



O Level Chemistry

RATE OF REACTION

5070-THEORY

2026 EDITION

5 A student adds large pieces of zinc to dilute hydrochloric acid. The zinc is in excess.

(b) Fig. 5.1 shows how the volume of hydrogen changes with time as the reaction proceeds.

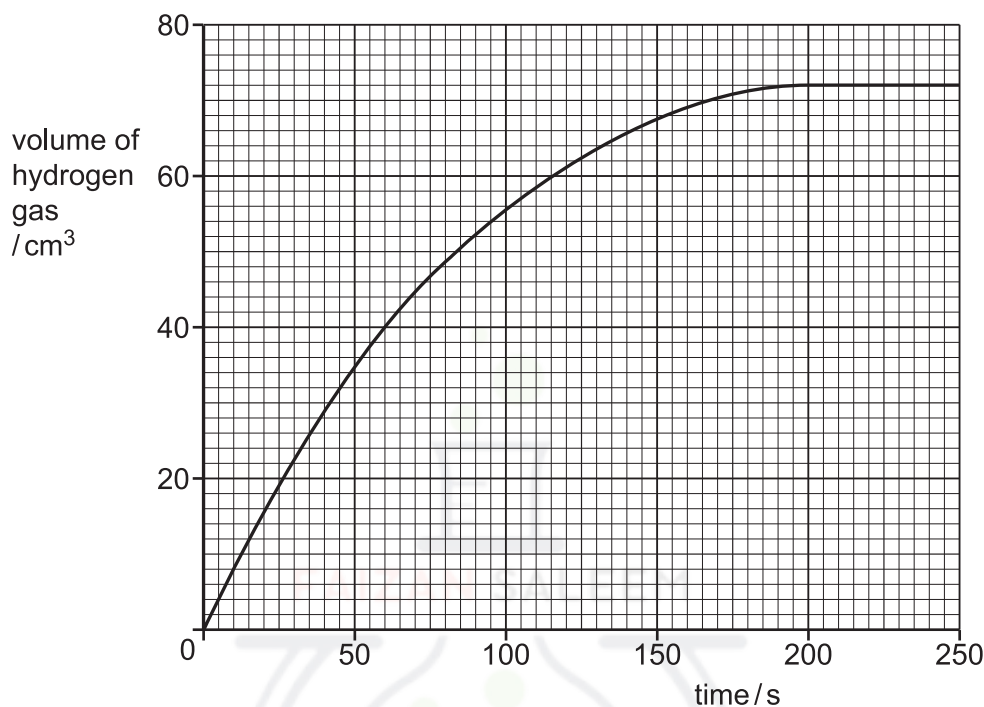


Fig. 5.1

(i) Describe how the shape of the curve in Fig. 5.1 shows that the rate of reaction decreases with time.

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.....
..... [1]

(ii) Explain in terms of collision theory why the rate of reaction decreases with time.

.....
.....
..... [2]

Q2

5070/22/M/J/21/Q7(b)

Definition - Hard

- 7 Sulfamic acid, $\text{NH}_2\text{SO}_3\text{H}$, is a white crystalline solid.

It reacts with aqueous sodium nitrite to make nitrogen gas, as shown in the equation.



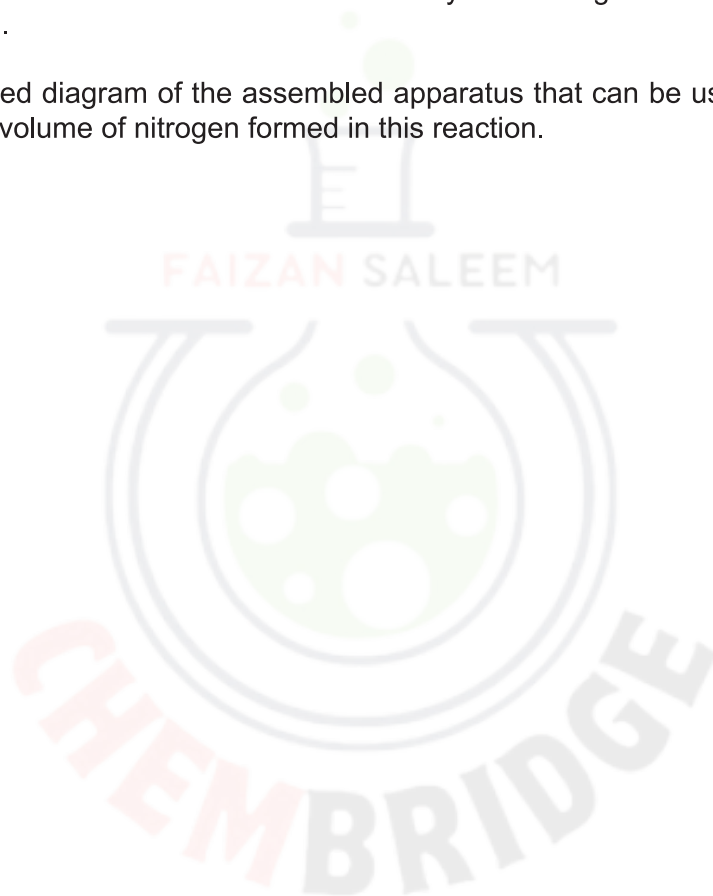
Q2 continued

5070/22/M/J/21/Q7(b)

Definition - Hard

- (b) The rate of this reaction can be determined by measuring the volume of nitrogen formed every second.

