Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

S23-3410UA0-1

3410UA0-1

FRIDAY, 16 JUNE 2023 – MORNING

CHEMISTRY – Unit 1:
Chemical Substances, Reactions and Essential Resources
HIGHER TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**11**	
3.	**9**	
4.	**8**	
5.	**5**	
6.	**9**	
7.	**12**	
8.	**9**	
9.	**8**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this examination paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

If you run out of space, use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in Question **6**(a).

The Periodic Table is printed on the back cover of this paper and the formulae for some common ions on the inside of the back cover.

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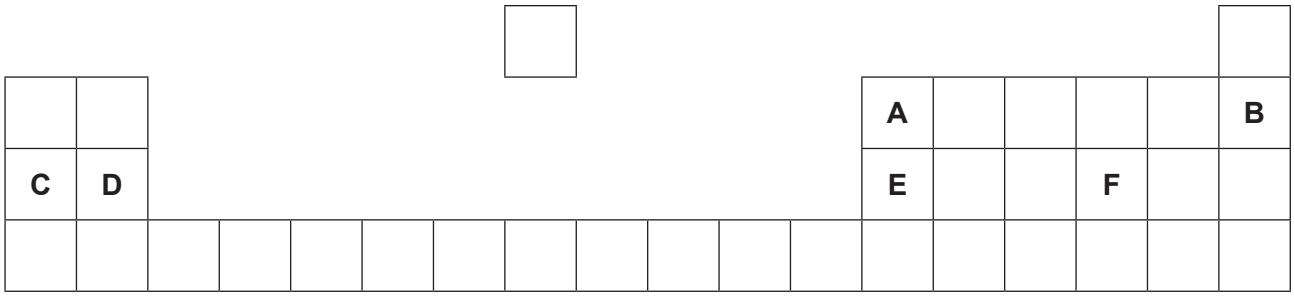
Answer **all** questions.

1. (a) The following diagram shows an outline of part of the Periodic Table.

The letters shown are NOT the chemical symbols of the elements.



Choose **letters** from the diagram to complete the table below. [4]

	Letter
The element in Group 3 and Period 2	.....
The element which has 10 protons in its nucleus	.....
The element with the electronic structure 2,8,6	.....
The element which forms a 2+ ion	.....

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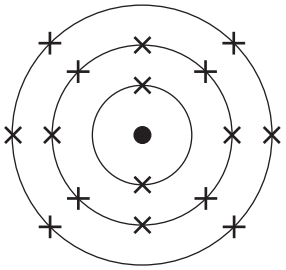
(b) The diagram below shows the electronic structure of an element in the Periodic Table.



In the space below, draw a diagram to show the electronic structure of the element which lies directly **above** it. [1]

(c) The table shows information about atoms **X**, **Y** and **Z**.

Atom	Symbol	Number of protons	Number of neutrons	Number of electrons
X	$^{31}_{15}\mathbf{X}$	.....	16	15
Y	$^{39}_{19}\mathbf{Y}$	19	.....	19
Z	$^{40}_{19}\mathbf{Z}$	19	21	.....

(i) Complete the table. [3]

(ii) Underline the term used to describe atoms **Y** and **Z**. [1]

ions **inert** **insoluble** **isotopes**

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2. (a) The table shows information about some Group 1 elements.

Element	Relative atomic mass	Number of electrons in the outer shell	Melting point (°C)	Boiling point (°C)	Density (g/cm^3)
lithium	7	1	180	1342	0.53
sodium	23	1	98	883	0.97
potassium	39	1	63	759	0.89
rubidium	85	1	39	688	1.53
caesium	134	1	29	671	1.93

Use the information in the table to answer parts (i) and (ii).

(i) State the information which explains why the elements have similar chemical properties. [1]

.....

(ii) State which **property** has a value which does **not** fit the trend down the group. [1]

.....

