr><th>Question number</th><th>Answer</th><th>Additional guidance</th><th>Marks</th></tr>
<tr><td>2 (a)</td><td>
<table>
<tr><th>Name of halogen</th><th>Physical state at room temperature</th><th>Colour</th></tr>
<tr><td>chlorine</td><td>gas</td><td>pale green</td></tr>
<tr><td>bromine</td><td>liquid</td><td>red-brown</td></tr>
<tr><td>iodine</td><td>solid</td><td>(dark) grey</td></tr>
</table>
</td><td>ALLOW black
ALLOW any combination of grey and black eg grey-black</td><td>2</td></tr>
<tr><td>(b)</td><td>M1 (35 × 77.78) + (37 × 22.22)
OR 3544.44

M2 3544.44 ÷ 100 OR 35.4444 OR M1 ÷ 100

M3 35.4</td><td>(35 × 0.7778) + (37 × 0.2222)
OR
35.4444/35.444/35.44 with no working scores 2

35.4 with no working scores 3

M3 can be ECF from an incorrect M2</td><td>3</td></tr>
</table>

(c)	An explanation that links together the following four points: **M1** add chlorine (solution) to potassium bromide (solution) **M2** (solution) turns orange **M3** bromine/Br_2 is displaced **M4** (therefore) chlorine is more reactive (than bromine)	 **ACCEPT** mix the two solutions **ALLOW** any combination of orange/yellow/brown **IGNORE** other observations eg bubbles **ALLOW** bromine/Br_2 is produced/formed **IGNORE** state of bromine **REJECT** bromide **IGNORE** a displacement reaction occurs **M3** can be scored by Br_2 as a product in an equation **ACCEPT** reverse argument "If a reaction occurs then chlorine is more reactive than bromine" scores **M4**	4
		Total	**9**

Question number	Answer	Notes	Marks
3 (a)	Most Z_2 Y_2 Least X_2	**ALLOW** Z Y X **ALLOW** lower case letters **IGNORE** size of number **IGNORE** any names given	1
(b)	bromine	**ALLOW** bromine water **OR** bromine solution / Br / Br_2 **REJECT** bromide	1
(c) (i)	(Fluorine) gas / vapour (chlorine) range between -150°C to 10°C inclusive (Astatine) dark grey / black	 **REJECT** blue-black	3
(c) (ii)	C – the halogens have the same number of outer shell electrons. The only correct answer is C because the halogens are in group 7 and have similar reactions because they have the same number of electrons in their outer shells. A is not correct because the fact halogens are non-metals does not make them react in a similar way. B is not correct because the fact halogens are molecules does not make them react in a similar way. D is not correct because elements in the same period have different numbers of outer shell electrons and react differently.		1
(d)(i)	Chlorine is toxic / poisonous	**IGNORE** harmful / dangerous / irritant **IGNORE** any reference to products	1
(d)(ii)	M1 $FeCl_3$ M2 $2Fe + 3Cl_2 \rightarrow 2FeCl_3$ M2 rest of the equation balanced	**ALLOW** correct charges on the ions **REJECT** incorrect capitals **REJECT** large or super-script 3 **ALLOW** multiples or fractions for M2 **M2 dep on M1**	2

Question number	Answer	Notes	Marks
2 (a) (i)	(pale/light) yellow		1
(ii)	The correct answer is **B** 1 as bromine is the only liquid at room temperature (20 °C) **A** 0 is incorrect because bromine is a liquid at room temperature (20 °C) **C** 2 is incorrect because bromine is the only liquid at room temperature (20 °C) **D** 3 is incorrect because bromine is the only liquid at room temperature (20 °C)		1
(iii)	At_2		1
(b) (i)	explanation including M1 oxidising agent is chlorine/Cl_2 M2 because chlorine/Cl_2 gains electron(s)/is reduced	 ACCEPT because bromide ions/Br^- lose electrons/are oxidised REJECT bromine ions M2 DEP M1 correct or missing	2

Question number	Answer	Notes	Marks
2 (b) (ii)	explanation containing three of following points M1 bromine and chlorine react by gaining electron/forming 1- or negative ion M2 bromine atom larger (than chlorine atom) M3 bromine (atom) has smaller/weaker attraction (from nucleus) for (outer shell) electrons (than chlorine) OWTTE M4 so (bromine has) less tendency to gain electron/form negative ion (so less reactive than chlorine) OWTTE	 ALLOW bromine has larger atomic radius ALLOW bromine outer (electron) shell further from nucleus ALLOW bromine atom has more (electron) shells (than chlorine) ALLOW reverse argument for chlorine in M2 M3 M4	3
(c)	The correct answer is **D** K^+ and Cl^- because both have electronic configuration of 2.8.8 A is not correct because Li^+ does not have electronic configuration of 2.8.8 B is not correct because F^- does not have electronic configuration of 2.8.8 C is not correct because neither Li^+ nor F^- have electronic configuration of 2.8.8		1

(Total for Question 2 = 9)

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>5 (a)</td><td><table><tr><td>Colour</td><td>Physical state at room temperature</td></tr><tr><td>pale yellow</td><td>gas</td></tr><tr><td>pale green</td><td>gas</td></tr><tr><td>brown /orange-brown /red-brown</td><td>liquid</td></tr><tr><td>dark grey</td><td>solid</td></tr><tr><td>black</td><td>solid</td></tr></table></td><td>do not accept red alone</td><td>3</td></tr>
<tr><td>(b) (i)</td><td>$Cl_2 + 2NaBr \rightarrow Br_2 + 2NaCl$

M1 all formulae correct

M2 equation correctly balanced</td><td>IGNORE state symbols even if incorrect

M2 dep on M1</td><td>2</td></tr>
<tr><td>(ii)</td><td>M1 no reaction

M2 bromine is less reactive than chlorine / chlorine is more reactive than bromine</td><td>

ALLOW bromine is not as good an oxidising agent as chlorine

do not allow bromide is less reactive than chlorine OR chloride is more reactive than bromine for M2

M2 dep on M1</td><td>2</td></tr>
<tr><td>(iii)</td><td>M1 astatide (ions)/At^- are oxidised/reducing agent as they lose electrons

M2 bromine (molecules)/Br_2 are reduced /oxidising agent as they gain electrons</td><td>ALLOW astatide (ions) are oxidised as their oxidation state increases

do not allow astatine is oxidised OR bromide is reduced

ALLOW bromine is reduced as its oxidation state deceases

ALLOW astatide (ions) are oxidised and bromine is reduced for 1 mark

ALLOW astatide loses electrons and bromine gains electrons for 1 mark</td><td>2</td></tr>
<tr><td></td><td></td><td></td><td>Total = 9</td></tr>
</table>

Question number	Answer	Notes	Marks
6 (a) (i)	**B** bromine A is incorrect as astatine is a solid at room temperature C is incorrect as chlorine is a gas at room temperature D is incorrect as fluorine is a gas at room temperature		1
(ii)	**C** dark grey A is incorrect as solid iodine is not black B is incorrect as solid iodine is not dark brown D is incorrect as solid iodine is not purple		1
(iii)	**M1** test with (damp blue) litmus paper **M2** bleaches/turns white	ALLOW Universal indicator paper/ pH paper **ACCEPT** turns red and then bleaches	2
(b)	**M1** 71.2 x 35 + 28.8 x 37 **OR** 3557.6 **M2** $\frac{71.2 \times 35 + 28.8 \times 37}{100}$ **OR** $\frac{3557.6}{100}$ **OR** 35.576 **M3** 35.6	Correct answer without working scores 3 **M2** subsumes **M1** 35.5 without working scores 0	3
(c)	An explanation that links the following four points **M1** add chlorine (solution) to sodium iodide (solution) **M2** solution turns brown **M3** iodine/I_2 is displaced **M4** (so) chlorine is more reactive (than iodine) ORA	 **ALLOW** mix the two solutions **ALLOW** iodine/I_2 is formed **REJECT** incorrect use of iodide or chloride once only	4 **Total 11**

Question number	Answer	Notes	Marks
8 (a)	M1 solid M2 dark grey / black		2
(b) (i)	Example calculation M1 (51 × 79) + (49 × 81) **OR** 7998 M2 7998 ÷ 100 M3 80.0	80.0 with no working scores 3 79.9 with no working scores 1 79.98 or 80 with no working scores 2	3
(ii)	same electron configuration	**ALLOW** same (total) number of electrons **IGNORE** same number of electrons in the outer shell **IGNORE** references to same number of protons	1
(c) (i)	An explanation that links the following three points M1 the order of reactivity is chlorine (most), bromine and iodine (least) M2 chlorine (is most reactive because it) displaces bromine and iodine/ oxidises bromide and iodide (ions) / reacts with sodium bromide and sodium iodide M3 bromine (is less reactive than chlorine since it) only displaces iodine / only oxidises iodide (ions) / only reacts with sodium iodide	**ACCEPT** bromine is only displaced by chlorine and iodine is displaced by chlorine and bromine scores M2 and M3 **ALLOW** chlorine has two reactions, bromine has one reaction and iodine no reactions for 1 mark out of M2 and M3 Deduct 1 mark for incorrect use of ine	3

		and ide e.g. bromine displaces iodide	
(ii)			1
	bromine cannot displace itself / bromine does not react with sodium bromide OWTTE	**ALLOW** there would be no reaction	2
(iii)			
	M1 bromine is reduced and iodide (ions)/I^- is oxidised M2 bromine gains electrons and iodide (ions)/I^- loses electrons	Deduct 1 mark for mention of iodine (ions) being oxidised or losing electrons	
	OR M1 bromine gains electrons so is reduced M2 iodide (ions) /I^- loses electrons so is oxidised	**REJECT** iodine (ions) loses electrons so is oxidised	

12 marks

Question number	Answer	Notes	Marks
3 (a)	**C** fluorine A is incorrect as astatine is black B is incorrect as bromine is brown D is incorrect as iodine is dark grey		1
(b)	**A** astatine B is incorrect as bromine is a liquid C is incorrect as chlorine is a gas D is incorrect as fluorine is a gas		1
(c)	An explanation that links the following four points **M1** fluorine is more reactive than chlorine ORA **M2** the outer shell is closer to the nucleus in fluorine / fluorine has fewer shells / fluorine has a smaller atomic radius ORA **M3** there is a stronger attraction to the nucleus for an electron in fluorine ORA **M4** so fluorine accepts an electron more readily ORA	**ALLOW** reactivity decreases down the group ORA **ALLOW** a fluorine atom is smaller than a chlorine atom ORA **ALLOW** there is less shielding in fluorine ORA	4
(d) (i)	$2Li + Cl_2 \rightarrow 2LiCl$	**ALLOW** multiples or fractions **IGNORE** state symbols even if incorrect **ACCEPT** $2Li^+Cl^-$ **REJECT** any charges on Li or Cl_2	1

(ii)	A description that refers to the following five points Test for lithium ions **M1** flame test **M2** red (flame) Test for chloride ions **M3** add nitric acid **M4** add silver nitrate (solution) **M5** white precipitate	 **ACCEPT** description of flame test **ALLOW** crimson/scarlet **REJECT** brick red/orange red **M2** dep on **M1** **REJECT** incorrect acid e.g. HCl or H_2SO_4 for **M3** only **ALLOW** acidified silver nitrate for **M3** and **M4** **M5** dep on addition of silver nitrate	5
			Total 12

Question number	Answer	Marks
7 (a) (i)	**B** bromine A is incorrect as astatine is a solid C is incorrect as chlorine is a gas D is incorrect as iodine is a solid	1
(ii)	**C** chlorine (as it is pale green) A is incorrect as astatine is black B is incorrect as bromine is brown C is incorrect as iodine is dark grey	1
(iii)	**A** astatine B is incorrect as bromine is more reactive than astatine C is incorrect as chlorine is more reactive than astatine D is incorrect as iodine is more reactive than astatine	1

(b)	(i)	**M1** (colourless solution turns) brown **M2** (solution stays) brown / no change	**ALLOW** no reaction	2
	(ii)	bromine would not react with (sodium) bromide / bromine cannot displace itself OWTTE	**ALLOW** bromine cannot react with itself **ALLOW** both contain bromine/same element/same halogen **ALLOW** because no reaction would occur **REJECT** bromine cannot displace bromide	1
	(iii)	Br_2 + 2NaI → 2NaBr + I_2	**ACCEPT** correct ionic equation $Br_2 + 2I^- \rightarrow 2Br^- + I_2$ **ALLOW** multiples and fractions	1

Question number	Answer	Notes	Marks
7 (c)	A description that makes reference to the following 6 points Test for cation **M1** add sodium hydroxide (solution) **M2** if blue precipitate forms solution contains copper(II) ion(s) / contains Cu^{2+} / is a copper compound **M3** if green precipitate forms solution contains iron(II) ion(s) / contains Fe^{2+} / is an iron compound	 **ALLOW** ammonia solution **IGNORE** qualifiers **REJECT** other colours **IGNORE** qualifiers **REJECT** other colours If no reagent or incorrect reagent but correct M2 and M3 score 1 **ALLOW** **M1** flame test or description of flame test **M2** if blue-green (flame) solution contains copper(II) ion(s) / contains Cu^{2+} / is a copper compound No **M3** for this test **ALLOW** **M1** addition of suitable metal above Cu in reactivity series **M2** brown/pink/pink-brown solid forms No **M3** for this test	6

	Test for anion **M4** add silver nitrate (solution) **M5** if white precipitate forms solution contains chloride ion(s) / contains Cl^- / is a chloride **M6** if cream precipitate forms solution contains bromide ion(s) / contains Br^- / is a bromide	**IGNORE** addition of nitric acid **REJECT** addition of hydrochloric acid for **M4** If no reagent or incorrect reagent but correct M5 and M6 score 1 **ALLOW** **M4** add chlorine water (to solution) **M5** if turns orange/yellow/brown solution contains bromide ion(s) / contains Br^- / is a bromide No **M6** for this test	**Total 13**

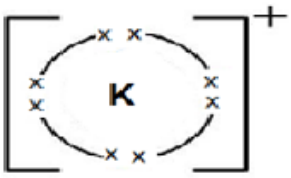
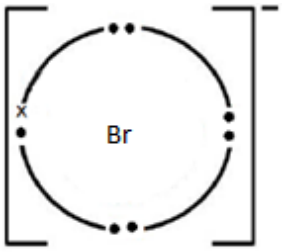
Question number	Answer	Notes	Marks
6 (a) (i)	halogens	**REJECT** halides	1
(ii)	(pale) green		1
(iii)	**M1** test with (damp) litmus paper **M2** bleaches	**ALLOW** (damp) universal indicator paper **ALLOW** turns white **IGNORE** turns red M2 dep on M1	2
(b)	A description that refers to the following three points **M1** add (dilute) nitric acid (to the unknown solution) **M2** add silver nitrate (solution) **M3** (pale) yellow precipitate	**M1** and **M2** can be in either order **REJECT** addition of incorrect acid **M3** dep on **M2**	3

Question number	Answer	Notes	Marks
6 c	An explanation that links the following six points chlorine solution and potassium bromide solution **M1** (solution) turns orange	 **ACCEPT** yellow **REJECT** brown/red	6
	M2 (because) chlorine displaces bromine	**ACCEPT** correct word equation, balanced chemical equation or ionic equation.	
	M3 (so) chlorine is more reactive than bromine		
	bromine solution and potassium iodide solution **M4** (solution) turns brown		
	M5 (because) bromine displaces iodine	**ACCEPT** correct word equation, balanced chemical equation or ionic equation	
	M6 (so) bromine is more reactive than iodine	If incorrect use of chlor**i**de, brom**i**de or iod**i**de in any marking point deduct 1 mark. **ALLOW** 1 mark for correct order of reactivity given if **M3** and **M6** not scored	
			Total 13

Question number	Answer	Notes	Marks
7 (a)	**M1** (number of protons) 53 **M2** (number of neutrons) (127 − 53 =) 74		2
(b)	**M1** 79 × 52.8 + 81 × 47.2 **OR** 7994.4 **M2** 7994.4 ÷ 100 **OR** 79.944 **M3** 79.9	correct answer without working scores 3 79.944 without working scores 2 **M3** dep on use of 79 & 81 in calculation	3
(c)	**M1** (amount of $AlCl_3$ =) 26.7 ÷ 133.5 **OR** 0.2(00) (mol) **M2** (amount of Cl_2 =) $\frac{0.2(00) \times 3}{2}$ **OR** 0.3(00) (mol) **M3** (mass of Cl_2 =) 0.3(00) × 71 = 21.3 (g) OR **M1** 213g of Cl_2 produces 267g of $AlCl_3$ **M2** (mass of Cl_2 =) $\frac{26.7}{267}$ × 213 **M3** = 21.3 (g)	correct answer without working scores 3 **ALLOW** ECF on **M1**, as long as an attempt has been made to find moles **ALLOW** ECF on **M2** **ALLOW** any number of sig figs except 1	3

(d)	An explanation which links six of the following points Pair 1 **M1** no reaction / no change (in colour) / stays yellow or orange **M2** bromine cannot displace chlorine / bromine does not react with chloride ions <u>to produce chlorine</u> **M3** therefore chlorine is more reactive than bromine Pair 2 **M4** turns brown **M5** bromine displaces iodine / bromine reacts with iodide ions <u>to produce iodine</u> **M6** therefore bromine is more reactive than iodine **M7** the overall order of reactivity is chlorine > bromine > iodine ORA	**ACCEPT** it stays any stated colour Penalise incorrect use of **-ine** and **-ide** **ACCEPT** $Br_2 + KCl \rightarrow Br_2 + KCl$ or ionic equation **ACCEPT** "bromine cannot displace chlorine because it is less reactive" OWTTE for **M2** and **M3** **ACCEPT** combinations that include brown eg red-brown Penalise incorrect use of **-ine** and **-ide** **ACCEPT** $Br_2 + 2KI \rightarrow I_2 + 2KBr$ or ionic equation **ACCEPT** "bromine displaces iodine because it is more reactive" OWTTE for **M5** and **M6** **IGNORE** references to reactivity up/down the group	6
			Total 14

Question number	Answer	Notes	Marks
4 (a)	**M1** fluorine - gas **M2** astatine - black	 **ACCEPT** very dark grey	2
(b)	An planation linking the following two points **M1** bromine / Br_2 is formed / displaced / produced **M2** as chlorine is more reactive (than bromine)	 **REJECT** bromide for bromine **ACCEPT** bromine/Br_2 shown as the product in an equation **IGNORE** state of bromine **REJECT** bromide/chloride	2

Question number	Answer	Notes	Marks
4 (c)	**M1** correct structure of potassium ion  **M2** correct structure of bromide ion  **M3** charges on both ions correct (with or without square brackets).	**ACCEPT** any combination of dots and crosses. **IGNORE** inner shells even if incorrect	3