Draw a labelled diagram of the assembled apparatus that can be used to make, collect and measure the volume of nitrogen formed in this reaction.



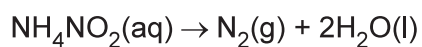
[2]

Q3

5070/21/M/J/24/Q3(b)-(c)

Factors affecting the rate of reaction - Easy

- 3 Aqueous ammonium nitrite decomposes when heated to form nitrogen.



- (b) Describe and explain the effect of increasing the temperature on the rate of this reaction.

.....
.....
..... [2]

- (c) Describe and explain the effect of decreasing the concentration of ammonium nitrite on the rate of this reaction.

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.....

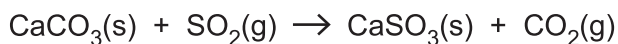
Q4

5070/22/M/J/22/Q7(c)(i)-(ii)

Factors affecting the rate of reaction - Hard

- (c) Sulfur dioxide produced at power stations can be removed by a process called flue gas desulfurisation.

In flue gas desulfurisation, sulfur dioxide reacts with calcium carbonate.



The reaction needs to be fast to remove as much sulfur dioxide as possible.

- (i) Explain, using ideas about particles, why the calcium carbonate needs to be a powder instead of a single solid lump.

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.....
..... [2]

- (ii) Explain, using ideas about particles, why decreasing the temperature decreases the rate of the reaction between calcium carbonate and sulfur dioxide.

.....
.....
.....
..... [2]

Q5

5070/22/M/J/25/Q5(b)(iii)

Rate and temperature - Easy

(b) Sulfur dioxide is removed from the emissions from a power station using calcium carbonate powder.

(iii) State and explain the effect of increasing the temperature on the rate of this reaction.

.....
.....
..... [2]



Q6

5070/21/O/N/23/Q3(c)

Rate and temperature - Hard

- 3 A student investigates the reaction of small pieces of zinc with dilute hydrochloric acid at 25 °C. The dilute hydrochloric acid is in excess.

(c) The student repeats the experiment at 30 °C.

All other conditions stay the same.

Describe and explain, using collision theory, how the rate of reaction differs when a temperature of 30 °C is used.

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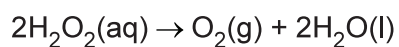
..... [2]

Q7

5070/22/M/J/24/Q3(c)

Rate and concentration - Easy

- 3 Aqueous hydrogen peroxide decomposes when heated to form oxygen.



- (c) Describe and explain the effect of increasing the concentration of hydrogen peroxide on the rate of this reaction.

.....

.....

..... [2]



Q8

5070/22/M/J/21/Q7(c)

Rate and concentration - Hard

- 7 Sulfamic acid, $\text{NH}_2\text{SO}_3\text{H}$, is a white crystalline solid.

It reacts with aqueous sodium nitrite to make nitrogen gas, as shown in the equation.



- (c) The concentration of $\text{NaNO}_2(\text{aq})$ is increased.

The temperature of the reaction remains constant.

State and explain how the rate of reaction changes.

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.....

..... [3]

Q9

5070/22/M/J/25/Q5(b)(iv)

Rate and surface area - Easy

(b) Sulfur dioxide is removed from the emissions from a power station using calcium carbonate powder.

(iv) Lumps of calcium carbonate are used instead of calcium carbonate powder.

State and explain the effect of this change on the rate of this reaction.

.....
.....
..... [2]



Q10

5070/21/M/J/22/Q6(b)(v)

Rate and surface area - Hard

- (v) Explain, using ideas about particles, why the catalyst in a catalytic converter needs to have a large surface area.

.....

.....

..... [2]

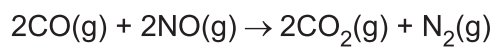


Q11

5070/21/M/J/25/Q5(c)(iv)

Rate and pressure - Easy

(c) A catalytic converter removes most of the CO and NO formed in a petrol engine.



(iv) State and explain the effect of decreasing the pressure on the rate of this reaction.

.....

.....

..... [2]



Q12

5070/21/M/J/23/Q5(c)

Rate and pressure - Hard

- 5 Ammonium chloride decomposes when heated to make hydrogen chloride and ammonia.

This reaction is reversible. The forward reaction absorbs thermal energy.



- (c) Predict what happens to the **rate of the backward reaction** when the pressure is increased and the temperature remains constant.

Explain your answer.

prediction

explanation

.....

.....

.....

[2]

Q13

5070/21/O/N/23/Q2(f)(i)

Rate and catalyst - Easy

(f) Copper can be used as a catalyst.

(i) State how a catalyst increases the rate of a chemical reaction.

..... [1]



Q14

5070/21/M/J/21/Q9(c)(ii)

Rate and catalyst - Hard

- (ii) The reaction uses concentrated sulfuric acid as a catalyst.

Describe how a catalyst speeds up a chemical reaction.

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.....

