C8 Rates and Equilibrium Exam Pack and Mark Scheme

Name: _____

Class: _____

Date: _____

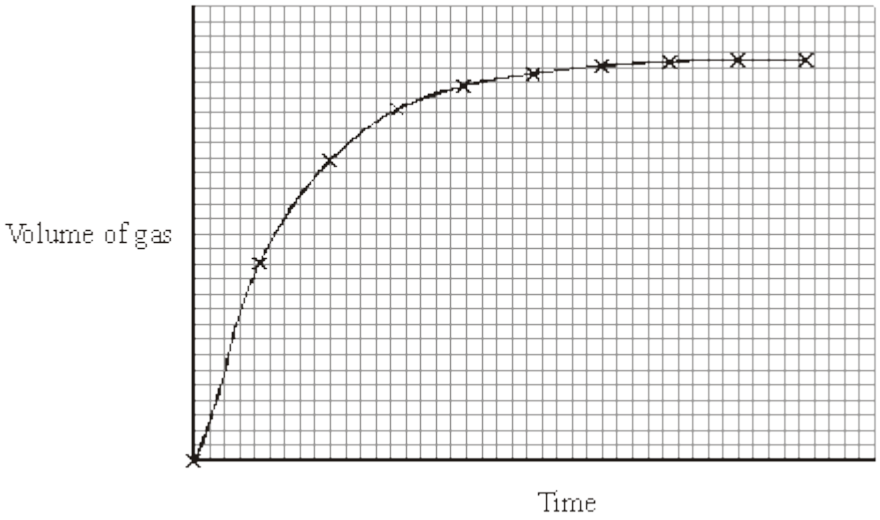
Time: **117 minutes**

Marks: **117 marks**

Comments:

1 Pieces of zinc react with dilute acid to form hydrogen gas.

The graph shows how the volume of hydrogen gas produced changes with time.



(a) Describe, as fully as you can, how the volume of gas produced changes with time.

.....

.....

.....

.....

(2)

(b) A student wants to make the reaction take place faster.

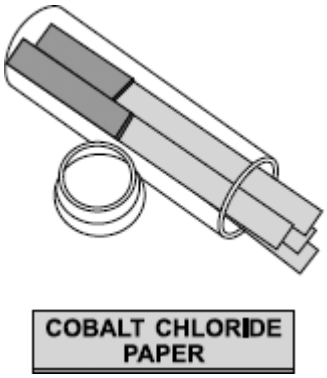
Some suggestions are given in the table.

Put ticks (✓) next to the **two** suggestions that would make the reaction take place faster.

Suggestions	(✓)
Use bigger pieces of zinc.	
Use a more concentrated acid.	
Use zinc powder.	
Decrease the temperature of the acid.	

(2)
(Total 4 marks)

2 Read the information and then answer the questions.



Cobalt chloride paper can be used to test for water.

The paper contains anhydrous cobalt chloride.

The jar containing the papers must be kept closed when not being used.

The equation shows the reaction between anhydrous cobalt chloride and water.

$$CoCl_2 + 6\,H_2O \rightleftharpoons CoCl_2.6H_2O$$

anhydrous cobalt chloride (blue) — hydrated cobalt chloride (pink)

(a) Choose **one** word from the box to complete the sentence.

endothermic	**exothermic**	**reversible**

The symbol $\rightleftharpoons$ means that the reaction is .....

(1)

(b) Describe the colour change when water is added to the cobalt chloride paper.

.....

.....

(1)

(c) Suggest why the jar containing the unused cobalt chloride papers must be kept closed.

.....

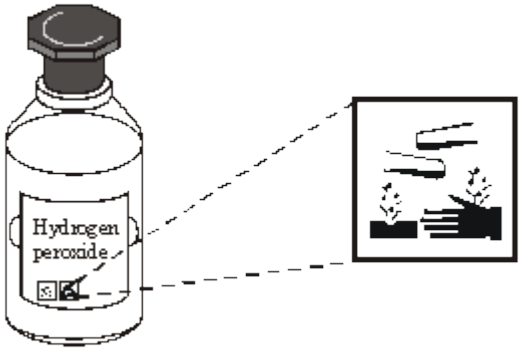
.....

(1)
(Total 3 marks)

3 Hydrogen peroxide (H_2O_2) contains the same elements as water (H_2O).

(a) Name the hazard symbol shown by using the correct word from the box.

corrosive	**flammable**	**oxidising**	**toxic**



.....