Question number	Answer	Notes	Marks
4 (d)	An planation linking the following five points **M1** water is covalently bonded / has a simple molecular structure **M2** water does not contain any free (moving) charged parti es (so does not conduct electricity) **M3** sodium chloride has a giant ionic structure / has an ionic lattice structure /is ionically bonded **M4** the ions are in fixed positions / cannot move (so does not conduct electricity) **M5** in solution/ aqueous sodium chloride the ions are free to flow / move (so the solution does conduct electricity)	**ALLOW** water is a covalent ound **ACCEPT** water does not contain any free ions/electrons or delocalised electrons **ALLOW** sodium chloride is an ionic ound/ contains ions **REJECT** mention of atoms/ molecules/intermolecular forces in Na for **M3** only **M4** subsumes **M3** **REJECT** electrons being unable to move for M4 **REJECT** reference to electrons conducting electricity in aqueous sodium chloride for **M5** **IGNORE** reference to ions carrying charge/current	5
(e) (i)	$2^{-} \rightarrow {}_{2} + 2e^{(-)}$	**ALLOW** $2^{-} - 2e \rightarrow {}_{2}$	1
(ii)	electrons are lost (by chloride ions/ $^{-}$)	**ACCEPT** oxidation number of chlorine increases (by 1) / changes from -1 to 0 **REJECT** chlorine loses electrons **IGNORE** references to gain of oxygen	1

(iii)	A hydrogen B is incorrect as oxygen is not formed at the cathode C is incorrect as sodium is not formed when graphite electrodes are used D is incorrect as water is not formed at the cathode		1 **Total 15**

Question number	Answer	Notes	Marks
1 (a) (i)	argon and helium	**ALLOW** Ar and He	1
(ii)	carbon dioxide	**ALLOW** CO_2 If both name and formula given both must be correct	1
(iii)	nitrogen	**ALLOW** N_2 **IGNORE** N	1
(iv)	carbon dioxide	**ALLOW** CO_2 If both name and formula given both must be correct	1
(b)	relights a glowing spill/splint		1 **Total 5**

Question number	Answer	Notes	Marks
5 (a)	Results are the same at the end	**ALLOW** there is a constant volume in the tube **ALLOW** the volume of gas stops decreasing **ALLOW** no change after 4 / 5 minutes **IGNORE** references to time **REJECT** the volume of gas stops increasing	1
(b)	(use a glass tube / scale with) smaller divisions.	**ALLOW** use a glass tube / scale with 0.1cm^3 divisions **ALLOW** use a smaller scale **IGNORE** references to repeating the experiment **IGNORE** references to temperature	1
(c)	**M1** Volume of oxygen = 11.5(cm^3) **M2** (11.5 ÷ 48.5) x 100 **M3** 23.7%	Correct answer to 1 dp with or without working scores 3 **ALLOW** ecf from M1 **M3** must be to 1dp	3

Question number	Answer	Notes	Marks
2 (a) (i)	nitrogen	**ALLOW** N_2/N	1
(ii)	carbon dioxide	**ALLOW** CO_2	1
(iii)	argon	**ALLOW** Ar	1
(iv)	carbon dioxide	**ALLOW** CO_2	1
(b)	lighted splint (produces squeaky) pop		1
			5 marks

Question number	Answer	Notes	Marks
1 (a) (i)	argon / helium	**ACCEPT** Ar / He	1
(ii)	nitrogen	**ACCEPT** N_2	1
(iii)	carbon dioxide	**ACCEPT** CO_2	1
(iv)	carbon dioxide	**ACCEPT** CO_2	1
(b) (i)	$S + O_2 \rightarrow SO_2$		1
(ii)	acid rain	**ACCEPT** an adverse effect of acid rain e.g. kills fish, damages plants, corrodes limestone/marble buildings/statues etc. **IGNORE** toxic/pollutant	1
			Total 6

Question number	Answer	Notes	Marks
1 (a) (i)	argon	**ALLOW** Ar	1
(ii)	nitrogen	**ALLOW** N_2/N	1
(iii)	hydrogen	**ALLOW** H_2/H	1
(b)	climate change/global warming /oceans becoming more acidic	**ALLOW** greenhouse effect **ALLOW** effects of global warming e.g. melting of polar ice caps/flooding/wild fires **IGNORE** acid rain **REJECT** references to ozone layer	1
(c)	**M1** bubble/pass/add the gas/carbon dioxide into limewater **M2** (limewater) turns cloudy/milky	 **ALLOW** white precipitate **M2** dep on mention of limewater **REJECT** addition of extra reagents for both marks	2
			Total 6

Question number	Answer	Notes	Marks
3 (a) (i)	argon / Ar		1
(ii)	**C** (nitrogen) A is not correct because nitrogen is more abundant than carbon dioxide methane or oxygen B is not correct because nitrogen is more abundant than methane D is not correct because nitrogen is more abundant than oxygen		1
(b) (i)	(hydrated) iron (III) oxide	REJECT other oxidation states ALLOW Fe_2O_3 IGNORE iron oxide	1
(ii)	(neon) has a full outer shell (of electrons)	ALLOW (neon) is unreactive / inert /has 8 electrons in the outer shell ALLOW (neon) does not lose or gain (or share) electrons	1
(iii)	M1 75 – 30 **OR** 45 (mm) M2 (45 ÷ 75 × 100) = 60(%)	 ALLOW ecf from M1 correct answer of 60% without working scores 2 answer of 40% without working scores 1	2
			Total for question = 6

Question number	Answer	Notes	Marks
2 (a) (i)	oxygen	ALLOW O_2	1
(ii)	nitrogen	ALLOW N_2	1
(iii)	chlorine	ALLOW Cl_2	1
(b)	M1 (hydrogen chloride) has (atoms of) two / different elements M2 (chemically) bonded/joined / (chemically) combined together	ALLOW two different atoms	2
(c)	D (chlorine has the strongest forces of attraction between its molecules) A is not the correct answer because covalent bonds are not broken when chlorine boils B is not the correct answer because covalent bonds do not occur between molecules C is not the correct answer because chlorine does not have ionic bonds		1
		Total = 6	

Question number	Answer	Notes	Marks
1 (a) (i)	helium and neon	both are required for the mark	1
(ii)	oxygen	ACCEPT O_2	1
(iii)	carbon dioxide	ACCEPT CO_2	1
(iv)	carbon monoxide	ACCEPT CO	1
(b)	M1 (bubble the gas through) limewater M2 which turns (from colourless to) cloudy/milky	M2 dependent on M1 ALLOW white precipitate	2
			Total = 6

Question number	Answer	Notes	Marks
2 (a) (i)	nitrogen	**ALLOW** N_2 **IGNORE** N	1
(ii)	argon	**ALLOW** Ar	1
(iii)	carbon dioxide	**ALLOW** CO_2/H_2O(g)/water vapour/CH_4/methane	1
(b) (i)	brown/red-brown/orange-brown	**ALLOW** orange **IGNORE** red **ALLOW** rusty/rust coloured (looks like)rust/rusted	1
(ii)	**M1** (change in length of column =) 84 – 69 **OR** 15 (mm) **M2** $\frac{15 \times 100}{84}$ = 17.86/17.9 (=18)	**M2** subsumes **M1** Working must be shown to score **M2** **Ecf for M2 eg 18/84 x100 =21.4** **REJECT** 17.85/17.8 as wrongly rounded	2
(iii)	not all the oxygen in the sample of air had reacted with the iron wool OWTTE /not enough iron wool	**ALLOW** there is water vapour in the column of air/changes in temperature / pressure / location ALLOW Reaction incomplete/reaction too slow	1
			Total 7

Question number	Answer	Notes	Marks
4 (a) (i)	Any one from: to increase the rate of reaction to give the particles enough energy to react	 ALLOW because copper does not react with oxygen when copper is cold ALLOW so that copper will react with oxygen	1
(ii)	because Ar does not (readily) gain / lose / share electrons	ACCEPT argon has a full outer shell / valence shell of electrons	1
(iii)	copper(II) oxide	ALLOW copper oxide REJECT copper(I) oxide	1
(b) (i)	results are the same (at the end)	ALLOW results stop decreasing	1
(ii)	M1 volume oxygen = 20 cm^3 M2 total volume = 253 cm^3 M3 (20÷253)×100 = 7.9%	 ALLOW correct evaluation from M1 and M2 ALLOW any number of significant figures REJECT incorrect rounding Correct answer of 7.9% with or without working scores 3	3
(iii)	Any one from: there is a leak in the apparatus temperature was not the same for all readings the apparatus was not left to cool (to room temperature)	 IGNORE not all oxygen reacted	1
			Total for question = 8 marks

Question number	Answer	Notes	Marks
2 (a) (i)	D nitrogen D is the only correct answer as nitrogen is the most abundant gas in unpolluted air. A is not correct as there are only trace amounts of hydrogen in unpolluted air. B is not correct as there are only trace amounts of methane in unpolluted air. C is not correct as there are only trace amounts of neon in unpolluted air.		1
(ii)	C 21% C is the only correct answer as the percentage of oxygen in the air is 21% A is not the correct answer as the percentage of oxygen in the air is not 0.04% B is not the correct answer as the percentage of oxygen in the air is not 0.9% D is not the correct answer as the percentage of oxygen in the air is not 35%		1
(b) (i)	<table><tr><td>cracking an alkane</td><td></td></tr><tr><td>complete combustion of an alkane</td><td>✔</td></tr><tr><td>reaction between magnesium and hydrochloric acid</td><td></td></tr><tr><td>rusting of iron</td><td></td></tr><tr><td>thermal decomposition of copper(II) carbonate</td><td>✔</td></tr></table>		2
(ii)	Any one from: M1 global warming M2 climate change	ALLOW greenhouse effect ALLOW an effect of global warming/climate change e.g. wildfires/ melting of polar ice caps/flooding	1
(iii)	argon		1
(c) (i)	nitric acid	ALLOW HNO_3/ nitrous acid /HNO_2	1
(ii)	sulfur dioxide	ALLOW SO_2 ALLOW other oxides of nitrogen	1
			Total for question = 8

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a)</td><td>
<table>
<tr><th>Information</th><th>Gas</th></tr>
<tr><td>the most abundant gas in air</td><td>nitrogen</td></tr>
<tr><td>a toxic gas that is a product of incomplete combustion of hydrocarbons</td><td>carbon monoxide</td></tr>
<tr><td>an unreactive gas that exists as atoms</td><td>helium</td></tr>
<tr><td>a gas produced by the fractional distillation of crude oil</td><td>methane</td></tr>
</table>
</td><td></td><td>4</td></tr>
<tr><td>(b) (i)</td><td>copper(II) oxide / CuO / copper oxide forms</td><td>REJECT copper(I) oxide</td><td>1</td></tr>
<tr><td>(ii)</td><td>the volume of a gas changes with temperature / gas expands when hot / heated / gas shrinks when cools OWTTE</td><td></td><td>1</td></tr>
<tr><td>(iii)</td><td>M1 138 – 108 OR 30 (cm^3)

M2 ((30÷138) × 100 =) 21.7</td><td>

ALLOW minimum 2 significant figures

21.7 / 21.74 / 22 scores 2

78.3 / 78.26 / 78 scores 1</td><td>2</td></tr>
<tr><td colspan="4">Total for question = 8</td></tr>
</table>

Question number	Answer	Notes	Marks
2 (a) (i)	white solid/powder/ash	**ALLOW** (pale/light) grey solid/powder /ash **REJECT** white precipitate **IGNORE** bright/white flame	1
(ii)	$2Mg + O_2 \rightarrow 2MgO$	**ALLOW** multiples and fractions **IGNORE** state symbols even if incorrect	1
(iii)	An explanation that links the following two points **M1** (oxygen is used in the reaction so) volume/amount of air/oxygen decreases /pressure decreases **M2 (**water level rises) to take the place of the oxygen /to equalise the pressure OWTTE	**ALLOW** arguments in terms of pressure	2
(b)	**M1** percentage of oxygen in air = 21% /percentage of air remaining = 79% **M2** volume of air remaining = $\frac{2000 \times 79}{100}$ (cm^3) **M3** 1580 (cm^3)	**ALLOW** 20% / 80% **M2** subsumes **M1** **ALLOW** ecf if incorrect percentage used use of 80% gives an answer of 1600 (cm^3) correct answer of 1580 or 1600 without working scores 3 420 /400 scores 2	3
(c)	The percentages of argon and carbon dioxide are very small OWTTE	**ACCEPT** references to approximate percentages **ALLOW** (all the oxygen has been removed and) only 1% / small amounts of the other gases remain	1
			Total 8

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>4 (a) (i)</td><td>(hydrated) iron(III) oxide</td><td>REJECT incorrect oxidation states</td><td>1</td></tr>
<tr><td>(ii)</td><td>M1 (barrier method involves)
coating iron in paint/oil/grease/plastic

M2 stops oxygen/air/water getting to the iron</td><td>ALLOW coating in named metal below iron in reactivity series eg tin

ALLOW stops iron reacting with oxygen/air/water</td><td>2</td></tr>
<tr><td>(b) (i)</td><td><table><tr><td>reading at start</td><td>20.5</td></tr><tr><td>reading at end</td><td>33.5 (1)</td></tr><tr><td>volume of oxygen used in cm^3</td><td>13.0 (1)</td></tr></table></td><td>CSQ on reading</td><td>2</td></tr>
<tr><td>(ii)</td><td>not all oxygen had reacted / not enough iron (wool)</td><td>ALLOW not left for long enough/ OWTTE</td><td>1</td></tr>
<tr><td>(c)</td><td>M1 calculation of volume oxygen used

M2 correct expression for percentage of oxygen

M3 correct evaluation

Example calculation:

M1 (35.5 – 20.0 =) 15.5

M2 (15.5 ÷ 80.0) x 100

M3 19.4(%)</td><td>

ALLOW ECF from M1

ACCEPT 19.375/19.38

correct answer with no working scores 3</td><td>3</td></tr>
</table>

(Total for Question 4 = 9)

Question number	Answer	Notes	Marks
5 (a)	Any one from: **M1** add more limewater (to cover tube on left) **M2** the glass tube on the left should be longer/in the limewater		1
(b) (i)	**M1** volume of carbon dioxide = 10 (cm^3) **M2** 10÷76 × 100 = 13.2 (%)	correct answer with or without working scores 2 marks. **ACCEPT** any number of significant figures except 1 **REJECT** incorrect rounding **ALLOW** ecf on incorrect volume of carbon dioxide **ALLOW** 66/76 x 100 = 86.8 for 1 mark	2
(ii)	limewater turns (from colourless to) cloudy or milky	**ALLOW** white precipitate	1
(iii)	**M1** the percentage/amount of carbon dioxide in the air is too small **M2** therefore the reading on the syringe would change by less than 1 cm^3	**ALLOW** there is 0.04% of carbon dioxide in the air **ALLOW** the change on the gas syringe would be too small **ALLOW** syringe not precise/accurate enough to measure small volume changes	2

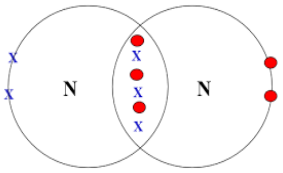
Question number	Answer	Notes	Marks
5 (c) (i)	copper(II) oxide	**ALLOW** copper oxide /CuO **REJECT** copper (I) oxide	1
(ii)	the powder has a greater surface area (than larger pieces of copper)	**ALLOW** the powder reacts more quickly (than larger pieces of copper)	1
(iii)	**M1** argon/it has a full outer shell of electrons **M2** therefore does not lose or gain (or share) electrons	**ALLOW** has eight outer shell electrons	2
			10

Question number	Answer	Notes	Marks
4 (a) (i)	water is needed for iron to rust / react	**ALLOW** reaction needs water (and oxygen) **ALLOW** increases rate of reaction	1
(ii)	brown (coating on iron)	**ALLOW** red-brown / orange-brown / orange / orange-red **IGNORE** red alone	1
(iii)	Fe_2O_3		1
(iv)	An explanation that links the following two points **M1 (**the powder has) a larger surface area **M2** so the iron will rust quicker/ the reaction will be faster / the results are (obtained) more quickly	 **ALLOW** (the powder has) higher surface area:volume **IGNORE** references to the collision theory	2
(b)	syringe reading at start: 81 syringe reading at end: 16 change in volume in cm^3: 65	**ALLOW** ecf on syringe reading at start if syringe reading at end read incorrectly correct volumes the wrong way round scores **1**	2
(c)	**M1** (volume of oxygen =) 90 – 22 **OR** 68 (cm^3) **M2** (total volume at start =) 260 + 90 **OR** 350 (cm^3) **M3** $\frac{68 \times 100}{350}$ = 19.4 (%)	correct answer without working scores 3 **ALLOW** ecf on **M1** and **M2** in **M3** as long as the answer is less than 100% **ACCEPT** any number of sig figs except 1 26.2 (%) scores 2 25.7 (%) scores 2 75.6 (%) scores 2 34.6 (%) scores 1	3 **Total 10**

Question number	Answer	Notes	Marks
2 (a)	**B** (carbon dioxide) A is incorrect as there is more argon in the atmosphere than carbon dioxide C is incorrect as there is more nitrogen in the atmosphere than carbon dioxide D is incorrect as there is more oxygen in the atmosphere than carbon dioxide		1
(b) (i)	**B** (decomposition) A is incorrect as this is not an addition reaction C is incorrect as this is not an oxidation reaction D is incorrect as this is not a substitution reaction		1
(ii)	**C** (green to black) A is incorrect as copper(II) carbonate is not blue B is incorrect as copper(II) carbonate is not blue and copper(II) oxide is not orange D is incorrect as copper(II) oxide is not orange		1
(iii)	$CuCO_3 \rightarrow CuO + CO_2$	**ALLOW** multiples **IGNORE** state symbols even if incorrect	1
(c)	**M1** (volume of oxygen =) 100 – 27 **OR** 73 (cm^3) **M2** (volume of air at start =) 280 + 100 **OR** 380 (cm^3) **M3** 73 ÷ 380 × 100 **OR** 19.2 (%) **M4** 19 (%)	correct answer with or without working scores 4 **ALLOW** ECF throughout Use of 280 gives an answer of 26 scores 3 Alternative method **M1** (volume of air left=) 280 + 27 **OR** 307 (cm^3) **M2** 307 ÷ 380 x 100 **OR** 80.8 (%) **M3** 100 – 80.8 **OR** 19.2 **M4** 19 (%)	4

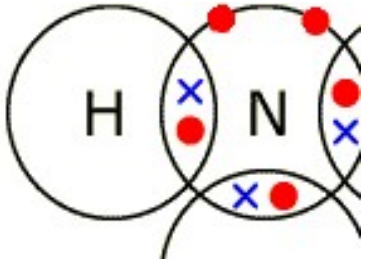
(d)	An explanation that links two of the following three points **M1** carbon dioxide is a greenhouse gas **AND** **M2** (that causes) climate change / global warming / global temperature rise **OR** **M3** melting of polar icecaps / flooding / wildfires / sea levels rising	 **ACCEPT** description of greenhouse effect e.g. carbon dioxide traps heat / infra-red rays in the atmosphere **ALLOW** oceans becoming more acidic / less basic /pH decreasing **REJECT** reference to the ozone layer for **M2** or **M3** **IGNORE** reference to acid rain	2
			Total 10

Question number	Answer	Notes	Marks
4 (a) (i)	nitrogen	**ALLOW** N_2	1
(ii)	carbon dioxide	**ALLOW** CO_2	1
(iii)	argon	**ALLOW** Ar	1
(iv)	hydrogen	**ALLOW** H_2	1
(v)	carbon dioxide	**ALLOW** CO_2	1
(vi)	(12 + 2 × 16 =) 44		1
(vii)	air is a mixture (of gases) / does not have a formula / does not have an M_r OWTTE		1
(b) (i)	(thermal) decomposition		1
(ii)	**M1** green **M2** (to) black	Mark independently colours must be in the correct order	2
(iii)	$CuCO_3 \rightarrow CuO + CO_2$	**ALLOW** multiples and fractions **IGNORE** state symbols even if incorrect	1
			Total 11