..... [2]



Q15

5070/21/O/N/24/Q5(b)(i)

Graph questions - Easy

- 5 A student adds large pieces of copper(II) carbonate to dilute hydrochloric acid. The copper(II) carbonate is in excess.

(b) Fig. 5.1 shows how the mass of the reaction mixture changes with time as the reaction proceeds.

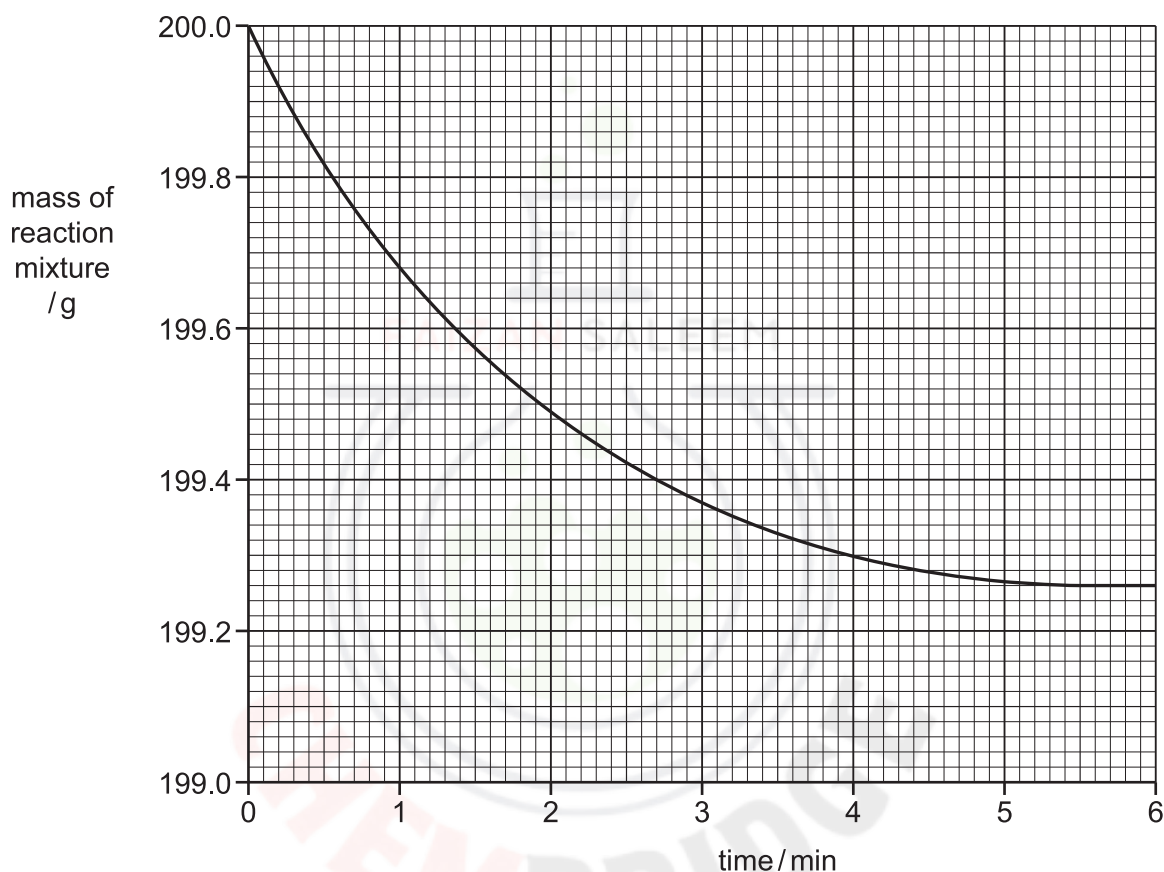


Fig. 5.1

- (i) In another experiment, powdered copper(II) carbonate is used instead of large pieces of copper(II) carbonate. All other conditions and the mass of copper(II) carbonate stay the same.

Draw a line on the grid in Fig. 5.1 to show how the mass of the reaction mixture changes with time. [2]

Q16

5070/21/O/N/23/Q3(b)(ii)

Graph questions - Hard

- 3 A student investigates the reaction of small pieces of zinc with dilute hydrochloric acid at 25 °C. The dilute hydrochloric acid is in excess.

(b) Fig. 3.1 shows the volume of hydrogen released as the reaction proceeds.