(1)

(b) Hydrogen peroxide decomposes in the presence of a catalyst.

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

(i) Complete the word equation for this chemical reaction.

hydrogen peroxide → water + ...

(1)

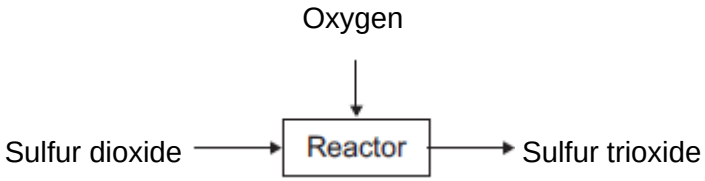
(ii) What does a catalyst do to a chemical reaction?

.....

.....

(1)
(Total 3 marks)

4 (a) The figure below represents the reaction of sulfur dioxide with oxygen.



(i) Complete the word equation for the reaction of sulfur dioxide with oxygen.

sulfur dioxide + ... ⟶ .....

(1)

(ii) Draw a ring around the correct answer to complete the sentence.

Sulfur dioxide (SO_2) is

a compound.
an element.
a mixture.

(1)

(b) The reactants are gases.

When the pressure of the gases is increased, the reaction gets faster.

Complete the sentence.

When the pressure of the gases is increased,

the frequency of the collisions ..... .

(1)

(c) The particles need energy to react.

Complete the sentence.

The minimum amount of energy that particles need to react is called

the ..... energy.

(1)

(d) Give **one** way of increasing the rate of the reaction other than changing the pressure.

.....

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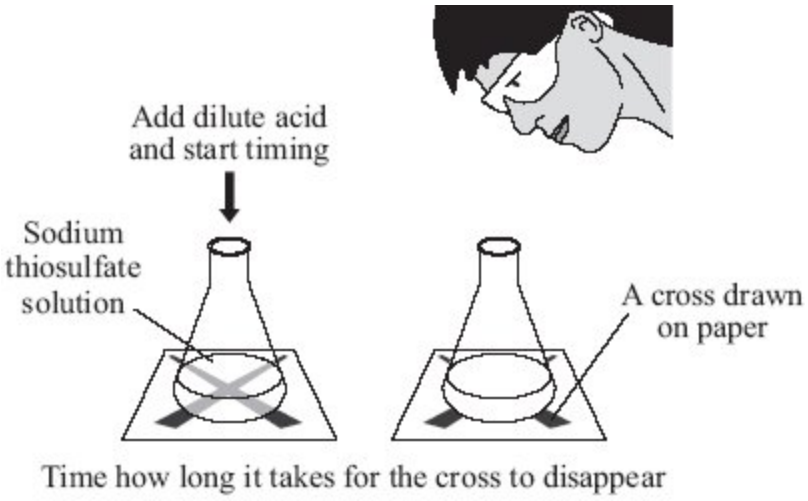
(1)

(Total 5 marks)

5 Sodium thiosulfate solution reacts with hydrochloric acid. As the reaction takes place the solution slowly turns cloudy.

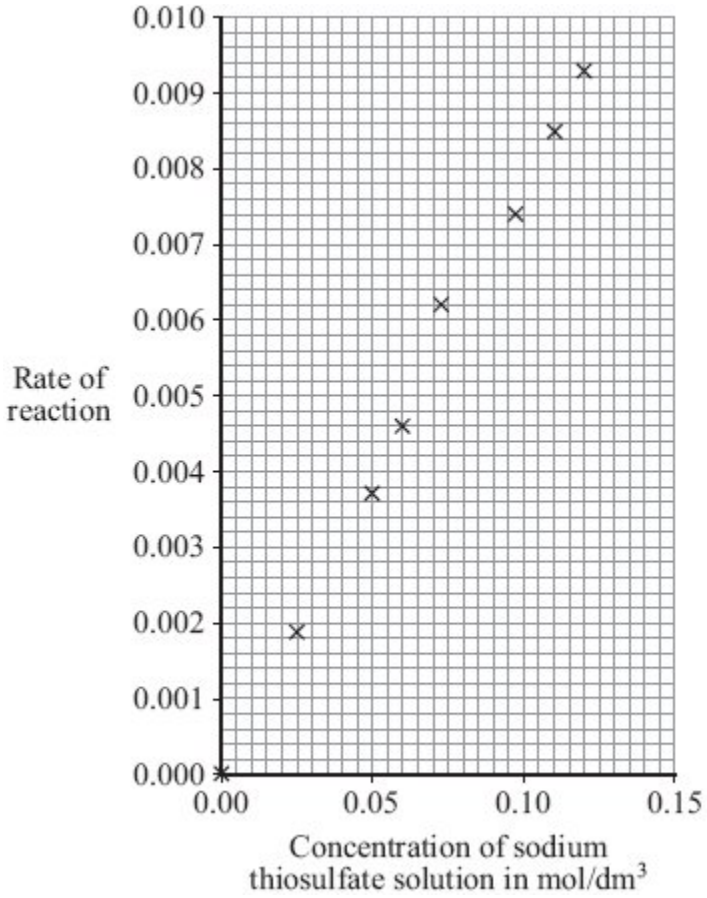
The diagram shows a method of measuring the rate of this reaction.



