GCSE SCIENCE YEAR 10 SUMMER PREPARATION WORK CHEMISTRY STUDENT BOOK HIGHER

Please complete all of these questions in this book and store this work in your student revision files.

This will provide a useful resource for revision.

Name	
Class	
Teacher	

Revision Question Book 1c

GCSE Science

This book is suitable for students currently in Year 9.

In the following booklet there are several questions based on GCSE Chemistry Paper One. These questions are additional to the work which you must do on your GCSE course.

To gain the highest grade possible in your GCSE examinations it is recommended that you complete these questions at home or in revision sessions outside of lessons.

This will both familiarise yourself with both the concepts found in the GCSE syllabus and the examination technique found in examinations.

The mark scheme to the questions is integrated in the book for you to use independently.

To improve competency in answering questions on GCSE Science and achieve mastery in this module, answer all of these questions independently.

When you have completed your work in this book, please store this work at home.

Many thanks for all of your hard work in GCSE Science.

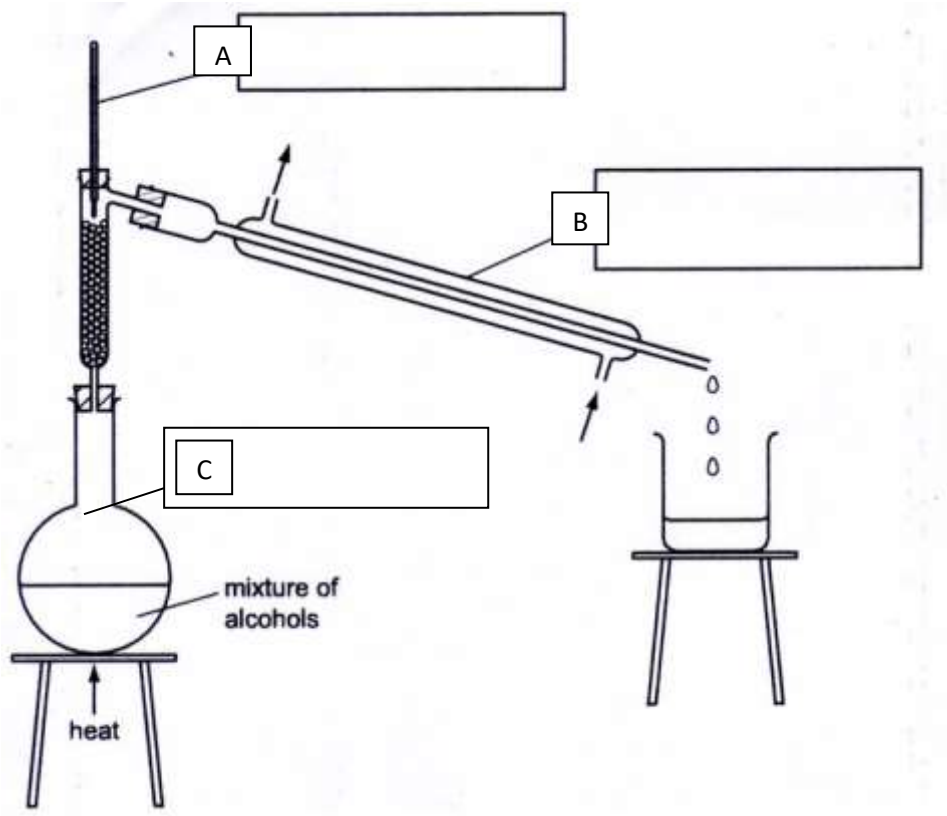
Mr. Turnbull

TOPIC 1: ATOMIC STRUCTURE

1.0 A student separated a mixture of two alcohols, ethanol (boiling point 78 °C) and butanol (boiling point 118 °C).

The apparatus is shown in **Figure 1**.

Figure 1



1.1 Complete the boxes in **Figure 1** to identify the pieces of apparatus labelled A, B and C

[3 marks]

1.2 What is the name of this separation process?

[1 mark]

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1.3 Suggest why the first liquid to collect in the beaker is ethanol.

[1 mark]

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1.4 Alcohols are flammable.
Suggest how the mixture of alcohols should be safely heated so that ethanol can be collected

[1 mark]

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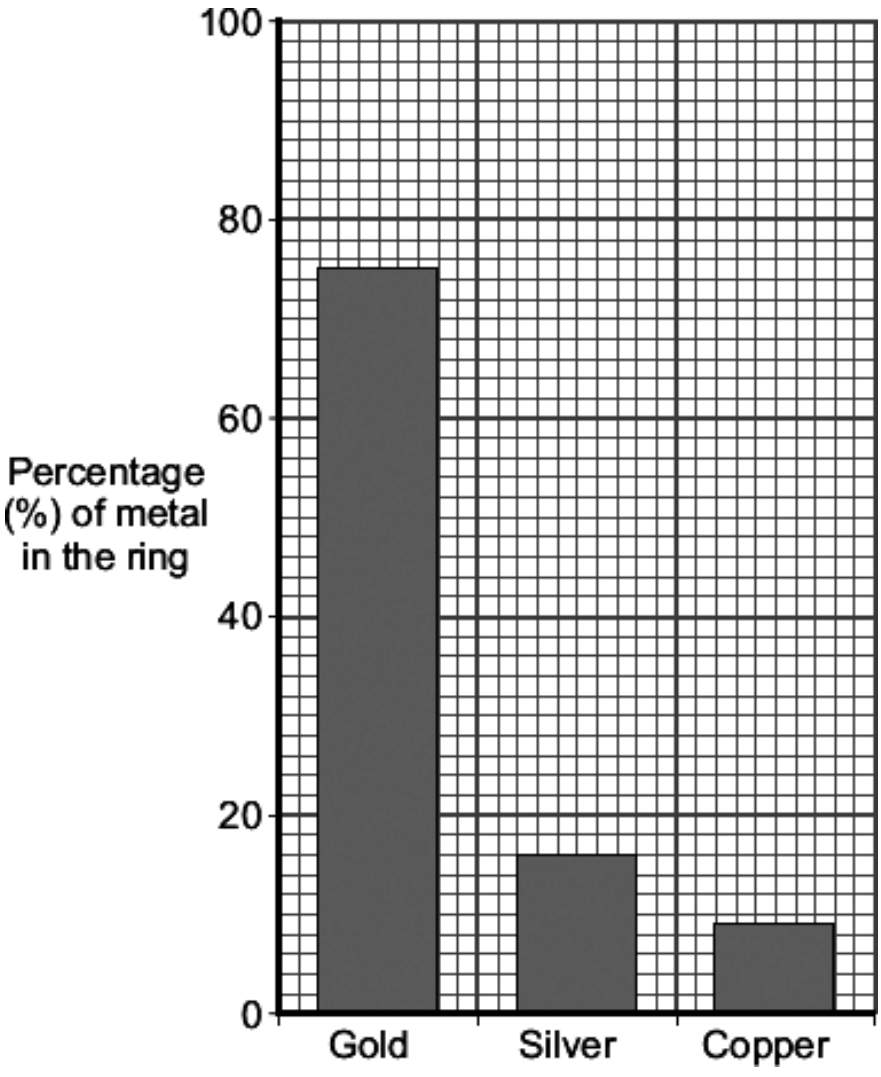
2.0 The picture shows a pair of gold rings.

Gold rings are made from alloys of gold.

Robert Chealb Creative commons license

The bar chart shows the composition of the alloy of gold used in the ring.



2.1 State the composition of the alloy used to make the ring.

[3 marks]

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2.2 An atom of gold can be represented as $^{197}_{79}Au$.

This shows that a gold atom has an atomic number of 79 and a mass number of 197.

Complete the table to show the numbers of each sub-atomic particle in this gold atom.

[3 marks]

Name	Number
Proton	
Electron	
Neutron	

3.0 A student is given a mixture of salt and sand.

Describe a method the student could use to separate the mixture.

The student should obtain:

- salt crystals
- dry sand

In your method you should name all of the apparatus you will use.

[6 marks]

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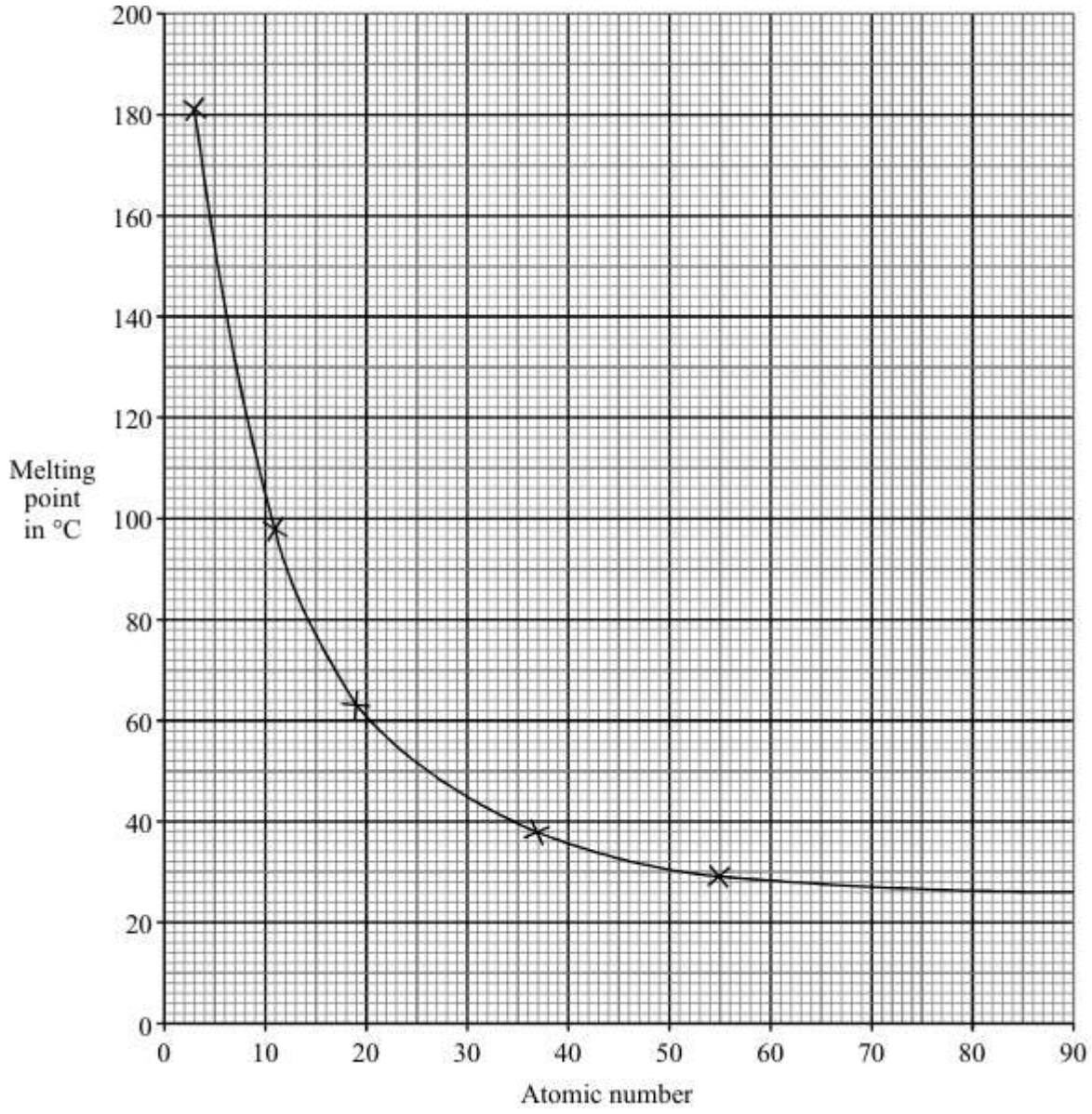
4.0 The **Graph 1** shows the melting points of the Group 1 metals plotted against their atomic numbers.