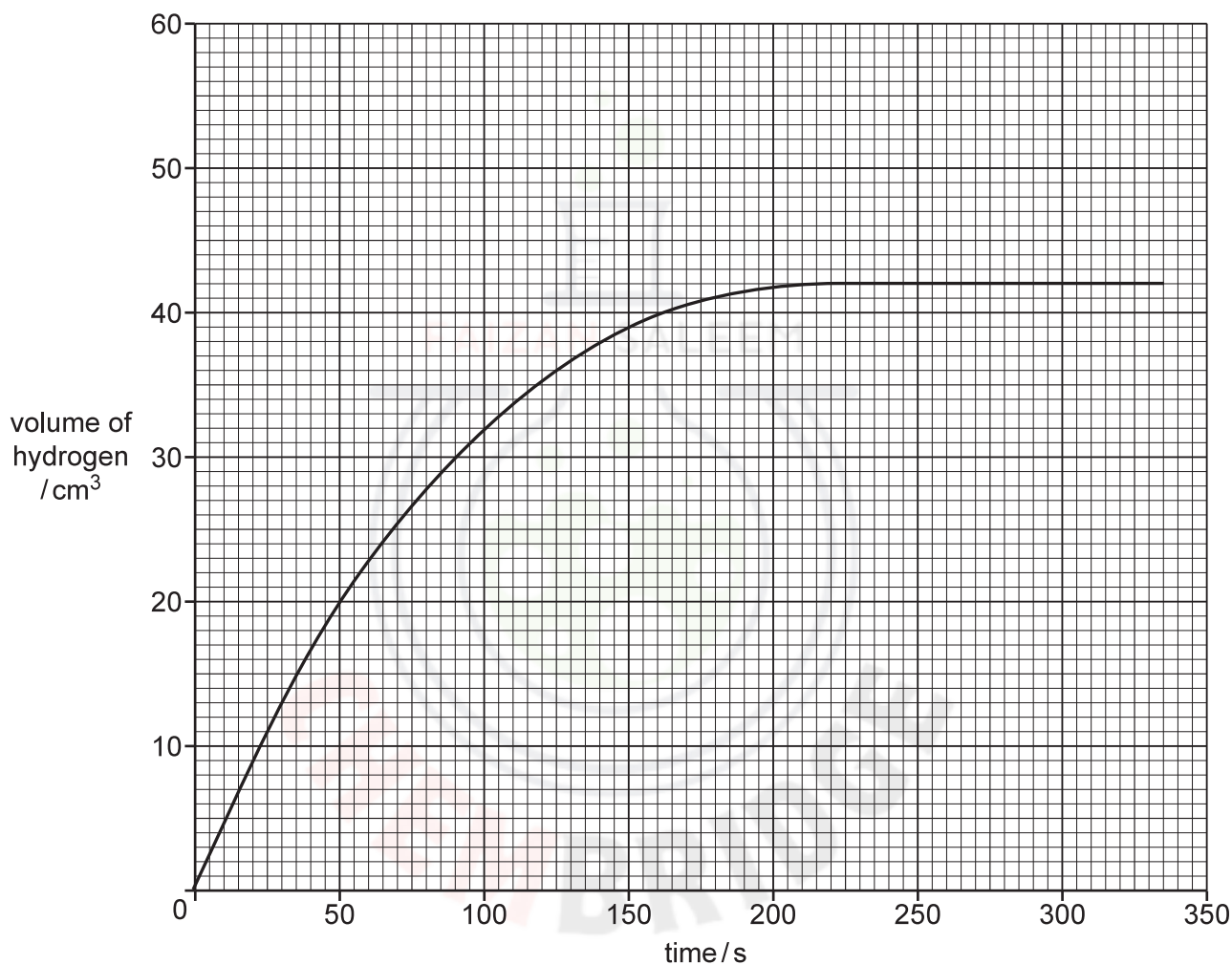


Fig. 3.1

Q16 continued 5070/21/O/N/23/Q3(b)(ii)

Graph questions - Hard

- (ii) The student repeats the experiment using dilute hydrochloric acid with a higher concentration.

All other conditions stay the same.

Draw a line on the grid in Fig. 3.1 to show how the volume of hydrogen changes when dilute hydrochloric acid with a higher concentration is used. [2]



Q17

5070/41/O/N/21/Q2(c)-(d)

ATP questions - Practice



The student does an experiment to find out how the rate of this reaction changes as the concentration of hydrochloric acid changes.

Method

The student:

- measures 100 cm^3 of 1.0 mol/dm^3 hydrochloric acid (an excess) and pours this into a beaker
- adds a known mass of calcium carbonate to the acid
- immediately starts a clock
- stops the clock when **all** the calcium carbonate has reacted
- records this reaction time.

The student repeats the experiment several times with different concentrations of hydrochloric acid.

The concentration of hydrochloric acid for each experiment is changed by changing the volume of 1.0 mol/dm^3 hydrochloric acid.

Water is added to make the total volume equal in each experiment.

All other variables likely to affect the rate of reaction are kept constant in each experiment.

Q17 continued

5070/41/O/N/21/Q2(c)-(d)

ATP questions - Practice

The results are shown in the table.

experiment	volume of hydrochloric acid/ cm^3	volume of water/ cm^3	reaction time/s
1	100	0	30
2		20	150
3	60	40	120
4	40	60	140
5	20		170

(b) Complete the table to show the two missing volumes.

(c) (i) State which experiment has an anomalous reaction time.

..... [1]

(ii) Suggest what the student should do to check if the reaction time in (c)(i) is anomalous.

..... [1]

(iii) State which experiment has the smallest rate of reaction.

..... [1]

(iv) Describe how the rate of this reaction changes as the concentration of the hydrochloric acid increases.

..... [1]

(d) There is no suitable catalyst for this reaction.

Suggest two variables, other than the concentration of the hydrochloric acid or the mass of calcium carbonate, that affect the rate of this reaction.