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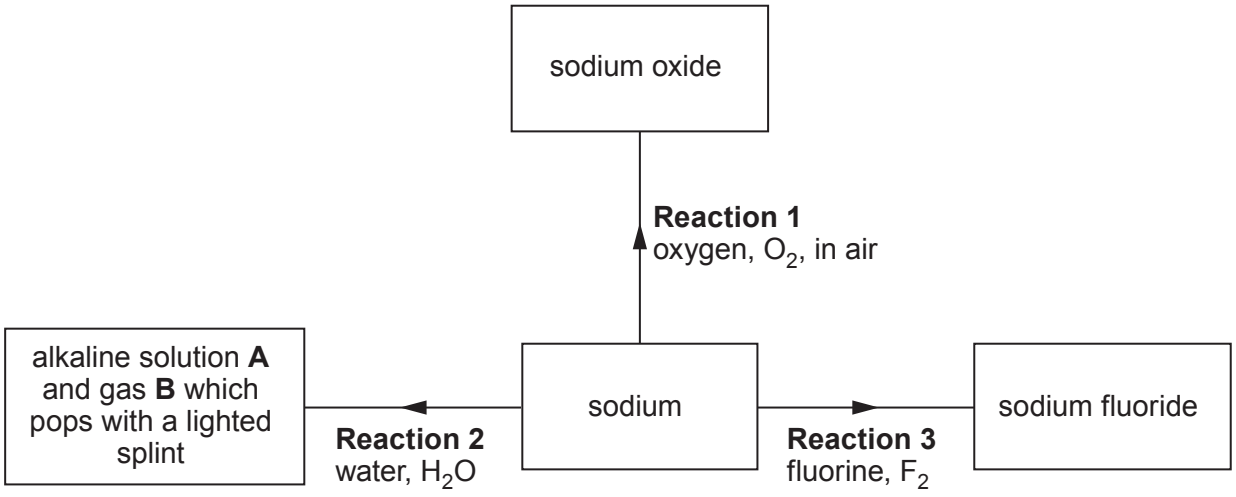
(b) The flow diagram shows some reactions of sodium.



(i) State how **Reaction 1** is prevented when storing sodium in the laboratory. [1]

.....

(ii) Give the names of alkaline solution **A** and gas **B**. [2]

..... and .....

(iii) Name the Group 1 metal which would react **least** violently with water. [1]

.....

(iv) Complete the symbol equation for **Reaction 3**. [1]

$2Na + F_2 \longrightarrow 2$ .....

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(c) Sodium fluoride is added to some UK public water supplies to reduce tooth decay in children.

In America sodium hexafluorosilicate, Na_2SiF_6, is more commonly used. The relative formula mass of sodium hexafluorosilicate is 188.

(i) Calculate the percentage of fluorine in sodium hexafluorosilicate. [2]

$A_r(F) = 19$ $M_r(Na_2SiF_6) = 188$

Percentage = ... %

(ii) State an **ethical** reason why some people oppose the fluoridation of water supplies. [1]

.....

.....

(iii) Apart from water supplies, state the most commonly used source of fluoride to reduce tooth decay. [1]

.....

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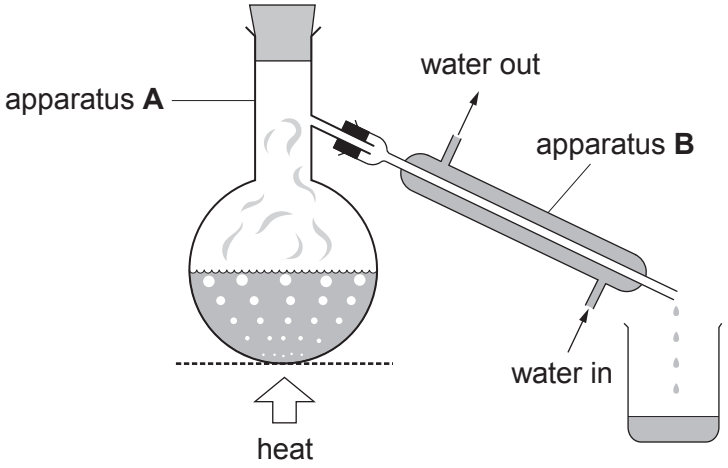
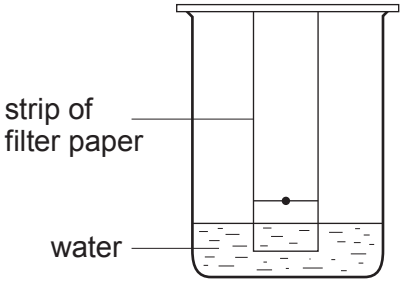
3. (a) The diagrams show two methods used to separate mixtures.



Method **1**



Method **2**

(i) I. Name the changes of state happening in apparatus **A** and apparatus **B** when water is separated from salt in Method **1**. [2]

Apparatus **A** .....

Apparatus **B** .....

II. Name this method of separation. [1]

.....

(ii) Explain how an orange dye is separated into a red spot and a yellow spot on the filter paper in Method **2**. [2]

.....

.....

.....

.....