Question number			Answer	Notes	Marks
7	(a)		**D** (80 %) A is incorrect as there is not approximately 1 % of nitrogen in the atmosphere B is incorrect as there is not approximately 20 % of nitrogen in the atmosphere C is incorrect as there is not approximately 70 % of nitrogen in the atmosphere		1
	(b)		**M1** 3 pairs of electrons between the two nitrogen atoms **M2** rest of molecule fully correct  	**ALLOW** any combination of dots and crosses **M2** dep on **M1**	2
	(c)	(i)	$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$ **M1** all formulae correct **M2** balancing of correct formulae	**ALLOW** multiples and fractions **IGNORE** state symbols even if incorrect **M2** dep on **M1**	2
		(ii)	any one environmental effect of acid rain e.g. acidifies lakes /kills fish /deforestation /damages plants /corrodes marble statues /corrodes buildings	**ACCEPT** any other environmental effect **REJECT** ozone layer **IGNORE** climate change	1
	(d)	(i)	**D** $(NH_4)_2CO_3$ A is incorrect as NH_3CO_3 is not the formula of ammonium carbonate B is incorrect as $(NH_3)_2CO_3$ is not the formula of ammonium carbonate C is incorrect as NH_4CO_3 is not the formula of ammonium carbonate		1

(ii)	A description that refers to the following six points Test for ammonium ions **M1** add sodium hydroxide solution (and heat) **M2** test the **gas/ammonia** with (damp) red litmus paper **M3** (red litmus) turns blue Test for carbonate ions **M4** add (hydrochloric) acid ONLY **M5** test the **gas/carbon dioxide** with limewater **M6** (limewater) turns cloudy/milky/white precipitate	**ACCEPT** universal indicator paper which turns blue/purple for **M2** and **M3** **M2** is dependent on **M1** **OR** can be awarded for heating the solution and producing a gas to test **M3** can be awarded independently if ammonia gas is correctly tested with correct colour change No **M2** and **M3** if litmus paper added directly to the solution **ACCEPT** other acids **M5** dependent on gaining **M4** by adding acid **ONLY** to the solution **M6** can be awarded independently if a correct limewater test on carbon dioxide gas is carried out No **M5** and **M6** if limewater added directly to the solution.	6 **Total 13**

Question number	Answer	Notes	Marks
7 (a) (i)	$N_2 + O_2 \rightarrow 2NO$	**ALLOW** fractions and multiples **IGNORE** state symbols, even if incorrect	1
(ii)	the reaction has a high activation energy / E_a	**ACCEPT** to give the reactants enough energy to react **ACCEPT** a lot of energy is required to break the bonds in the reactants **ALLOW** nitrogen is unreactive	1
(iii)	acid rain	**ACCEPT** references to respiratory problems **ALLOW** a specific harmful effect of acid rain **ALLOW** references to smog **ALLOW** references to greenhouse gases / global warming / climate change **ALLOW** toxic	1
(b) (i)	**M1** catalyst provides an alternative reaction route/ pathway **M2** with lower activation energy		2
(ii)	**M1** particles / molecules are closer together **M2** therefore more collisions **M3** per unit time	**ACCEPT** more particles in a smaller volume /space more frequent collisions scores **M2** and **M3** any reference to increasing energy max = 1	3

(c)	(i)	**M1** one pair of electrons between the nitrogen and each hydrogen **M2** two non-bonding electrons on the nitrogen  	 M2 dep on M1	2 2
	(ii)	**M1** (electrostatic) attraction between nuclei **M2** and shared pair(s) of electrons OR **M1** (electrostatic) attraction between shared pair(s) of electrons **M2** and nuclei (of both atoms)	nuclei must be plural **ALLOW** bonding pair(s) of electrons **ALLOW** bonding pair(s) of electrons nuclei must be plural	2
	(iii)	**M1** forces between molecules/intermolecular forces (of attraction) are weak **M2** and therefore require little energy to overcome	**ALLOW** intermolecular bonds are weak **IGNORE** less energy Mention of breaking covalent bonds = 0	
				14

Question number	Answer	Notes	Marks
6 a	**B** (Z X Y W) A is not correct as Z is the most reactive metal C is not correct as Z is the most reactive metal D is not correct as X is more reactive than Y		**1**
b i	W		**1**
ii	X		**1**
c	**M1** brown/pink/pink-brown solid forms	**ALLOW** red-brown /orange-brown **IGNORE** red or orange alone **ALLOW** precipitate for solid	**2**
	M2 solution turns colourless	**ALLOW** solution becomes paler **IGNORE** clear **IGNORE** incorrect initial colour of solution **IGNORE** references to magnesium disappearing **IGNORE** references to heat	
		Total	**5**

Question number	Answer	Notes	Marks
5 (a) (i)	copper	ALLOW Cu REJECT copper(II) /Cu^{2+}	1
(ii)	magnesium cannot displace itself	ALLOW magnesium does not react with magnesium sulfate /magnesium ions /Mg^{2+} IGNORE magnesium does not react with magnesium /itself	1
(b) (i)	magnesium /Mg aluminium /Al X copper /Cu	ALLOW 1 mark if aluminium and X are swapped. If copper(II) instead of copper 1 mark only	2
(ii)	zinc / iron	ALLOW all other valid answers	1
(c)	An explanation that links the two points M1 magnesium /Mg (is the reducing agent) M2 magnesium /Mg donates electrons (causing Al^{3+} ions to be reduced)	 ALLOW magnesium / Mg gives (away) / loses electrons (causing Al^{3+} to be reduced) /Al^{3+} gains electrons No M2 if reference to aluminium/Al instead of aluminium ions/Al^{3+} IGNORE Mg is oxidised M2 dep on M1	2
			Total for question = 7 marks

Question number	Answer	Notes	Marks
3 (a) (i)	Q		1 cler
(ii)	might be explosive/dangerous/unsafe		1 grad
(iii)	R S P Q		1 cler
(b) (i)	galvanising/galvanisation		1 grad
(ii)	Any one from paint/oil/grease/sacrificial protection OWTTE	IGNORE barrier method If answer to (i) missing or incorrect credit galvanising in (ii)	1 grad
(c) (i)	zinc displaces copper	ALLOW zinc replaces copper/zinc takes oxygen from copper	1 grad
(ii)	M1 copper(II) oxide/CuO M2 because copper(II) oxide/CuO/it loses oxygen	ALLOW because copper(II) oxide/CuO/it gives oxygen to zinc/is reduced M2 DEP M1 or near miss e.g. Cu as it gives oxygen to zinc scores 1 mark for M2 IGNORE references to electrons	2 expert

Total for Q3 = 8 marks

Question number	Answer	Notes	Marks
2 (a) (i)	(hydrated) iron(III) oxide / Fe_2O_3	**IGNORE** iron oxide **REJECT** iron(II) oxide	1
(ii)	**D** oxidation A is incorrect as it is not a combustion reaction B is incorrect as it is not a decomposition reaction C is incorrect as it is not a neutralisation reaction		1
(iii)	zinc	**ALLOW** Zn	1
(b) (i)	$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$	**ALLOW** multiples and fractions **IGNORE** state symbols even if incorrect	1
(ii)	(squeaky) pop with lighted splint/lit with a (Bunsen) flame	**IGNORE** just 'burns with a squeaky pop' **REJECT** use of glowing splint	1
(c) (i)	displacement	**ACCEPT** redox /oxidation **and** reduction	1
(ii)	pink-brown /pink (solid)	**ACCEPT** pink / brown / orange alone or in combinations eg orange-brown **ALLOW** red-brown **REJECT** red **IGNORE** copper	1
(d)	iron is less reactive/lower in the reactivity series (than magnesium) ORA	**IGNORE** just 'iron is not reactive enough' with no comparison	1
			Total 8

Question number			Answer	Notes	Marks
2	(a)	(i)	most reactive Q S R least reactive P		1
		(ii)	R		1
		(iii)	aluminium + hydrochloric acid → aluminium chloride + hydrogen	**ALLOW** $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$ or multiples or fractions	1
		(iv)	copper/silver/gold	**ALLOW** platinum or any other metal that does not react with hydrochloric acid **ALLOW** correct symbol	1
		(v)	explosive/dangerous/violent/unsafe	**IGNORE** volatile/vigorous	1
	(b)	(i)	heat/thermal energy is given out/released (to the surroundings)	**IGNORE** energy on its own	1
		(ii)	aluminium is more reactive/ higher in the reactivity series (than iron) **ORA**	**ACCEPT** aluminium is a better/stronger reducing agent **ALLOW** Al	1
		(iii)	An explanation that links the following two points **M1** aluminium/Al gains oxygen and iron(III) oxide /Fe_2O_3 loses oxygen **M2** (so) aluminium/Al is oxidised and **iron(III) oxide /Fe_2O_3** is reduced OR **M1** Aluminium/Al gains oxygen so is oxidised **M2 Iron(III) oxide/Fe_2O_3** loses oxygen so is reduced	 **ACCEPT** aluminium/Al loses electrons and iron ions/Fe^{3+} gain electrons for **M1** **ACCEPT** correct changes in oxidation numbers **ACCEPT** aluminium/Al loses electrons so is oxidised scores for **M1** and iron ions/Fe^{3+} gain electrons so is reduced for **M2** **REJECT** iron loses oxygen for M2	2
					Total 9

Question number	Answer	Notes	Marks
8 (a) (i)	**M1** white flame/light		2
	M2 white powder/solid (formed)	**ALLOW** white smoke **ALLOW** white ash **REJECT** white precipitate	
(ii)	magnesium gains oxygen	**ACCEPT** magnesium loses electrons/ oxidation state (of Mg) increases / goes from / changes from 0 to +2	1
(b) (i)	gives out/releases heat (energy)/thermal energy	**IGNORE** energy alone	1
(ii)	$2Mg + CO_2 \rightarrow 2MgO + C$	**ALLOW** multiples and fractions	1
(iii)	Any one from		1
	the fire would keep burning OR the carbon dioxide would not put out the fire OR a large amount of heat/thermal energy would be released	**ALLOW** Any other sensible suggestion	

Question number	Answer	Notes	Marks
8 (c)	An explanation giving two linked changes **M1** (the student should) lift and replace the lid **M2** (to allow) oxygen/air to enter the crucible (to react with the magnesium) AND **M3** reheat and reweigh / heat to constant mass **M4** to make sure that all the magnesium has reacted		4 **Total 10**

Question number	Answer	Notes	Marks
3 (a) (i)	magnesium	ALLOW Mg	1 cler
(ii)	explanation including the following points M1 silver M2 because it is the least reactive (of the metals)	 ALLOW it is very unreactive	2 grad
(b)	explanation including the following points: M1 Method 1/ heating the metal oxide/lead(II) oxide with carbon M2 (because) lead is less reactive than iron (and iron is obtained from iron oxide by carbon extraction) M3 $2PbO + C \rightarrow 2Pb + CO_2$	 ALLOW carbon is more reactive than lead ACCEPT reverse arguments ALLOW $PbO + CO \rightarrow Pb + CO_2$ ALLOW $PbO + C \rightarrow Pb + CO$	3 exp

Question number	Answer	Notes	Marks
3 (c)	Explanation containing the following points Pure metal: M1 (particles/ions/atoms are same size in a regular arrangement so) layers can easily slide over each other Alloy: M2 diagram of alloy structure showing minimum of three layers with at least one different sized circle M3 (having different sized particles/ions/atoms) disrupts/breaks up regular arrangement OWTTE M4 so hard(er) for layers to slide over each other	REJECT molecules once only ALLOW disrupts the lattice / layers / rows (of particles/ions /atoms) ALLOW layers cannot slide over each other IGNORE references to strength/breaking of forces/(metallic) bonds	4 exp

Total for Q3 = 10

Question number	Answer	Notes	Marks
7 (a)	**M1** (bright) white flame/light **M2** white powder/solid (formed)	 **ALLOW** white smoke/ash **ALLOW** grey powder **REJECT** white precipitate	2
(b) (i)	gives out/releases heat (energy)/thermal energy	**IGNORE** energy alone	1
(ii)	$2Al + Fe_2O_3 \rightarrow 2Fe + Al_2O_3$	**ALLOW** multiples and fractions	1
(iii)	An explanation that links two of the following pairs of points **M1** aluminium/Al gains oxygen so is oxidised **M2** iron oxide/Fe_2O_3 loses oxygen so is reduced **OR** **M1** aluminium/Al is oxidised and iron oxide/Fe_2O_3 is reduced **M2** as aluminium/Al gains oxygen and iron oxide /Fe_2O_3 loses oxygen	 **ACCEPT** aluminium loses electrons so is oxidised **ACCEPT** iron ions/Fe^{3+} ions gain electrons so are reduced **ACCEPT** aluminium loses electrons and iron ions/Fe^{3+} ions gain electrons **ALLOW** answers in terms of change in oxidation number	2
(c) (i)	An explanation that links the following two points **M1** to allow air/oxygen to enter the crucible OWTTE **M2** so that oxygen can react with the magnesium		2
(ii)	A description that refers to the following points **M1** heat the crucible again and reweigh **M2** repeat until constant mass	 Heat and reweigh to constant mass scores 2	2
			Total 10

Question number	Answer	Notes	Marks
5 (a)	(thermal) decomposition (1)		1
(b)	any two of the following: M1 (use the same) amount of metal carbonate M2 (use the same) sized pieces/surface area M3 (use the same) volume of limewater M4 (use same) size flame / distance of flame from boiling tube OWTTE	 ALLOW mass ALLOW amount	2
(c)	bubbles are air (from tube) / caused by air (expanding on heating)	ALLOW gas in tube expands (on heating)	1
(d)	explanation including M1 (when limewater turns milky/cloudy it) shows carbon dioxide produced M2 showing metal carbonate has reacted/decomposed	 ALLOW carbon dioxide comes from carbonate (reacting/decomposing)	2
(e) (i)	M1 (from) green M2 (to) black	IGNORE qualifiers eg light	2
(ii)	$CuCO_3 \rightarrow CuO + CO_2$	ALLOW products in either order	1

Question number	Answer	Notes	Marks
5 (f) (i)	M1 the lower the metal is (in the reactivity series) M2 the more easily the (metal) carbonate reacts/decomposes	ALLOW the less reactive a metal is ALLOW the more easily the (metal) carbonate produces carbon dioxide ALLOW references to the less time the (metal) carbonate takes to react/decompose ALLOW references to the faster the (metal) carbonate reacts/decomposes ACCEPT reverse arguments	2
(ii)	repeat (the investigation) using different / other / more (metal) carbonates		1

(Total for Question 5 = 12)

Question number	Answer	Notes	Marks
11 (a) (i)	displacement	**ALLOW** redox	1
(ii)	(manganese) chromium cadmium tin		1
(b)	(copper and magnesium sulfate) **M1** no colour change **M2** copper is less reactive than magnesium ORA /copper cannot displace magnesium (zinc and iron sulfate) **M3** zinc turns (from light grey to) dark grey **M4** solution turns (from green to) colourless **M5** zinc is more reactive than iron ORA/ zinc displaces iron	 **ALLOW** copper is below magnesium in the reactivity series ORA **IGNORE** copper and magnesium sulfate do not react **M2** dep on **M1** **ALLOW** zinc becomes coated in a dark grey metal **ALLOW** zinc is above iron in the reactivity series ORA **ALLOW** zinc reduces iron ions (ignore charge given as long as the charge is positive)	5
(c) (i)	Any two from **M1** concentration of dilute sulfuric acid **M2** temperature **M3** surface area of the metal	 **ALLOW** size of piece of metal	2
(ii)	calcium sulfate forms a layer / coating around the calcium metal	**ALLOW** calcium sulfate prevents the sulfuric acid coming into contact with calcium.	1

(d)	**M1** (moles of aluminium =) 1÷27 **OR** 0.0370 moles **M2** (moles of sulfuric acid required = $\frac{0.0370 \times 3}{2}$ =) 0.0556 moles (and there is more moles of sulfuric acid) **OR** **M1** (moles of aluminium required =) 0.0400 **M2** (mass of aluminium required = 27 × 0.0400 =) 1.08 g (and there is less than 1.08 g)	**ALLOW** any number of significant figures except 1 **ALLOW** 0.0555 if candidate has used rounded value of 0.0370 moles	2
			12

Question number	Answer	Notes	Marks
1 (a)	**M1** oxygen **M2** water / water vapour	**ALLOW** air **ALLOW** moisture **ALLOW** answers in either order	2
(b) (i)	iodine		1
(ii)	methane		1
(iii)	gold		1
			Total 5

Question number	Answer	Notes	Marks
2 (a) (i)	**M1** oxygen **M2** water	**ALLOW** air /O_2 **ALLOW** moisture / water vapour /H_2O	2
(ii)	painting/oiling/coating with plastic/galvanising /electroplating /waxing /greasing	**REJECT** sacrificial protection	1
(b)	An explanation that links the following two points **M1** a more reactive metal is connected to/coated on the iron OWTTE **M2** the more reactive metal will react /oxidise /corrode instead of iron	 **ACCEPT** a suitable metal, e.g. zinc/magnesium /aluminium **IGNORE** an element **REJECT** a more reactive metal rusts instead of iron	2 **Total 5**

Question number	Answer	Notes	Marks
2 (a) (i)	red-brown (coating on nail)	**ACCEPT** orange-brown / brown **ALLOW** orange **IGNORE** rust colour **IGNORE** red alone	1
(ii)	(hydrated) iron(III) oxide/ferric oxide	**ACCEPT** (hydrated) iron oxide **REJECT** iron oxide with incorrect oxidation state	1
(b)	An explanation that links 4 of the following 5 points tube 1 **M1** air/oxygen is needed for rusting **M2** boiled water does not contain air/oxygen **M3** oil keeps air/oxygen out tube 2 **M4** water/moisture is needed for rusting **M5** drying agent keeps water/moisture out	 **ALLOW** 1 mark for no air/oxygen present as an alternative to **M1** and **M2** **ALLOW** 1 mark for no water/moisture present as an alternative to **M4** and **M5**	4 **Total 6**

Question number	Answer	Notes	Marks
3 (a) (i)	magnesium		1
(ii)	**M1** gold **M2** is the least reactive	IGNORE silver **M2** DEP on **M1** ALLOW it is (the most) unreactive	2
(b) (i)	(an alloy is) a **mixture** of metals **OR** (an alloy is) a **mixture** of a metal and another metal	 ALLOW (an alloy is) a **mixture** of a metal and carbon REJECT references to compounds / combining of metals	1
(ii)	**M1** the regular arrangement of atoms is distorted / disrupted / disturbed OWTTE OR carbon atoms are smaller than iron atoms / because iron atoms are larger than carbon atoms **M2** (therefore) it is more difficult for the atoms/layers to slide over one another	ALLOW lattice / layers / rows of atoms are disrupted / distorted / are less regular / are irregular ALLOW carbon and iron atoms are of different sizes ALLOW the atoms are not the same size / the atoms are different sizes IGNORE references to the strength of metallic bonds	2
			Total 6