1

2

[2]

Q18

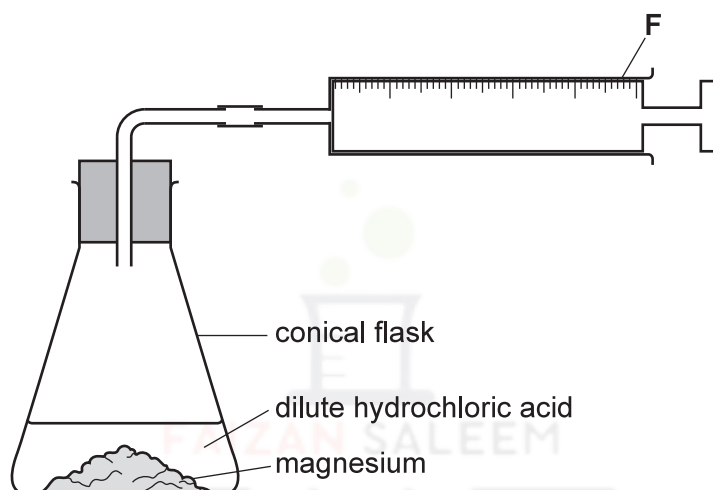
5070/42/O/N/22/Q3(a)-(b), Q3(c)(ii), Q3(d)-(e)

ATP questions - Practice

- 3 The equation for the reaction of magnesium with dilute hydrochloric acid is shown.



A student investigates the rate of this reaction at three different temperatures.



In each experiment the student adds dilute hydrochloric acid to magnesium. The volume of hydrogen in apparatus F is recorded every 30 seconds.

- (a) Name apparatus F.

..... [1]

- (b) Name a piece of apparatus that the student could use to keep the temperature of the conical flask and its contents constant.

..... [1]

Q18 continued

5070/42/O/N/22/Q3(a)-(b), Q3(c)(ii), Q3(d)-(e)

ATP questions - Practice

- (ii) The student uses the measurement of volume as time increases to determine the rate of this reaction.

State a **different** measurement that the student could make as time increases to determine the rate of this reaction.

..... [1]

(d) In each of the three experiments the contents of the flask are at a different temperature.

All other variables are kept constant.

The three experiments are labelled **X**, **Y** and **Z**.

experiment	temperature / °C
X	20
Y	40
Z	60

The hydrochloric acid is in excess in each of the three experiments.

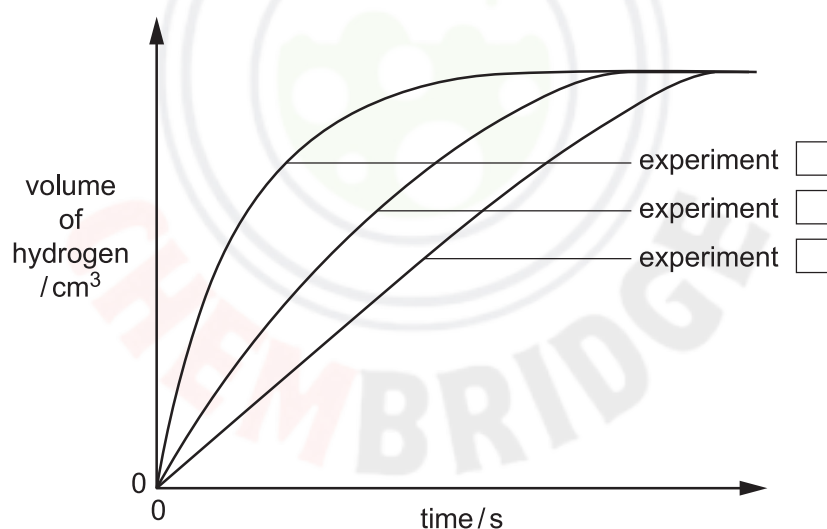
A catalyst is not used.

Identify two variables that are kept constant in this investigation.

1

2 [2]

(e) The student plots a graph of the results.



(i) Describe how the graph is used to decide which experiment has the greatest rate.

.....
 [1]

(ii) Write a letter in each box on the graph to identify experiments **X**, **Y** and **Z**. [1]

(iii) Describe how the graph shows that the reactions stop.

..... [1]

(iv) Explain why the reactions stop.

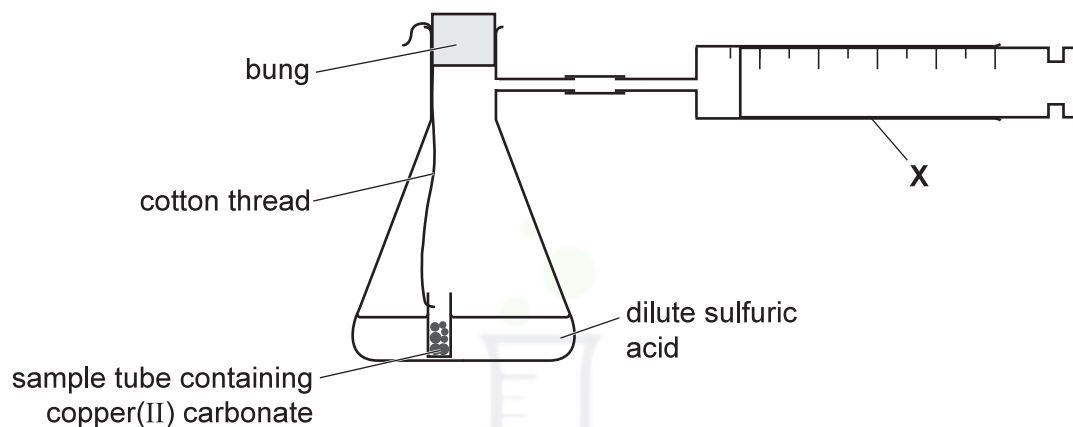
..... [1]

Q19

5070/42/M/J/22/Q5(a)-(c)

ATP questions - Practice

- 5 A student uses the apparatus shown to investigate the rate of reaction between excess copper(II) carbonate and dilute sulfuric acid.



