

GCSE Chemistry (9 – 1)

Rates of Reaction

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/6
2	/12
3	/7
4	/10
5	/15
6	/13
7	/11
Total	/74
%	
Grade	

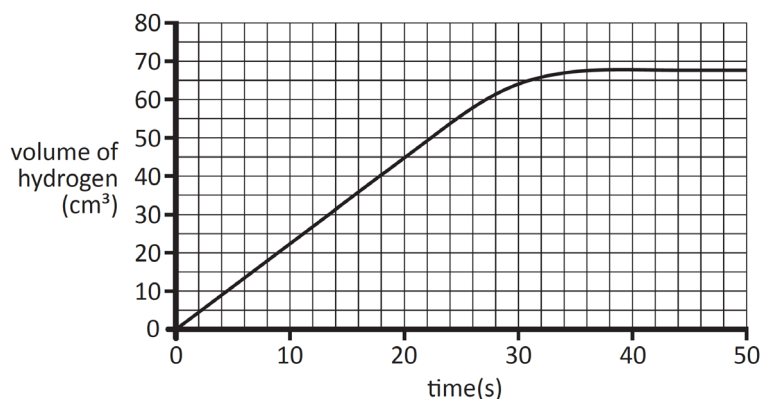
Information

- The maximum mark for this paper is 74 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



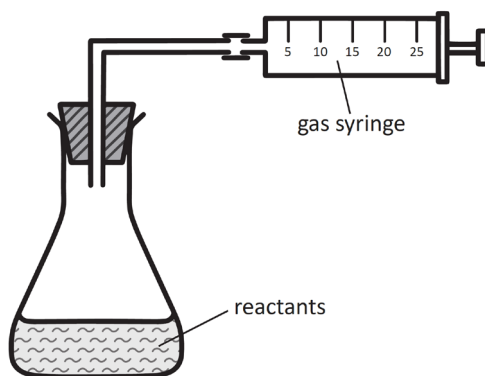
1. The rate of a chemical reaction is the measure of how quickly a reactant is used up or a product is formed. Circle the letter of the correct answer for each of the following questions.

- a. The graph below shows the volume of hydrogen gas made in an experiment. Calculate the mean rate of reaction over the first 20 seconds.



- | | | | |
|-------------------------|-------------------------|------------------------|-----------------------|
| A | B | C | D |
| 0.44 cm ³ /s | 2.25 cm ³ /s | 900 cm ³ /s | 25 cm ³ /s |
| | | | (1 mark) |

- b. The apparatus in the diagram below is used to determine the rate of a chemical reaction.



Which equation represents a reaction where the speed can be measured using this apparatus?

- A** $\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- B** $\text{H}_2\text{SO}_4(\text{aq}) + 2\text{KOH}(\text{aq}) \rightarrow \text{K}_2\text{SO}_4(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$
- C** $\text{AgNO}_3(\text{aq}) + \text{KCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{KNO}_3(\text{aq})$
- D** $2\text{KI}(\text{aq}) + \text{Cl}_2(\text{aq}) \rightarrow 2\text{KCl}(\text{aq}) + \text{I}_2(\text{aq})$

(1 mark)

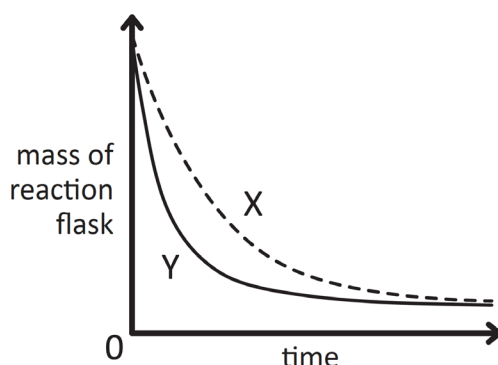
- c. Why does increasing the concentration of a reactant in a solution increase the rate of reaction?

- A** It lowers the activation energy of the reaction.
- B** The reactant particles gain more kinetic energy and move faster.
- C** It increases the frequency of collisions between reactant particles.
- D** The particles become larger and have a greater surface area.