Question number	Answer	Notes	Marks
4 (a)	Example calculation M1 (volume of oxygen =) 100 – 25 **OR** 75 (cm^3) M2 75 ÷ 365 × 100 M3 20.5 (%)	Correct answer of 20.5 % with or without working scores 3 **ALLOW** ecf from M1 **ALLOW** ecf from M2 **ALLOW** 2 or more significant figures **REJECT** incorrect rounding Use of 265 instead of 365 gives an answer of 28.3 and scores 2 Alternative method M1 (volume of air left =) 265 + 25 **OR** 290 (cm^3) M2 290 ÷ 365 × 100 **OR** 79.5 (%) M3 (100 – 79.5 =) 20.5 (%)	3
(b) (i)	M1 paint provides a barrier M2 which prevents oxygen / water getting to /reacting with the iron	**ALLOW** paint forms a coating (on the iron) / paint is non-permeable **ALLOW** air	2
(ii)	M1 zinc is more reactive/higher in the reactivity series (than iron) M2 zinc will oxidise / react / corrode instead of /before iron	**ALLOW** zinc is a sacrificial metal **IGNORE** references to zinc rusting **IGNORE** references to galvanising	2
			7 marks

Question number	Answer	Notes	Marks
3 (a) (i)	oxygen	**IGNORE** air **ACCEPT** O_2	1
(ii)	(hydrated) iron (III) oxide	**ALLOW** iron oxide /ferric oxide **REJECT** incorrect oxidation states of iron	1
(b) (i)	**M1** plastic acts as a barrier **M2** therefore stops oxygen / water getting to the iron	**ALLOW** forms a protective layer **ALLOW** air in place of oxygen	2
(ii)	galvanising	**ALLOW** sacrificial protection **IGNORE** sacrificial method	1
(iii)	**M1** zinc is more reactive than iron /higher in the reactivity series than iron **M2** therefore reacts / oxidises / corrodes in preference to iron	**IGNORE** references to rates of reaction **REJECT** references to zinc rusting	2
			7

Question number	Answer	Notes	Marks
2 (a) (i)	water	ALLOW moisture /water vapour /steam	1
(ii)	(hydrated) iron**(III)** oxide	ALLOW ferric oxide /Fe_2O_3 If alternatives are present all must be correct	1
(b) (i)	M1 (paint) acts as a barrier/coated with paint /protective layer M2 which prevents oxygen/air/water getting to the iron		2 1
(ii)	galvanising /galvanisation	ALLOW sacrificial protection	
(iii)	M1 zinc is **more** reactive (than iron) M2 zinc oxidises /zinc reacts / zinc loses electrons in preference to iron /zinc oxide forms /zinc corrodes /zinc is a reducing agent	ALLOW zinc is higher in the reactivity series REJECT zinc rusts for M2	2
			Total = 7

Question number	Answer	Notes	Marks
3 (a)	aluminium/it is more reactive than carbon/aluminium/it is above carbon in the reactivity series ORA		1
(b)	An explanation which links two pairs of points **Pair 1** **M1** drink cans **M2** malleable/low density **Pair 2** **M1** aircraft/aeroplanes/bicycle frames/car bodies **M2** low density **Pair 3** **M1** (overhead) power cables **M2** (good) conductor of electricity /low density /malleable /ductile **Pair 4** **M1** pans **M2** (good) conductor of heat **Pair 5** **M1** (aluminium) foil **M2** malleable	In all cases **M2** is dep on **M1** **ALLOW** does not corrode/ non-toxic/doesn't react with the drink **ALLOW** does not corrode **ALLOW** wires **ALLOW** does not corrode/ non-toxic /doesn't react with the food **ALLOW** does not corrode/ non-toxic /doesn't react with the food /prevents heat loss **ACCEPT** any correct use with corresponding relevant property **REJECT** any incorrect answer for **M2**	4

(c)	An explanation that links the following three points **M1** in pure metal layers (of atoms/cations /particles) slide over each other (easily) OWTTE **M2** in an alloy the different sized/larger atoms /cations/particles disrupt the structure/are more randomly arranged **M3** which prevents layers (of atoms/cations /particles) sliding over each other	**ALLOW** sheets/rows for layers **REJECT** molecules /intermolecular forces /negative ions /anions /ionic /covalent for 1 mark only Deduct 1 mark if no mention of layers/sheets/rows	3
			Total 8

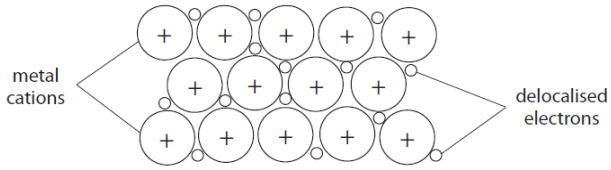
Question number	Answer	Notes	Marks
3 (a) (i)	M1 oxygen	ALLOW air ALLOW O_2	2
	M2 water	ALLOW moisture ALLOW H_2O	
(ii)	(hydrated) iron **(III)** oxide	ALLOW ferric oxide ALLOW Fe_2O_3	1
(b) (i)	M1 paint acts as a barrier / (protective) layer OWTTE	NOT galvanising NOT coating/covering	2
	M2 which prevents water/oxygen/air getting to the iron/reacting with iron		
(ii)	galvanising	ALLOW sacrificial protection	1
(iii)	M1 zinc is more reactive than iron OR zinc has a greater tendency to lose electrons	ALLOW zinc reacts instead of iron NOT zinc reacts more rapidly/faster	2
	M2 zinc oxidises / forms zinc oxide/reacts before iron	REJECT references to zinc rusting REJECT zinc reacts with iron	
		Total = 8	

Question number	Answer	Notes	Marks
2 (a) (i)	M1 layers (of atoms or ions or particles) M2 (atoms /ions) can slide over one another	ALLOW rows or sheets no marks if mention of intermolecular forces or electrons sliding	2
(ii)	M1 electrons are delocalised M2 and (electrons) can move / flow (throughout the structure)	any reference to ions moving scores 0 must mention electrons in the answer in M1	2
(b)	M1 carbon extraction / extraction using carbon M2 iron is less reactive (than carbon) OR carbon is more reactive (than iron)	no marks if electrolysis in M1	2
(c)	M1 add sodium hydroxide (to both solutions) M2 iron(II) sulfate forms a green precipitate /ppt	IGNORE OH^-/ hydroxide ions for M1 but allow M2 IGNORE sluggish green or green sludge IGNORE iron(III) sulfate even if incorrect unless it is a green precipitate M2 dep on M1 or any soluble hydroxides	2
		Total = 8	

Question number	Answer	Notes	Marks
2 (a) (i)	M1 oxygen / air M2 water		2
(ii)	(hydrated) iron(III) oxide	REJECT (hydrated) iron (II) oxide	1
(iii)	C C is the correct answer because rusting involves the oxidation of iron. A is not the correct answer because the rusting of iron is not combustion. B is not the correct answer because the rusting of iron is not neutralisation. D is not the correct answer because the rusting of iron is not thermal decomposition.		1
(b) (i)	galvanising	ALLOW galvanisation IGNORE sacrificial protection	1
(ii)	M1 zinc is more reactive (than iron) M2 zinc reacts / oxidises / corrodes before / instead of iron	ALLOW zinc is higher in the reactivity series (than iron) REJECT references to zinc rusting	2
(iii)	Any two from: painting plastic coating oiling / greasing chromium plating sacrificial protection cathodic protection	 ALLOW powder coating	2
			Total for question = 9 marks

Question number	Answer	Notes	Marks
6 (a)	**M1** (moles of TiO_2 =) $\frac{20 \times 10^6}{80}$ **OR** 2.5×10^5 (mol) **M2** (moles of Cl_2 =) $2.5 \times 10^5 \times 2$ **OR** 5.0×10^5 (mol) **M3** (vol of Cl_2 =) $5.0 \times 10^5 \times 24$ **OR** 12 000 000 (dm^3) **M4** 1.2×10^7 (dm^3)	correct answer with or without working scores 4 **ACCEPT** 250 000 (mol) **ACCEPT** 500 000 (mol) **ALLOW** ecf on **M2** and **M3** 6×10^6 scores 3 3×10^6 scores 3 6 000 000 scores 2 3 000 000 scores 2 2.083×10^4 scores 3	4
(b)	An explanation that links the following two points **M1** argon is unreactive/inert **M2** (so argon) will not react with/oxidise the magnesium **OR** oxygen (in air) will react with/oxidise the magnesium	 **ALLOW** argon will not react with/oxidise titanium **OR** oxygen (in air) will react with/oxidise the titanium	2
(c)	An explanation that links the following three points **M1** in pure titanium all atoms are the same size **OR** layers/atoms can slide over each other (making it soft /malleable) **M2** the alloy has atoms of different sizes **M3** (which disrupts the structure so that) atoms/layers do not/harder to slide over each other (making it stronger) OWTTE	all marks can be awarded from labelled diagrams **ALLOW** cations/ions /particles in place of atoms throughout **REJECT** mention of molecules once only	3
			Total 9

Question number	Answer	Notes	Marks
3 (a)	galvanising	**ACCEPT** galvanisation	1
(b) (i)	rust		1
(ii)	**M1** oxygen / air	**ACCEPT** O_2 **IGNORE** O	2
	M2 water	**ACCEPT** H_2O/moisture **ACCEPT** in either order	
(c) (i)	(a reaction which) gives out / produces / releases heat (energy) / thermal energy	**IGNORE** energy without mention of heat or thermal	1
(ii)	An explanation that links the following two points		2
	M1 aluminium/Al is more reactive than iron/Fe	**ACCEPT** aluminium/Al is higher in reactivity series than iron/Fe **ACCEPT** reverse argument	
	M2 (because) aluminium/Al displaces iron/Fe (from its oxide)	**ALLOW** replaces/takes place of	
(iii)	An explanation that links the following three points		3
	M1 aluminium is oxidised and iron/iron oxide is reduced	**ALLOW** both oxidation and reduction occur	
	M2 aluminium gains oxygen	**ALLOW** aluminium/Al loses electrons	
	M3 iron oxide/iron loses oxygen	**ALLOW** iron ions /Fe^{3+} gains electrons **ALLOW** correct references to changes in oxidation number for **M2** and **M3**	
			Total 10

Question number	Answer	Notes	Marks
5 (a) (i)	A labelled diagram showing **M1** at least three rows of at least three cations/atoms in a regular arrangement **M2** surrounded by (delocalised) electrons Example of diagram  	Max 1 if no labels Minimum requirement for 2 marks is + signs on atoms and electrons labelled or shown as e^-	2 Exp
(ii)	An explanation that links the following two points **M1** delocalised electrons **M2** flow/are mobile/move/are free to move	 **IGNORE** free electrons/ sea of electrons **M2** dep on mention of electrons Any mention of ions/atoms moving scores 0	2 Exp
(b)	Any two of the following properties **M1** low density **M2** does not react with drink **M3** malleable	 **ALLOW** lightweight **IGNORE** light **IGNORE** less dense **ALLOW** does not corrode/non-toxic **IGNORE** does not rust **ALLOW** easy to bend/ easy to shape **IGNORE** references to cost **IGNORE** can be recycled **IGNORE** any irrelevant properties e.g. high melting/boiling point/ good conductor/ductile	2 Exp

Question number	Answer	Notes	Marks
5 (c) (i)	aluminium/it is more reactive/higher in the reactivity series than carbon ORA	**ALLOW** aluminium is too reactive/too high in the reactivity series	1 Grad
(ii)	electrons are gained (by aluminium ion/Al^{3+})	**ACCEPT** oxidation state of aluminium/Al is decreased/ changes from +3 to 0 **REJECT** aluminium/Al gains electrons **IGNORE** references to loss of oxygen	1 Exp
(iii)	$2O^{2-} \rightarrow O_2 + 4e^{(-)}$ **M1** correct formulae of products **M2** balancing of correct formulae	**ACCEPT** multiples and fractions **M2** dep on **M1**	2 Exp **Total 10**

Question number	Answer	Notes	Marks
5 (a) (i)	ore(s)	IGNORE minerals	1
(ii)	gold/platinum	ALLOW silver/copper ALLOW symbols	1
5 (b) (i)	(calcium from calcium chloride) M1 electrolysis M2 (because) calcium is more reactive than carbon **OR** carbon cannot displace calcium	 ALLOW reverse argument M2 dep on M1	2
(ii)	(lead from lead oxide) M1 carbon extraction M2 (because) carbon is more reactive than lead **OR** carbon can displace lead	 ALLOW reverse argument M2 dep on M1	2

Question number	Answer	Notes	Marks
5 (c)	M1 2-D diagram showing at least two layers of particles M2 particles labelled atoms or (positive) ions (malleable because) M3 layers can slide over each other		3
(d)	M1 calculation of M_r of Al_2O_3 M2 moles of Al_2O_3 M3 calculation of mass of aluminium exemplar M1 102 M2 1275÷102 OR 12.5(moles) M3 (12.5×2×27) = 675g	 ALLOW M1×2 ALLOW ecf from M1 ALLOW ecf from M2 675g without working scores 3 0.675 without working scores 2 337.5 without working scores 2 1350 without working scores 2	3

Total marks for Question 5 = 12

Question number	Answer	Notes	Marks
5 (a) (i)	M1 water M2 oxygen	ALLOW moisture / H_2O ALLOW air / O_2 answers can be in either order	2
(ii)	oxidation	ALLOW oxidisation / oxidising / redox	1
(b) (i)	M1 paint acts as a barrier / layer M2 which prevents air / oxygen / water getting to / reacting with the iron		2
(ii)	galvanising	ALLOW galvanisation IGNORE sacrificial protection	1
(iii)	M1 zinc is more reactive than iron M2 (therefore) is oxidised / reacts with oxygen / loses electrons more readily / in preference to /instead of iron	ALLOW corrodes instead of iron REJECT zinc rusts	2
(c) (i)	M1 aluminium is more reactive than iron / ORA M2 because aluminium displaces iron (from iron(III) oxide)		2
(ii)	M1 iron(III) oxide (is the oxidising agent) M2 iron(III) oxide donates oxygen to aluminium	ALLOW iron oxide / iron ions / Fe^{3+} ions throughout ALLOW (iron(III) oxide / iron ions / Fe^{3+} ions) takes electrons from aluminium ALLOW (iron(III) oxide / iron ions / Fe^{3+} ions) causes aluminium to be oxidised	2
			Total for question = 12

Question number	Answer	Notes	Marks
6 (a) (i)	explanation including **M1** carbon above iron in reactivity series **M2** so carbon can remove oxygen from iron(III) oxide	 ALLOW carbon is more reactive than iron ACCEPT reverse arguments ALLOW carbon can reduce iron(III)oxide ALLOW carbon can displace iron (from iron(III) oxide)	2
(ii)	electricity not been discovered OWTTE	IGNORE electrolysis not discovered	1
(b) (i)	explanation including **M1** ions **M2** can move	 If refs to electrons moving then scores 0 M2 DEP M1	2
(ii)	The correct answer is **C** Na^+ **A** is incorrect because H^+ ions not present in molten sodium chloride **B** is incorrect because Cl^- ion is not a cation **D** is incorrect because OH^- ion not present in molten sodium chloride		1
(iii)	explanation including **M1** water/moisture reacts with sodium **M2** to produce hydrogen (which ignites/burns/reacts in oxygen/air causing the small explosions)		2
(iv)	**M1** (anode) $2Cl^- \rightarrow Cl_2 + 2e^{(-)}$ **M2** (cathode) **(2)**$Na^+ + (2)e^{(-)} \rightarrow (2)Na$	ACCEPT $2Cl^- - 2e^{(-)} \rightarrow Cl_2$ both half-equations correct but order reversed scores 1	2

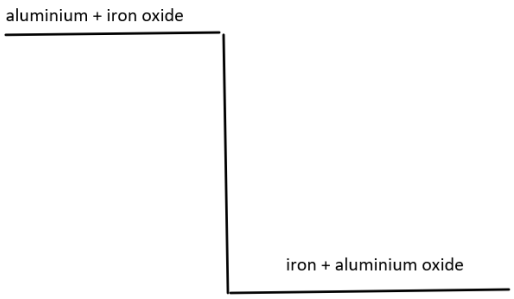
Question number	Answer	Notes	Marks
6 (c)	explanation including **M1** outer electron in potassium (atom) is further away (from nucleus) **M2** outer electron in potassium (atom) less strongly attracted by nucleus OWTTE **M3** so (outer) electron more easily lost OWTTE	ALLOW reverse arguments ALLOW potassium (atom) has more (electron) shells than lithium (atom) ALLOW potassium (atom) larger than lithium (atom) ALLOW potassium has greater atomic radius	3

(Total for Question 6 = 13 marks)

Question number	Answer	Notes	Marks
6 (a)	**M1** oxygen /O_2 **M2** water /H_2O	**ALLOW** air **ALLOW** moisture /water vapour /steam	2
(b)	**A (galvanisation)** B oxidation is not the name of the process C reduction is not the name of the process D sacrificial protection is not the name of the process		1
(c)	**C (aluminium zinc iron copper)** A this is not the correct order of reactivity B this is not the correct order of reactivity D this is not the correct order of reactivity		1
(d)	**M1** add sodium hydroxide (solution) **M2** a brown precipitate (forms)	 **ACCEPT** red-brown /orange-brown **M2** dependent on **M1**	2
(e) (i)	An explanation that links the following points **M1** iron(III) oxide /Fe_2O_3 loses oxygen so is reduced **M2** carbon monoxide gains oxygen so is oxidised **OR** **M1** iron(III) oxide /Fe_2O_3 is reduced and carbon monoxide /CO is oxidised **M2** iron(III) oxide /Fe_2O_3 loses oxygen and carbon monoxide /CO gains oxygen	 **ACCEPT** Fe^{3+} gains electrons and is reduced	2

(ii)	**M1** (amount of Fe =) 28 ÷ 56 OR 0.5(0) (mol) **M2** (amount of Fe_2O_3 =) 0.5 ÷ 2 OR 0.25 (mol) **M3** (mass of Fe_2O_3 = 0.25 × 160 =) 40 (g)	**ALLOW** ecf throughout correct answer without working scores 3	3
(iii)	**M1** $\frac{21}{28}$ x 100 **M2** 75 (%)	correct answer without working scores 2 **ALLOW** ecf for any correct calculation involving 21 as the numerator 0.75 scores 1	2 **Total 13**

Question number	Answer	Notes	Marks
5 (a) (i)	M1 layers / rows (of atoms / ions) M2 can slide over one another	 M2 is dependent on mention of layers / rows in M1	2
(ii)	M1 delocalised electrons M2 can move / can flow / are free to move (throughout the structure)	 **IGNORE** references to charge or current **IGNORE** free electrons M2 dependent on mention of electrons in M1	2
(b)	aluminium is more reactive than carbon	**ALLOW** references to position in reactivity series e.g. aluminium is higher in reactivity series than carbon. **ALLOW** carbon is less reactive than aluminium	1
(c) (i)	M1 aluminium / Al^{3+} ions are attracted to the negative electrode / cathode (because they are positively charged) M2 where they gain electrons (forming aluminium)	 **ALLOW** $Al^{3+} + 3e^- \rightarrow Al$ **IGNORE** references to reduction	2
(ii)	$2O^{2-} \rightarrow O_2 + 4e^-$	**ALLOW** $2O^{2-} - 4e^- \rightarrow O_2$	1
(iii)	M1 electrodes are made of carbon M2 which reacts with / burns in oxygen		2

