Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3410UA0-1

Z22-3410UA0-1

FRIDAY, 17 JUNE 2022 – AFTERNOON

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.	**5**	
2.	**9**	
3.	**6**	
4.	**9**	
5.	**5**	
6.	**8**	
7.	**5**	
8.	**7**	
9.	**11**	
10.	**9**	
11.	**6**	
Total	**80**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid. You may use a pencil for graphs and diagrams only.

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(s) 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.

Question **9**(a) is a quality of extended response (QER) question where your writing skills will be assessed.

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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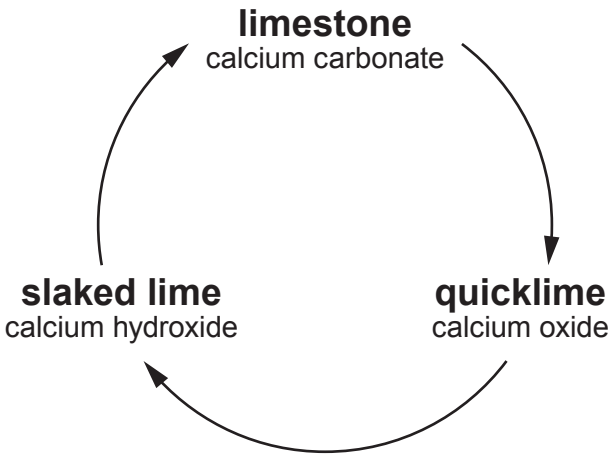
Answer **all** questions.

1. Limestone is a rock which consists mostly of calcium carbonate. The diagram shows a cycle of reactions involving limestone.



(a) (i) When limestone is heated, calcium carbonate is converted to calcium oxide and carbon dioxide.

I. State the name for this type of reaction. [1]

.....

II. Write a balanced symbol equation for the reaction. [2]

..... ⟶ ..... + ...

(ii) State what must be added to calcium oxide to form calcium hydroxide. [1]

.....

(b) Give **one** use of limestone in the construction industry. [1]

.....