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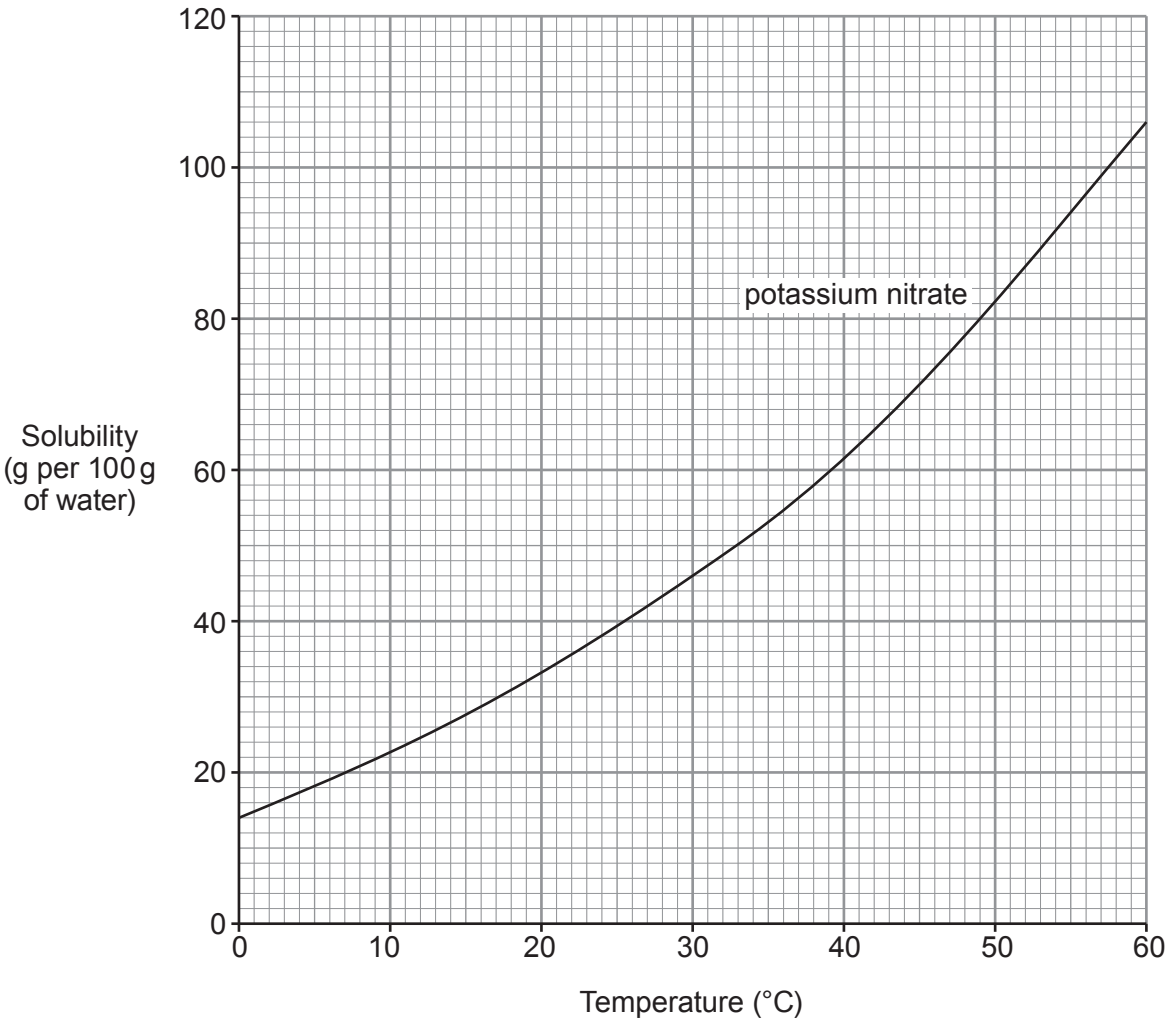
(b) The graph below shows the solubility of potassium nitrate at different temperatures.



Use the information in the graph to answer parts (i) and (ii).

(i) 60 g of potassium nitrate was added to 100 g of water at 30 °C. After stirring the mixture some of the potassium nitrate did not dissolve.

Calculate the mass of potassium nitrate which did **not** dissolve. [1]

Mass = ... g

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(ii) On cooling a saturated solution of potassium nitrate containing 100 g of water from 55 °C to a lower temperature, 36 g of solid was formed.

Determine the temperature to which the solution was cooled.