Graph 1



4.1 Give **two** conclusions that can be drawn from the graph.

[2 marks]

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4.2 The alkali metal francium has an atomic number of 87.

Estimate the melting point of francium.

[1 mark]

Melting point of francium = _____ °C

4.3 Lithium has 3 electrons. Draw a diagram to show the electronic structure of lithium.

[1 mark]

4.4 Describe what you would see when sodium is added to water.

[3 marks]

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4.5 Complete the balanced equation for the reaction of sodium with water.

[2 marks]

_____ + _____ → _____ NaOH + H_2

4.6 Describe the trend in reactivity of group 1 metals with water.

[1 mark]

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4.7 Explain the trend in reactivity of group 1 metals with water.

[3 marks]

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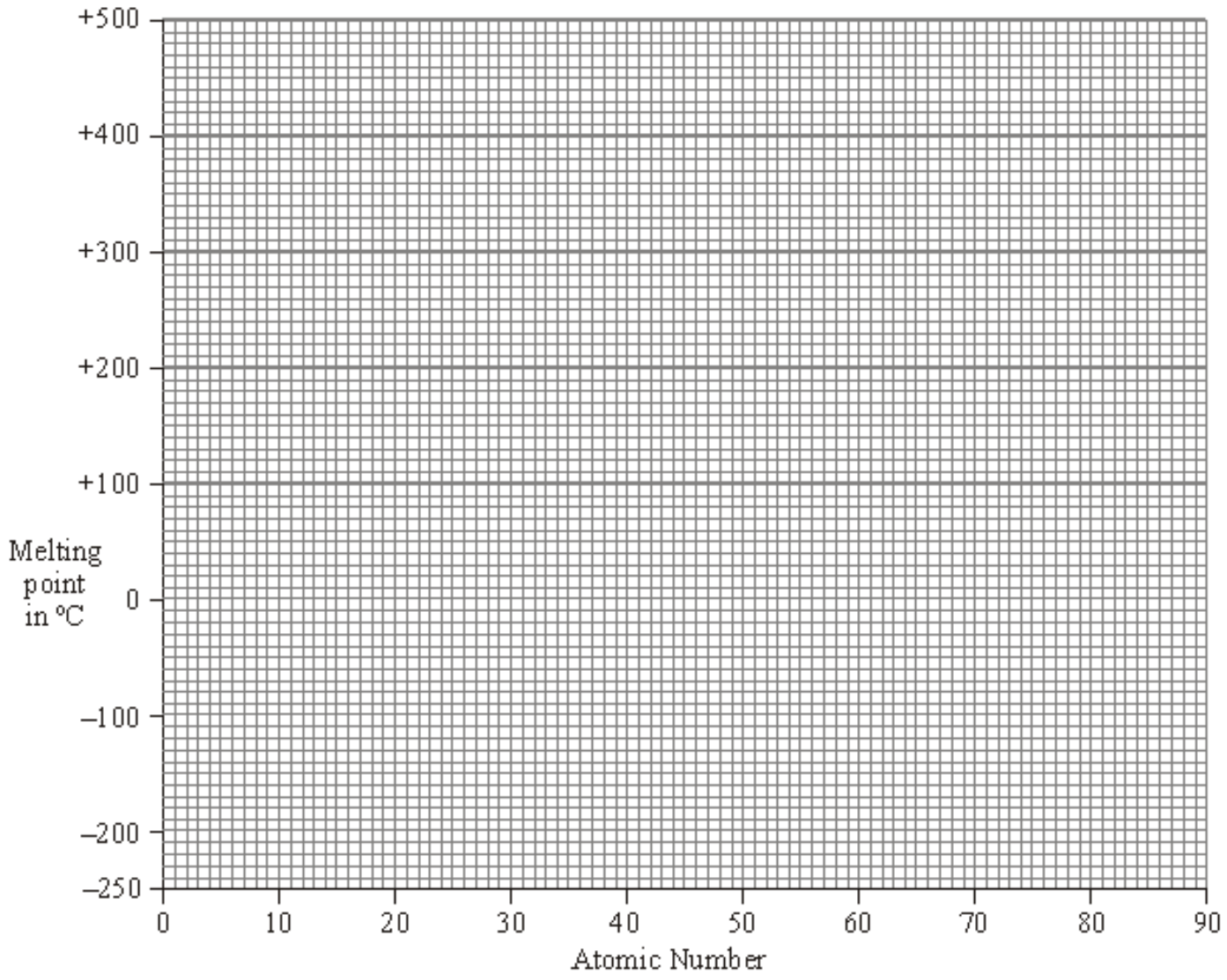
5.0 The table gives the melting points of some of the elements of Group 7.

Element	Atomic number	Melting point in °C
Fluorine	9	–220
Chlorine	17	
Bromine	35	–7
Iodine	53	114
Astatine	85	301

5.1 Plot a graph of the melting point against atomic number.

Draw a line of best fit.

[2 marks]



5.2 Estimate the melting point of chlorine

[1 mark]

_____ °C

5.3 What is the state of iodine at 25 °C?

[1 mark]

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5.4 Chlorine has two isotopes $^{35}_{17}Cl$ and $^{37}_{17}Cl$
Why do these two isotopes have a different mass number?

[2 marks]

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5.5 The relative formula mass of chlorine is 35.5.
Explain why this is not a whole number.

[1 mark]

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6.0 Dmitri Mendeleev was one of the first chemists to classify the elements.

Mendeleev arranged the elements in order of their atomic weight in a table.

Part of his table is shown below.

Use the periodic table and the information in the table below to help you to answer the questions.

	Group							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Period 1	H							
Period 2	Li	Be	B	C	N	O	F	
Period 3	Na	Mg	Al	Si	P	S	Cl	
Period 4	K Cu	Ca Zn	– –	Ti –	V As	Cr Se	Mn Br	Fe Co Ni

6.1 Which group of the periodic table on the modern periodic table is missing from Mendeleev's table?

[1 mark]

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6.2 Mendeleev placed hydrogen at the top of Group 1 in his version of the periodic table.
The modern periodic table does not show hydrogen in Group 1.
State one **similarity** between hydrogen and the elements in Group 1.

[1 mark]

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6.3 Mendeleev changed the position of iodine in his version of the periodic table so it was in the same group as chlorine.
Give **two** reasons why he put iodine in the same group as chlorine.

[2 marks]

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6.4 Protons and electrons were discovered after Mendeleev proposed his version of the periodic table. Describe how the numbers of protons and electrons in atoms is used to place elements in the modern periodic table.

[2 marks]

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MARK SCHEME

Qu No.		Extra Information	Marks
1.1	**A** thermometer **B** (Liebig) condenser **C** (round bottomed) flask	 allow conical flask	1 1 1
1.2	(fractional) distillation		1
1.3	has the lowest boiling point		1
1.4	heat the mixture(in **C**) using a water bath/electric heater	accept description of water bath	1

Qu No.		Extra Information	Marks
2.1	75 % gold 16 % silver 9 % copper	 Allow chemical symbols If no other mark obtained, allow 1 mark for gold, silver and copper	1 1 1
2.2	(proton) 79 (electron) 79 (neutron) 118		1 1 1

Qu No.		Extra Information	Marks
Level 3:	A coherent method is described with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered with the dependent and control variables correctly identified. The method would lead to the production of valid results.		5–6
Level 2:	The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.		3–4
Level 1:	Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.		1–2
Level 0	No relevant content		0
Indicative content			

Named apparatus

- stirring rod
- spatula
- beaker
- filter funnel and filter paper
- evaporating basin
- Bunsen burner
- tripod and gauze
- bench mat
- beaker
- oven

Method

- place mixture in a beaker
- add water to the mixture
- stir
- filter the mixture
- residue is sand
- dry residue in a warm oven
- evaporate some of the water from the filtrate (using a water bath)
- allow solution (to cool and) to form crystals
- remove and dry crystals

Qu No.		Extra Information	Marks
4.1	any **two** from: • group 1 melting points decrease as their atomic number increases • the decrease in melting point decreases as the atomic number increases • the decrease in melting point levels off		2
4.2	26 °C	Allow 25 – 27 °C	1
4.3	Diagram showing an electronic structure of 2.1		1
4.4	any **three** from: • fizzes/ effervescence • floats • moves (on surface) • melts • dissolves / disappears	Allow gas given off Allow gets smaller	3
4.5	$2Na + 2H_2O \rightarrow 2NaOH + H_2$	Allow correct multiples Allow **1** mark for $Na + H_2O \rightarrow$	2
4.6	Get more reactive down the group	Allow converse	1
4.7	Outer shell electron further from the nucleus (Outer shell) electron less tightly held by nucleus (Outer shell) electron more easily lost	Allow (Outer shell) Electron more shielded	1 1 1

Qu No.		Extra Information	Marks
5.1	Points correctly plotted Line of best fit drawn	Allow tolerance of ± ½ a square	1 1
5.2	–101 °C	allow value from their graph ± ½ square	1
5.3	Solid		1
5.4	(Isotopes have) different numbers of neutrons $^{35}_{17}Cl$ has 18 neutrons and $^{37}_{17}Cl$ has 20 neutrons	If neutrons calculated but incorrect award M1 as long as they are different Allow $^{37}_{17}Cl$ has more neutrons or $^{35}_{17}Cl$ has fewer neutrons	1 1

Qu No.		Extra Information	Marks
6.1	Group 0	Allow noble gases	1
6.2	Any **one** from: • one electron in outer shell / energy level • forms ions with a 1+ charge		1
6.3	Any **two** from: • iodine has similar properties to other elements in the same group / group 7 • iodine has similar reactivity to other elements in the same group / group 7 • iodine reacts with metals • iodine is diatomic	Ignore references to electrons Allow any correct named property e.g. low melting point / boiling point	2
6.4	(elements) placed in order of atomic / proton number (elements in) same group have same number of <u>outer</u> electrons		1 1

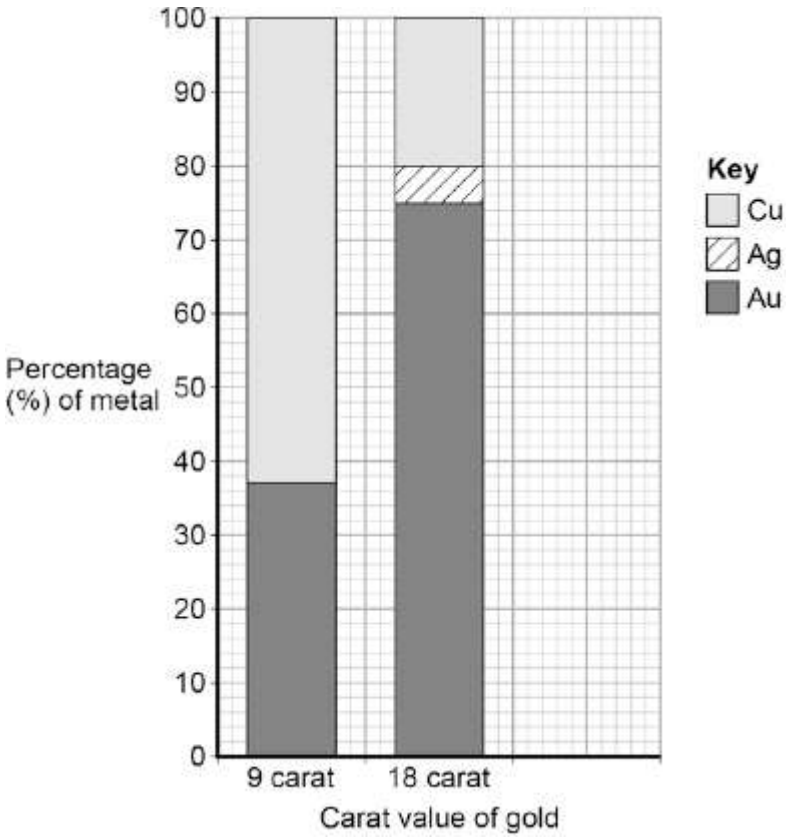
TOPIC 2: BONDING AND STRUCTURE

1.0 This question is about mixtures of metals.

Gold is mixed with other metals to make jewellery.