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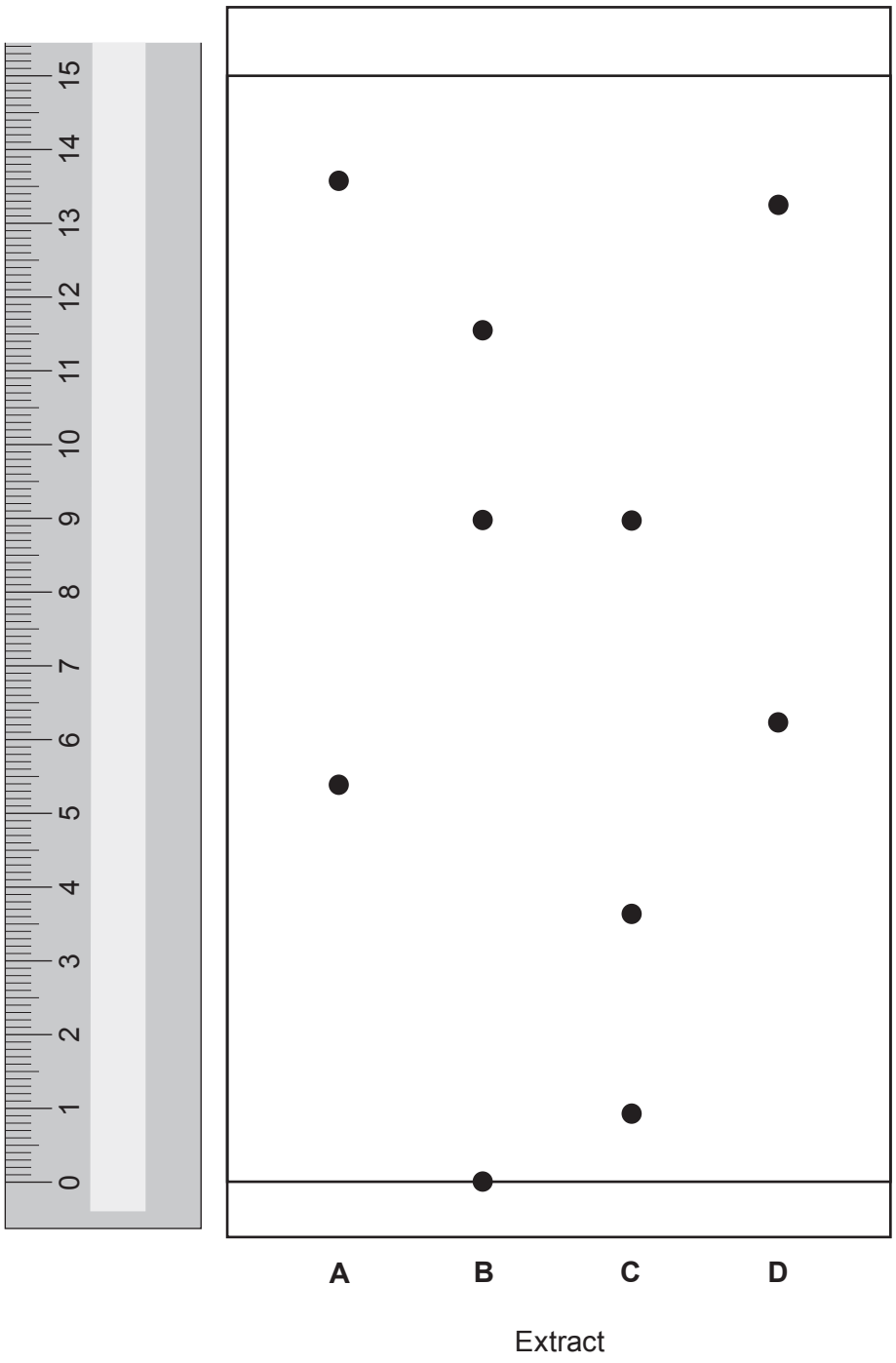
2. Paper chromatography can be used to identify plant leaf pigments. This process uses a chemical called acetone as the solvent instead of water.

The diagram shows the chromatogram of plant leaf extracts **A**, **B**, **C** and **D** in acetone.



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(a) All of the extracts contain a mixture of pigments with different R_f values.

For which plant leaf extract, **A**, **B**, **C** or **D**, is the **highest** R_f value 0.60?

Give your reasoning. [3]

Extract .....

Reasoning .....

.....

.....

(b) Explain why the pigments travel different distances on the chromatogram. [2]

.....

.....

.....

(c) One of the extracts contains a pigment which is insoluble in acetone.

State the **letter** of this extract. Explain your choice. [2]

Extract .....

Explanation .....

.....

(d) The chemical formula of the solvent acetone is C_3H_6O. Calculate the percentage by mass of carbon in acetone.

The relative formula mass (M_r) of acetone is 58. [2]

$A_r(C) = 12$

Percentage = ... %

9

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3. (a) The Earth's early atmosphere contained large amounts of water vapour and carbon dioxide. Explain why the amounts of water vapour and carbon dioxide decreased over geological time. [4]

Water vapour .....

.....

.....

.....

Carbon dioxide .....

.....

.....

.....

(b) State the percentages of nitrogen and oxygen in the present atmosphere. [2]