(1 mark)

- d. The reaction between calcium carbonate and hydrochloric acid produces carbon dioxide gas.

To measure the reaction rate, the mass of the unsealed flask and its contents was recorded over time. The graph shows the total mass lost for two separate experiments, X and Y.



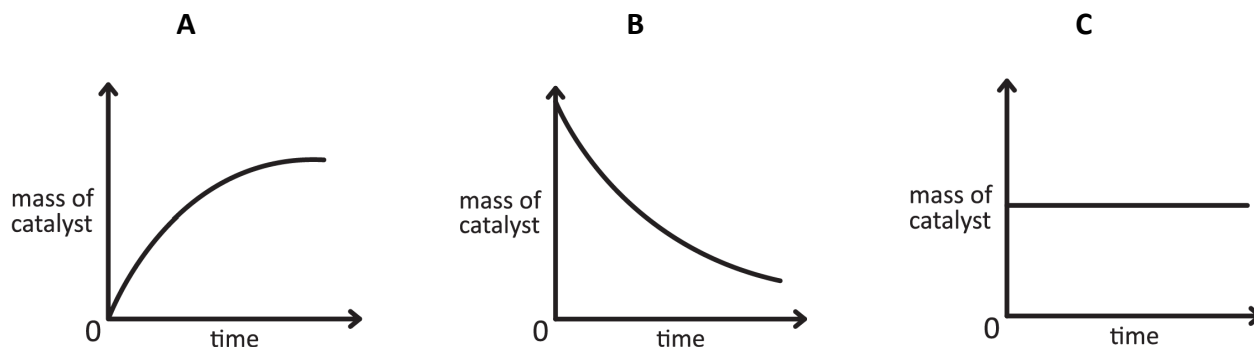
Which change explains the difference between X and Y?

- A A catalyst is added in X.
- B A higher temperature is used in X.
- C Bigger marble chips are used in Y.
- D Hydrochloric acid is more concentrated in Y.

(1 mark)

- e. A catalyst is a substance that can be used to increase the rate of a chemical reaction.

Which of the following graphs show the mass of a catalyst as a chemical reaction takes place?



(1 mark)

- f. Reactions can be exothermic and endothermic.

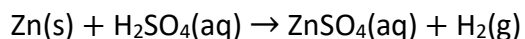
Which of the following describes a reaction that is endothermic?

- A An acid neutralising alkali causing heat to be given out.
- B Adding some solid magnesium to a solution of hydrochloric acid.
- C A sample of calcium carbonate decomposing when heated.
- D The combustion of pentane.

(1 mark)

(Total for Question 1 is 6 marks)

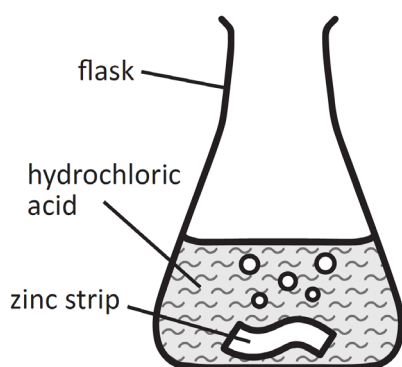
2. A student investigated the reaction of zinc metal with dilute sulfuric acid.
The equation below shows the balanced equation for the reaction.



They measured the volume of hydrogen gas produced at regular time intervals.