Graph 1 below shows the composition of different carat values of gold.

Graph 1



1.1 What is the carat value for 92 % gold?

Tick **one** box.

[1 mark]

12 ☐ **20** ☐ **22** ☐ **24** ☐

1.2 What is the ratio of gold to copper (Cu) in 9 carat gold?

[1 mark]

Gold : copper ratio = _____ : _____

1.3 What is the composition of 18 carat gold?

[3 marks]

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1.4 Suggest **two** reasons why 9 carat gold is often used instead of pure gold to make jewellery.

[2 marks]

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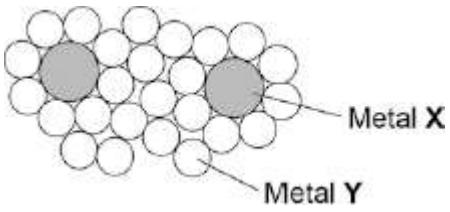
1.5 **Figure 1** shows the structure of a different mixture of metals.

Figure 1



What percentage of the atoms in the metal mixture are atoms of **X**?

Give your answer to 2 significant figures.

[2 marks]

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Percentage of **X** atoms in mixture = _____ %

1.6 What are mixtures of metals called?

Tick **one** box.

[1 mark]

Alloy ☐

Compound ☐

Element ☐

Polymer ☐

2.0 This question is about bonding and atomic structure.

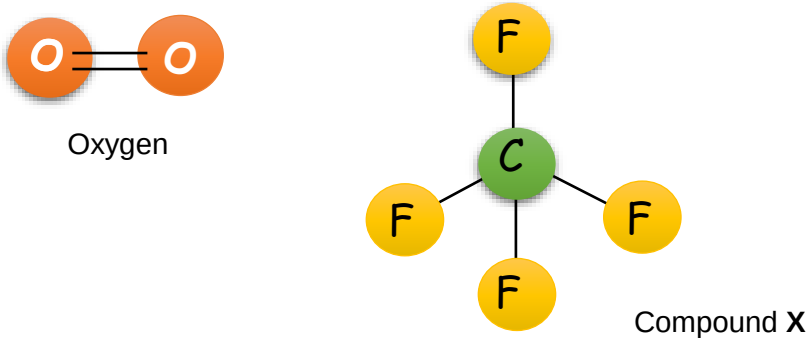
2.1 Draw one line from each type of bonding to the description of bonding.

[2 marks]

Type of bonding	Description of bonding
Covalent bonding	Positive ions surrounded by delocalised electrons
Metallic bonding	Strong electrostatic forces of attraction
Ionic bonding	Sharing of electrons

Figure 2 shows the structure of two small molecules, oxygen and compound **X**.

Figure 2



2.2 Oxygen (O_2) is described as a diatomic element.

Suggest what is meant by the term *"diatomic element".*

[1 mark]

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2.3 Give the molecular formula of compound **X**

[1 mark]

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2.4 Complete the sentence by putting a ring around the correct word.

[1 mark]

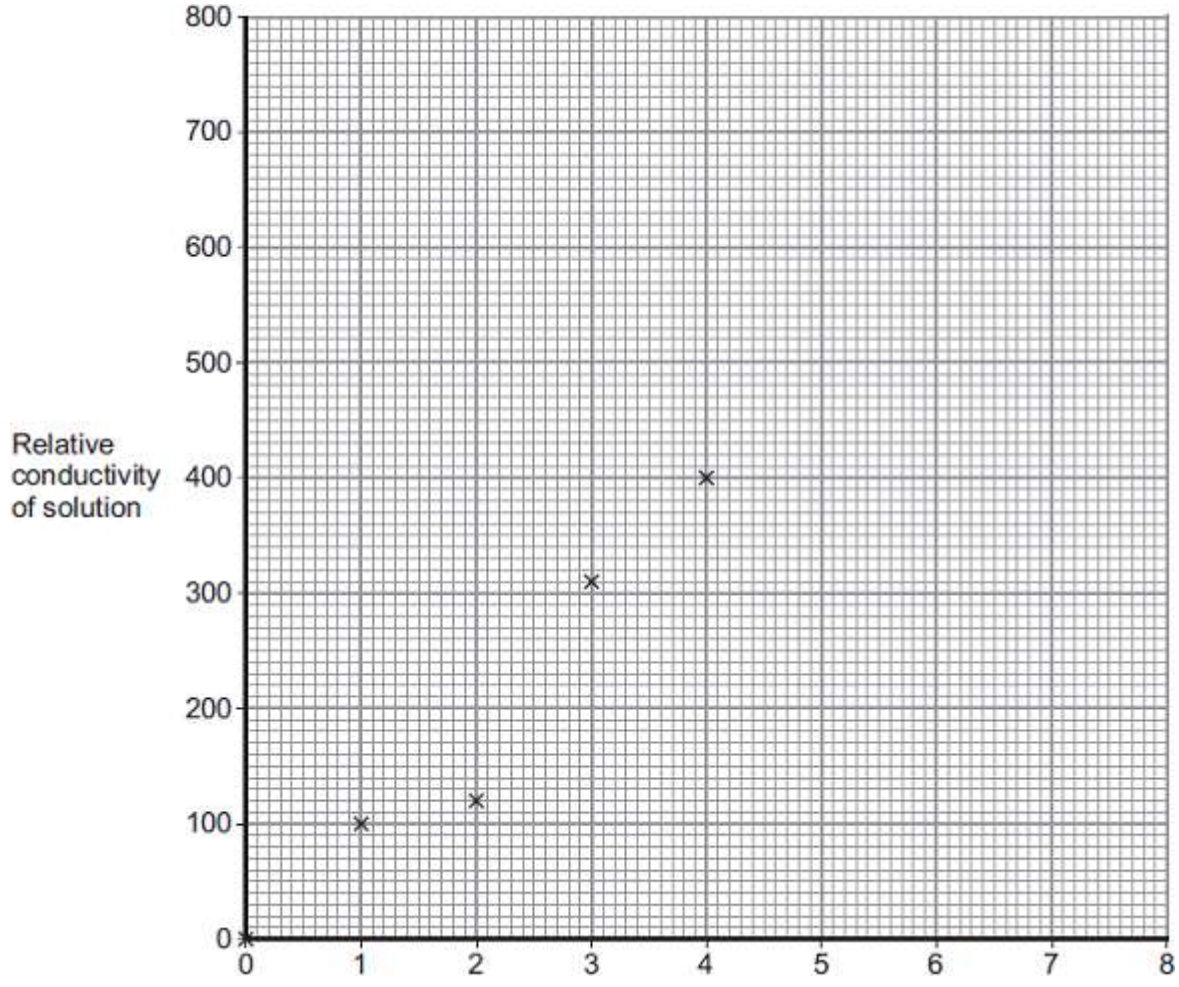
Chemicals with small molecules usually have a **low / medium / high** melting point.

3.0 A student investigated the conductivity of different concentrations of sodium chloride solution. The student's results are shown below.

Number of drops of sodium chloride solution added	Relative conductivity of solution
0	0
1	100
2	120
3	310
4	400
5	510
6	590
7	710
8	800

The student plotted some of the results on the graph shown in **Figure 3**.

Figure 3



3.1 On the graph:

- Plot the remaining results
- Draw a line of best fit.

[2 marks]

3.2 Draw a ring around the anomalous point.

[1 mark]

3.3 The student compared the conductivity of sodium chloride solution with the conductivity of potassium chloride solution.

State **one** variable the student should keep constant when measuring the conductivity of the two solutions.

[1 mark]

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3.4 Explain why sodium chloride solution conducts electricity.

[3 marks]

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4.0 Some students were discussing whether to make wires for a phone charger from copper metal or graphite.

4.1 Compare the properties of copper and graphite to decide which material would be better for making the wire.

[6 marks]

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4.2 The surface of some metals, such as iron, corrode when exposed to the air.

Explain how this affects the electrical conductivity of the metal.

[3 marks]

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5.0 Sodium Chloride is an ionic compound.

5.1 Explain why ionic compounds are usually solid at room temperature.

[2 marks]

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5.2 Recent research has developed a new type of substance, ionic liquids.
Ionic liquids have melting points at close to or below room temperature.
Ionic liquids are used in batteries as they conduct electricity.

Explain why ionic liquids are used in batteries but solid ionic compounds are not.

[3 marks]

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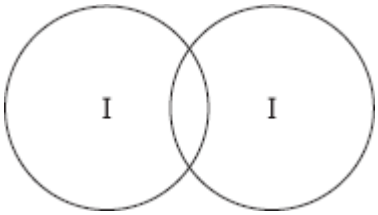
6.0 Iodine is in Group 7.

6.1 Complete the diagram below to show the bonding in iodine, I_2.
Show the outer electrons only.

[2 marks]



6.2 Explain, in terms of particles, why liquid iodine does not conduct electricity.

[3 marks]

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6.3 Many people do not have enough iodine in their diet.
Some scientists recommend that salt should have a compound of iodine added.
Give **one** ethical reason why a compound of iodine should **not** be added to food.

[1 mark]

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7.0 A student was investigating a compound, **X**.
The student decided that compound X was an ionic compound.
Give **three** properties of ionic compounds that the student may have found.

[3 marks]

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8.0 Carbon nanotubes are cylindrical fullerenes.

Explain the properties of carbon nanotubes.

Answer in terms of structure and bonding.