Show your working. [3]

Temperature = ... °C

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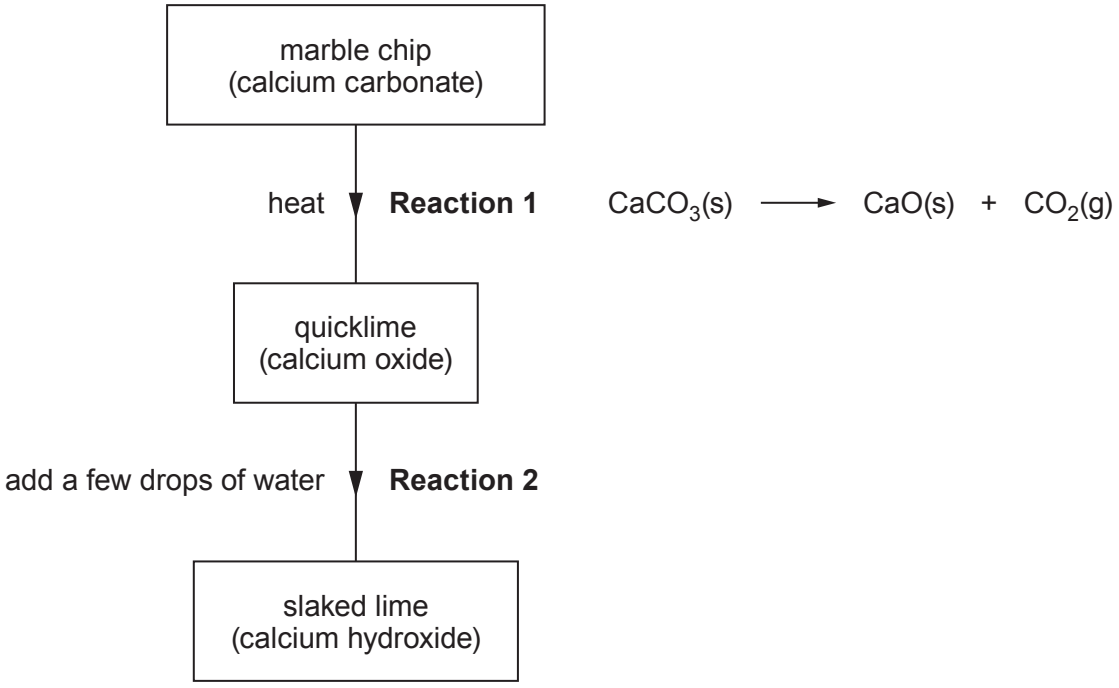
4. (a) The flow diagram shows the reactions necessary to make slaked lime (calcium hydroxide) from a marble chip (calcium carbonate).



(i) In **Reaction 1**, one compound breaks down when heated to form two products.

Complete the name of this type of reaction. [1]

thermal .....

(ii) Give **two** observations you would expect to make as **Reaction 2** happens. [2]

1 .....

2 .....

(iii) Complete the symbol equation for the reaction between calcium oxide and water in **Reaction 2**. [1]

..... + H_2O ⟶ .....

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(b) (i) The relative formula mass of calcium hydroxide is 74.

Calculate the number of moles of calcium hydroxide in 2.96 g. [2]

Number of moles = ... mol

(ii) Explain why calcium hydroxide is used to treat some soils. [2]

.....

.....

.....

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5. Temporary hard water is caused by the presence of dissolved calcium hydrogencarbonate, $Ca(HCO_3)_2$.

The table shows three different methods of removing temporary hardness from water.

Method	Product(s) in softened water
1. Adding sodium carbonate	insoluble calcium carbonate dissolved sodium hydrogencarbonate
2. Boiling	insoluble calcium carbonate carbon dioxide
3. Passing through an ion exchange column containing Na^+ ions	dissolved sodium hydrogencarbonate

(a) Complete the symbol equation for the reaction taking place in Method **1**. [1]

$Ca(HCO_3)_2$ + ... ⟶ $CaCO_3$ + $2NaHCO_3$

(b) Underline the ratio of calcium ions to sodium ions exchanged in Method **3**. [1]

2:1 **1:1** **1:2** **2:2**

(c) Give the number of the method which does **not** form limescale. Give the reason for your answer. [2]

Number .....

Reason .....

.....

(d) Tick (✓) the box next to the name of a compound that causes permanent hardness when dissolved in water. [1]

calcium sulfate ☐

potassium sulfate ☐

magnesium hydrogencarbonate ☐

sodium sulfate ☐

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6. (a) The table shows the approximate percentages of some gases found in the Earth's **original** atmosphere and the Earth's atmosphere **today**.