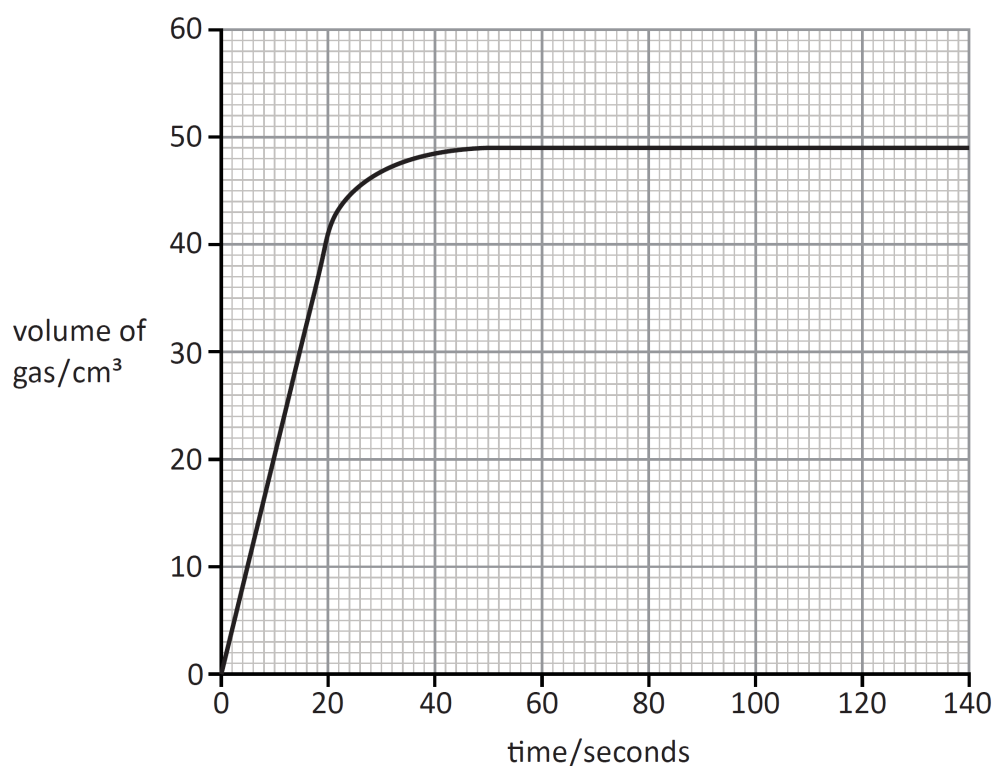
The diagram below shows an incomplete setup.

- a. Complete the diagram to show how the student would collect and measure the volume of gas produced.



(3 marks)

- b. The student carried out the reaction at 30 °C using magnesium ribbon.
Her results are shown on the graph below.



i. How long does it take for the reaction to stop?

.....seconds

(1 mark)

ii. What is the volume of hydrogen made after 20 seconds?

..... cm³

(1 mark)

iii. Use the graph to calculate the rate of reaction at 20 seconds.
You **must** show your working on the graph by drawing a tangent. State the units in your final answer.

Rate of reaction = ... Units = ...

(4 marks)

iv. Explain why the rate of reaction at 40 seconds is slower than the rate at 20 seconds.
Use ideas about collision theory in your answer.

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(3 marks)

(Total for Question 2 is 12 marks)

3. Nitrogen and hydrogen are reacted together to make ammonia.
A catalyst can be added to speed the reaction up without being used up itself.
- a. Explain, in terms of activation energy, how this catalyst increases the speed of the reaction.

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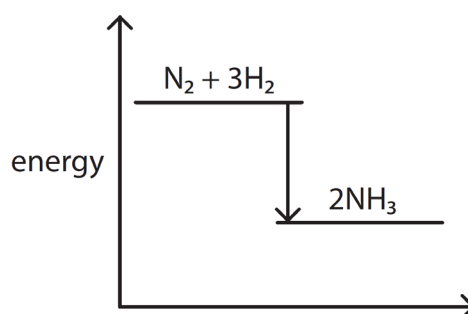
(2 marks)

- b. The reaction to produce ammonia reaction is **reversible**.
- i. Complete the equation below by adding the sign for a reversible reaction.



(1 mark)

- ii. The energy level diagram for this reaction is shown.
Is this reaction exothermic or endothermic? Give a reason for your answer.



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(2 marks)

- c. The student wanted to do a test to prove that the substance produced was ammonia.
Describe a test for ammonia.

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(2 marks)

(Total for Question 3 is 7 marks)

4. Sulfur dioxide (SO_2) is a toxic, colourless gas with a sharp, pungent odour, it primarily comes from the burning fossil fuels that contain sulfur.