A student used this method to investigate how changing the concentration of the sodium thiosulfate solution affects the rate of this reaction.

The student used different concentrations of sodium thiosulfate solution. All the other variables were kept the same.

The results are shown on the graph below.



(a) (i) Draw a line of best fit on the graph.

(1)

(ii) Suggest **two** reasons why all of the points do not lie on the line of best fit.

1 .....

.....

2 .....

.....

(2)

(b) (i) In a conclusion to the investigation the student stated that:

'The rate of this reaction is directly proportional to the concentration of the sodium thiosulfate solution.'

How does the graph support this conclusion?

.....

.....

(1)

(ii) Explain, in terms of particles, why the rate of reaction increases when the concentration of sodium thiosulfate is increased.

.....

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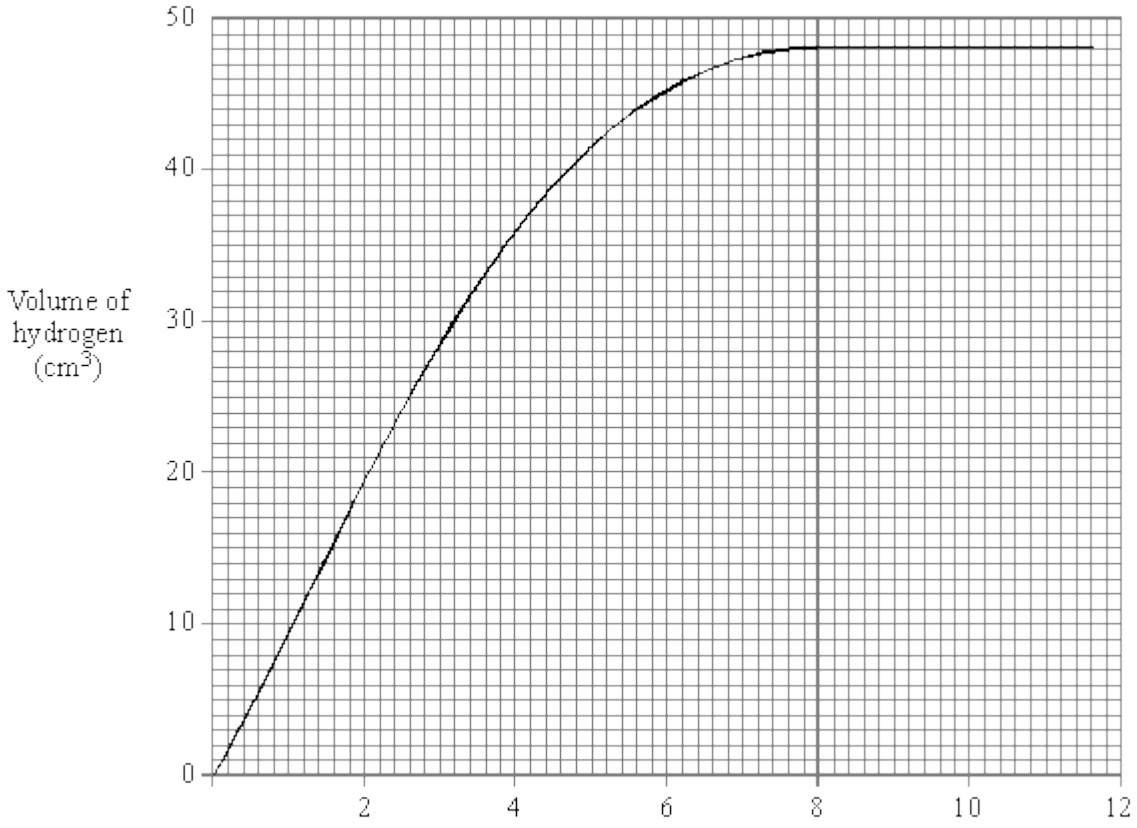
(2)
(Total 6 marks)