(d) (i)	iron oxide loses oxygen	**IGNORE** references to electrons	1
(ii)	 M1 right hand line below left hand line M2 correct name / formula of **both** reactants M3 correct name / formula of **both** products	**IGNORE** horizontal axis drawn **IGNORE** activation energy if shown If only use words *reactants* (on left) and *products* (on right) award 1 mark from M2 and M3 M2 and M3 can be scored from an endothermic diagram	3
			14 marks

Question number	Answer	Notes	Marks
1 (a)	**C** red is correct because litmus indicator in an acidic solution is red **A** is incorrect because litmus indicator in an acidic solution is not blue **B** is incorrect because litmus indicator in an acidic solution is not orange **D** is incorrect because litmus indicator in an acidic solution is not yellow		1
1 (b)	**C** 7 is correct because the pH value of a neutral solution is 7 **A** is incorrect because the pH value of a neutral solution is not 0 **B** is incorrect because the pH value of a neutral solution is not 4 **D** is incorrect because the pH value of a neutral solution is not 14		1

Question number	Answer	Notes	Marks
1 (c)	**D** is correct because a solution with a pH value of 9 is weakly alkaline **A** is incorrect because a solution with a pH value of 9 is not strongly acidic **B** is incorrect because a solution with a pH value of 9 is not strongly alkaline C is incorrect because a solution with a pH value of 9 is not weakly acidic		1
1 (d)	**A** is correct because HNO_3 is the chemical formula of an acid **B** is incorrect because H_2O is not the chemical formula of an acid **C** is incorrect because NaCl is not the chemical formula of an acid **D** is incorrect because NaOH is not the chemical formula of an acid		1

Question number	Answer	Notes	Marks
1 (e)	neutralisation	**ALLOW** exothermic	1
1 (f)	**M1** potassium chloride **M2** water	**ACCEPT** in either order **ALLOW** correct chemical formulae	2

Total for Question 1 = 7 marks

Question number			Answer	Notes	Marks
7	(a)	(i)	Measuring cylinder / burette / (volumetric) pipette		1
		(ii)	Neutralisation	**ACCEPT** exothermic **IGNORE** base or alkali	1
	(b)	(i)	12.4		1
		(ii)	$15cm^3$ - red/orange $30cm^3$ - blue/purple		2
		(iii)	OH^- / hydroxide (ion)	**REJECT** OH	1
	(c)		**M1** the reaction is exothermic (therefore the temperature rises)	**ALLOW** the reaction gives out heat (energy) **or** thermal energy **IGNORE** energy alone	3
			M2 (after $25cm^3$ of sodium hydroxide) the reaction is complete OWTTE	**ALLOW** (after $25cm^3$ of sodium hydroxide) neutralisation happens	
			M3 so adding more sodium hydroxide / liquid / solution cools the mixture down	**ALLOW** so no more heat (energy) **or** thermal energy is given out OWTTE **IGNORE** energy alone	

Question number	Answer	Notes	Marks
4 (a)	**M1** (from) yellow **M2** (to) orange	 **ACCEPT** red **ALLOW** pink 1 mark for two correct colours in the wrong order	2
(b)	A description that makes reference to any **four** of the following points **M1** he should not rinse flask with sodium hydroxide solution **or** he should rinse flask with water **M2** he should use a pipette to measure out the sodium hydroxide solution **M3** he should not rinse the burette with water **or** he should rinse the burette with sulfuric acid **M4** he should record the initial burette reading **M5** he should place a white tile under the flask **M6** he should swirl the flask whilst adding the acid **M7** he should add the acid dropwise near the end-point **M8** repeat the titration (to obtain an average/ concordant results)	 **ACCEPT** he should use a pipette instead of a measuring cylinder **ALLOW** white paper **IGNORE** stir	4

Question number	Answer	Notes	Marks
4 (c)	• calculate the amount, in moles, of sodium hydroxide • calculate the amount, in moles, of sulfuric acid • calculate the concentration of sulfuric acid Example calculation **M1** n(NaOH) = 0.0250 × 0.200 **or** 0.005 (mol) **M2** $n(H_2SO_4)$ = 0.005 ÷ 2 **or** 0.0025 (mol) **M3** conc^n = (0.0025 ÷ 0.0167) = 0.150 (mol/dm^3)	 answer to **M1** ÷ 2 answer to **M2**÷0.0167 **ALLOW** 0.1497 or any number of sig fig except one Correct answer without working scores 3 **ACCEPT** alternative methods	3 **Total 9**

Question number	Answer	Notes	Marks
2 (a) (i)	**M1** (X) measuring cylinder **M2** (Y) pipette	 **ALLOW** graduated pipette	2
(ii)	(volume measurement with Y is) more precise ORA	**ALLOW** (volume measurement with Y is) more accurate ORA **ALLOW** (Y gives) a (more) exact volume /exactly 25 cm^3	1
(b) (i)	yellow		1
(ii)	there is no clear end point/ colour change is gradual (at the end point)/no sharp colour change OWTTE	**ALLOW** it has a range of colours	1
(c)	**M1** moles of $HNO_3 = \frac{21.5 \times 0.6(00)}{1000}$ **OR** 0.0129 **M2** moles of $Ba(OH)_2$ = 0.0129 ÷ 2 **OR** 0.00645 **M3** conc. of $Ba(OH)_2 = \frac{0.00645 \times 1000}{25}$ = 0.258 (mol/dm^3)	correct answer with or without working scores 3 **ALLOW** ecf on **M2** **ACCEPT** alternative methods 0.516 scores 2 1.032 scores 2 **ALLOW** 2 sig figs correctly rounded throughout Penalise rounding to 1 sig fig once only	3
(d)	barium sulfate is insoluble /does not dissolve /forms a precipitate		1
			Total 9

Question number	Answer	Notes	Marks
4 (a) (i)	hydroxide/OH^-	ALLOW HO^- REJECT OH	1 grad
(ii)	**C** 11 is correct because 11 is a possible pH for ammonia solution **A** is not correct because 3 is not a possible pH for ammonia solution **B** is not correct because 6 is not a possible pH for ammonia solution **D** is not correct because 14 is not a possible pH for ammonia solution		1 comp
(b) (i)	**C** a proton donor is correct because an acid acts as a proton donor **A** is not correct because an acid does not act as a neutron donor **B** is not correct because an acid does not act as a neutron acceptor **D** is not correct because an acid does not act as a proton acceptor		1 comp
(ii)	**C** is correct because phenolphthalein is pink in alkali and colourless in acid **A** is not correct because phenolphthalein is not orange in alkali and red in acid **B** is not correct because phenolphthalein is not yellow in alkali and red in acid **D** is not correct because phenolphthalein is not colourless in alkali and pink in acid		1 comp

Question number	Answer	Notes	Marks
(c) (i)	M1 ammonium ion is charged 1^+ / NH_4^+ AND sulfate ion is charged 2^- / SO_4^{2-}		2 grad
	M2 so charges balance/cancel (each other) OWTTE	ALLOW so that ammonium sulfate has no overall charge M2 not dep on M1	
(ii)	[[2x(14+4) + 32 + (4x16)] =] 132		1 exp
(iii)	Example calculation	mark CQ from (i) 212 without working scores 3 marks	3 exp
	M1 132(g) ammonium sulfate contains 28(g) nitrogen / 1(g) ammonium sulfate contains (28÷132) (g) nitrogen M2 1000(g) ammonium sulfate contains 1000 x (28÷132) (g) nitrogen M3 = 212(.12) (g) **OR** M1 (moles of ammonium sulfate =) 1000 ÷ 132 **OR** 7.58 M2 (mass of nitrogen =) 28 x 1000 ÷ 132 **OR** 7.58 x 28 M3 = 212 (g)	If 7.58 used in calculation answer is 212.24 If 14 used instead of 28 answer of 106.(06) scores 2 marks with or without working ALLOW any number of sig figs except 1	

Total for Q4 = 10

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>6 (a) (i)</td><td>pipette</td><td>ALLOW graduated pipette</td><td>1</td></tr>
<tr><td>(ii)</td><td>The correct answer is D yellow because methyl orange is yellow in alkaline solution
A is incorrect because methyl orange is not blue in alkaline solution
B is incorrect because methyl orange is not orange in alkaline solution
C is incorrect because methyl orange is not red in alkaline solution</td><td></td><td>1</td></tr>
<tr><td>(b) (i)</td><td>ticks under titration numbers 1, 2 and 4
<table><tr><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>20.65</td><td>20.60</td><td>20.90</td><td>20.55</td></tr><tr><td>✓</td><td>✓</td><td></td><td>✓</td></tr></table></td><td></td><td>1</td></tr>
<tr><td>(ii)</td><td>M1 $\frac{(20.65 + 20.60 + 20.55)}{3}$ =
M2 20.60</td><td>M1 CSQ on results ticked
M2 CSQ on correct calculation from M1

Answer to M2 must be correct to 2dp

20.60 without working scores 2
20.6 with or without working scores 1

If no ticks then only use of 2 or 3 concordant titres can score M1 and M2 in (ii)

If only one tick then M2 can be scored for averaging two or more titre values correctly</td><td>2</td></tr>
</table>

Question number	Answer	Notes	Marks
6 (c) (i)	M1 mol (KOH) = $\frac{0.0370 \times 25}{1000}$		2
	M2 = 9.25×10^{-4} / 0.000925	ALLOW any number of sig fig except one If no division by 1000 giving answer of 0.925 award 1 mark correct answer with no working scores 2	
(ii)	M2 from (i) divided by 2 expected answer 4.625×10^{-4} / 0.0004625	ALLOW any number of sig fig except one	1
(iii)	M1 answer to $\frac{\text{(ii)} \times 1000}{21.20}$		2
	M2 correctly evaluated expected answer if (i) and (ii) correct 0.0218	ACCEPT any number of sig fig except one (unless ECF answer is exactly 1 sig fig) correct answer with no working scores 2	

(Total for Question 6 = 10)

Question number	Answer	Notes	Marks
10 (a) (i)	measuring cylinder / burette / pipette	**ALLOW** syringe	1
(ii)	**M1** and **M2** all the points correct ± half a square	If only one plotting error scores M1	2
(iii)	2 straight lines of best fit, ignoring the anomalous point	Left line does not have to go through/use (0.0, 10.0) if point has not been plotted	1
(iv)	as the volume of sulfuric acid increases the (electrical) conductivity decreases	**IGNORE** references to gradient/slope/correlation	1
(v)	(the student) forgot to stir the mixture	**ALLOW** any reference to adding less acid/lower volume (than should have done) OWTTE	1
(b) (i)	M1 barium sulfate has a (giant) ionic structure **OR** has ionic bonding		3
	M2 ionic substances do not conduct when solid	**ALLOW** only conduct when dissolved/molten **ALLOW** in solid ions cannot move	
	M3 water has covalent bonding **and** covalent compounds do not (usually) conduct electricity	**ALLOW** water does not conduct because it is covalent **IGNORE** explanations of why covalent do not conduct	
(ii)	filtration **OR** filtering		1

Total for question 10 = 10 marks

Question number	Answer	Notes	Marks
9 (a) (i)	**B** 5 A is incorrect as 1 is the pH of a strong acid C is incorrect as 7 is the pH of a neutral solution D is incorrect as 9 is the pH of a weak alkali		1
(ii)	**D** acids are proton donors A is incorrect as alkalis contain OH^- ions not acids B is incorrect as acids do not donate electrons C is incorrect as bases are proton acceptors not acids		1
(b) (i)	(thermal) decomposition		1
(ii)	$PbCO_3 \rightarrow PbO + CO_2$	**ALLOW** multiples	1

Question number	Answer	Notes	Marks
9 (c) (i)	liquid (shown in table)	**ALLOW** if liquid written in space under question **ALLOW** l or L	1
(ii)	An explanation which links any six of the following points **M1** silicon dioxide has a giant (covalent) structure **M2** covalent bonds are (very) strong **M3** (in silicon dioxide) many/all the covalent bonds need to be broken **M4** a large amount of / more energy is required to break the bonds (in silicon dioxide) **M5** silicon(IV) chloride has a simple molecular structure **M6** the forces between the molecules/intermolecular forces (in silicon(IV) chloride) are weak **M7** little / less energy is needed to overcome the forces in silicon(IV) chloride	No **M3 or M4** if reference to overcoming / breaking intermolecular forces in silicon dioxide No **M6 or M7** if any reference to weak covalent bonds or breaking of covalent bonds in silicon(IV) chloride A statement such as 'more energy is needed to break the bonds in silicon dioxide than to overcome the forces in silicon(IV) chloride' scores **M4** and **M7**	6 **Total 11**

Question number	Answer	Notes	Marks
6 (a) (i)	zinc would react with sulfuric acid/solution X	IGNORE zinc is too reactive	1 grad
(ii)	bubbles	ALLOW fizzing / effervescence IGNORE gas evolved IGNORE incorrectly named gas	1 grad
(iii)	**B** a burning splint gives a squeaky pop is correct because this is the test for hydrogen **A** is incorrect because a glowing splint relights is not the test for hydrogen **C** is incorrect because a burning splint goes out is not the test for hydrogen **D** is incorrect because limewater turns cloudy is not the test for hydrogen		1 comp
(b)	description including M1 add barium chloride/$BaCl_2$	ACCEPT barium nitrate/$Ba(NO_3)_2$ IGNORE references to adding (dilute) HCl/HNO_3 REJECT add H_2SO_4	2 Grad
	M2 white ppt forms	M2 DEP M1	
(c) (i)	(graduated) pipette	ALLOW burette	1 Cler

(ii)	calculation with following steps M1 setting out of how to calculate n(KOH) M2 evaluation Example calculation M1 n(KOH) = 0.125 x 25 ÷ 1000 M2 = 0.003125 / 3.125 x10^{-3}	ALLOW any number of sig figs except one If no division by 1000 giving answer of 3.125 award 1 mark correct answer with no working scores 2	2 Exp

(iii)	calculation with following steps M1 calculate n (H_2SO_4) = M2 from (i) ÷ 2 M2 calculate vol H_2SO_4 = (M1 x 1000) ÷ 0.10 M3 evaluation of volume Example calculation M1 0.003125 ÷ 2 = 0.0015625 / 1.5625 x10^{-3} M2 0.0015625 x 1000 ÷ 0.10 M3 = 15.625/15.63/15.6 /16 (cm^3)	Mark ECF from M1 Mark ECF from M2 ALLOW any number of sig figs except one correct answer with no working scores 3 Do not penalise not multiplying by 1000 in (iii) if they have not divided by 1000 in (ii) 31.25/31.3/31 scores 2 62.5/63 scores 2	3 Exp

Total for Q6 = 11

Question number	Answer	Notes	Marks
3 (a)	A description that includes six of the following points **M1** use the pipette to add (25 cm^3 of) potassium hydroxide (solution) to the (conical) flask **M2** add a few drops of methyl orange (to the flask) **M3** add sulfuric acid to the burette and record the initial burette reading **M4** add sulfuric acid (from the burette) to the flask, swirling (continuously) **M5** until the (methyl orange) indicator turns red/orange **M6** take the final burette reading and find volume of acid added (by finding difference between initial and final burette readings) **M7** repeat (the titration) adding the acid dropwise near the end-point / repeat (the titration) to obtain concordant results	 ALLOW fill burette with sulfuric acid to "0" mark ALLOW shaking (gently) / stirring **ALLOW** take final burette reading only if previously filled burette to "0" mark **ACCEPT** repeat (the titration) to obtain results within 0.2 cm^3 of each other	6
(b) (i)	**M1** 0.0250 x 0.240 **OR** $\frac{25.0 \times 0.240}{1000}$ **M2** 0.006(00)	correct answer without working scores 2 If no division by 1000 giving an answer of 6 award 1 mark	2
(ii)	(0.006 ÷ 2 =) 0.003	**ALLOW** ECF from (i)	1
(iii)	**M1** $\frac{0.003(00) \times 1000}{15.00}$ **M2** 0.2(00)	 **ALLOW** ECF from (ii) correct answer without working scores 2 answer to (ii) ÷ 15.00 scores 1 do not penalise not multiplying by 1000 in (iii) if they have not divided by 1000 in (i)	2
			Total 11

Question number	Answer	Notes	Marks
7 (a)	to (more) easily/clearly see the colour change (at end point) OWTTE		1
(b)	**M1** litmus **M2** blue **OR** **M1** methyl orange **M2** yellow **OR** **M1** phenolphthalein **M2** pink	M2 DEP M1 ALLOW purple ALLOW orange ALLOW any other suitable indicator and correct final colour	2
(c)	Description including any five from the following **M1** rinse/wash the conical flask (with distilled/deionised water) **M2** (repeat titration/experiment) adding sodium hydroxide (from burette) slowly/dropwise (near end point) **M3** swirling flask **M4** record initial and final volume burette reading (at end point) /record volume sodium hydroxide added (at end point) **M5** repeat until obtain concordant results **M6** find mean/average (of concordant results)	 REJECT if rinsed/washed using solution IGNORE names of indicators and any colour changes ALLOW shaking/stirring ALLOW reference to subtraction of initial and final readings ALLOW results within 0.2 cm^3 (or less)	5
(d) (i)	moles of NaOH = $\frac{(0.350 \times 18.80)}{(1000)}$ = 0.00658	ACCEPT 6.58×10^{-3}	1
(ii)	amount of HNO_3 = 0.00658	ALLOW ECF from (i)	1
(iii)	conc. of HNO_3 = $\frac{0.00658 \times 1000}{25.0}$ = 0.263(2)	ALLOW ECF from (ii) If not divided by 1000 in (i) do not penalise if not multiplied by 1000 in (iii) ALLOW 2, 3 or 4 sig figs throughout Penalise use of 1 sig fig once only	1

(Total for Question 7 = 11 marks)

Question number	Answer	Notes	Marks
4 (a)	pipette		1
(b)	**M1** (colour in potassium hydroxide) yellow **M2** (colour in sulfuric acid) red	 **ALLOW** pink	2
(c)	to see the colour (change more) clearly (at the end-point) OWTTE		1
(d)	to mix the solutions (more thoroughly) OWTTE	**ALLOW** to speed up the reaction between the acid and alkali OWTTE	1
(e)	titres/results within (+ or −) 0.2 (cm^3 of each other)	**ALLOW** within 0.1 **REJECT** > 0.2 or < 0.1	1
(f)	**M1** $n(H_2SO_4)$ = 0.0150 × 0.180 **or** 0.0027(0) (mol) **M2** $n(KOH)$ = 0.0027(0) × 2 **or** 0.0054(0) (mol) **M3** conc^n = (0.0054(0) ÷ 0.0250) = 0.216 (mol/dm^3)	correct answer with or without working scores 3 answer to **M1** × 2 answer to **M2** ÷ 0.0250 **ALLOW** any number of sig figs except 1 common answers: 0.108 and 0.054 scores 2	3
(g)	An explanation that links the following two points **M1** an H^+ ion is a proton **M2** the OH^- (ion) reacts / bonds with the H^+ (ion) (to form water)	 **ALLOW** donates a proton / H^+ (ion) to the OH^- **IGNORE** accepts a proton	2
			Total 11