Gas	Approximate percentage (%) of gases in the Earth's atmosphere	
	Original	**Today**
carbon dioxide	75	0.04
water vapour	25	variable, between 1-2
oxygen	0	21

Explain how the changes to these gases have taken place over geological time. [6 QER]

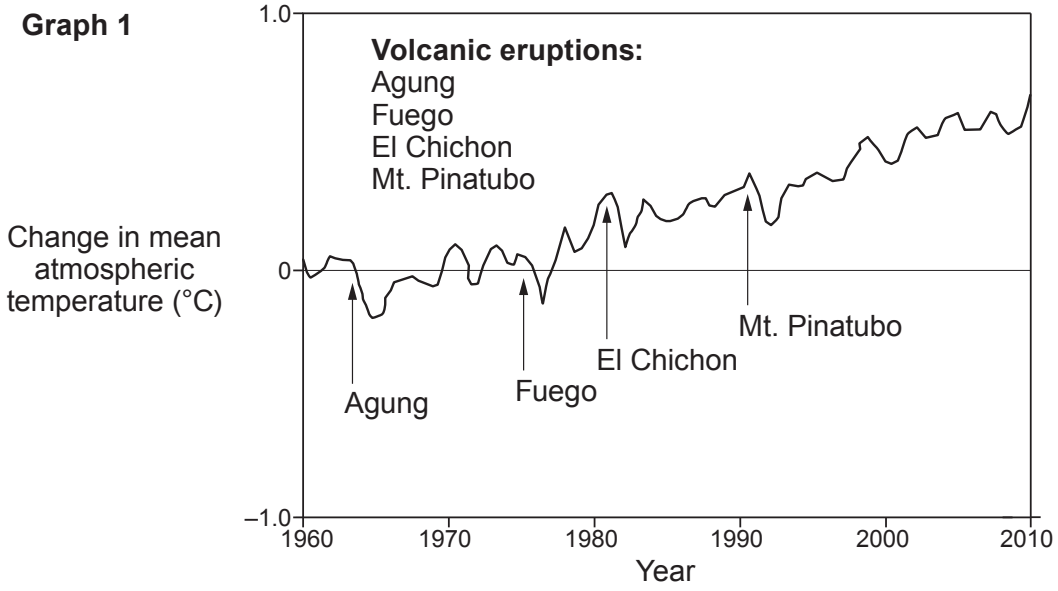
(b) Use the information on this page to answer parts (i)–(iii).

Do Volcanoes Cause Global Warming?

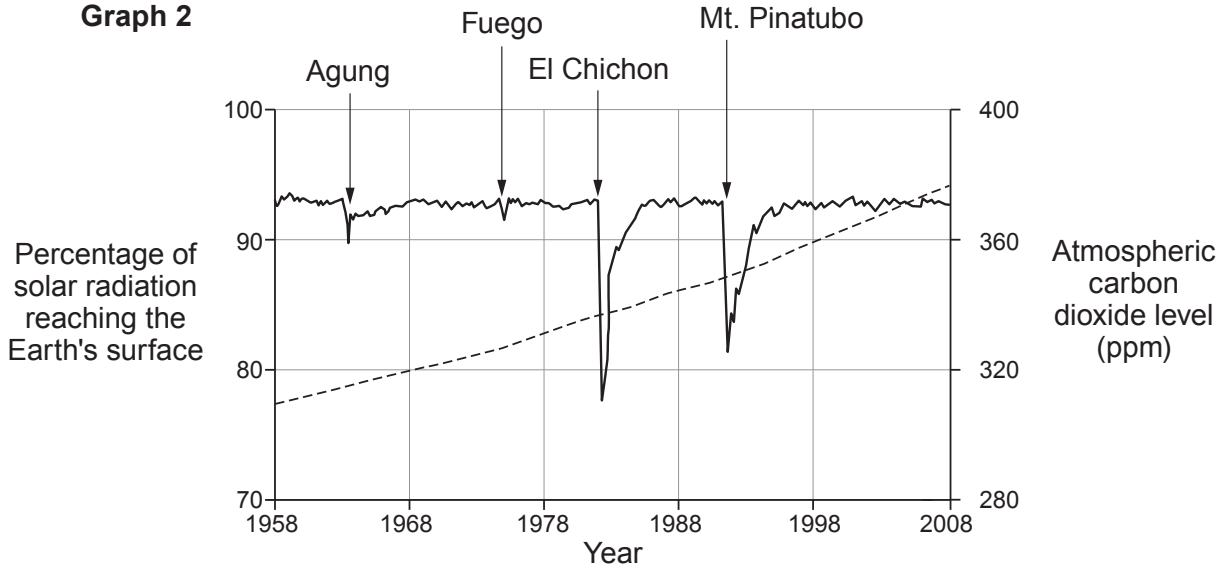
Volcanoes release vast amounts of greenhouse gases, such as carbon dioxide, which contribute to global warming. **Graph 1** shows the effect of four volcanic eruptions on the mean atmospheric temperature.