Nitrogen ..... %

Oxygen ..... %

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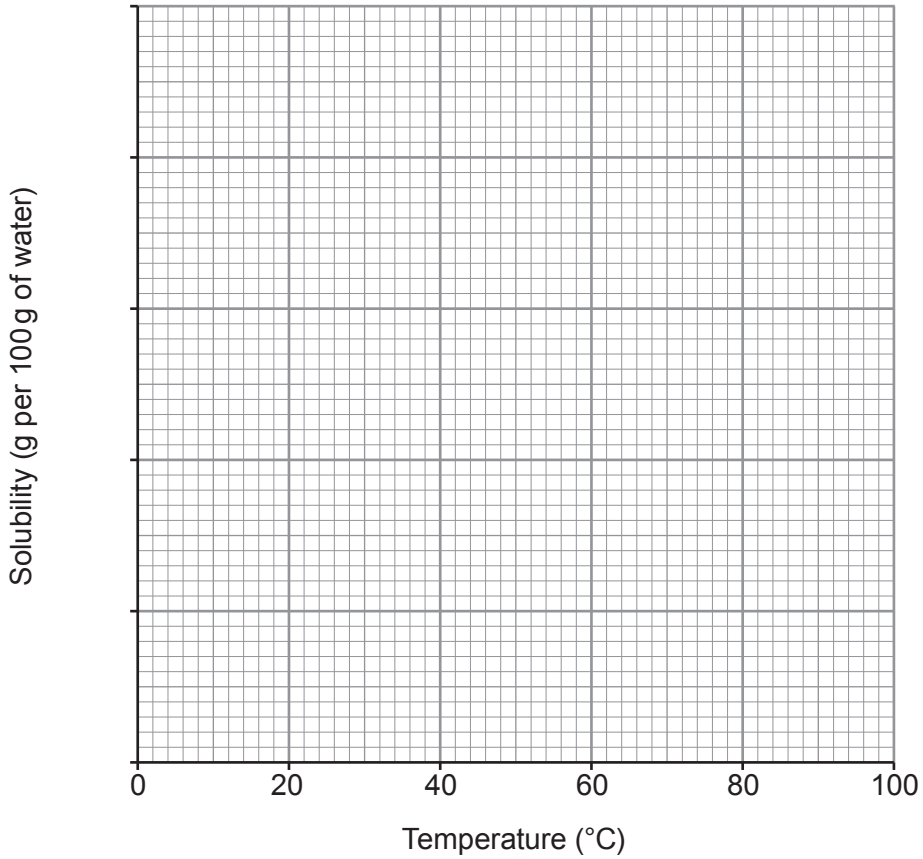
4. (a) The table shows the solubility of potassium nitrate in water at different temperatures.

Temperature (°C)	Solubility (g per 100 g of water)
0	13
20	32
40	64
60	110
80	169
100	246

(i) Choose a suitable scale for the *y*-axis and plot the data on the grid.

Draw a line of best fit. [4]



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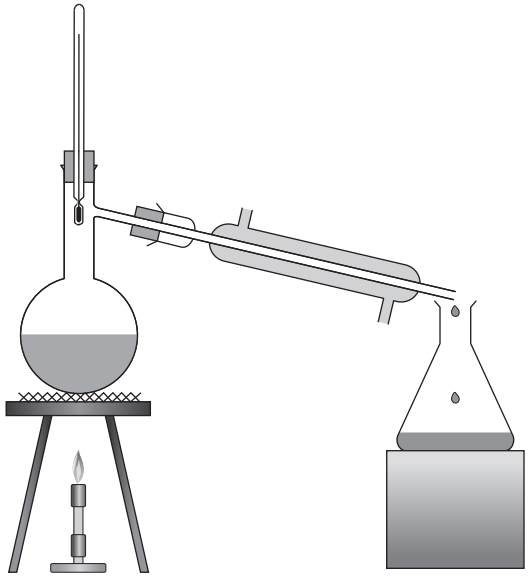
(ii) Calculate the mass in grams of potassium nitrate that would be crystallised if 250 cm^3 of a saturated solution were cooled from 80 °C to 30 °C. [3]

Mass = ... g

(b) Ethanol can be separated from water by distillation using the apparatus shown.



Explain how ethanol and water are separated by distillation. [2]

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.....

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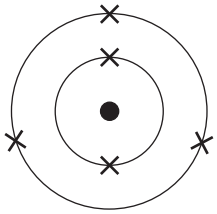
5. (a) The diagram shows an atom of element **X**.