Question number	Answer	Notes	Marks
6 (a)	**M1** (X) pipette **M2** (Y) burette		2
(b)	methyl orange/phenolphthalein/litmus (solution)	**REJECT** universal indicator **REJECT** litmus paper **IGNORE** pp indicator **ACCEPT** other alternative appropriate indicators	1
(c) (i)	**M1** (moles of Na_2CO_3 =) $\frac{0.220 \times 25.0}{1000}$ **OR** 0.0055(0) **M2** (moles of HNO_3 =) 0.0055(0) × 2 **OR** 0.011(0) **M3** (volume of HNO_3 = $\frac{0.011(0) \times 1000}{0.350}$ =) 31.4 (cm^3)	Correct answer without working scores 3 If they use mega moles can still score 3 for 31.4 **ALLOW** ecf from **M1** **ALLOW** ecf on incorrect moles in **M2** **ACCEPT** any number of sig figs except 1 **ACCEPT** alternative methods 7.86 /7.9 /7.857 scores 2 15.7 /16 scores 2	3
(ii)	**M1** (moles of Na_2CO_3 = $\frac{0.220 \times 25.0}{1000}$ = 0.0055(0) so) moles of CO_2 = 0.0055(0) **M2** (volume of CO_2 = 0.0055(0) × 24 000 =) 132 (cm^3)	Correct answer without working scores 2 **ALLOW** ecf on incorrect number of moles from (i) If they use mega moles in (i) only 1 mark for 132000	2

(d)	A description that refers to the following three points **M1** add (dilute) hydrochloric acid (to the sodium carbonate) **M2** bubble/pass the gas through limewater **OR** test the gas with limewater **M3** (limewater) turns milky/cloudy	 **ALLOW** any suitable named acid **REJECT** any other incorrect reagent for **M1** and **M2** **M2** dep on **M1** or mention of adding acid **ALLOW** white precipitate **M3** dep on limewater	3
			Total 11

Question number	Answer	Notes	Marks
7 (a)	**M1** X conical flask **M2** Y pipette **M3** Z burette		3
(b)	**B** colourless A is not correct as the colour of phenolphthalein in phosphoric acid is not blue C is not correct as phenolphthalein is pink in alkali not in acid D is not correct as the colour of phenolphthalein in phosphoric acid is not red		1

Question number	Answer	Notes	Marks
7 (c) (i)	ticks in boxes 1, 2 and 4		1
(ii)	**M1** $\frac{30.35 + 30.25 + 30.30}{3}$		
	M2 30.30	30.30 without working scores 2 30.3 without working scores 1 If no results ticked then only use of 2 or 3 concordant titres can score both marks in (ii) If only one result ticked then **M2** can be scored for averaging two or more titre values correctly **M1** CQ on results ticked **M2** CQ on correct calculation from **M1** Answer to **M2** must be correct to 2dp	
(d) (i)	**M1** $\frac{30.40 \times 0.525}{1000}$	If no division by 1000 giving an answer of 15.96 award 1 mark	2
	M2 0.01596 (mol)	correct answer without working scores 2	
(ii)	(0.01596 ÷ 3) = 0.00532 (mol)	**OR** answer to (i) ÷ 3	1
(iii)	**M1** $\frac{0.00532 \times 1000}{25.0}$	**OR** $\frac{\text{answer to (ii)} \times 1000}{25.0}$	2
	M2 0.2128 (mol/dm^3)	**OR** answer to **M1** evaluated correctly correct answer without working scores 2 **ACCEPT** answers to any number of sig figs except 1 throughout (d) If no division by 1000 in (i) and no multiplication by 1000 in (iii) do not penalise twice	
			Total 12

Question number	Answer	Notes	Marks
6 (a)	(results that are) within 0.2(0) (cm^3) of each other	ACCEPT other values if less than 0.2	1
(b)	An explanation that links two of the following pairs of points **M1** a pipette should have been used instead of measuring cylinder/to measure the sodium hydroxide solution **M2** a pipette is more precise/a measuring cylinder is less precise **M3** methyl orange/phenolphthalein/litmus should have been used instead of universal indicator **M4** methyl orange/phenolphthalein/litmus would give a clear/sharp colour change/end-point /universal indicator would not give a clear/sharp colour change/end-point **M5** use white tile (under conical flask) **M6** easier to see colour change (at end point) OWTTE	ALLOW a pipette is more accurate/ a measuring cylinder is less accurate ALLOW pipette would give exactly 25 cm^3 ALLOW universal indicator would give a range of colours ALLOW methyl orange/ phenolphthalein/litmus only have two colours/ are one colour in acid and one in alkali (colours given for a named indicator do not need to be correct) ALLOW easier to see colour change with methyl orange/ phenolphthalein/litmus	4

(c)	**M1** amount of NaOH = $\frac{25.0 \times 1.50}{1000}$ **OR** 0.0375 (mol) **M2** amount of H_2SO_4 = $\frac{0.0375}{2}$ **OR** 0.01875 (mol) **M3** volume of H_2SO_4 = $\frac{(0.01875 \times 1000)}{(0.600)}$ = 31.25 (cm^3)	correct answer without working scores 3 ALLOW ECF throughout ALLOW 2, 3 or 4 sig figs throughout Penalise use of 1 sig fig once only 62.5/125 scores 2 ACCEPT alternative methods	3

(d)	A description that refers to four of the following **M1** heat the solution **M2** to evaporate some of the water/ to form a saturated solution/ to crystallisation point **M3** leave the solution to cool / leave the solution for (more) crystals to form **M4** filter off the crystals **M5** suitable method of drying the crystals	 ALLOW boil Max 1 mark if solution evaporated to dryness If solution left to partially evaporate without heating only **M4** and **M5** can be awarded leave solution to cool and (then) filter off crystals scores **M3** and **M4** ALLOW decant off solution **IGNORE** references to washing e.g. dry between filter papers/dry in a warm oven/ leave to dry **REJECT** hot oven or direct heating with Bunsen burner **M5** DEP on crystals having been formed No **M5** if crystals are washed after drying	4 **Total 12**

Question number	Answer	Notes	Marks
6 (a) (i)	pipette		1 CI
(b) (i)	**M1** (colour in NaOH) pink **M2** (colour in HCl) colourless/no colour	**ACCEPT** magenta **ALLOW** red **IGNORE** clear 1 mark for two correct colours in the wrong order	2 Grad
(ii)	There is no clear (colour change at the) end point/ difficult to determine which shade of green is pH 7 OWTTE	**ALLOW** it has a range of colours	1 Exp

Question number	Answer	Notes	Marks
6 (c) (i)	A description that makes reference to the following two points **M1** add 21.5 cm^3 of hydrochloric acid **M2** to 25 cm^3 of sodium hydroxide solution	0 marks if mention of adding indicator **ALLOW** repeat the titration without indicator for 1 mark **ALLOW** the following alternative method **M1** add activated charcoal (to absorb the indicator) **M2** filter (to remove the activated charcoal and indicator) **M2** dep on **M1**	2 Exp

(ii)	A description that makes reference to the following four points **M1** heat the solution to evaporate some of the water/ to form a saturated solution/ to crystallisation point **M2** leave the solution to cool /leave the solution for (more) crystals to form **M3** filter off the crystals **M4** suitable method of drying the crystals	Max 1 mark if solution evaporated to dryness If solution left to partially evaporate without heating only **M3** and **M4** can be awarded **IGNORE** references to washing e.g. dry between filter papers/dry in a warm oven/ leave to dry **REJECT** hot oven or direct heating with Bunsen burner No **M4** if crystals are washed after drying	4 Exp
6 (d)	• calculate the amount, in moles, of NaOH • divide amount in moles by volume in dm3 • evaluation to obtain correct answer	correct answer without working scores 3 marks	3 Exp
	Example calculation **M1** *n*(NaOH) = 0.0250 x 0.800 or 0.02(00) **M2** conc = (0.02 ÷ 0.0215) **M3** 0.930	 answer to **M1** ÷ 0.0215 **ALLOW** any number of sig fig except 1	
		ALLOW ecf on **M2**	
			Total 13

Question number	Answer	Notes	Marks
5 (a) (i)	(volumetric) pipette	REJECT dropping pipette	1
(ii)	yellow to red	ALLOW yellow to orange / yellow to pink must be in the correct order	1
(iii)	any one from: M1 (universal indicator) does not give a sharp colour change M2 (universal indicator) changes colour over a range of pH values	 ALLOW has no clear end point ALLOW there are a wide range of colours / colour change is too gradual	1
(b) (i)	M1 volume at end 23.80(cm^3) **and** volume at start 2.15(cm^3) M2 volume added 21.65(cm^3)	no M1 for 23.8 ALLOW ecf if M1 values are incorrect but correct subtraction to 2 decimal places	2
(ii)	M1 volumes from titrations 1 and 3 used M2 (21.30+21.50)÷2 M3 21.40(cm^3)	 ALLOW ECF from M1 ALLOW ECF from M2 common answers are 21.48/22.38/21.83/22.23 21.50/22.40/21.85/22.25	3
(c)	M1 repeat using the same volumes of NaOH and HNO_3 **OR** repeat without indicator M2 heat until crystals first start to form /heat to crystallisation point / heat until crystals form on the end of a glass rod M3 leave to cool (and crystallise) M4 pour off excess liquid OR filter (to remove crystals) M5 leave (in a warm place) to dry	M1 only if heated to dryness ALLOW heat to evaporate some/most of the water /to form a saturated solution lose 1 mark if no mention of crystals for M3, M4, M5 IGNORE wash crystals ALLOW dry in a (warm) oven/in a dessicator /dry with filter paper /towel/cloth	5
		Total = 13	

Question number	Answer	Notes	Marks
5 (a) (i)	pipette		1
(ii)	can see colour change (more) clearly OWTTE		1
(b)	**M1** 32.25 **M2** 28.10	each value must be given to 2 decimal places **ALLOW** ecf for **M2** if **M1** is incorrect	2
(c) (i)	<table><tr><td>27.40</td><td>27.65</td><td>27.30</td><td>27.35</td></tr><tr><td>✓</td><td></td><td>✓</td><td>✓</td></tr></table>		1
(ii)	(mean =) 27.35 (cm^3)	**ALLOW** ecf if different ticks are involved No ecf if no ticks or only one tick is present **REJECT** 3 decimal places	1
(d) (i)	**M1** (*n* KOH =) 0.025 x 0.5(00) **OR** 0.0125 (mol) **M2** (*n* H_2SO_4 =) 0.0125 ÷ 2 **OR** 0.00625 (mol) **M3** (conc = 0.00625 ÷ 0.0265 =) 0.236 (mol/dm^3) ALTERNATIVE METHOD C1 X V1 = C2 X V2 0.5 X 25.0 /26.5 = C2 C2 = 0.472 Divide by 2 =0.236 So 1000 can be ignored	correct answer scores 3 marks **ALLOW** 0.472 /0.118 for 2 marks **ALLOW** any number of sig figs except 1 **REJECT** incorrect rounding for 1 mark	3

(ii)	A description that refers to the following points **M1** heat the solution of potassium sulfate until it is partly evaporated / crystals form /saturated solution **M2** allow the solution to cool / to crystallise **M3** filter (the solution) to obtain the crystals **M4** leave the crystals to dry / dry the crystals with filter paper /dry in a (warm) oven /dry in a warm place	If heated to dryness max 1 mark If just left the solution to evaporate only **M3** and **M4** can be scored **ALLOW** decant the solution/liquid from the crystals **IGNORE** wash the crystals **ALLOW** place the crystals in a desiccator No **M4** if heated directly with a Bunsen burner/ hot oven	4 **Total 13**

Question number	Answer	Notes	Marks
5 (a) (i)	(volumetric) pipette	ALLOW burette REJECT measuring cylinder	1
(ii)	M1 fill a burette (with sodium hydrogensulfate) M2 add sodium hydrogensulfate until the indicator changes colour M3 swirl (the conical flask) M4 add sodium hydrogensulfate dropwise near to the endpoint/end M5 repeat until concordant results	REJECT NaOH in burette for M1	5
(b)	M1 heat until crystals first start to form/a saturated solution forms/crystallisation point is reached M2 cool and crystallise/leave to crystallise M3 pour off any excess liquid M4 leave in a warm place to dry	ALLOW heat until volume is about half original volume ALLOW filter IGNORE washing with water ALLOW leave to dry OR dry using a desiccator OR warm oven OR dry between pieces of filter paper If heated to dryness then MAX 1 MARK	4

(c)	M1 mass of sodium sulfate = 2.84 g M2 mass of water = 3.6 g M3 moles of sodium sulfate = 0.02 **AND** moles of water = 0.20 M4 x = 10 OR M1 mass of sodium sulfate = 2.84g M2 mass of hydrated salt = 6.44g M3 Mr of hydrated salt = 6.44/0.02 = 322 M4 xH_2O = 322-142 = 180 so x = 10	Answer of 10 without working scores 4 Allow ecf for M4 if dividing by the smallest number but only if x is given as a whole number	4
			Total marks for question 5 = 14

<table>
<tr><th colspan="3">Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>6</td><td>(a)</td><td>(i)</td><td>pipette</td><td></td><td>1</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>red wine would mask the colour of the indicator / difficult to see colour change (at end point)</td><td>ACCEPT indicator and red wine are a similar colour OWTTE</td><td>1</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>to mix the contents (of the flask so that they can react) OWTTE</td><td>ACCEPT to ensure the colour change is permanent OWTTE

ALLOW to speed up the reaction/ to ensure lete reaction</td><td>1</td></tr>
<tr><td></td><td></td><td>(iv)</td><td>so as not to add more wine than is needed (for lete reaction)/ so as not to overshoot the end point OWTTE</td><td>ACCEPT to find the act/precise point of neutralisation

IGNORE to obtain an accurate reading</td><td>1</td></tr>
<tr><td></td><td>(b)</td><td></td><td><table><tr><td>M1</td><td>final burette reading in cm^3</td><td>22.70</td></tr><tr><td>M2</td><td>initial burette reading in cm^3</td><td>2.15</td></tr><tr><td>M3</td><td>volume of wine added in cm^3</td><td>20.55</td></tr></table></td><td>MAX 2 if final and initial burette readings are reversed.

MAX 2 if readings not given to 2 decimal places.

ALLOW ECF for M3 on correct subtraction of M1 – M2</td><td>3</td></tr>
</table>

Question number	Answer	Notes	Marks
6 (c) (i) ip	Ticks in boxes 1, 3 and 4		1
(ii) ip	• setting out of calculation • answer **M1** $\frac{20.40 + 20.35 + 20.45}{3}$ **M2** 20.40	20.40 without working scores 2 20.4 with or without working scores 1 If no results ticked then only use of 2 or 3 concordant titres can score both marks in (ii) If only one result ticked then **M2** can be scored for averaging two or more titre values correctly **M1** CQ on results ticked **M2** CQ on correct calculation from M1 Answer to **M2** must be correct to 2dp	2

(d)	(i)	• setting out of calculation • final answer **M1** $\frac{25.0 \times 0.05(00)}{1000}$ **M2** 0.00125	If no division by 1000 giving an answer of 1.25 award 1 mark Correct answer without working scores 2	2
	(ii)	0.00125 **OR** answer to (i)		1
	(iii)	• setting out of calculation • final answer **M1** $\frac{0.00125 \times 1000}{19.50}$ **OR** $\frac{\text{answer to (ii)} \times 1000}{19.5}$ **M2** 0.0641 **OR** answer to **M1**	**ACCEPT** any number of sig fig cept 1 Correct answer without working scores 2 $\frac{\text{answer to (ii)}}{19.5}$ correctly evaluated to 2 or more sig figs. scores 1 Do not penalise not multiplying by 1000 in (iii) if they have not divided by 1000 in (i)	2
				Total 15

Question number	Answer	Notes	Marks
6 (a)	any two of the following pairs of points: **M1** use a pipette (instead of a measuring cylinder) **M2** so the volume of alkali added is more precise OR **M1** add the acid dropwise towards the endpoint **M2** so the exact endpoint is seen **OR** **M1** swirl the flask **M2** so the acid and alkali are fully mixed/reacted **OR** **M1** repeat the titration **M2** so concordant results are obtained OR so anomalous results can be ignored **OR** **M1** do the titration on a white tile **M2** so the colour change can easily be seen **OR** **M1** rinse the burette with acid **M2** so that the concentration of acid in the burette is not affected	IGNORE choice of indicator M2 is dependent on M1 ALLOW accurate ALLOW stir	4
(b)	M1 (amount of potassium hydroxide) (25 × 0.150) ÷ 1000 **OR** 0.00375 (mol) M2 0.00375 ÷ 3 OR 0.00125 (mol) M3 (0.00125 ÷ 0.04) × 1000 M4 31.3(cm^3)	 ALLOW M1÷3 ALLOW ecf from M2 M3 to 3 sig figs 31.3 (cm^3) scores 4 31.25 (cm^3) scores 3 93.8 (cm^3) scores 3 93.75 (cm^3) scores 2	4
(c) (i)	$2K_3PO_4 + 3CaCl_2 \rightarrow Ca_3(PO_4)_2 + 6KCl$		1

(ii)	M1 (amount of calcium phosphate) 0.0200 (mol) M2 (mass of calcium phosphate) 6.2 (g) M3 (5.7 ÷ 6.2 × 100) = 91.9 % OR M1 (amount of calcium phosphate) = 5.7/310 OR 0.0184 (mol) M2 0.0184 × 2 OR 0.0368 (mol) M3 (0.0368/0.04 × 100) = 91.9 %	 ALLOW M1 × 310 ALLOW any number of significant figures from 2 ALLOW M1 × 2 ALLOW any number of significant figures from 2	3
(iii)	M1 filter (the calcium phosphate) M2 wash the residue (with distilled water) M3 leave to dry (on a windowsill) /dry between filter papers /dry in a desiccator / dry in a warm oven	If evaporation to form crystals/a soluble salt method then **M3 only** for a suitable drying method. REJECT hot oven or direct heating with Bunsen Burner for M3 REJECT if solid is washed again after drying for M3	3
			Total = 15

Question number	Answer	Notes	Marks
3 (a)	B Precipitation The only correct answer is B the reaction of two solutions to produce an insoluble solid is precipitation. A is not correct because this reaction is not neutralisation C is not correct because this reaction is not a redox reaction D is not correct because this reaction is not thermal decomposition		1
3 (b)	**M1** wash the solid with (deionised) water **M2** suitable method of drying solid eg dry between filter papers/on paper towel/in (warm) oven/in a desiccator	**ALLOW** leave to dry **ALLOW** leave in a warm place **ALLOW** leave for the water to evaporate **IGNORE** dry it alone **REJECT** hot oven or any method of direct heating eg Bunsen burner **REJECT** references (direct or inferred) to silver chloride solution or crystallisation for **M1** and **M2** No M2 if solid washed after drying	2
3 (c)	Any one from: **M1** (hydrochloric acid/it) contains chloride ions **M2** (hydrochloric acid/it) produces a (white) precipitate with silver nitrate **M3** (hydrochloric acid/it) reacts with silver nitrate	**ALLOW** contains Cl^-	1
3 (d)	**M1** n($AgNO_3$ or AgCl) = 0.0025 **M2** (mass AgCl) = 0.0025 x 143.5 = 0.35(9)g	**ALLOW** ECF from M1 **ALLOW** one or more sig fig Correct answer without working scores 2 marks.	2