- (a) Identify the piece of apparatus labelled X.

..... [1]

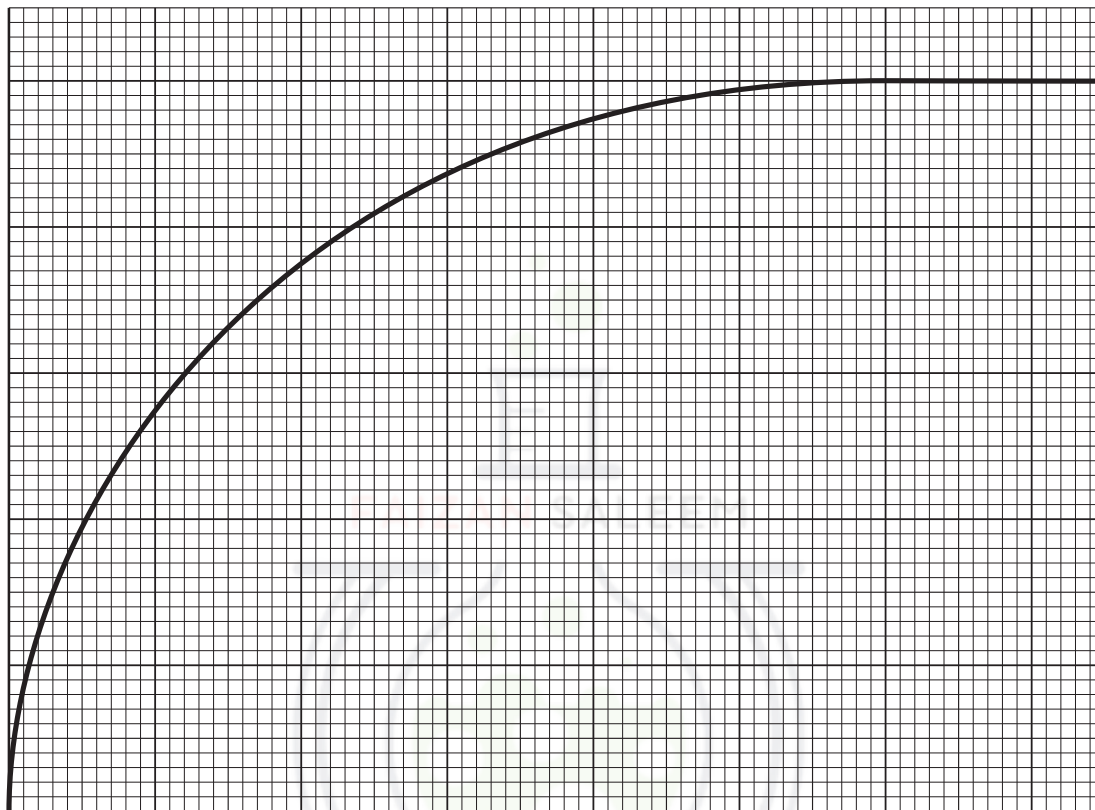
- (b) The student starts the reaction by tipping the sample tube so that the copper(II) carbonate and acid come into contact.

Explain why this method is used instead of adding the copper(II) carbonate to the acid and then replacing the bung.

.....
..... [1]

- (c) The student takes a reading on apparatus **X** every 10 seconds until the reaction has stopped.

The student plots a graph of the results.



- (i) Give the labels for each axis of the graph.

horizontal axis

vertical axis

[1]

- (ii) List three things the student **sees** happening in the flask during the reaction.

1

2

3

[3]

- (iii) Use the graph to explain what happens to the rate of reaction during the reaction.

.....

.....

.....

..... [2]

Q20

5070/41/O/N/23/Q1(a)-(b)

ATP questions - Practice

- 1 A student investigates the rate of reaction between calcium carbonate and dilute hydrochloric acid.

Fig. 1.1 shows part of the apparatus the student uses.

The student determines the rate of reaction by measuring the volume of carbon dioxide produced in a fixed time.

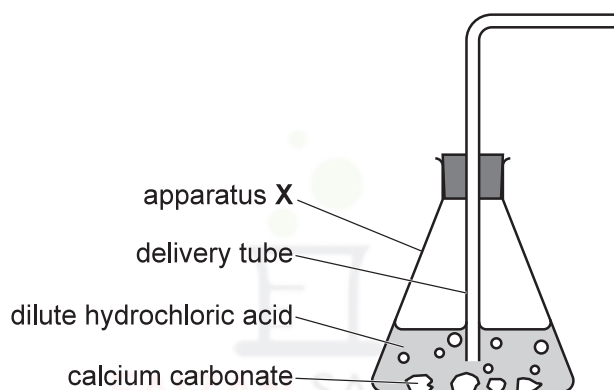


Fig. 1.1

- (a) Name apparatus X.