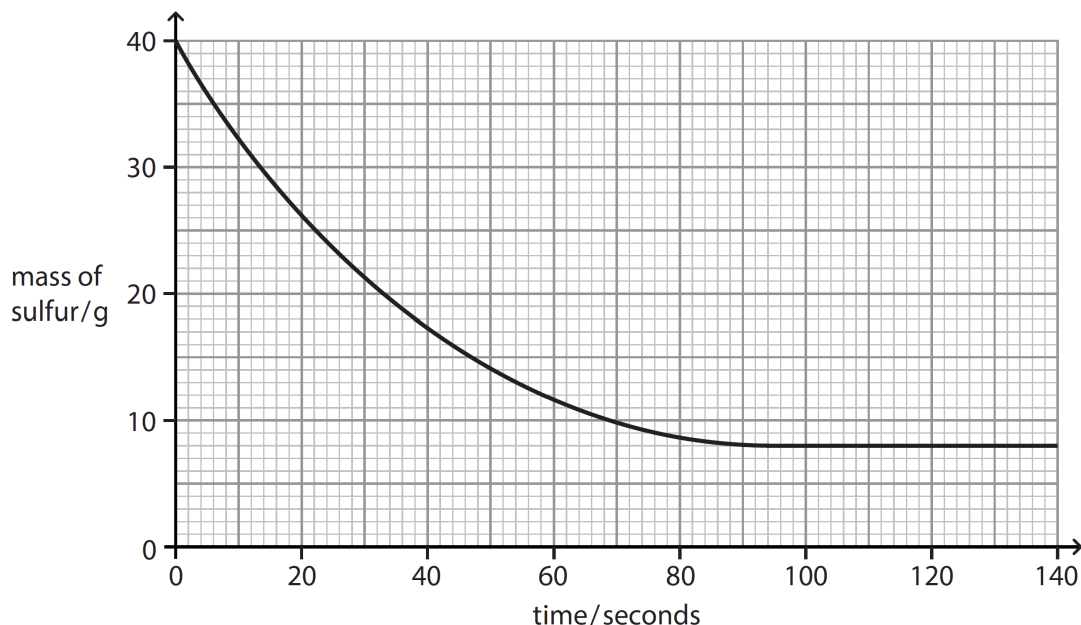
Large pieces of solid sulfur burn in **excess** oxygen to produce sulfur dioxide gas.

- a. Write the balanced symbol equation for this reaction. You must include state symbols.

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(3 marks)

- b. The figure below shows how the mass of sulfur changes as the combustion of sulfur occurs.



- i. How long did it take for the combustion of sulfur to be completed. seconds

(1 mark)

- ii. The combustion was repeated using **powdered** sulfur.

Describe the effect on the rate of reaction of using powdered sulfur rather than large pieces of sulfur.

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(2 marks)

- iii. Use the graph to calculate the rate of reaction at 40 seconds.

You **must** show your working on the graph by drawing a tangent.

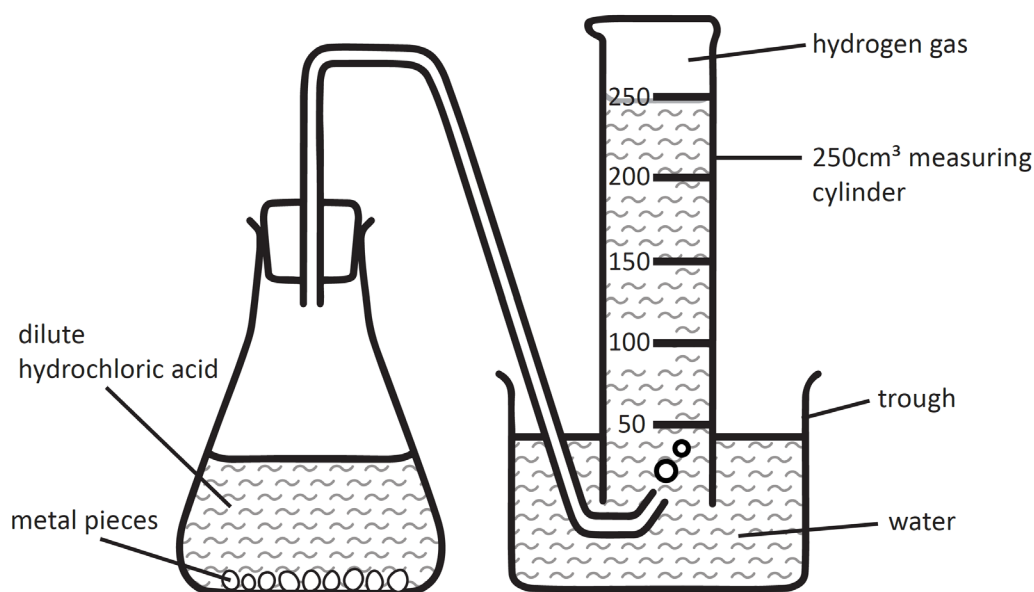
Give the units in your final answer.