[6 marks]

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	222		1
1.2	37.5 : 62.5	Allow 4 : 6	1
1.3	 Gold / Au 75 % Copper / Cu 20 % Silver / Ag 5 %	Max of **2** marks if elements are not named If no other mark obtained allow 1 mark for gold, silver and copper	 1 1 1
1.4	any **two** from: • 9 carat gold is harder • 9 carat gold is cheaper • different colour / appearance	 Allow pure gold is too soft Allow pure gold is too expensive	2
1.5	$\frac{2}{27} \times 100$ 7.4 (%)	Allow 7.4074074 An answer of 7.4 % without working can be awarded **2** marks	1 1
1.6	Alloy		1

Qu No.		Extra Information	Marks
2.1	Covalent bonding → Sharing of electrons Metallic bonding → Positive ions surrounded by delocalised electrons Ionic bonding → Strong electrostatic forces of attraction	Do **not** allow 2 lines from one type of bonding. Allow **1** mark for 1/2 correct	2
2.2	Molecule containing two atoms	Allow 2 atoms bonded together	1
2.3	CF_4		1
2.4	low		1

Qu No.		Extra Information	Marks
3.1	points correctly plotted line of best fit	Allow tolerance of ± ½ small square	1 1
3.2	2 drops, 120 relative conductivity		1
3.3	Any **one** from: • concentration (of solution) •volume (of drops) of solution added	Allow reasonable alternatives	1
3.4	Ions in sodium chloride solution can move and carry the charge / current	Allow Na^+ **and** Cl^-	1 1 1

Qu No.		Extra Information	Marks
4.1			
Level 3:	A detailed and coherent comparison is given, which considers a range of relevant points and demonstrates a broad understanding of the key scientific ideas. The response comes to a conclusion consistent with the reasoning.		5-6
Level 2:	An attempt to relate relevant points and come to a conclusion. The logic may be inconsistent at times but builds towards a coherent argument.		3-4
Level 1:	Simple statements are made. The logic may be unclear and the conclusion, if present, may not be consistent with the reasoning.		1-2
Level 0	No relevant content		0
Indicative content			
Graphite properties • conducts electricity • soft • slippery • brittle • high melting point Copper properties • Can be bent or malleable • Ductile or can be shaped into wires • strong / not brittle • conducts electricity • high melting point Conclusion Copper would be more suitable with a justification			
4.2	Conductivity will decrease as an ionic compound formed which will not conduct electricity when solid		1 1 1

Qu No.		Extra Information	Marks
5.1	strong electrostatic forces which require a lot of energy to overcome	allow strong forces between oppositely charged ions	1 1
5.2	in ionic liquids, ions are able to move (so) ions carry charge (however) in a solid, ions are unable to move		1 1 1

Qu No.		Extra Information	Marks
6.1	one bonding pair of electrons 6 unbonded electrons on each atom	accept dot, cross or e or – or any combination, eg 	1 1
6.2	iodine has no delocalised / free electrons iodine has no ions so cannot carry charge / current	Allow iodine molecules have no overall charge for 1 mark if MP 1 and 2 not awarded.	1 1 1
6.3	any one from: people should have right to choose insufficient evidence of effect on people individuals may need different amounts	allow too much could be harmful ignore cost / religious reasons ignore reference to allergies	1

Qu No.		Extra Information	Marks
7	High melting point Conducts electricity when molten / dissolved Does not conduct when solid	Any three properties that could be reasonably found from experiment	1 1 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08	**Level 3:** A detailed and coherent explanation applying knowledge of the properties of nanotubes, with clear and logical links to reasons why carbon nanotubes have these properties		5–6	AO2/1
	Level 2: Description contains relevant statements that demonstrate clear knowledge of the properties of nanotubes. Attempt made to link properties to explanation of why these properties occur, but logic may be unclear		3–4	AO1/1
	Level 1: Simple relevant statements of the properties of nanotubes, demonstrating knowledge, but no linking to an explanation of why these properties occur.		1–2	AO1/1
	No relevant content.		0	
	Indicative content properties: • high tensile strength • high electrical/thermal conductivity • high melting point explanations: • nanotubes are fullerenes based on hexagonal rings of carbon atoms • which means that each carbon forms three covalent bonds with three other carbon atoms • covalent bonds are strong **or** need a lot of energy to break them • so nanotubes are strong/have high tensile strength • and have a high melting point • the structure means that one electron from each carbon atom is delocalised • as in metals and graphite, the delocalised electrons can move throughout the structure • allowing the carbon nanotube/fullerene to conduct thermal energy and electricity			4.8.1.1 4.6.2.4 4.6.2.7
Total			**6**	

TOPIC 3: QUANTITATIVE CHEMISTRY

1.0 This question is about carbonates.

1.1 Sodium carbonate, Na_2CO_3, is used as a water softener.
Give the number of atoms of each type in sodium carbonate.

[3 marks]

Sodium (Na) atom(s): _____

Carbon (C) atom(s): _____

Oxygen (O) atom(s): _____

1.2 Calculate the relative formula mass (M_r) of sodium carbonate, Na_2CO_3
Relative atomic masses (A_r): Na = 23; C = 12; O = 16.

[2 marks]

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Relative formula mass (M_r) of sodium carbonate =_____

1.3A student heated a sample of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

This is an example of thermal decomposition.
What is meant by 'thermal decomposition'?

[2 marks]

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1.4 Both calcium carbonate and calcium oxide are white solids.
The student weighed the white solid before and after heating.
Explain why a decrease in mass was observed.
Use the equation in **part 1.3** to help you answer the question.

[2 marks]

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1.5 One type of copper ore is mainly copper carbonate ($CuCO_3$).

Copper carbonate	**+ carbon**	**copper**	**+ carbon dioxide**
____ tonnes	24 tonnes	254 tonnes	264 tonnes

Calculate the mass of copper carbonate needed to produce 254 tonnes of copper.

[2 marks]

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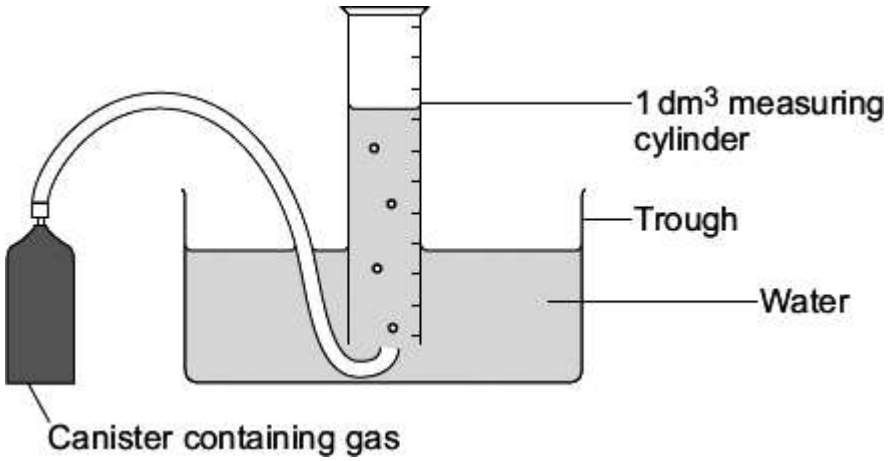
Mass = _____ tonnes

2.0 A student did an experiment to find the relative formula mass (M_r) of a gas.
The equipment used is shown in **Figure 1**

Figure 1



The student:

- measured the mass of the canister of gas
- filled the measuring cylinder with 1 dm^3 of the gas from the canister.
- measured the mass of the canister of gas again.
- measured the temperature of the laboratory
- measured the air pressure in the laboratory
- repeated the experiment.

2.1 The student calculated values for the relative formula mass (M_r) of the gas.
The results are shown in the table below.

Experiment	**1**	**2**	**3**	**4**
Relative formula mass (M_r)	45.4	51.5	46.3	45.8

Calculate the mean value for these results.
Give your answer to 3 significant figures.

[2 marks]

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Mean = _____

2.2 The experiments gave different results for the relative formula mass of the gas.

This was caused by experimental error.
Suggest **one** experimental errors that the student may have made.

[1 mark]

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2.3 Give one reason why it is important to repeat the experiment.

[2 marks]

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3.0 A student investigated the thermal decomposition of calcium carbonate.
The equation for the reaction is:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

The relative formula masses (M_r) are: $CaCO_3$ = 100**;** CaO = 56; CO_2 = 44

Describe how this experiment could be used to provide evidence for the Law of conservation of mass.
Include in your answer:

- The method
- Which measurements should be taken
- How the student could show evidence for conservation of mass

[6 marks]

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4.0 A student made some copper sulfate crystals, $CuSO_4$
The student used 7.95g of copper oxide and 100cm^3 of a 2.00 mol/dm^3 solution of sulfuric acid.
The equation for the reaction is:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

4.1 Calculate the number of moles of copper oxide in 7.95 g copper oxide.
Relative atomic masses A_r: O = 16; Cu = 63.5

[2 marks]

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Answer = _____ moles

4.2 Calculate the number of moles of sulfuric acid in 100 cm^3 of 2.00 mol/dm^3 sulfuric acid.

[2 marks]

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Answer = _____ moles

4.3 It is common to use an excess of one reactant.
Explain why a reactant is used in excess.

[2 marks]

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4.4 Another student made copper sulfate using 0.250 moles of copper oxide and 0.500 moles sulfuric acid.
Calculate the **maximum** mass of copper sulfate which could be produced
Give your answer to 3 significant figures.
Relative formula mass (M_r) $CuSO_4$ = 159.5

[4 marks]

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Maximum mass of copper sulfate = _____ g

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	2 1 3	In this order	1 1 1
1.2	(2 x 23) + 12 + (3 x 16) **or** 46 + 12 + 48 106	An answer of 106 without any working shown gains **2** marks	1 1
1.3	Breaking down Using heat		1 1
1.4	Carbon dioxide is produced which goes into the atmosphere	Allow a gas is produced	1 1
1.5	(254 + 264) – 24 **or** 518 – 24 494 (tonnes)	An answer of 494 (tonnes) without any working shown gains **2** marks	1 1

Qu No.		Extra Information	Marks
2.1	(45.4 + 46.3 + 45.8) ÷ 3 45.8	Allow 46 or 45.83(33…) Allow 47.3 Allow **2** marks for an answer of 45.8 without working	1 1
2.2	any **one** from: • loss of gas or leak • error in measurement of volume of gas • error in weighing the canister / gas at start • error in weighing the canister / gas at end • change in temperature • change in pressure	 allow incorrect measurement of temperature allow incorrect measurement of pressure	1
2.3	any **one** from: • check for anomalous results • to find the mean	 Allow to find the average	1

Qu No.		Extra Information	Marks
3			
Level 3:	A coherent method is described and explained with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered and would lead to the production of valid results. An explanation of the expected results is provided.		5–6
Level 2:	The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail. An attempted explanation of the expected results is given.		3–4
Level 1:	Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.		1–2
	No relevant content		0
Indicative content			
Method • measure mass of suitable container e.g. boiling tube • mass measured using balance • place calcium carbonate in boiling tube • measure mass of boiling tube and calcium carbonate • heat boiling tube and calcium carbonate • allow to cool • reweigh tube and contents • repeat heating, cooling and weighing until constant mass is obtained Conservation of mass • Identifies the conservation of mass • Carbon dioxide produced as a gas • Carbon dioxide escapes to the surroundings • so mass will decrease during the reaction • suggests initial mass to be heated • use the initial mass to suggest final mass in boiling tube • uses suggested masses to confirm law of conservation of mass			