Question number	Answer	Notes	Marks
8 (a)	Any six from: **M1** add barium carbonate (one spatula at a time) to the acid **M2** until the barium carbonate is in excess **M3** filter off the excess barium carbonate **M4** heat solution to evaporate some of the water **M5** cool or leave to crystallise **M6** filter the crystals (from the solution) **M7** leave crystals in a warm place to dry	 **ALLOW** until some barium carbonate is left/no longer effervesces /fizzes/bubbles **M3** dep on **M2** **ALLOW** heat until crystals start to form **ALLOW** heat until solution is saturated **ALLOW** heat until crystals form on the end of a glass rod/heat to crystallisation point **M6** dep on **M5** **IGNORE** washing **ALLOW** leave to dry **ALLOW** dry on filter paper **ALLOW** dry in a desiccator **ALLOW** dry in a (warm) oven If solution is evaporated to dryness **M5**, **M6** and **M7** cannot be scored	6
(b)	**M1** add (dilute) acid before adding the barium chloride **M2** white precipitate	**ALLOW** any named acid except sulfuric acid **M2** is dependent on **M1**	2
			8

Question number	Answer	Notes	Marks
7 (a)	C C is the correct answer because a precipitate of calcium sulfate will form in tube 1, no precipitate will form in tube 2 as both products are soluble in water and a precipitate of copper(II) carbonate will form in tube 3. A, B and D are not the correct answers as no precipitate will form in tube 2.		1
(b) (i)	white		1
(b) (ii)	Any five from: M1 filter M2 heat/boil (the solution) M3 to evaporate some of the water M4 leave / cool (to crystallise) M5 pour off excess liquid **OR** filter (to obtain crystals) M6 suitable method of drying the crystals	 ALLOW until crystals form on the end of a glass rod ALLOW until crystals first start to form ALLOW until the solution is saturated M4 dep on M2 M5 dep on crystals having been formed IGNORE references to washing e.g. place in (warm) oven / leave to dry (in warm place) / use filter paper / kitchen towel / / desiccator If solution heated to dryness or left to evaporate all of the water only M1 and M2 can be awarded. If method produces silver chloride only M1 and M6 can be awarded	5
(iii)	any one from:		1

	to make sure the silver nitrate and sodium chloride fully reacted	ALLOW so all the reactants react OR so nothing left unreacted OR so neither reagent is in excess	
	to make sure the products only contained silver chloride and sodium nitrate		
	to ensure the highest possible yield		
		ALLOW to make sure the sodium nitrate (crystals) would be pure ALLOW If either solution were in excess, it would contaminate the sodium nitrate OWTTE	
			Total for question = 8 marks

Question number	Answer	Notes	Marks
3 (a)	B A is not correct because mixing sodium sulfate and potassium nitrate does not produce an insoluble salt. C is not correct because mixing sodium chloride and ammonium nitrate does not produce an insoluble salt. D is not correct because mixing sodium hydroxide and potassium sulfate does not produce an insoluble salt.		1
(b)	M1 filter (the solid lead sulfate) M2 wash / rinse (with deionised / distilled water) M3 leave (in a warm place) to dry	If the method starts with crystallisation then, max (2) ALLOW leave on a windowsill / dry using filter paper / dry in a (warm / drying) oven If the reaction mixture is just heated to dryness, score M3 only	3
(c) (i)	6 points plotted ± half a square		1
(ii)	smooth curve of best fit through, or within a square, of all points		1
(iii)	M1 working shown on graph M2 solubility at 90°C – solubility at 30°C	ALLOW any evidence of temperatures marked on graph eg dots / lines Expected answer of 74-82 scores 2 <u>provided some working is shown on graph</u> If no working shown, score M2 only Mark ECF on (ii), even if a straight line is drawn	2
			Total for question = 8

Question number	Answer	Notes	Marks
6 (a)	**D (as a proton donor)** A is not the correct answer as acids are not electron acceptors B is not the correct answer as acids are not electron donors C is not the correct answer as acids are not proton acceptors		1
(b)	effervescence / bubbles / fizzing / a colourless solution forms /magnesium dissolves / magnesium gets smaller/gets warm	IGNORE gas produced	1
(c)	to ensure all the (hydrochloric) acid has reacted	ALLOW acid used up for reacted ALLOW to ensure it has neutralised	1
(d)	A description connecting any 5 of the following: M1 filter (the excess magnesium) M2 heat M3 until crystals first start to form M4 allow to cool and crystallise M5 pour off excess liquid M6 leave in a warm place to dry	 ALLOW heat to evaporate some of the water ALLOW heat until a saturated solution forms ALLOW filter / decant IGNORE washing the crystals ALLOW dry with a paper towel OR in a warm oven OR dry in a desiccator OR leave to dry If sample is heated to dryness award M1 and M2 only	5
			Total = 8

Question number	Answer	Notes	Marks
6 (a)	<table><tr><td>precipitate of barium carbonate</td><td>precipitate of barium sulfate</td></tr><tr><td>no precipitate</td><td>no precipitate</td></tr><tr><td>precipitate of calcium carbonate</td><td>precipitate of calcium sulfate</td></tr></table>	if barium sulfate and calcium carbonate correct but without including 'precipitate of' scores 1 out of 2 **ALLOW** correct formulae	3
(b)	A description that refers to any six of the following points M1 do a flame test M2 sodium chloride produces a yellow flame M3 add acid M4 potassium carbonate effervesces / bubbles M5 add dilute nitric acid M6 add silver nitrate (solution) M7 potassium chloride gives a white precipitate M8 potassium iodide gives a yellow precipitate	**ACCEPT** any description of a flame test **ACCEPT** yellow-orange or orange **IGNORE** any flame colour given for the potassium compounds **ALLOW** any named acid **ACCEPT** carbon dioxide/gas given off which turns limewater cloudy for M4 M4 is dep on M3 M7 and M8 are dep on M6 **ALLOW** addition of chlorine/bromine solution as an alternative to M6 M7 no colour change with potassium chloride	6

		M8 solution turns brown with potassium iodide If this alternative given no M5	
			9 marks

Question number		Answer	Notes	Marks
10	(a)	to remove excess/unreacted/undissolved/insoluble zinc/solid/metal		1
	(b)	A description that refers to the following four points **M1** heat the solution to evaporate some of the water/ to form a saturated solution/ to crystallisation point **M2** leave the solution to cool /leave the solution for (more) crystals to form **M3** filter off the crystals **M4** suitable method of drying the crystals	Max 1 mark if solution evaporated to dryness If solution left to partially evaporate without heating only **M3** and **M4** can be awarded Decant/pour off solution/pick out crystals **IGNORE** references to washing e.g. dry between filter papers/dry in a warm oven/ leave to dry **REJECT** hot oven or direct heating with Bunsen burner No **M4** if crystals are washed after drying	4
	(c) (i)	**M1** moles of zinc = $\frac{9.75}{65}$ **OR** 0.15(0) **M2** mass of $Zn(NO_3)_2.6H_2O$ = 297 × 0.15(0) (g) = 44.55 (g)	 44.55 / 44.6 (g) without working scores 2 ALLOW 297 X 9.75/65 =44.55/44.6 for 2 marks 297 X 9.75 /30 = 96.52 scores 0	2
	(ii)	**M1** 36.4 ÷ 44.55 × 100 **M2** 81.7(%)	**ALLOW** ecf from (i) **ALLOW** any number of sig figs except 1 but rounded correctly correct answer without working scores 2 use of 44.6 gives 81.6(%)/82 use of 45 gives 80.9(%)/81	2
				Total 9

Question number	Answer	Notes	Marks
9 (a) (i)	$Zn(s) + 2HNO_3(aq) \rightarrow Zn(NO_3)_2(aq) + H_2(g)$	**ACCEPT** upper case letters	1
(ii)	effervescence/bubbles/fizzing	**IGNORE** gas produced /given off **IGNORE** hydrogen produced / given off **ALLOW** colourless solution formed/gets hot/exothermic reaction/zinc dissolves IGNORE crystals form	1
(b) (i)	so all the nitric acid reacts/is neutralised		1
(ii)	A description which refers to the following five points M1 filter off the excess zinc M2 heat the solution until crystals form M3 leave the solution to cool (and crystallise) M4 pour/filter off excess liquid (to obtain crystals) M5 leave (crystals) to dry	 ALLOW heat until the solution is saturated/ heat until crystals form on the end of a glass rod/heat to evaporate some of the water IGNORE washing ALLOW any method of drying that avoids excess heat e.g. filter paper, a desiccator, a warm oven If heated to dryness only M1 can be scored If solution is not heated only M1, M4 and M5 can be scored	5
(c)	$2Zn(NO_3)_2.6H_2O \rightarrow 2ZnO + 4NO_2 + O_2 + 12H_2O$ **M1** all formulae correct **M2** balancing of correct formulae	 **M2** dep on **M1**	2 **Total 10**

Question number	Answer	Notes	Marks
6 (a) (i)	$Pb(NO_3)_2(aq) + 2KCl(aq) \rightarrow PbCl_2(s) + 2KNO_3(aq)$	**ALLOW** upper case letters for state symbols	1
(ii)	Pb^{2+} **and** NO_3^-		1
(iii)	**M1** 207 + (14 + 16 × 3) × 2 **M2** 331	Correct answer without working scores **ALLOW** ECF on **M1** if other multiples of atomic masses added together eg 207 + 14 + (16 x 3) = 269 for 1 mark **REJECT** use of atomic numbers for both marks	2
(b) (i)	all points plotted correctly to the nearest grid line		1
(ii)	point at 2.9 cm/6.0 cm^3 circled	**ALLOW** ecf from incorrect plotting	1
(iii)	**M1** best fit straight line through first four points ignoring the anomalous point **M2** horizontal straight line through last three points	 **ALLOW** max (1) if lines do not cross or meet, or if a smooth curve is drawn, avoiding the anomalous point	2
(iv)	Any two from **M1** precipitate not allowed to settle **M2** height (of precipitate) measured incorrectly eg reference to parallax when measuring height **M3** more than 2 cm^3 (of lead(II) nitrate) added / (total volume of lead(II) nitrate added was) more than 6 cm^3	 **ACCEPT** height measured too soon **ALLOW** too much lead(II) nitrate added	2
(v)	no precipitate as no lead(II) nitrate added OWTTE		1
(vi)	value read from graph where lines cross	no mark if lines do not cross/meet or if there aren't two lines eg a curve is drawn	1
			Total 12

Question number	Answer	Notes	Marks
7 (a) (i)	$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$	**ACCEPT** upper case letters	1
(ii)	effervescence/bubbles/fizzing	**ACCEPT** zinc gets smaller or disappears **IGNORE** hydrogen / gas produced / given off	1
(b) (i)	An explanation that links the following two points **M1** to make sure all of the acid reacts **M2** (so that) a pure zinc sulfate solution is obtained/pure zinc sulfate crystals are obtained OWTTE		2
(ii)	**M1** filter funnel containing filter paper **M2** suitable container to collect filtrate e.g. beaker, conical flask, evaporating basin	**M2** dep on a filter funnel in **M1**	2

Question number	Answer	Notes	Marks
7 (c) (i)	• setting out of calculation • evaluation Example calculation **M1** 65 + 32 + (4 x 16) + (7 x 18) **M2** 287	correct answer without working scores 2	2
(ii)	• multiply moles by M_r • evaluation Example calculation **M1** (mass of $ZnSO_4.7H_2O$ =) 287 x 0.02(00) **M2** (mass of $ZnSO_4.7H_2O$ =) 5.74 (g)	correct answer (5.74) without working scores 2 **ALLOW** ecf from (i)	2
(iii)	**M1** 4.28÷5.74 OR 0.7456 **M2** 0.7456 × 100 **M3** 74.6	correct answer to 3 sig figs without working scores 3 **ALLOW** ecf from (ii) **ALLOW** use of 6g **ALLOW** any number of sig fig greater than 1 **ALLOW** use of 6g giving answer of 71.3 Must be 3 sig figs to score M3	3
			Total 13

Question number	Answer	Notes	Marks
11 (a) (i)	M1 so all the nitric acid reacts/is neutralised AND M2 therefore the solution only contains magnesium nitrate OR M3 if acid is still present it will contaminate the crystals OWTTE	 ALLOW so the excess magnesium can be removed by filtration	2
(ii)	M1 moles of Mg that reacts = 0.0250 ÷ 2 **OR** 0.0125 M2 mass of Mg that reacts = 0.0125 x 24 **OR** 0.3 (g) M3 mass of Mg remaining = 0.45 (g) OR M1 moles of Mg = 0.0250 ÷ 2 **OR** 0.0125 M2 moles of Mg remaining = 0.75 ÷ 24 – 0.0125 **OR** 0.03125 – 0.0125 **OR** 0.01875 M3 mass of Mg remaining (= 0.01875 x 24) = 0.45 (g)	 ALLOW M1 × 24 ALLOW 0.75 - M2 ALLOW 0.03125 – M1 ALLOW M2 x 24 Correct answer without working scores 3 0.15 (g) scores 2	3
(iii)	M1 filter off the excess magnesium M2 heat the solution until crystals first start to form M3 leave the solution to cool (and crystallise) M4 pour/filter off excess liquid (to obtain crystals) M5 leave (crystals) to dry	 ALLOW heat until the solution is saturated / heat until crystals form on the end of a glass rod /heat to evaporate some of the water IGNORE washing ALLOW any method of drying that avoids excess heat e.g. filter paper, a desiccator, a warm oven If heated to dryness only M1 can be scored If solution is not heated only M1, M4 and M5 can be scored	5

(b)	M1 tangent drawn (at 40 s) M2 change in volume of hydrogen ÷ change in time M3 correct answer between 2.75 and 3.75 (cm^3/s) inclusive	If no tangent drawn allow 1 mark for 240 ÷ 40 = 6 (cm^3/s)	3
			Total for question = 13

Question number	Answer	Notes	Marks
5 (a)	**M1** mix / react the two solutions (together)	IGNORE volumes IGNORE heating at this stage REJECT an indication that solids are mixed for **M1**	4
	M2 filter (the solid lead bromide)		
	M3 wash (using deionised water)	IGNORE any washing before filtering	
	M4 method of drying	eg leave to dry / dry in an oven / leave in a warm place / dry with filter paper REJECT direct heating of final product for **M4** REJECT if solid is washed again after drying for **M4** Methods of producing a soluble salt eg evaporating after mixing, leaving solutions in an evaporating basin scores **M1** only	
(b)	**M1** 0.150 × 367 **OR** 55.05 g **M2** (49.6 ÷ 55.05) × 100 **OR** **M1** (49.6 ÷ 367) **OR** 0.1351 **M2** (0.1351 ÷ 0.150) x 100	ALLOW 0.135 ALLOW a final answer of 90% by either method REJECT (49.6 ÷ 0.15) = 330.67 (330.67 ÷ 367) x 100 for both marks	2
(c) (i)	all 6 points plotted ± half a square		1
(ii)	straight line of best fit ignoring the anomalous result at volume = 20 cm^3		1

(iii)	**M1** the conductivity decreases (when the volume of lead(II) nitrate added increases)	IGNORE proportional /inversely proportional REJECT directly proportional ACCEPT negative correlation between volume of lead(II) nitrate and electrical conductivity ALLOW the conductivity increases when the volume of lead(II) nitrate decrease	2
	M2 there are fewer ions in the mixture	ALLOW ions are being removed (as lead(II) bromide is formed)	
(iv)	the student forgot to stir the mixture	ALLOW the student didn't allow enough time for the reaction to take place before measuring conductivity REJECT the student added less / too little lead(iI) nitrate solution	1
(v)	the conductivity would increase		1
(d)	electrons are lost (from bromide ions)	REJECT bromine / bromine ions lose electrons	1
			Total 13

Question number	Answer	Notes	Marks
14 a	to increase the rate of reaction	**ACCEPT** to make the reaction faster/ to speed up the reaction **REJECT** any reference to increasing the solubility of copper(II) oxide	**1**
b	(the copper(II) oxide/it) stops disappearing **OR** mixture turns cloudy (black) **OR** (black) solid settles (at the bottom of the beaker)	**ALLOW** stops dissolving **REJECT** any other colour **REJECT** any other colour **ALLOW** copper(II) oxide/ it settles (at the bottom of the beaker) **IGNORE** precipitate	**1**
c	to remove excess/unreacted copper(II) oxide/solid/base (from the mixture)	**ACCEPT** to separate the copper(II) sulfate solution (from the copper(II) oxide/unreacted solid/excess solid)	**1**
d	blue		**1**

Question number	Answer	Notes	Marks
14 e	**M1** heat/boil the filtrate	**NOTE:** If the solution is heated to remove all the water then only **M1** can be awarded **NOTE** If the solution is left to evaporate all the water without heating only 1 mark can be awarded	**5**
	M2 until crystals form in a cooled sample/ on a glass rod	**ACCEPT** to crystallisation point /to form a saturated solution /until crystals start to form /to remove some of the water **M2** dep on **M1**	
	M3 leave the solution to cool/crystallise	**NOTE**: If the solution is left to completely evaporate after heating then award MAX 3	
	M4 filter (to remove the crystals)	**ACCEPT** decant the (excess) solution **IGNORE** references to washing the crystals	
	M5 dry the crystals on filter paper/on paper towel/in a warm oven /in a desiccator /leave to dry	**REJECT** hot oven or any method of direct heating e.g. Bunsen burner No **M5** if crystals washed after drying	

Question number	Answer	Notes	Marks
14 f i	• calculate the moles of CuO • calculate the mass of $CuSO_4.5H_2O$ • give the answer to an appropriate number of significant figures Example calculation **M1** *n*[CuO] = 9.54 ÷ 79.5 OR 0.120 (mol) **M2** mass of $CuSO_4.5H_2O$ = 0.120 × 249.5 **OR** 29.94 (g) **M3** = 29.9 **OR** **M1** 79.5 (g) → 249.5 (g) **M2** 9.94 (g) → (249.5 ÷ 79.5) × 9.54 (g) **OR** 29.94 (g) **M3** = 29.9	Final answer must be to 3 sig figs Final answer must be to 3 sig figs 29.94 with no working scores 2 29.9 with no working scores 3	**3**
ii	**M1** (23.92 ÷ 29.9) × 100 OR (23.92 ÷ **M3** from (i)) × 100 **M2** = 80(%)	**ALLOW** use of **M2** from (i) 29.94 gives 79.89% **ALLOW** any number of sig figs **ACCEPT** answer of 79.7(3)% using 30g Correct answer without working scores 2	**2**
		Total	**14**

Question number	Answer	Notes	Marks
7 a (i)	**M1** Mg^{2+} **M2** NO_3^-		2
7 a (ii)	**Part 1** making magnesium nitrate solution - a description linking any **three** of the following points **M1** warm / heat the acid (in a beaker/flask) **M2** add magnesium oxide (to acid a little at a time) until in excess /no more dissolves **M3** stir **M4** filter to remove excess magnesium oxide/excess solid	REJECT boil **M3 DEP** on use of acid and oxide	6

		Part 2 using (magnesium nitrate) solution/filtrate - a description linking any three of the following points M5 heat/boil (magnesium nitrate solution/filtrate) M6 until crystals form in a cooled sample/on glass rod M7 leave the solution to cool/crystallise M8 filter (to remove crystals) M9 suitable method to dry the crystals eg using filter paper/using paper towel/in warm oven/in a desiccator	**NOTE if added excess but not filtered off – MAX 2 for Part 2** **ACCEPT to crystallisation point / to form a saturated solution / until crystals start to form / to remove some of the water** **M6 DEP M5** **ACCEPT decant the (excess) solution IGNORE references to washing the crystals** **REJECT hot oven or any method of direct heating e.g. Bunsen** **ALLOW leave to dry but not just dry the crystals M9 DEP M8 No M9 if then wash crystals after drying**