Rate of reaction = ... Units = ...

(4 marks)

(Total for Question 4 is 10 marks)

5. To investigate reaction speed, a student added zinc pieces to a flask of dilute hydrochloric acid. Using the apparatus shown, they collected the hydrogen gas produced and recorded its total volume every minute.



- a. Using the apparatus shown, how would the student know when the reaction has **finished**?

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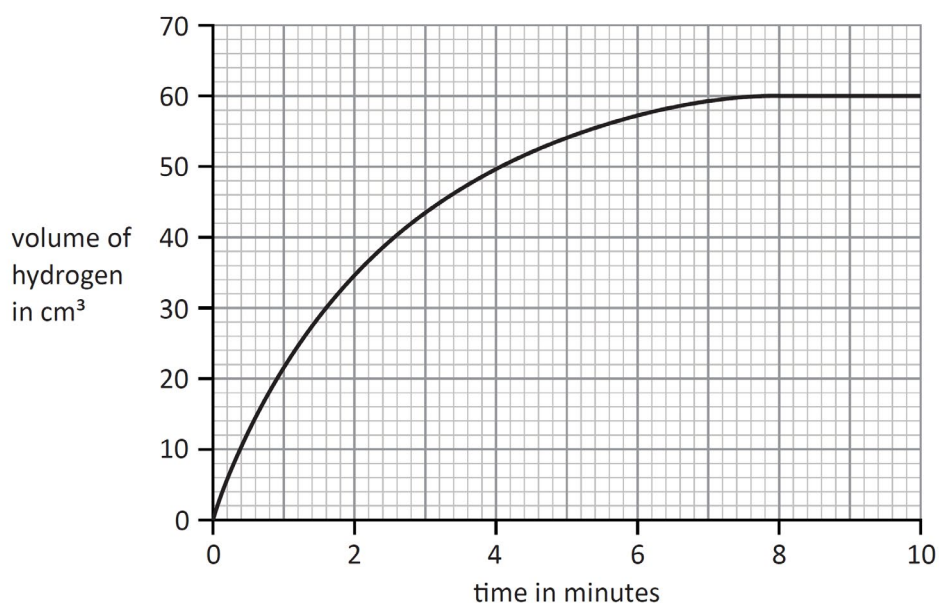
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(1 mark)

- b. The student repeats the experiment using the same mass of zinc, but this time as a fine powder instead of pieces. The volume and concentration of the hydrochloric acid are kept the same.

On the axes below, sketch the curve you would expect for this second experiment.

Label this curve 'Powder'. The curve for the original experiment with zinc pieces is shown for comparison.



(2 marks)

- c. Calculate the mean rate of production of hydrogen over the first 240 seconds, in cm^3 per second.

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rate = ... cm^3/s

(3 marks)

- d. Explain, using collision theory, why the curve for zinc powder is a different shape from the curve for zinc pieces.

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(3 marks)

- e. The student carried out two additional experiments using zinc.

The same mass of zinc and the same sized pieces of zinc were used in each experiment.

The results are shown in the table below.

	Dilute hydrochloric acid (mol/dm^3)	Temperature ($^{\circ}\text{C}$)	Rate of reaction
Experiment 1	0.75	15	Slow
Experiment 2	2.00	30	Fast

Evaluate these results, explaining the reasons **why** the rate of reaction in experiment 2 is faster than the rate of reaction in experiment 1.

In your answer you should refer to the frequency and energy of collisions between particles.