Draw the electronic structure of the element directly **below** element **X** in the Periodic Table. [1]

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(b) The table below shows information about particles **A-F**.

The letters **A-F** are **not** the chemical symbols of the particles.

Particle	Number of protons	Number of electrons	Number of neutrons
A	9	10	10
B	6	6	8
C	7	7	7
D	6	6	6
E	9	9	10
F	3	2	4

(i) Give the **letters** of **two** particles which are **isotopes** of the same element. Explain your answer. [2]

Letters ..... and .....

.....

.....

(ii) Give the **letters** of **two** particles which are **ions**. Explain your answer. [2]

Letters ..... and .....

.....

.....

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6. (a) **S** and **T** are two metal halide compounds. The ions in each compound were identified by observations from a flame test and the addition of silver nitrate solution.

(i) Complete the table. [4]

Compound	Flame test colour	Symbol of ion	Observation on adding silver nitrate solution	Symbol of ion
S	brick red	.....	yellow precipitate	.....
T	.....	Ba^{2+}	white precipitate	.....

(ii) Suggest why a silver nitrate test would not be able to distinguish clearly which halide ions are present in a **mixture** of compounds **S** and **T**. [1]

.....

.....

(b) Write an **ionic** equation for the formation of the precipitate in the reaction between sodium chloride solution and silver nitrate solution.

Include state symbols. [3]

..... + ... ⟶ .....

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7. A catalyst is a substance that causes significant changes to the rate of a chemical reaction. Catalysts interact with the reactants in a chemical reaction and eventually release the product allowing the catalyst to be recovered.

Enzymes are biological molecules which catalyse reactions in living organisms. Enzymes tend to have an optimum temperature of 37 °C.

Hydrogen peroxide is a colourless liquid with the chemical formula H_2O_2. It has many uses including as a bleach and an antiseptic. It is also found in all animals and plants. The decomposition of hydrogen peroxide happens very slowly on its own.

$$2H_2O_2(aq) \longrightarrow 2H_2O(l) + O_2(g)$$

The reaction can be catalysed by several substances including iron(III) oxide, Fe_2O_3, manganese dioxide, MnO_2, and the enzyme catalase.

Four catalysts were tested to determine which was the most efficient. An equal mass of each catalyst was added to equal volumes of hydrogen peroxide solution of equal concentration. The volume of oxygen produced in 1 minute was recorded. The experiment was repeated at different temperatures.

Temperature (°C)	Volume of oxygen produced in 1 minute (cm^3)			
	Catalyst **W**	Catalyst **X**	Catalyst **Y**	Catalyst **Z**
10	0.8	1.2	0.4	0.9
20	1.4	1.4	0.9	1.5
30	1.9	2.1	1.3	2.1
40	2.5	2.6	1.6	2.5
50	3.4	3.8	1.2	3.5
60	4.6	4.8	0.7	4.7
70	5.2	5.4	0.3	5.3

Examiner only

(a) Give the **number** of the statement which is **not** correct. [1]

1 Catalyst **W** is more efficient than **Y** but less efficient than **X** and **Z**

2 Catalyst **X** is the most efficient of the four

3 Catalyst **Y** is less efficient than all of the others

4 Catalyst **Z** is more efficient than **Y** but less efficient than **W** and **X**

.....

(b) State which catalyst, **W**, **X**, **Y** or **Z**, could be catalase. Explain your answer. [3]

Catalyst .....

.....

.....

.....

(c) Three students made statements about the properties of catalysts.

- Katrina said that a catalyst does not get used up in the reaction but makes it happen faster.
- Jo said that the reactants are used up in less time because a catalyst makes a different product.
- Rhys said that adding a catalyst allows the reaction to happen with a lower activation energy, but the same products are made.