..... [1]

- (b) The student has incorrectly positioned the delivery tube in the apparatus shown in Fig. 1.1.

Complete Fig. 1.2 to show:

- the correct position of the delivery tube
- the rest of the apparatus the student uses to collect and measure the volume of gas produced.

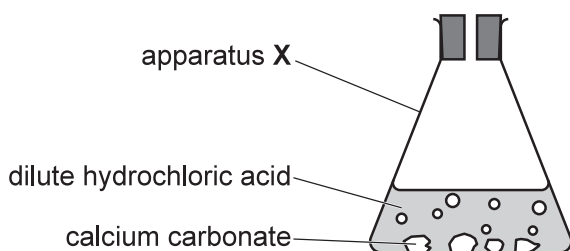


Fig. 1.2

[3]

Q21

5070/42/O/N/25/Q1(a)-(e)

ATP questions - Practice

- 1 A student investigates the rate of a reaction.

Fig. 1.1 shows the apparatus the student uses.

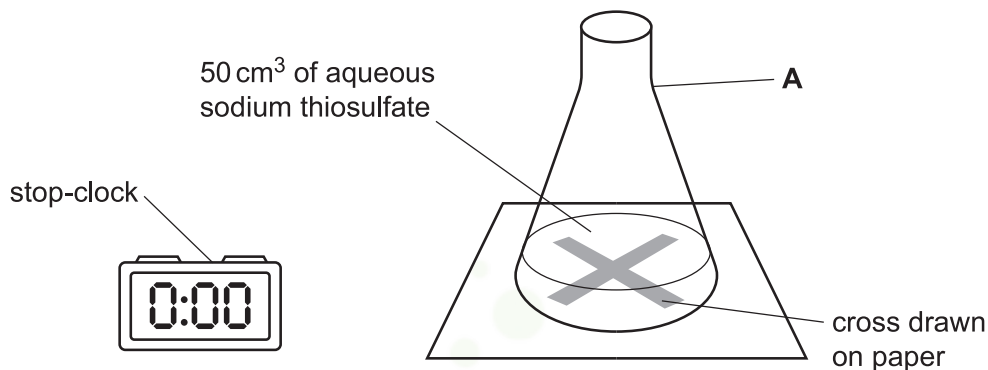


Fig. 1.1

- (a) State the name of the piece of apparatus labelled **A** in Fig. 1.1.

..... [1]

- (b) The student adds a fixed volume and concentration of dilute hydrochloric acid to **A**, swirls the mixture in **A** and places it back on the cross.

- The mixture in the flask slowly turns cloudy.
- The student records the time taken for the solution to become so cloudy that the cross is no longer visible through the mixture.

State the name of a piece of apparatus needed which is **not** shown in Fig. 1.1.

..... [1]

- (c) The student repeats the experiment with the same fixed volume and concentration of dilute hydrochloric acid and with increasing concentrations of aqueous sodium thiosulfate, using a new cross drawn on paper for each experiment.

Explain why drawing a new cross on paper in each experiment reduces the accuracy of the results.

.....

..... [2]

- (d) The student then:

- uses the same cross drawn on paper
- repeats the experiment with the same fixed volume and concentration of dilute hydrochloric acid and with increasing concentrations of aqueous sodium thiosulfate.

Suggest the effect of increasing the concentration of aqueous sodium thiosulfate on the time taken for the cross to become no longer visible.

..... [1]

(e) Sulfur dioxide gas is produced during this reaction.

Sulfur dioxide causes breathing difficulties in humans.

Suggest **one** precaution necessary in this investigation to avoid breathing difficulties.

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..... [1]

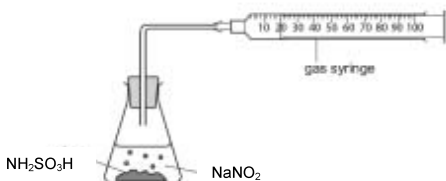


MARKING SCHEME

Q1 5070/22/O/N/24/Q5(b)(i)-(ii)

5(b)(i)	the gradient decreases (as time increases)	1
5(b)(ii)	M1 the particles get further apart (1) M2 frequency of collisions (of the particles) decreases (1)	2

Q2 5070/22/M/J/21/Q7(b)

7(b)	 correct method of collection including arrangement of apparatus (1) workable apparatus e.g. no gas leaks (1)	2
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Q3 5070/21/M/J/24/Q3(b)-(c)

3(b)	rate increases because particles move faster / particles have more kinetic energy / particles have gained kinetic energy (1) more successful collisions / more collisions/particles) with equal or more than activation energy / more effective collisions / more energetic collisions (1)	2
3(c)	rate decreases / reaction is slower because particles are less crowded / distance between particles is smaller / fewer particles per unit volume (1) fewer collisions per second / lower collision frequency (1)	2

Q4 5070/22/M/J/22/Q7(c)(i)-(ii)