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[illegible]

(6 marks)

(Total for Question 5 is 15 marks)

6. A teacher is demonstrating the classic 'iodine clock reaction' to a class. In this type of reaction, a noticeable change, like a colour appearing or disappearing, happens after a measurable period of time.
- The teacher mixes solution A and solution B, which immediately form a deep purple mixture. The class is told to watch as this purple colour will slowly fade until the solution becomes completely colourless.
- a. To begin the demonstration, the teacher measures out 25 cm^3 of solution A and 25 cm^3 of solution B. For speed, the teacher uses a beaker for this.

Suggest a piece of apparatus the teacher **should** have used to measure the 25 cm^3 volumes more precisely, and **explain** why it is an improvement over a beaker.

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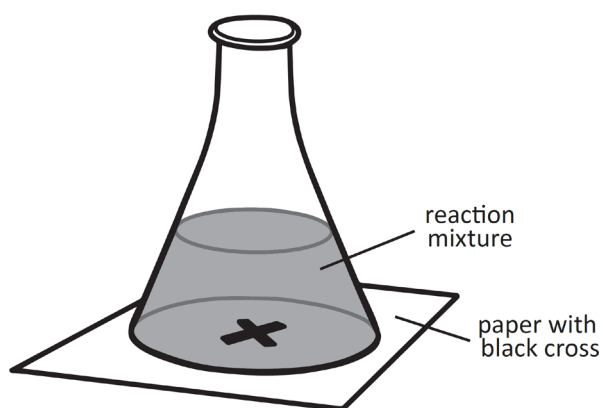
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(2 marks)

The teacher investigates this reaction using the apparatus shown in the figure below.

The teacher measures the time taken for the cross to become visible.

The experiment is repeated at different temperatures.



The experiment was repeated at several different temperatures. The results are shown in the table below.

Temperature in $^{\circ}\text{C}$	Time in s
20	45
30	28
40	19
50	14
60	10
70	6

- b. For the investigation to be a fair test, variables that could affect the rate of reaction must be controlled.

Other than the concentration of the solutions, identify **one** variable that must be kept the same in each experiment.

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(1 mark)

- c. State, and explain in terms of the energy of particles, how the time taken for the cross to become visible would change if a temperature of 90 °C had been investigated.

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(3 marks)

The teacher repeats the experiment at 30 °C, with the addition of a catalyst.

- d. State the function of a catalyst and **explain** how the addition of a catalyst will affect the rate of reaction.

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(4 marks)

- e. The concentration of solution A is 0.40 mol/dm^3 .
The relative formula mass (M_r) of solid A is 67.

Calculate the mass of solid A present in 25 cm^3 of the solution.

You will need to use these **two** formulae:

$$\text{moles} = \text{concentration (mol dm}^3\text{)} \times \text{volume (dm}^3\text{)}$$

$$\text{mass (g)} = \text{moles} \times M_r$$

mass of solid A = ...

(3 marks)

(Total for Question 6 is 13 marks)

7. The reaction between calcium carbonate and hydrochloric acid produces carbon dioxide gas.



To 100 cm³ of hydrochloric acid, 2.0 g of small calcium carbonate chips were added. The volume of carbon dioxide formed was measured every 30 seconds.

The average reaction rate was calculated for each 30 second interval.

Time /s	Volume of carbon dioxide in cm ³	Average reaction rate in cm ³ /s
0	0	
30	45	1.5
60	75	1.0
90	96	
120	105	0.3
150	105	0.0

- a. Explain how the average reaction rate, 1.5 cm³/s, was calculated for the first 30 seconds.

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(2 marks)

- b. Complete the table by calculating the average reaction rate between 60 and 90 seconds. **(1 mark)**

- c. Explain why the average reaction rate decreases with time.

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(2 marks)

- d. The experiment was repeated using 2.0 g of powdered calcium carbonate instead of small chips. What effect, if any, would this have on the reaction rate and on the final volume of carbon dioxide? Give a reason for each answer.

Effect on rate:

Reason:

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(3 marks)

Effect on the final volume of carbon dioxide:

Reason:

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(3 marks)

(Total for Question 7 is 11 marks)