Erupting volcanoes also emit large quantities of sulfur dioxide into the atmosphere. Unlike carbon dioxide, sulfur dioxide increases the reflection of radiation from the Sun back into space, which cools the Earth's atmosphere. **Graph 2** shows the effect of the same four large volcanic eruptions on the percentage of solar radiation reaching the Earth's surface. The graph also shows the change in carbon dioxide levels in the atmosphere over the same time period.

Graph 1



Graph 2



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(i) Tick (✓) the box next to the statement which best describes the effect of volcanic eruptions on the overall level of carbon dioxide in the atmosphere. [1]

No significant impact on the overall level of carbon dioxide ☐

A significant increase in the level of carbon dioxide ☐

A significant decrease in the level of carbon dioxide ☐

(ii) Tick (✓) the box next to the statement which best describes the effect that volcanic eruptions have on the mean atmospheric temperature. [1]

Mean atmospheric temperature decreases ☐

Mean atmospheric temperature increases ☐

No effect on the mean atmospheric temperature ☐

(iii) Tick (✓) the box next to the statement which best explains the change in solar radiation reaching the Earth's surface after volcanic eruptions. [1]

Solar radiation decreases because it is reflected by sulfur dioxide ☐

Solar radiation increases because it is absorbed by carbon dioxide ☐

Solar radiation increases because it is absorbed by carbon dioxide and sulfur dioxide ☐

Solar radiation decreases because it reacts with sulfur dioxide forming sulfuric acid ☐

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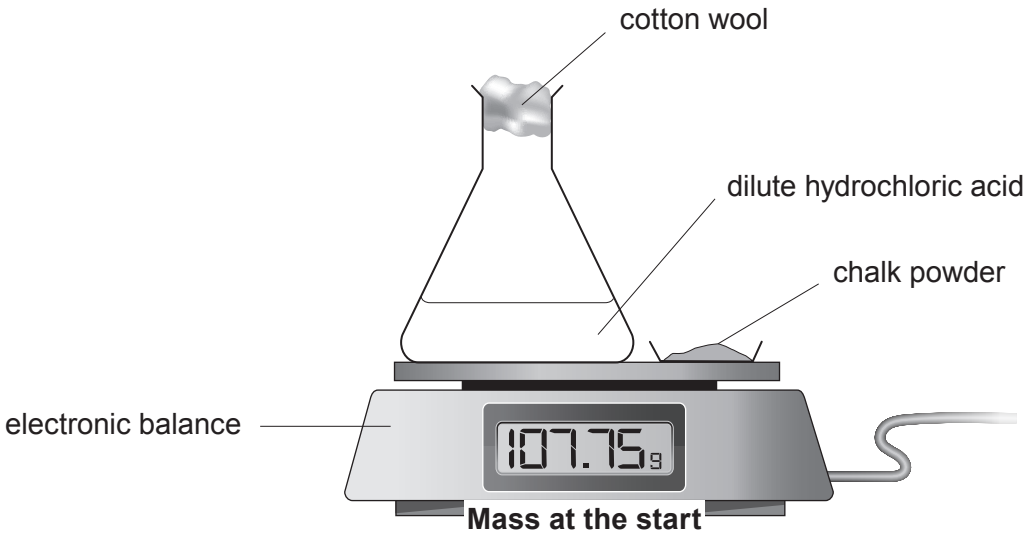
7. Chalk is a form of calcium carbonate, $CaCO_3$.

A student carried out an experiment to investigate the rate of reaction between **powdered** chalk and **excess** dilute hydrochloric acid at 20 °C.

Chalk reacts with dilute hydrochloric acid forming carbon dioxide gas.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

The diagram shows the apparatus used.



(a) State the purpose of the cotton wool. [1]

.....

(b) The student recorded the mass of the flask and contents every 10 seconds for 70 seconds.