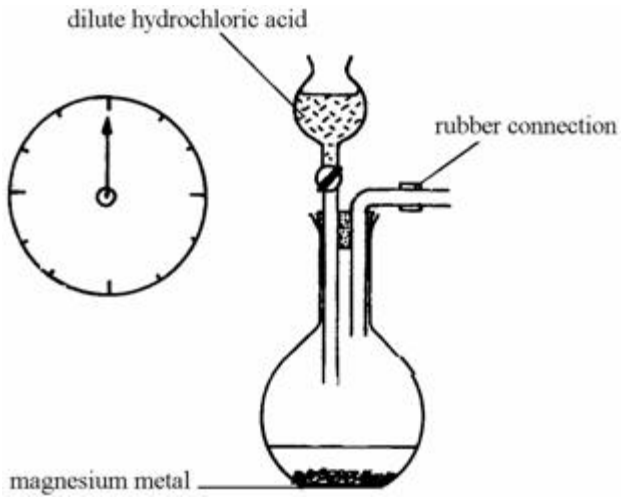
6 A student does an experiment to examine the rate of reaction between magnesium and dilute hydrochloric acid.
She adds 25 cm^3 of the acid to a weighed amount of the metal.
The reaction produces hydrogen gas.

Magnesium + hydrochloric acid ⟶ magnesium + hydrogen chloride

She collects the gas and measures the volume collected at one minute intervals.
All the metal reacted but there was some acid left unreacted.
Her results are shown on the graph.



(a) The diagram shows part of the apparatus she used for the experiment.
Complete the diagram to show how the student could collect the hydrogen produced and measure the volume after each minute.



(2)

(b) (i) When is the rate of reaction at its fastest?

.....

(1)

(ii) State **one** way in which she could increase the rate of reaction.

.....

(1)

(c) (i) What is the total volume of hydrogen collected in the experiment?

..... cm^3

(1)

(ii) State **one** way in which she could increase the final volume of hydrogen collected.

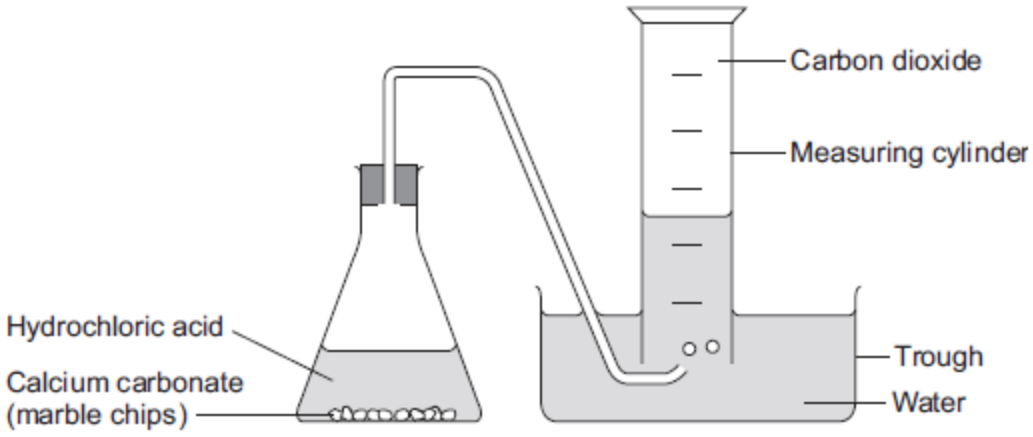
.....

(1)
(Total 6 marks)

7 A student investigated the rate of reaction between calcium carbonate (marble chips) and hydrochloric acid.

The student used the apparatus shown in **Figure 1**.

Figure 1



The student:

- recorded the volume of gas collected every 5 seconds
- repeated the experiment using hydrochloric acid at different temperatures.