Qu No.		Extra Information	Marks
4.1	$\frac{7.95}{16+63.5}$ or $\frac{7.95}{79.5}$ 0.1 (moles)	 allow **2** marks for an answer of 0.1 (moles) without working	1 1
4.2	$\frac{100}{1000} \times 2$ 0.2 (moles)	 allow **2** marks for an answer of 0.2 (moles) without working	1 1
4.3	(So that) the other reactant is completely used up		1 1
4.4	Evidence of sulfuric acid in excess or copper oxide limiting reagent Moles copper sulfate = moles copper oxide = 0.250 (mass of copper sulfate =) 0.25 x 159.5 39.9 (g)	 Allow ecf for steps 2/3/4 allow **4** marks for an answer of 0.2 (moles) without working	1 1 1 1

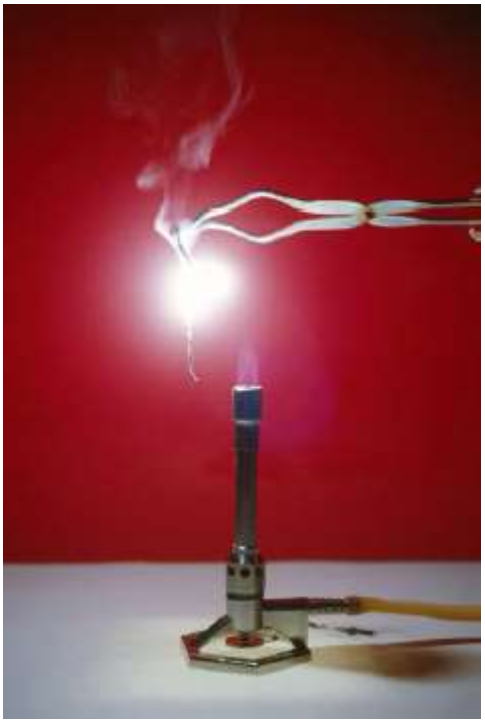
TOPIC 4: ENERGY CHANGES

Note

This has not been covered in class yet.

1.0 The **Figure 1** shows magnesium burning in air.

Figure 1



© Charles D Winters/Science Photo Library

1.1 Give **one** observation that you can make from **Figure 1** that shows that a Chemical reaction is taking place.

[1 mark]

……

……

1.2 The Bunsen burner flame provides energy to start the magnesium burning.

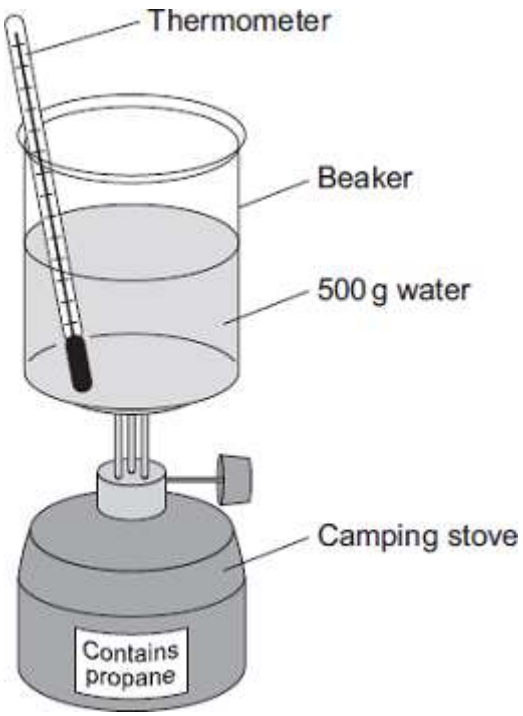
Draw a ring around the name given to the energy needed to start a chemical reaction.

[1 mark]

Activation energy **Potential Energy** **Solar Energy**

2.0 A camping stove uses propane gas.

A student investigated the energy released when propane gas is burnt.



The student:

- put 500 g water into a beaker
- recorded the starting temperature of the water
- heated the water by burning propane for 1 minute
- recorded the temperature of the water after burning the propane.

Table 1 shows the student's results for the investigation.

Table 1

Starting temperature of water in °C	**Temperature of water after burning propane in °C**	**Temperature change of water in °C**
19	34	

2.2 Calculate the temperature change of the water.

[1 mark]

……

……

Temperature change = _____°C

2.3 Calculate the energy released in joules when propane is burned for 1 minute.

Use the equation:

energy released (J) = mass of water (g) × 4.2 × temperature change (°C)

[2 marks]

……

……

Energy released = _____ J

3.0 A student investigated how the temperature of water changed when different masses of ammonium nitrate were added to the same volume of water. The water used was at room temperature.

The student's results are shown in the **Table 2**.

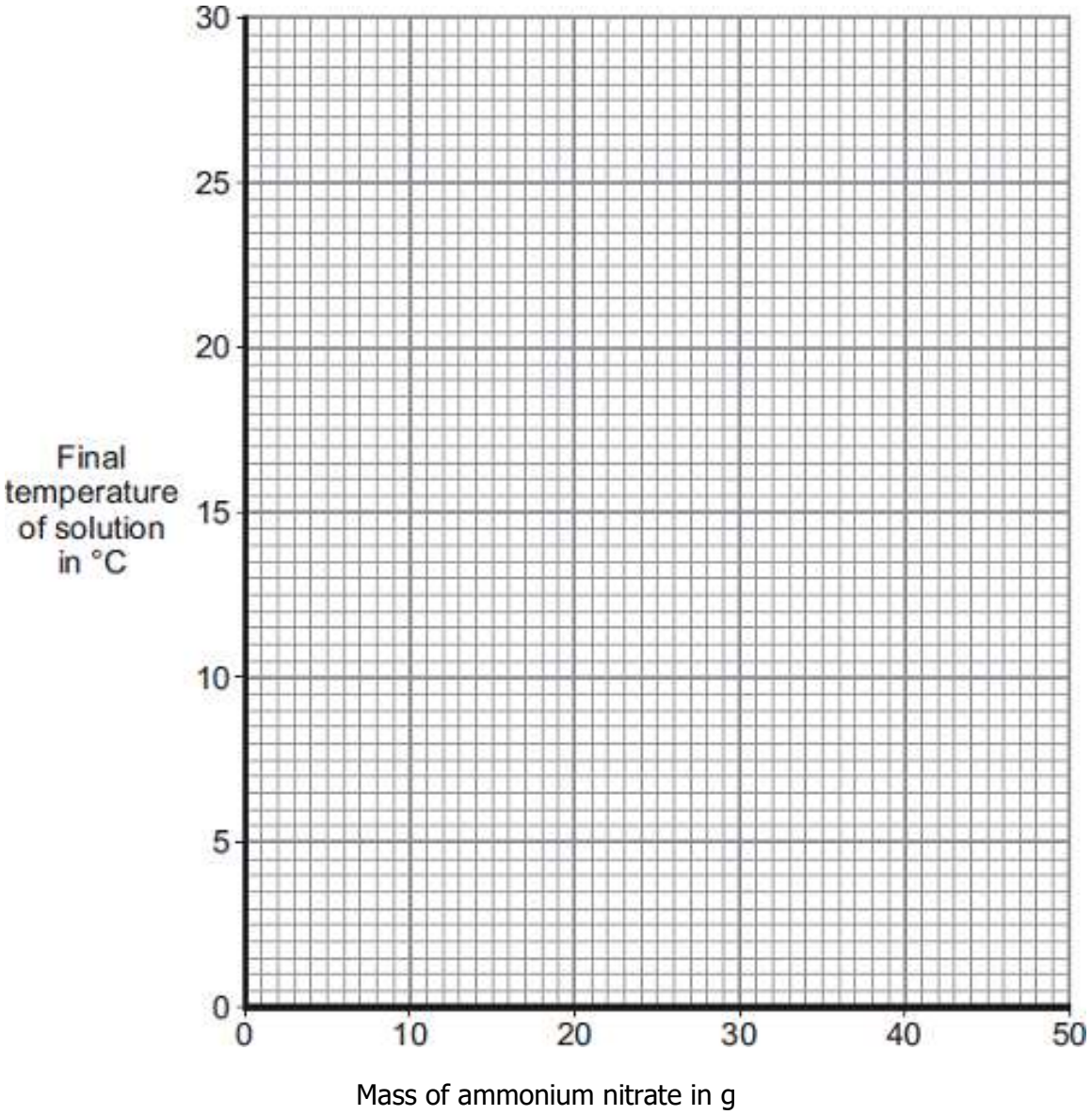
Table 2

Mass of ammonium nitrate in g	Final temperature of solution in °C
10	15.0
15	12.5
20	10.0
25	7.5
30	5.0
35	5.0
40	5.0

3.1 Plot the results on the grid.

Draw two straight lines of best fit through the points.

[4 marks]



4.0 A student investigated the energy produced when different metals react with copper sulfate solution.

4.1 What is the independent variable in this investigation?

[1 mark]

……

……

4.2 What is the dependent variable in this investigation?

[1 mark]

……

……

4.3 State **two** control variables the student should keep the same.

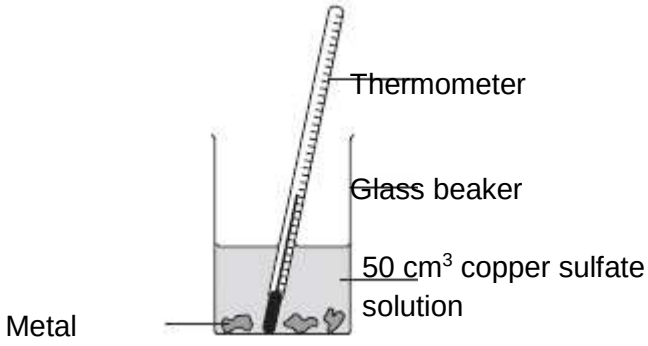
[1 mark]

……

……

4.4 Figure 2 shows the equipment the student used for the investigation.

Figure 2



Explain how the student could have improved the **equipment** used for this investigation.

[4 marks]

……

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……

5.0 Ammonia is used in the manufacture of fertilisers. The equation for the formation of ammonia (NH_3) from nitrogen (N_2) and hydrogen (H_2) is:

$$N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$$

This question refers to the **forward** reaction which is exothermic.

Bond energies for the reaction are given in **Table 1**.