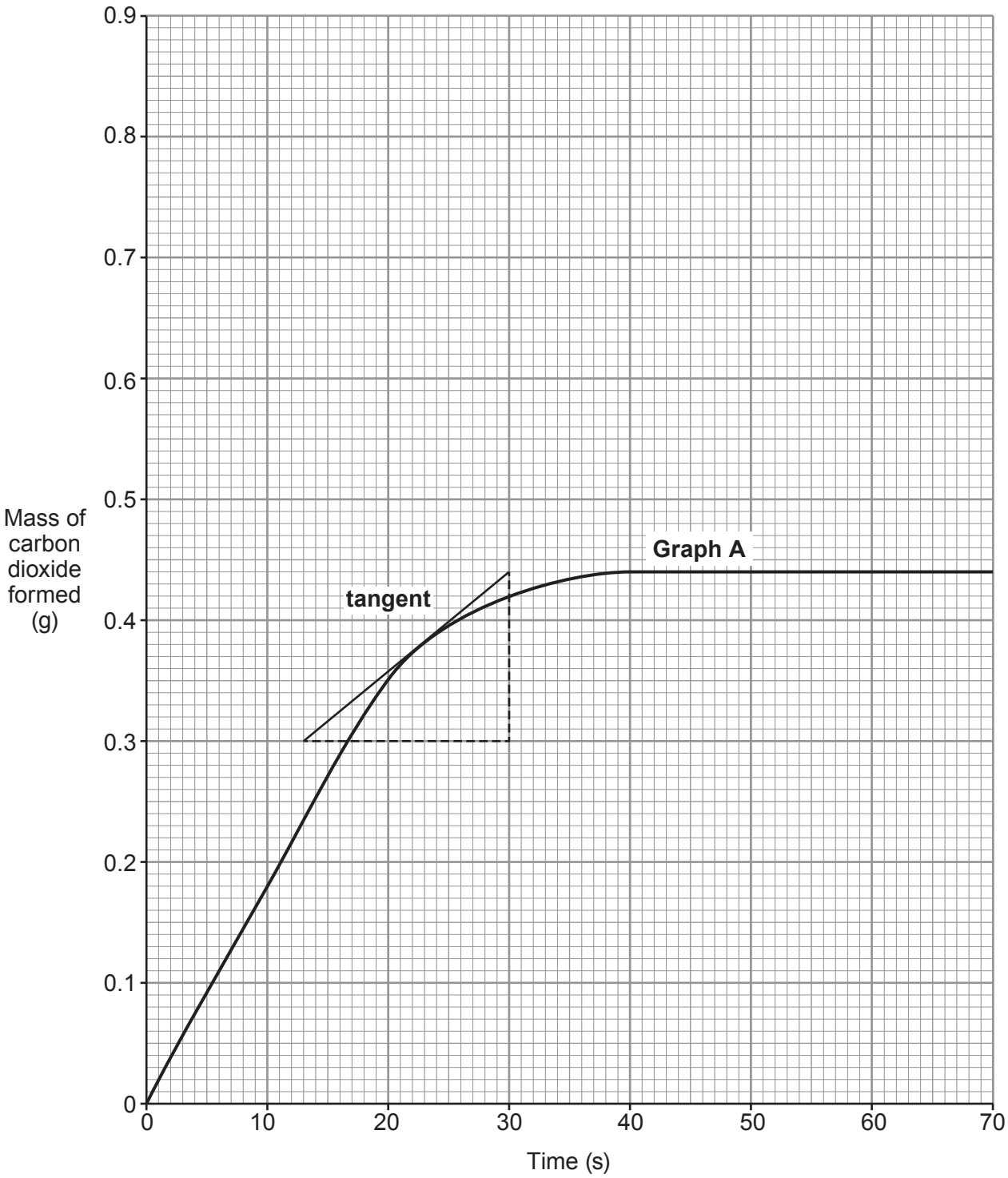
Describe what the student must do to calculate the mass of carbon dioxide formed in the first 10 seconds. [1]

.....

.....

(c) Graph **A** shows the mass of carbon dioxide formed against time.

A tangent to the graph has been drawn at 23 s.



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Use the tangent and the equation below to calculate the rate of reaction at 23 s.

Show your working. Give your answer to **two** significant figures. [3]

$$\text{rate} = \frac{\text{change in mass}}{\text{change in time}}$$

Rate = ... g/s

(d) The student repeated the experiment using the **same** mass of chalk powder as the original experiment but a **different concentration** of acid. The table shows the mass of carbon dioxide formed.

Time (s)	0	10	20	30	40	50	60	70
Mass of carbon dioxide formed (g)	0.00	0.11	0.20	0.28	0.35	0.40	0.43	0.44

(i) Plot the results from the table on the grid opposite and draw a suitable line.

Label this graph **B**. [3]

(ii) Use particle theory to explain why the rate of this reaction is lower than that in the original experiment. [3]

.....