7(c)(i)	to increase the surface area (1) more exposed particles / more collisions per second (1)	2
7(c)(ii)	particles move slower / particles have less kinetic energy (1) fewer successful collisions / fewer collisions above that of activation energy (1)	2

Q5 5070/22/M/J/25/Q5(b)(iii)

5(b)(iii)	rate increases particles move faster / particles have more kinetic energy (1) more successful collisions / more effective collisions / more collisions with energy above that of the activation energy / more particles with energy above activation energy (1)	2
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Q6 5070/21/O/N/23/Q3(c)

3(c)	rate of reaction increases particles move more quickly / particles have more kinetic energy (1) more successful collisions / more collisions / particles with equal or more than activation energy / more effective collisions (1)	2
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Q7 5070/22/M/J/24/Q3(c)

3(c)	rate increases / reaction is faster because particles are more crowded / distance between particles is smaller / more particles per unit volume (1) more collisions per second / greater collision frequency (1)	2
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Q8 5070/22/M/J/21/Q7(c)

7(c)	increases (1) more crowded particles / more particles per unit volume / smaller space between particles (1) collision frequency increases / more collisions per second / increase rate of collisions (1)	3
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Q9 5070/22/M/J/25/Q5(b)(iv)

Question	Answer	Marks
5(b)(iv)	rate decreases surface area (to volume ratio) decreases / fewer exposed particles (1) less frequent collisions / lower collision frequency / collisions less often / less collisions per second (1)	2

Q10 5070/21/M/J/22/Q6(b)(v)

6(b)(v)	more exposed particles (1) more collisions per second (1)	2
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Q11 5070/21/M/J/25/Q5(c)(iv)

5(c)(iv)	rate decreases particles are less crowded / fewer particles per unit volume / less concentrated particles / particles are more spread out / particles are further apart (1) less frequent collisions / lower collision frequency / collisions less often / less collisions per second (1)	2
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MARKING SCHEME

Q12 5070/21/M/J/23/Q5(c)

5(c)	rate increases because more particles per unit volume (1) greater collision frequency (1)	
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Q13 5070/21/O/N/23/Q2(f)(i)

2(f)(i)	lowers the activation energy (of the reaction)	1
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Q14 5070/21/M/J/21/Q9(c)(ii)

9(c)(ii)	lowers activation energy (1) by having an alternative pathway / alternative mechanism (1)	2
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Q15 5070/21/O/N/24/Q5(b)(i)

5(b)(i)	initial gradient steeper and line starts at 200.0 (1) line is curved and ends at same final mass (1)	2
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Q16 5070/21/O/N/23/Q3(b)(ii)

3(b)(ii)	initial gradient steeper and starts at 0–0 (1) final volume ends up as horizontal line at 42 cm ³ (1)	2
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Q17 5070/41/O/N/21/Q2(c)-(d)

2(b)	80 AND 80	1
2(c)(i)	2	1
2(c)(ii)	repeat experiment 2 / plot a graph and see if the point lies on the line or curve	1
2(c)(iii)	5	1
2(c)(iv)	rate increases as concentration increases	1
2(d)	particle size of calcium carbonate / surface area of calcium carbonate (1) temperature (1)	2

Q18 5070/42/O/N/22/Q3(a)-(b), Q3(c)(ii), Q3(d)-(e)

3(a)	gas syringe	1
3(b)	thermostatically controlled water bath	1

Q18 continued 5070/42/O/N/22/Q3(a)-(b), Q3(c)(ii), Q3(d)-(e)

3(c)(ii)	mass of flask and contents	1
3(d)	Any two from: - concentration of acid - volume of acid - particle size or surface area of magnesium - mass of magnesium	2
3(e)(i)	Steepest gradient (is greatest rate) OR (graph that) levels off first (is greatest rate)	1
3(e)(ii)	Z Y X	1
3(e)(iii)	(graph) level off OR (graph become) parallel to the x-axis OR (graph become) horizontal OR gradient becomes zero	1
3(e)(iv)	the magnesium is used up	1

Q19 5070/42/M/J/22/Q5(a)-(c)

Question	Answer	Marks
5(a)	gas syringe	1
5(b)	(avoids) loss of gas	1
5(c)(i)	(horizontal) time / s AND (vertical) volume (of gas / carbon dioxide / CO ₂) / cm ³	1
5(c)(ii)	M1 solid disappears (1) M2 effervescence / fizzing / bubbling (1) M3 solution turns blue (1)	3
5(c)(iii)	M1 rate decreases (1) M2 as concentration of acid decreases or as gradient decreases / becomes less steep (1)	2

Q20 5070/41/O/N/23/Q1(a)-(b)

Question	Answer	Marks
1(a)	conical flask	1
1(b)	M1 delivery tube should be above level of acid M2 gas syringe / any inverted collection vessel over water in trough M3 labelled gas syringe or measuring cylinder or graduations shown on collection vessel	3

Q21 5070/42/O/N/25/Q1(a)-(e)

Question	Answer	Marks
1(a)	conical / Erlenmeyer flask	1
1(b)	measuring cylinder	1
1(c)	M1 (the crosses) may be darker / lighter M2 affects the time taken (to become no longer visible) / concentration is not the only variable (that changes)	2
1(d)	(the time taken) decreases	1
1(e)	use a well-ventilated room	1