Table 1

Bond	Bond energy in kJ per mole
N ≡ N	945
H – H	436
N – H	390

The structures are shown in **Figure 1.**

Figure 1

$N \equiv N$ $\quad$ $H - H$ $\quad$ $H - \underset{\underset{H}{|}}{N} - H$

5.1 Calculate the overall energy change for the **forward** reaction.

[3 marks]

……

……

……

……

……

……

5.2 Draw an energy level diagram for the **forward** reaction

Mark on the energy level diagram:

• Nitrogen (N_2), Hydrogen (H_2) and Ammonia (NH_3)

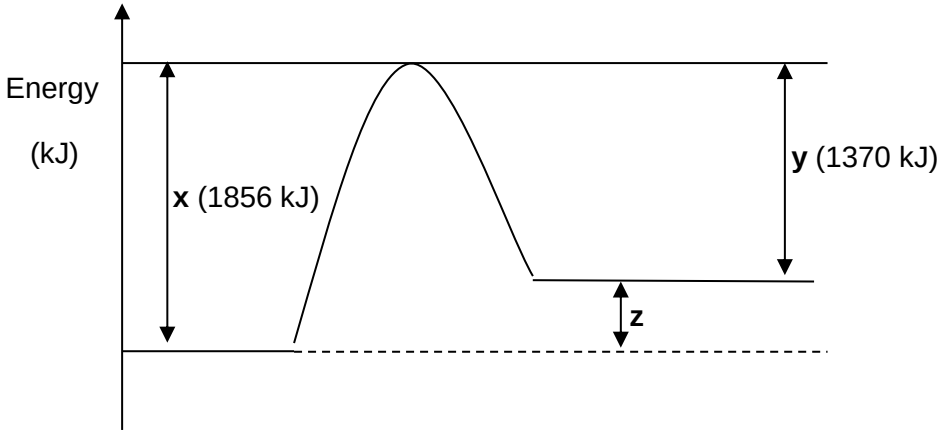
[3 marks]

6.0 Water decomposes to form hydrogen and oxygen.

The equation for the reaction is:

$$2H_2O \rightarrow 2H_2 + O_2$$

The reaction profile for this reaction is shown below.



Explain the significance of **x**, **y** and **z** in the reaction profile in terms of energy transfers that occur in the reaction.

In your answer make reference to:

- the substances involved
- the bonds broken and formed
- the overall energy transfer

[6 marks]

7.0 The rate of chemical reactions can be changed by changing the conditions.

7.1 Methane burns in oxygen to produce carbon dioxide and water.

The activation energy for the reaction is 2648 kJ/mol.

The reaction gives out 818 kJ/mol of energy.

Figure 1 shows the reaction profile for this reaction.

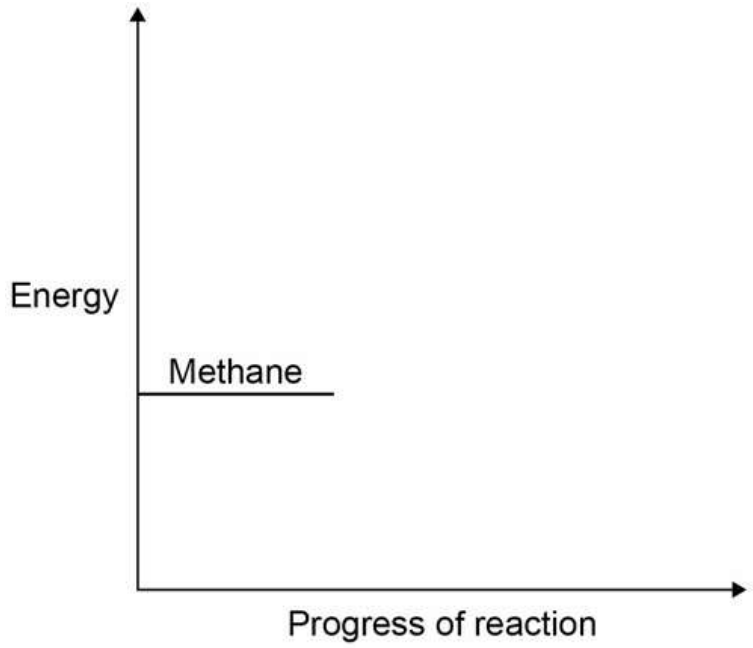
Complete the reaction profile.

Draw arrows to represent:

- the activation energy
- the energy given out.

[4 marks]

Figure 1



7.2 What percentage of the activation energy is the energy given out?

[1 mark]

……

……

7.3 Calcium carbonate decomposes when it is heated:

The decomposition of calcium carbonate is an endothermic reaction.

How would the reaction profile for decomposition of calcium carbonate be different from the reaction profile of methane burning in oxygen?

[1 mark]

……

……

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7.4 Catalysts are used in chemical reactions in industry.

Give **two** properties of catalysts.

For each property, explain why it makes the catalyst useful in industry.

[4 marks]

……

……

……

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……

……

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	any **one** from: • there was a flame • (white) smoke was formed • the magnesium turned into a (white) powder		1
1.2	activation energy		1

Qu No.		Extra Information	Marks
2.1	thermometer		1
2.2	15 °C		1
2.3	31500 (J)	Allow ecf from 2.1 Allow **1** mark for 500 × 4.2 × 15 or 500 × 4.2 × (ans 2.1)	2

Qu No.		Extra Information	Marks
3.1	all 7 points plotted correctly	Allow 5/6 points plotted correctly for **1** mark	2
	straight line through first 5 points		1
	straight line through last three points		1

Qu No.		Extra Information	Marks
4.1	Type of metal	Allow metal	1
4.2	Temperature change		1
4.3	Any **two** from: • Volume of copper sulfate solution • Concentration of copper sulfate solution • Mass of metal used • Starting temperature		2
4.4	Used a lid To reduce heat loss or to improve insulation Used a thermometer with a higher resolution. To measure the temperature, change more accurately	Allow insulate outside of beaker Allow measure to the nearest 0.5 °C or 0.1 °C	1 1 1 1

Qu No.		Extra Information	Marks
5.1	(energy taken in) =945 + (3 × 436) = 2253 (kJ) (energy given out)= 6 × 390 = 2340 (kJ) (energy change) 2253 – 2340 = (–) 87 (kJ)	 Allow ecf from step 1/ 2 Correct answer with/without working gains **3** marks.	1 1 1
5.2	Reactant energy lower than the product energy Curve for the reaction correctly drawn Nitrogen and hydrogen shown as reactants and ammonia as a product		1 1 1

Qu No.		Extra Information	Marks
6			
Level 3:	A detailed and coherent explanation is given, which demonstrates a broad understanding of the key scientific ideas. The response makes logical links between the points raised and uses sufficient examples to support these links.		5-6
Level 2:	An explanation is given which demonstrates a reasonable understanding of the key scientific ideas Links are made but may not be fully articulated and / or precise.		3-4
Level 1:	Simple statements are made which demonstrate a basic understanding of some of the relevant ideas. The response may fail to make logical links between the points raised.		1-2
	No relevant content		0
Indicative content			
Substances • reactant is water • products are oxygen and hydrogen significance of x, y and z • x is energy required to break the bonds in reactant / water • x is activation energy • y is the energy released given out when bonds form • y is the energy released given out when hydrogen and oxygen form • z is difference between × and y • z is the overall energy transfer overall energy transfer • z = 1856 – 1370 = (+)486 kJ • overall, energy is absorbed in the reaction • energy required to break existing bonds is greater than the energy released when new bonds form • so, reaction is endothermic			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
7.1	products below reactants correct energy profile activation energy correctly labelled energy given out correctly labelled		1 1 1 1	AO1/1 AO1/1 AO2/1 AO2/1 4.7.4.4
7.2	31 (%)		1	AO2/1 4.7.4.4
7.3	the products would be above the reactants		1	AO2/1 4.7.4.4
7.4	catalysts increase rate of reaction so products formed in less time **or** catalysts lower activation energy so lowers energy requirements **or** catalysts not used up in the reaction so only an initial outlay needed **or** only a small amount of catalyst needed so small initial cost	**1** mark for each property **1** mark for each explanation explanation must be linked correctly to the property to gain the mark	max. 4	AO1/1 AO2/1 4.7.4.6

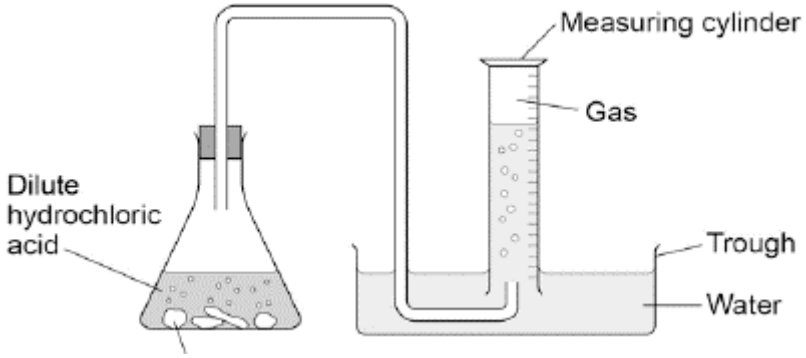
TOPIC 5: CHEMICAL CHANGES

Note

This has not been covered in class yet.

1.0 A student investigated the reaction of sodium carbonate with dilute hydrochloric acid.
The student used the apparatus shown in **Figure 1**.

Figure 1



Sodium carbonate

This is the method used.

1. Place a known mass of sodium carbonate in a conical flask.
2. Measure 15 cm^3 of dilute hydrochloric acid using a measuring cylinder.
3. Pour the acid into the conical flask.
4. Place a bung in the flask and collect the gas as shown in **Figure 1**.

1.1 Balance the equation for the reaction.

[1 mark]

Na_2CO_3 (s) + _____ HCl (aq) → _____ NaCl (aq) + H_2O (l) + CO_2 (g)

1.2 Name the substance produced as a gas.

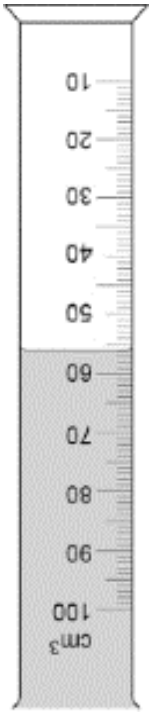
[1 mark]

……

……

Figure 2 shows the measuring cylinder.

Figure 2



What volume of gas has been collected?