.....

.....

.....

.....

(e) Sketch on the grid the curve you would expect if the experiment was repeated using the **original** acid and **twice** the mass of chalk. Assume that the acid is still in excess.

Label this graph **C**. [1]

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8. (a) The table shows information about some Group 7 elements.

Element	Radius of the atom (nm)	Number of electrons in outer shell
chlorine	0.099	7
bromine	0.114	7
iodine	0.133	7

(i) State how the radius of the atom changes down Group 7. [1]

.....

(ii) Explain in terms of electronic structure why the reactivity of the elements decreases down Group 7. [2]

.....

.....

.....

(b) Sea water contains sodium bromide, which is the raw material for the production of bromine.

Between 1953 and 2004 bromine, Br_2, was manufactured from sea water at a chemical plant in Amlwch, Anglesey.

Sea water was treated with chlorine, which converts sodium bromide into bromine.

Complete the balanced equation for the reaction between chlorine and sodium bromide. [3]

..... + 2NaBr $\longrightarrow$ Br_2 + ☐ .....

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(c) 4.47 g of copper bromide was found to contain 1.27 g of copper.

(i) Calculate the mass of bromine in 4.47 g of the copper bromide. [1]

Mass = ... g

(ii) Calculate the simplest formula of the copper bromide.

You **must** show your working. [2]

A_r(Br) = 80 A_r(Cu) = 63.5

Simplest formula .....

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9. (a) A student tested compounds **A**, **B** and **C** to identify them.

Her observations are recorded in the tables below.

Compound **A**	Observation	Ion present
Flame test	apple-green flame	barium
Add silver nitrate solution	white precipitate	chloride

Compound **B**	Observation	Ion present
Flame test	lilac flame	
Add silver nitrate solution	cream precipitate	

Compound **C**	Observation	Ion present
Flame test	brick-red flame	
Add silver nitrate solution	yellow precipitate	

(i) Use your knowledge of the tests for ions to complete the tables for compounds **B** and **C**. [3]

(ii) Write the chemical formula for compound **A**. [1]

.....

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(b) When silver nitrate solution reacts with sodium chloride solution to produce a white precipitate the following reaction occurs.

$$AgNO_3(aq) + NaCl(aq) \longrightarrow NaNO_3(aq) + AgCl(s)$$

Put a tick (✓) in the box which shows the ionic equation for the formation of the precipitate. [1]

$Na^+(aq) + NO_3^-(aq) \longrightarrow AgCl(s)$ ☐

$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \longrightarrow NaNO_3(s) + AgCl(s)$ ☐

$Ag^+(aq) + NO_3^-(aq) \longrightarrow AgNO_3(s)$ ☐

$Ag^+(aq) + Cl^-(aq) \longrightarrow AgCl(s)$ ☐

$Ag^+(aq) + Cl^-(aq) \longrightarrow NaNO_3(s)$ ☐

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(c) When silver carbonate is heated it breaks down to give silver metal and carbon dioxide and oxygen gas.

$$2Ag_2CO_3 \longrightarrow 4Ag + 2CO_2 + O_2$$

Calculate the mass of silver that would be produced from heating 13.8 g of silver carbonate. [3]

$M_r(Ag_2CO_3) = 276$ $A_r(Ag) = 108$

Mass = ... g

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END OF PAPER

Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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FORMULAE FOR SOME COMMON IONS

POSITIVE IONS		NEGATIVE IONS	
Name	**Formula**	**Name**	**Formula**
aluminium	Al^{3+}	bromide	Br^-
ammonium	NH_4^+	carbonate	CO_3^{2-}
barium	Ba^{2+}	chloride	Cl^-
calcium	Ca^{2+}	fluoride	F^-
copper(II)	Cu^{2+}	hydroxide	OH^-
hydrogen	H^+	iodide	I^-
iron(II)	Fe^{2+}	nitrate	NO_3^-
iron(III)	Fe^{3+}	oxide	O^{2-}
lithium	Li^+	sulfate	SO_4^{2-}
magnesium	Mg^{2+}		
nickel	Ni^{2+}		
potassium	K^+		
silver	Ag^+		
sodium	Na^+		
zinc	Zn^{2+}		

THE PERIODIC TABLE

Group 1	2											3	4	5	6	7	0
1 H Hydrogen 1																	4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulfur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	63.5 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
86 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	99 Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57	179 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	210 Po Polonium 84	210 At Astatine 85	222 Rn Radon 86
223 Fr Francium 87	226 Ra Radium 88	227 Ac Actinium 89															

Key