7 (b) (i)		24 + (2 x 14) + (6 x 16) + (12 x 1) + (6 x 16) or equivalent working	Some working must be seen **ALLOW** 24 + 124 +108	
	(ii)	• Calculate moles of magnesium nitrate • Setting out of calculation of mass • Final answer **M1** moles = (0.05 / 2) **OR** 0.025 **M2** mass = 0.025 x 256 **M3** 6.4 (g)	6.4(g) with no working scores 3 only **ALLOW** ECF M2 from M1	
	(iii)	• Setting out of calculation • Final answer **M1** $\frac{4.8}{6.4}$ x 100 **M2** 75 (%) OR **M1** $\frac{4.8}{6}$ x 100 **M2** 80 (%)	75 (%) with or without working scores 2 marks 80 (%) with or without working scores 2 marks **ALLOW** ECF from b(ii) $\frac{6.4}{4.8}$ x 100 AND $\frac{6}{4.8}$ x 100 both score 0 Answers of 25% and 20% score 1	2 **Tota 14**

Question number	Answer	Notes	Marks
7 (a) (i)	calcium + water → calcium hydroxide + hydrogen	**ACCEPT** fully correct balanced chemical equation. $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$ **IGNORE** state symbols even if incorrect	1
(ii)	Any two from **M1** effervescence/fizzing/bubbles **M2** calcium/metal/solid disappears/becomes smaller OWTTE **M3** test tube/beaker feels warm/hot	 **IGNORE** gas given off **ALLOW** calcium/metal /solid dissolves **ALLOW** heat produced /temperature increases	2
(b) (i)	A description that makes reference to the following five points **M1** dissolve each of the solids in water/make a solution of each of the solids **M2** mix/add (the two solutions together) **M3** filter (the mixture) **M4** wash the precipitate/solid/barium sulfate /salt/residue (with water) **M5** suitable method of drying the solid	 **ALLOW M1** and **M2** if just one of the solids is dissolved in water and then the other solid is added to it. **M2** dep on **M1** or on reference to the **solutions** being mixed If implication is that filtering is to obtain crystals from the solution no **M3** e.g. dry in a (warm) oven/dry between filter papers **ALLOW** leave to dry **REJECT** hot oven or direct heating (with Bunsen burner) If evaporation of solution to form crystals do not award **M4** but allow **M5** for suitable drying method	5

(ii)	$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ **M1** all formulae correct **M2** state symbols correct	If formulae incorrect or full equation given (even if incorrect) **M2** can still be awarded for correct state symbols. If NaCl in equation must be (aq).	2

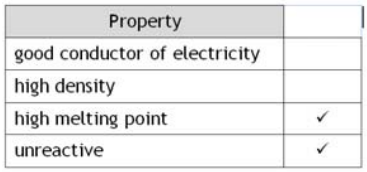
Question number	Answer	Notes	Marks
7 (c) (i)	**C** decomposition A is incorrect as it is not an addition reaction B is incorrect as oxygen is not a reactant D is incorrect as nothing is neutralised here		1
(ii)	• calculate the amount, in moles, of magnesium nitrate • use the equation to find the total amount, in moles, of gas produced • multiply this amount by 24 • answer given to two significant figures Example calculation **M1** *n*(magnesium nitrate) = 7.7 ÷ 148 **or** 0.052 (mol) **M2** *n*(gas) = 5 x 0.052 ÷ 2 **or** 0.13 (mol) **M3** Total volume of gas = 0.13 x 24 **or** 3.12 **M4** 3.1(dm^3)	5 x answer to **M1** ÷2 answer to **M2** x 24 answer to **M3** to 2 sig fig Allow any number of sig fig for **M1**, **M2** and **M3** 3.1 without working scores 4 3.12 without working scores 3	4 **Total 15**

Question number	Answer	Notes	Marks
10 (a) (i)	neutralisation	ALLOW acid - base	1
(ii)	acid donates proton(s)/base accepts proton(s)	ALLOW metal oxide for base	1
(b) (i)	description including M1 appropriate use of at least three named pieces of apparatus AND any four of the following points M2 add copper(II) carbonate to (dilute sulfuric) acid (a spatula/little at a time and stir after each addition) M3 until no more effervescence M4 filter (to remove excess copper(II) carbonate/to obtain (copper(II) sulfate) solution) M5 heat/warm filtrate/(copper(II) sulfate) solution until crystals start to appear (solution saturated) OWTTE M6 filter to obtain (the saturated) solution	ALLOW until no more reacts/dissolves ALLOW until in excess IGNORE if continue and prepare crystals instead of saturated solution	5
(b) (ii)	M1 calculation of actual mass of crystals obtained M2 division by expected mass of crystals (6.4) and multiplication by 100 to convert to percentage M3 correct to 1 dp Example calculation M1 (6.40 – 1.80 =) 4.6(0) M2 (% yield =) $\frac{4.6}{6.4}$ x100 OR 71.875 (%) M3 = 71.9 (%)	M2 ECF M1 M3 DEP M2	3

Question number	Answer	Notes	Marks
10 (c) (i)	M1 find percentage of water M2 divide each percentage by Mr to find number of moles M3 divide each answer by smallest to find ratio and value of x Expected calculation: M1 (79%) $CaSO_4$ 21% H_2O M2 $\frac{79}{136}$ (= 0.58) $\frac{21}{18}$ (= 1.17) M3 $\frac{0.58}{0.58}$ $\frac{1.17}{0.58}$ = 1 : 2 so x = 2	correct answer without working scores 3	3
(ii)	description including M1 do a flame test M2 orange-red flame	ALLOW description of flame test	2
			(Total for Question 10 = 15)

Question number	Answer	Notes	Marks
6 (a)	M1 mix / stir / add (silver nitrate and copper (II) chloride) M2 filter (the silver chloride) M3 wash with (deionised / distilled) water M4 dry in a warm oven **or** dry with filter paper **or** leave / allow to dry (on a windowsill) **or** dry in a desiccator	**IGNORE** references to heating If evaporation is mentioned to form crystals max = 1	4
(b) (i)	M1 and M2 all points correctly plotted to ± half a square	Deduct 1 mark for every incorrect point.	2
(ii)	M3 two straight lines of best fit which must meet at 3 cm and 6 cm^3		1
(iii)	Any **one** from: the precipitate wasn't left to settle (for long enough) the tube was on a slant not enough / less than 3.0 cm^3 of silver nitrate added	 **ALLOW** measured the height too early **IGNORE** references to human error unqualified	1
(iv)	all the copper [(II)] chloride has reacted	**ALLOW** the silver nitrate is in excess / not all the silver nitrate has reacted	1

Question number	Answer	Notes	Marks
(c) (i)	Any **one** from:		1
	burette	**ALLOW** measuring cylinder	
	(volumetric) pipette	**REJECT** beaker	
(ii)	Example calculation		3
	M1 moles of coper chloride = (25 x 0.50) ÷ 1000 **OR** 0.0125 moles		
	M2 moles of silver chloride = 0.0250	**ALLOW** answer to M1 x 2	
	M3 mass of silver chloride = 3.59 g	**ALLOW** answer to M1 or M2 × 143.5 **ALLOW** 2 or more significant figures Correct answer of 3.59 g scores 3 marks	
(iii)	M1 (0.744 ÷ 0.850) × 100		2
	M2 87.5(%)	**ALLOW** 2 or more significant figures	
			15 marks

Question number	Answer	Notes	Marks
3 a	Li^+	**ALLOW** Sr^{2+}	**1**
b	silver bromide / AgBr	If correct name given ignore incorrect formula	**1**
c	lithium bromide / LiBr	Mark CSQ on (a) and (b) If both name and formula given both must be correct	**1**
d i	Impurities/ other ions/ other substances could alter/interfere with the colour of the flame /with the results of the test OWTTE	**ALLOW** impurities/other ions/ other substances contaminate the flame/the test /the wire /it	**1**
ii			**2**
		Total	**6**

Question number	Answer	Notes	Marks
9 (a)	**M1** copper(II) carbonate is green **M2** copper(II) carbonate is insoluble/cannot form a solution OWTTE	**IGNORE** is not white/is a different colour	2
9 (b)	Description including six of following points (Test for potassium ions) **M1** flame test **M2** lilac flame (Test for carbonate ions) **M3** add acid (to mixture of solids/solution) **M4** (pass/bubble) gas/carbon dioxide into limewater **M5** which goes cloudy/milky / white ppt forms (Test for iodide ions) **M6** (add dilute nitric acid followed by) silver nitrate (solution) **M7** yellow ppt/solid	 **ALLOW** description of flame test **ALLOW** any named acid **IGNORE** references to concentration **M4** DEP on **M3** **M5** DEP on mention of limewater **M7** DEP on mention of silver nitrate	6

Total for Question 9 = 8 marks

<table>
<tr><th>Question number</th><th>Answer</th><th>Notes</th><th>Marks</th></tr>
<tr><td>15 a</td><td>
<table>
<tr><th>Test</th><th>Observation</th></tr>
<tr><td>addition of acidified barium chloride solution</td><td>white precipitate</td></tr>
<tr><td>addition of sodium hydroxide solution</td><td>brown precipitate</td></tr>
<tr><td>Addition of sodium hydroxide and gas tested with universal indicator paper</td><td>(universal indicator) turns blue/indigo/purple</td></tr>
</table>
</td><td>1 mark for each correct observation

ALLOW red-brown /foxy brown /orange-brown
IGNORE red or orange alone

ALLOW litmus turns blue

Penalise effervescence once only in tests 1 and 2</td><td>3</td></tr>
<tr><td>b i</td><td>6.65 (g)</td><td></td><td>1</td></tr>
<tr><td>ii</td><td>5.4(0) (g)</td><td></td><td>1</td></tr>
<tr><td>iii</td><td>• calculate moles of $(NH_4)_2SO_4.Fe_2(SO_4)_3$
• calculate moles of H_2O
• divide moles of water by moles of $(NH_4)_2SO_4.Fe_2(SO_4)_3$
• give the value of x to the nearest whole number
Example calculation

M1 $n[(NH_4)_2SO_4.Fe_2(SO_4)_3]$ = 6.65 ÷ 532 OR 0.0125 (mol)

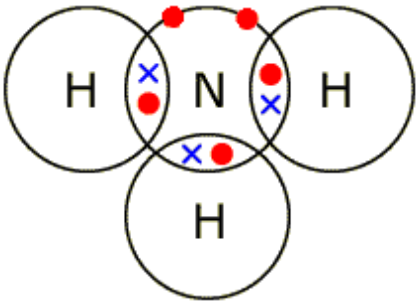
M2 $n[H_2O]$ = 5.4(0) ÷ 18 OR 0.3(00) (mol)

M3 x = 0.3(00) ÷ 0.0125

M4 x = 24

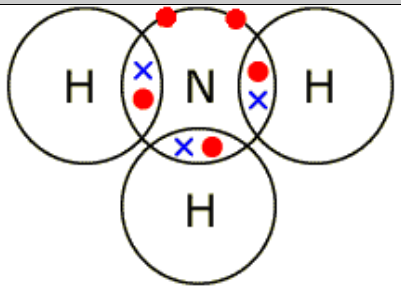
OR
M2 ÷ M1 evaluated correctly and quoted to the nearest whole number</td><td>correct answer without working scores 4
Total</td><td>4
9</td></tr>
</table>

Question number	Answer	Notes	Marks
4 (a)	NH_4^+	**ALLOW** NH_4^{+1} and NH_4^{1+}	1
(b)	**M1** add sodium hydroxide solution (and warm) **M2** (test the gas with damp) red litmus **M3** turns blue **OR** **M2** expose the gas to concentrated hydrochloric acid **M3** white smoke produced	 **ALLOW** (test the gas with damp) universal indicator If universal indicator is used allow blue / purple for **M3** **M3** dep on litmus or universal indicator in **M2** If sodium hydroxide solution is not added **max = 1**	3
(c)	(the reaction is) reversible	**ACCEPT** reaction that goes both ways / both forwards and backwards reactions occur **IGNORE** references to equilibrium	1
(d)(i)	**M1** (molecules / particles of) ammonia move / diffuse faster **M2** because the ammonium chloride forms near(er) to the HCl **OR** because the ammonia has travelled further (in the same time)	 **IGNORE** references to the masses / sizes of the particles	2
(d)(ii)	Any **two** from: **M1** (gas particles) move in random directions / don't travel in straight lines OWTTE **M2** (gas particles) collide with air / other particles **M3** (gas particles) collide with the walls / sides (of the tube) OWTTE	 **ALLOW** air / other particles slow them down **IGNORE** any references to rate of reaction / collisions	2

Question number	Answer	Notes	Marks
8 (a)	A description which refers to the following six points Test for ammonium ions: **M1** add sodium hydroxide (solution) (and warm) **M2** test the gas with (damp) (red) litmus paper/(damp) universal indicator paper **M3** (litmus) turns blue /(universal indicator) turns blue/purple (if ammonium ions are present) Test for sulfate ions: **M4** add (dilute hydrochloric/nitric) acid **M5** add barium chloride (solution) /barium nitrate (solution) **M6** white precipitate (if sulfate ions are present)	 **ALLOW** other alkalis No **M2** or **M3** if solution tested with litmus/ universal indicator paper **M4** and **M5** can be in either order No **M4** or **M6** if sulfuric acid added **M6** dep on **M5**	6
(b) (i)	neutralisation	**ALLOW** acid-base OR acid-alkali	1
(ii)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$	**ALLOW** multiples	1
(iii)	**M1** 3 bonding pairs correct **M2** rest of molecule correct  	 **M2** dep on **M1** **ALLOW** any combination of dots and crosses	2
			Total 10

Question number	Answer	Notes	Marks
7 (a)	A description that refers to the following six points **M1** add sodium hydroxide (solution) **M2** if a green precipitate forms it is an iron(II)/Fe^{2+} compound **M3** if a brown precipitate forms it is an iron(III)/Fe^{3+} compound **M4** add silver nitrate (solution to a fresh sample) **M5** if cream precipitate forms it is a bromide/Br^- **M6** if white precipitate forms it is a chloride/Cl^-	 **ALLOW** add (aqueous) ammonia **M2** and **M3** dep on **M1** **ALLOW red-brown/orange-brown precipitate** **IGNORE** addition of nitric acid **REJECT** addition of hydrochloric or sulfuric acid for **M4** **M5** and **M6** dep on addition of silver nitrate	6
(b)	**M1** moles of iron = 2.8 ÷ 56 = 0.05(0) **M2** 2 mol iron reacts with 3 mol chlorine **M3** moles of Fe to react with Cl_2 = $\frac{0.060 \times 2}{3}$ = 0.04(0) (so iron is in excess) **OR** **M2** 2 mol iron reacts with 3 mol chlorine/ 3 mol chlorine reacts with 2 mol iron **M3** moles of Fe to react with Cl_2 = $\frac{0.060 \times 2}{3}$ = 0.04(0) **M4** 0.04(0) × 56 = 2.24 g (so iron is in excess) **OR** **M1** moles of iron = 2.8 ÷ 56 = 0.05(0) **M2,M3** moles of Cl_2 to react with Fe = $\frac{0.05(0) \times 3}{2}$ = 0.075 (so 0.060 moles is not enough, so iron is in excess)	 MAXIMUM 3 MARKS	3
(c) (i)	red	**ALLOW** pink REJECT red-orange	1
(ii)	H^+	**ALLOW** H_3O^+	1
			Total 11

Question number	Answer	Notes	Marks
9 (a) (i)	M1 Ca^{2+} M2 NO_3^-	Max 1 for use of incorrect subscripts, case	2
(ii)	M1 (calcium nitrate) has a giant ionic structure /lattice M2 strong electrostatic forces / attraction M3 between oppositely charged ions /negative and positive ions / anions and cations M4 which take a lot of energy to overcome (the forces) / break the bonds	ALLOW strong ionic bonds No M2 or M3 if reference to sharing of electrons or intermolecular forces IGNORE more energy /heat	4
(iii)	$2Ca(NO_3)_2 \quad 2CaO + 4NO_2 + O_2$	ALLOW fractions and multiples	1
(b)	Any 2 from M1, M2 and M3 **flame test** M1 do a flame test M2 sodium chloride and sodium sulfate give a yellow flame M3 calcium chloride and calcium bromide give an orange-red flame Any 4 from M4 to M8 **halide ion test** M4 add acidified silver nitrate / add nitric acid and silver nitrate M5 calcium bromide / bromide ions gives a cream precipitate M6 calcium chloride / sodium chloride /chloride ions give a white precipitate **sulfate ion test** M7 add acidified barium chloride / barium nitrate M8 sodium sulfate / sulfate ions gives a white precipitate	ALLOW description of flame test ALLOW sodium (ions) ALLOW orange/brick-red ALLOW calcium (ions) REJECT any extra incorrect reagent for M4 REJECT hydrochloric or sulfuric acid for M4 M5 and M6 dep on silver nitrate in M4 REJECT any extra incorrect reagent for M7 ALLOW any named acid except sulfuric acid M8 dep on barium chloride / barium nitrate in M7	6
			Total for question = 13

Question number	Answer	Notes	Marks
10 (a)	 **M1** 3 bonding pairs **M2** rest of molecule fully correct	**M2** dep on **M1** **ALLOW** any combination of dots and crosses	2
(b) (i)	<table><tr><td>**M1** ammonium chloride</td><td>ammonium carbonate</td></tr><tr><td>NH_4Cl</td><td>**M2** $(NH_4)_2CO_3$</td></tr></table>		2
(ii)	$2NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$	**ALLOW** multiples **IGNORE** state symbols even if incorrect	1
(iii)	**M1** add sodium hydroxide (solution) **M2** test (gas / ammonia) with (damp) red litmus paper / (damp) universal indicator paper **M3** (red litmus) turns blue / universal indicator) turns blue / purple	**REJECT** if solution / ammonium (sulfate) tested with litmus / universal indicator paper	3

(c)	(i)	**M1** 2 x 14 ÷ 80 **OR** 0.35 **M2** (0.35 x 100 =) 35 (%)	correct answer without working scores 2 **ALLOW** 1 mark for 17 / 17.5 / 18 (%)	2
	(ii)	An answer that links any 4 points: **M1** (NH_3) higher % of N **OR** (($(NH_4)_2SO_4$) lower % of N **M2** $(NH_4)_2SO_4$ easy to use (to soil) **/** easy for the plants to absorb / less wastage **OR** (NH_3) difficult to use (to soil) **/** difficult for the plants to absorb / more wastage / has to be dissolved (in water) first **M3** $(NH_4)_2SO_4$ pH close to that of (rain) water **/** will not alter the pH (of the soil/water) **M4** NH_3 will cause (the soil/water) to become alkaline / will raise the pH (of the soil/water) / neutralise (the water / soil) / may stunt growth of plants / may damage / kill plants **M5** NH_3 and or $(NH_4)_2SO_4$ soluble so runoff / wastage of fertiliser / water pollution / eutrophication / leaching	**REJECT** NH_3 has a pH close to rainwater **REJECT** ammonia causes the soil / water to become acidic	4 **Total 14**