[1 mark]

……

……

Volume = _____ cm^3

1.3 Table 1 shows the student's results.

Table 1

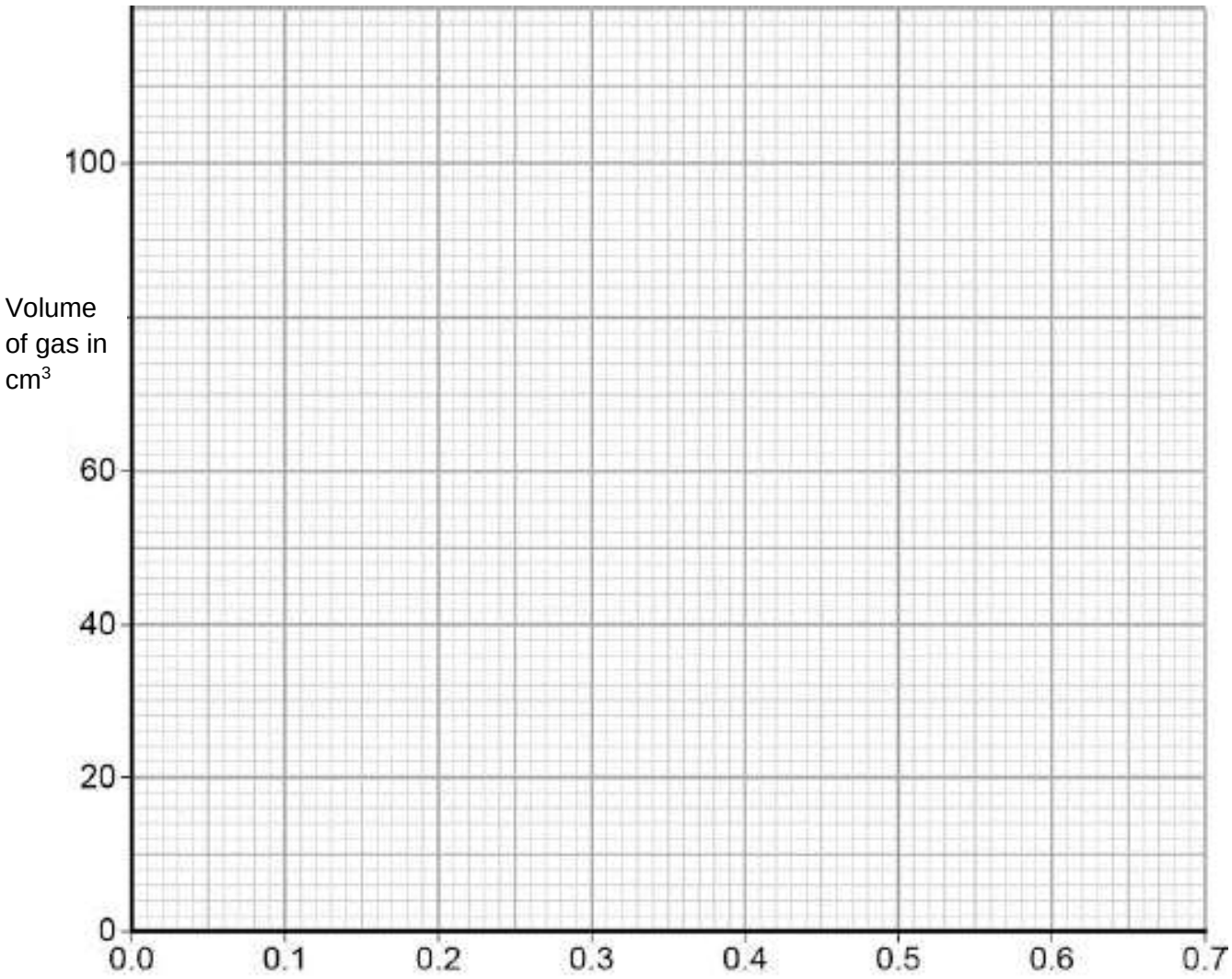
Mass of sodium carbonate in g	Volume of gas in cm^3
0.0	0
0.1	23
0.2	28
0.3	69
0.4	92
0.5	98
0.6	98
0.7	98

On **Figure 3**:

- Plot these results on the grid.
- Complete the graph by drawing **two** straight lines of best fit.

[4 marks]

Figure 3



1.4 Describe **two** patterns the graph shows when sodium carbonate is added.

[2 marks]

……

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……

……

2.0 Describe a safe method for making pure crystals of magnesium chloride from magnesium carbonate and dilute hydrochloric acid.
In your method you should name all of the apparatus you will use.

[6 marks]

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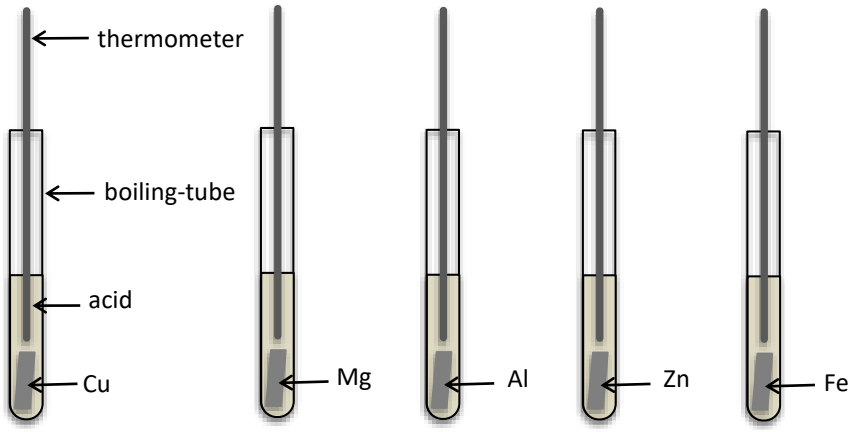
3.0 A student investigated the reactivity of metals with acids.
Five different metals were investigated.
Figure 4 shows the apparatus the student used.

Figure 4



The method the student used was:

- measured 10 cm^3 of dilute acid using a 50cm^3 measuring cylinder
- placed 10 cm^3 of dilute acid in a boiling tube
- added a 2 cm length of metal to the dilute acid
- measured the highest temperature reached
- repeated the experiment using different metals.

Table 1 shows the student's results

Table 1

Metal	Temperature change (°C)			
	Test 1	Test 2	Test 3	Mean
Aluminium	33	10	35	
Copper	1	0	2	1
Iron	22	21	20	21
Magnesium	44	46	45	45
Zinc	25	27	26	26

3.1 State the dependent and independent variables in the investigation.

[2 marks]

Dependent variable:

Independent variable:

3.2 Name **two** control variables the student kept the same.

[2 marks]

……

……

3.3 Calculate the mean temperature change for aluminium.

[1 mark]

……

……

Mean temperature change for aluminium = _____ °C

3.4 Suggest **two** changes that could improve the accuracy of the investigation.

[2 marks]

……

……

3.5 Use the data in **Table 1** to list the metals in order of reactivity from most reactive to least reactive.

[1 mark]

……

……

3.6 Suggest why the student did not use any Group 1 metals in the investigation.

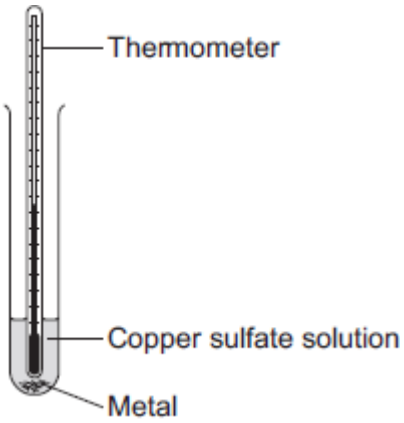
[1 mark]

……

……

4.0 A student investigated displacement reactions of metals.
The student added different metals to copper sulfate solution and measured the temperature change.
The more reactive the metal is compared with copper, the bigger the temperature change.
The apparatus the student used is shown in **Figure 5.**

Figure 5



The student repeated the experiment three times with each metal.
Table 2 shows the mean temperature change for each metal.

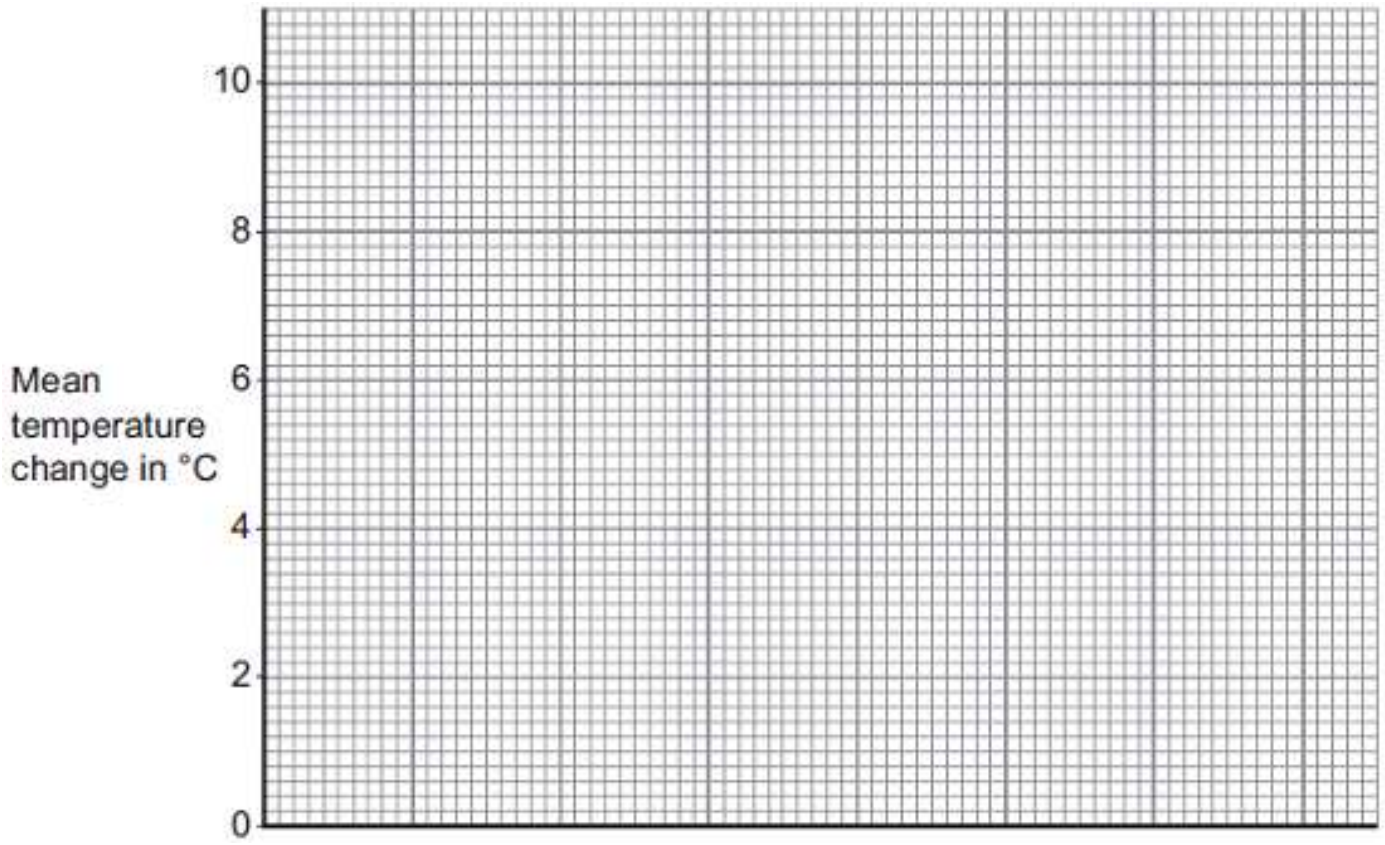
Table 2

Metal	**Mean temperature change in °C**
Copper	0.0
Iron	6.5
Lead	1.2
Magnesium	10.0
Silver	0.0
Zinc	7.8

4.1 On **Figure 6**, draw a bar chart to show the results.

[2 marks]

Figure 6



4.2 Why is a bar chart the most suitable way of showing the results?

[1 mark]

……

……

4.3 Explain how these results can be used to work out a reactivity series.

[1 mark]

……

……

4.4 Iron can be extracted by reacting iron oxide with carbon in a blast furnace.
What type of reaction produces iron from iron oxide?