Which of the students' statements are correct? [1]

A Jo only

B Rhys and Jo, but not Katrina

C Katrina and Rhys, but not Jo

D All three students

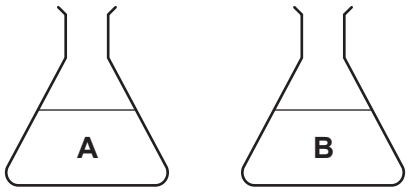
.....

5

Examiner only

8. Hard water can be softened using different methods, including boiling the water and passing it through an ion exchange column.

(a) Two hard water samples, **A** and **B**, were tested for hardness, using soap solution. Both samples were tested before and after boiling, and after passing through an ion exchange column.



	Volume of soap solution needed to produce a lather (cm^3)		
Water sample	Before boiling	After boiling	After ion exchange
A	15	15	2
B	17	9	2

State the type (or types) of hard water that each sample contains. Give your reasoning. [4]

A .....

.....

.....

B .....

.....

.....

.....

.....

Examiner only

(b) Sodium carbonate (washing soda) can also be used to soften hard water. It reacts with the magnesium compounds in the water.

Write a balanced symbol equation for the reaction between sodium carbonate and magnesium chloride, to form sodium chloride and magnesium carbonate. [3]

.....

7

Examiner only

9. (a) Give the observations made during the reactions of lithium, sodium and potassium with water. Explain the trend in reactivity in terms of electronic structure. [6 QER]

Examiner only

(b) Potassium reacts with oxygen to produce potassium oxide.

$$4K + O_2 \longrightarrow 2K_2O$$

(i) Calculate the maximum mass of potassium oxide that could be produced when 15.6 g of potassium reacts completely with oxygen. [3]

$A_r(K) = 39$ $A_r(O) = 16$

Mass = ... g

(ii) Another reaction requires 0.050 mol of oxygen gas. Calculate the number of molecules in 0.050 mol of oxygen gas. Give your answer in **standard form**. [2]

Avogadro's number = 6.0×10^{23}

Number of molecules = ...

11

10. (a) Tables **A**, **B**, **C** and **D** show the results recorded by four different groups in a class investigating the reactivity of Group 7 elements (the halogens).

Each group added iodine, bromine and chlorine to solutions of sodium halides.

A tick (✓) indicates when a reaction took place and a cross (×) indicates no reaction. Only **one** table shows the expected results for this experiment.

Table **A**

	sodium chloride	sodium bromide	sodium iodide
bromine	✓	✓	×
chlorine	✓	×	✓
iodine	✓	✓	✓

Table **B**

	sodium chloride	sodium bromide	sodium iodide
bromine	✓	✓	✓
chlorine	×	×	✓
iodine	×	✓	✓

Table **C**

	sodium chloride	sodium bromide	sodium iodide
bromine	×	×	✓
chlorine	×	✓	✓
iodine	×	×	×

Table **D**

	sodium chloride	sodium bromide	sodium iodide
bromine	×	✓	×
chlorine	✓	×	✓
iodine	×	✓	✓

Examiner only

(i) Give the **letter** of the table which shows the expected results for this experiment. Explain why these are the expected results. [3]

Letter .....

.....

.....

.....

(ii) Write a balanced symbol equation for the reaction between chlorine, Cl_2, and sodium iodide solution. [3]

.....

(b) A sample of iron bromide with a mass of 37.0 g contains 7.0 g of iron. Find the simplest formula of the iron bromide.

You **must** show your working. [3]

A_r(Fe) = 56 A_r(Br) = 80

Simplest formula .....