[1 mark]

……

……

5.0 Magnesium is extracted by the electrolysis of molten magnesium chloride**.**

5.1 Complete the half equation for the formation of magnesium at the negative electrode.

[2 marks]

Mg^{2+} + →

5.2 Chlorine gas is also produced.
Describe how chlorine is produced during the process.

[4 marks]

……

……

……

……

……

……

5.3 Some metals are extracted from their ores using carbon.
Why is it not possible to extract magnesium using carbon?

[1 mark]

……

……

5.4 Aqueous magnesium chloride is not used to extract magnesium.
Explain why.

[3 marks]

……

……

……

……

6.0 Bath bombs contain solid citric acid and solid sodium hydrogen carbonate.

6.1 Citric acid reacts with sodium hydrogen carbonate to produce a salt, sodium citrate.
The equation for the reaction is:

$$H_3C_6H_8O_7\,(s) + 3NaHCO_3\,(s) \rightarrow Na_3C_6H_8O_7\,(aq) + 3CO_2\,(g) + 3H_2O\,(l)$$

Which part of the equation shows that this reaction only takes place when bath bombs are added to water?

[1 mark]

……

……

6.2 Bath bombs fizz when added to water.
What causes the fizzing?

[2 marks]

……

……

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……

6.3 Citric acid is a weak acid.
State what is meant by the term weak acid.

[1 mark]

……

……

7.0

The salt copper sulfate can be made by reacting copper carbonate with dilute sulfuric acid.

$$CuCO_3(s) + H_2SO_4(aq) \longrightarrow CuSO_4(aq) + H_2O(l) + CO_2(g)$$

7.1 Write a method that a student could use to prepare a pure, dry sample of copper

You do not need to write a risk assessment or include safety points.

[6 marks]

7.2 Calculate the number of molecules in 14 g of carbon dioxide.

Give your answer in standard form.

Relative atomic masses (Ar): C = 14; O = 16

[4 marks]

……

……

……

……

Answer = _____ molecules

8.0 A student investigates a potassium salt, X.

She finds that salt X:

- has a high melting point
- does not conduct electricity when it is solid
- dissolves in water and the solution does conduct electricity.

8.1 What is the type of bonding in salt X?

[1 mark]

Tick **one** box.

Covalent	☐
Giant molecular	☐
Ionic	☐
Metallic	☐

8.2 What is the name given to solutions that conduct electricity?

[1 mark]

……

……

8.3 Why does a solution of salt X in water conduct electricity?

[1 mark]

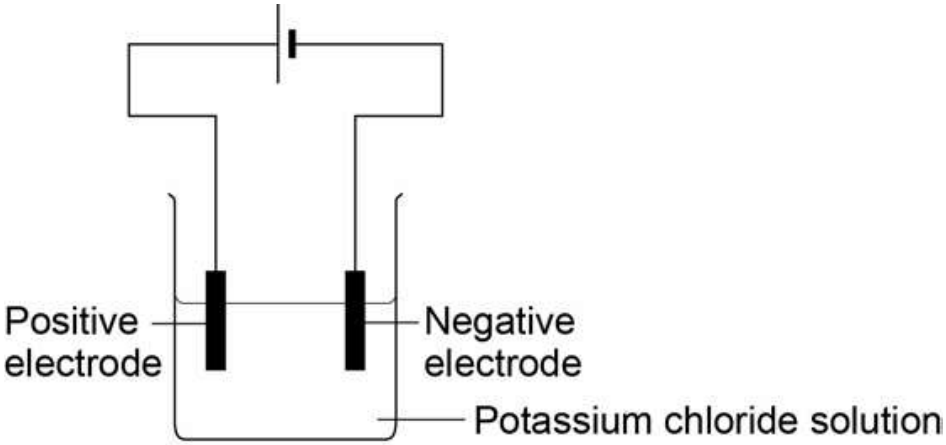
……

……

8.4 The student electrolyses a solution of potassium chloride.

Figure 1 shows the apparatus she uses.

Figure 1



When the current is switched on, bubbles of hydrogen gas are given off at the negative electrode.

Explain why hydrogen is produced and not potassium.

[2 marks]

……

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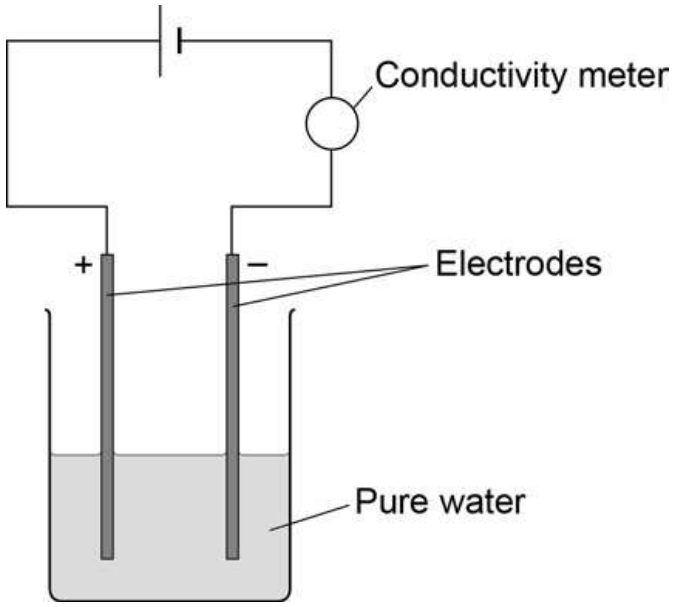
……

The student then compares the relative conductivity of different concentrations of potassium chloride.

Figure 2 shows the apparatus she uses.

Figure 2



This is the method used.

1. Add potassium chloride solution to the water one drop at a time.

2. Stir the mixture.

3. Record the reading on the conductivity meter.

Table 1 shows the student's results.

Table 1

Number of drops of potassium chloride solution	Relative conductivity of solution
0	0
1	90
2	180
3	270
4	360
5	450
6	540

8.5 When there is no potassium chloride in the beaker no electrical charge flows.

Suggest why pure water does not conduct electricity.

[2 marks]

……

……

……

……

8.6 Describe the relationship shown in **Table 1**.

[2 marks]

……

……

……

……

MARK SCHEME

Qu No.		Extra Information	Marks
1.1	Na_2CO_3 (s) + 2 HCl (aq) → 2NaCl (aq) + H_2O (l) + CO_2 (g)		1
1.2	Carbon dioxide		1
1.3	56 (cm^3)		1
1.4	all points correct 2 best fit lines drawn	± ½ small square allow **1** mark if 6 or 7 of the points are correct must not deviate towards anomalous point allow **1** mark if 1 line correct	2 2
1.5	Any **two** from: • as mass of lithium carbonate increases volume of gas produced increases • no more gas is produced after 0.5 g of sodium carbonate is added • until 0.4 g of sodium carbonate is added the graph is linear / (directly) proportional		2

Qu No.		Extra Information	Marks
Level 3:	A coherent method is described with relevant detail, and in correct sequence which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered. The method would lead to the production of valid results.		5-6
Level 2:	The bulk of the method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.		3-4
Level 1:	Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.		1-2
Level 0:	No relevant content		0
Indicative content			
• hydrochloric acid in beaker (or similar) • add magnesium carbonate one spatula at a time • until magnesium carbonate is in excess or until no more effervescence occurs • filter using filter paper and funnel • filter excess magnesium carbonate • pour solution into evaporating basin / dish • heat using Bunsen burner • leave to crystallise / leave for water to evaporate / boil off water • decant solution • pat dry (using filter paper) • wear safety spectacles / goggles			

Qu No.		Extra Information	Marks
3.1	Dependent variable Temperature change Independent variable Type of metal		1 1
3.2	Any **two** from: • Concentration of acid • Volume of acid • Type of acid • Mass of metal • Size of metal • Surface area of metal		2
3.3	34 (°C)		1
3.4	any **two** from: • Measure the mass of the metal (instead of length) • Used a thermometer that reads to more decimal places/ has more scale divisions. • Use a burette or pipette to measure volume of acid • Use a 10cm^3 measuring cylinder (instead of 50cm^3) • Use a measuring cylinder with more scale divisions	Allow use a digital thermometer that reads to more decimal places	2
3.5	Most reactive Magnesium Aluminium Zinc Iron copper	Allow ecf from calculation of mean	1
3.6	They would be too reactive/dangerous		1

Qu No.		Extra Information	Marks
4.1	four bars of correct height bars labelled	tolerance is ± half square allow 3 bars correct for 1 mark	2 1
4.2	one variable is non-continuous / categoric	allow qualitative or discrete allow no values between the metals	1
4.3	most reactive metal has the highest temperature change		1
4.4	Reduction		1

Qu No.		Extra Information	Marks
5.1	$Mg^{2+} + 2e^- \rightarrow Mg$	Allow 1 mark for e^-	2
5.2	chloride ions attracted to positive electrode (where they) lose electrons chlorine atom / molecule produced		1 1 1 1
5.3	magnesium too reactive or carbon not reactive enough		1
5.4	Magnesium ions and hydrogen ions attracted to negative electrode hydrogen is formed in preference to magnesium as hydrogen less reactive (than magnesium)		1 1 1

Qu No.		Extra Information	Marks
6.1	(aq) means aqueous solution		1
6.2	Carbon dioxide produced Which is released as a gas	Allow carbon dioxide gas is produced	1 1
6.3	Does not fully ionise/dissociate	Allow only partially ionises/dissociates	1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
7.1	**Level 3:** A full, detailed and coherent plan covering all the major steps is provided, which outlines the apparatus required and sets out the steps needed in a logical manner that could be followed by another person to produce a pure, dry sample of copper nitrate.		5–6	AO1/2
	Level 2: The substantive content of a plan is present but may be missing some steps. The plan may not be in a completely logical sequence but leads towards the production of a pure, dry sample of copper nitrate.		3–4	
	Level 1: Simple statements relating to relevant apparatus or steps are made but they may not be in a logical order. The plan would not allow another person to produce the sample.		1–2	
	No relevant content		0	
	Indicative content • pour a suitable volume of nitric acid into a suitable container • add a small amount of copper carbonate to the acid and stir until the effervescence stops • continue to add small amounts of copper carbonate to the acid and each time stir until any effervescence stops • eventually when there is no reaction/effervescence when the copper carbonate is added filter the mixture to remove the excess copper carbonate • pour the filtrate (copper nitrate solution) into an evaporating basin and heat to evaporate a small amount of the water • leave the copper nitrate solution to crystallise • remove the crystals from the solution remaining and dry the crystals			RPA17
7.2	1 mole carbon dioxide = 14 + (16 × 2) = 46 g		1	AO2/1
	14 g is 0.30 mole		1	AO2/1
	1 mole is 6.02×10^{23} molecules		1	AO1/1
	so 14 g has 1.81×10^{23} molecules	allow 1.81×10^{23} with no working shown for **4** marks answer not given in standard form max. **3** marks	1	AO2/1 4.5.2.4
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
8.1	Ionic		1	AO2/1 4.6.2.3
8.2	electrolyte		1	AO1/1 4.7.5.2
8.3	because the ions are free to flow		1	AO1/1 4.7.5.2
8.4	because potassium is higher in the reactivity series than hydrogen so less easily discharged than hydrogen		1 1	AO2/1 RPA21
8.5	because water is covalent / molecular /contains molecules so there are no free electrons to move **or** does not have an overall electrical charge		1 1	AO2/1 AO2/1 RPA21
8.6	conductivity of the solution increases with concentration in a linear relationship **or** directly proportional		1 1	AO3/1a RPA21
Total			**9**	

Acknowledgements

This document has been produced by Mr J Turnbull.

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