9

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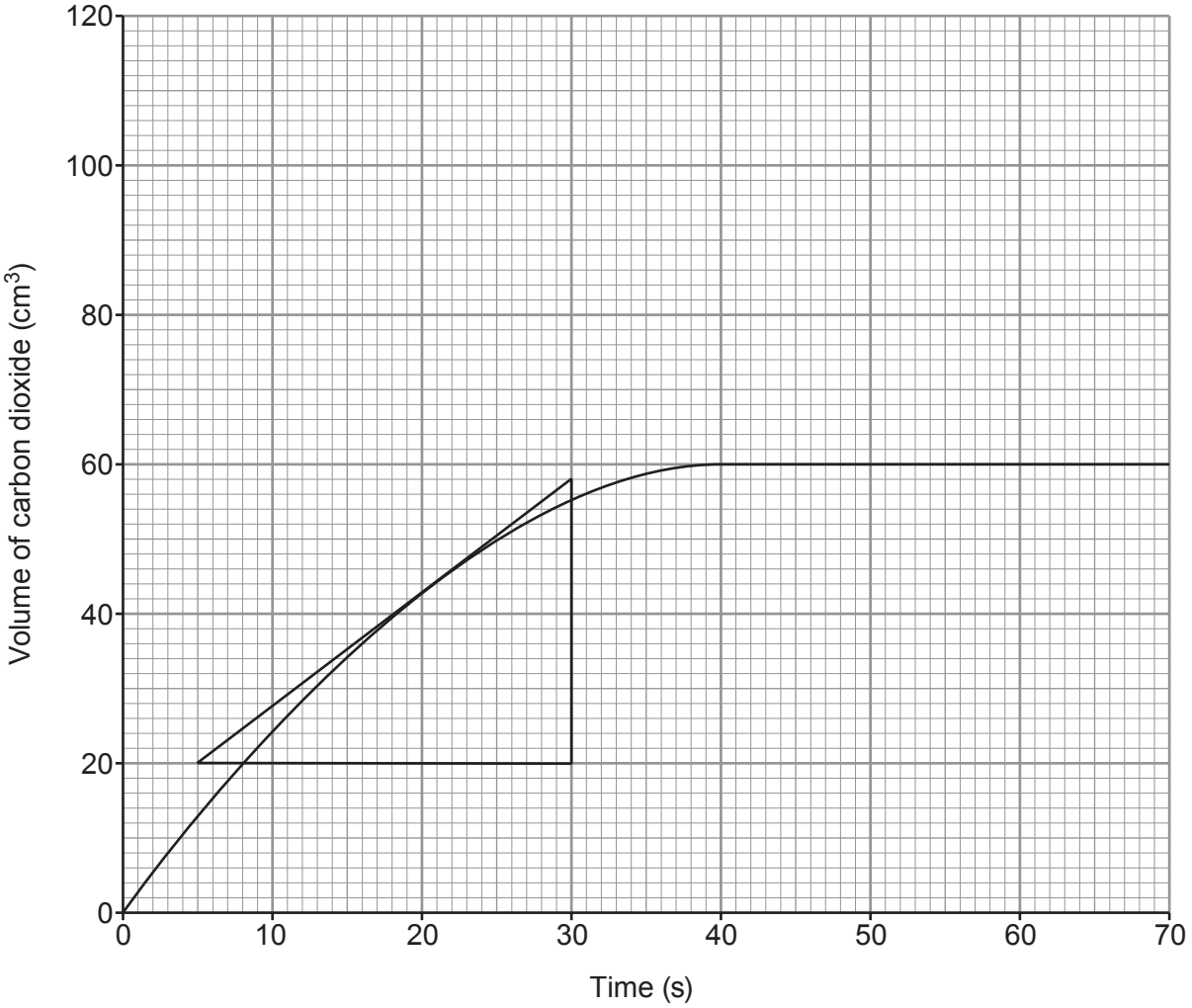
11. The graph shows the volume of gas produced in a reaction between 0.40 g of calcium carbonate powder and excess 1 mol / dm^3 hydrochloric acid.



(a) Use the tangent drawn to calculate the rate of the reaction at 20 s. [2]

Rate = ... cm^3 / s

Examiner only

(b) (i) On the same grid, sketch the graph that would be seen if the reaction were repeated with 0.60 g of calcium carbonate powder and acid of the same concentration and still in excess. [2]

(ii) Explain the graph that you have sketched using your knowledge of particle theory. [2]

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END OF PAPER

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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