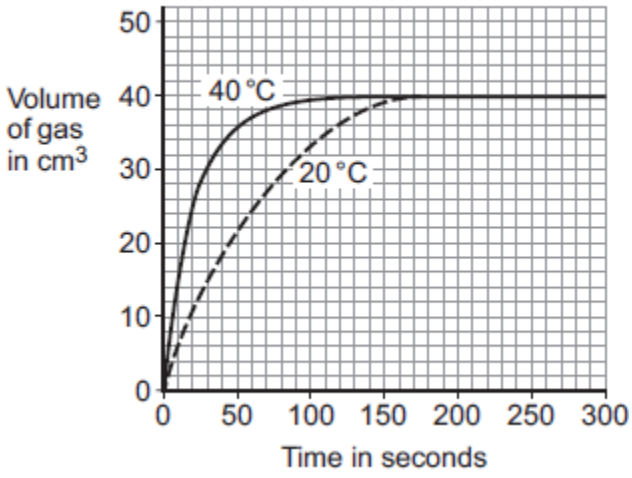
The equation for the reaction is:

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

(a) The student plotted results for the hydrochloric acid at 20 °C and 40 °C on a graph.

Figure 2 shows the student's graph.

Figure 2



Use information from **Figure 2** to answer these questions.

(i) State **one** conclusion the student could make about the effect of temperature on the rate of the reaction.

.....

.....

(1)

(ii) Give **one** reason why the student could make this conclusion.

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(1)

(iii) For the hydrochloric acid at 60 °C the student had collected 30 cm^3 after 15 seconds.

Calculate the average rate of reaction from 0 to 15 seconds.

.....

.....

Rate of reaction = ... cm^3 per second

(1)

(b) The student then investigated how the surface area of marble chips affected the rate of reaction.

(i) Which **two** variables should the student keep constant?

Tick (✓) **two** boxes.

Amount of water in the trough ☐

Concentration of acid ☐

Mass of marble chips ☐

Size of marble chips ☐

Volume of measuring cylinder ☐

(2)

(ii) Explain, in terms of particles and collisions, the effect that increasing the surface area of the marble chips has on the rate of reaction.

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(2)

(c) Calcium carbonate is a catalyst for the industrial production of biodiesel.

Give **one** reason why using a catalyst reduces costs.

.....

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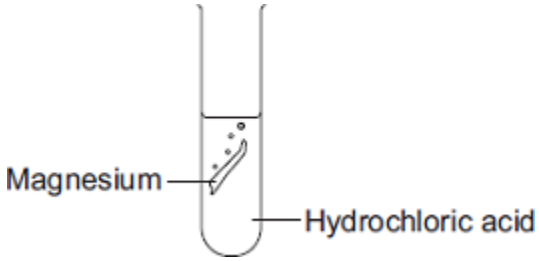
(1)
(Total 8 marks)

8 A student investigated the reaction between magnesium and hydrochloric acid.



The equation for the reaction is:

Mg(s) magnesium	+	2 HCl(aq) hydrochloric acid	⟶	MgCl2(aq) magnesium chloride	+	H2(g) hydrogen

(a) Give **two** observations the student could make during the reaction.

1 .....

.....

2 .....

.....

(2)

(b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The student investigated how the rate of this reaction changed when the concentration of hydrochloric acid was changed.

Write a plan the student could use.

In your plan you should:

- describe how you would carry out the investigation and make it a fair test
- describe the measurements you would make.

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(6)
(Total 8 marks)

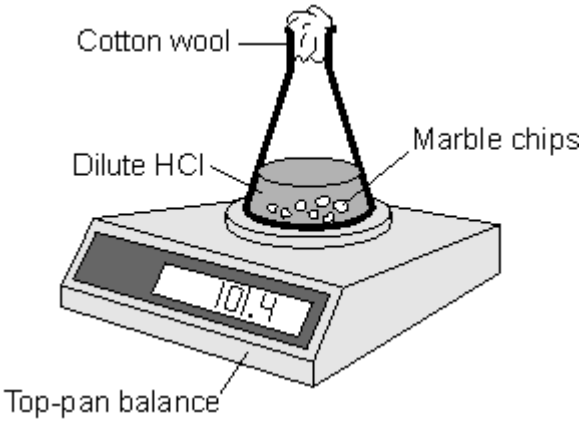
9 A student investigated the rate of reaction between marble and hydrochloric acid.

The student used an excess of marble.

The reaction can be represented by this equation:

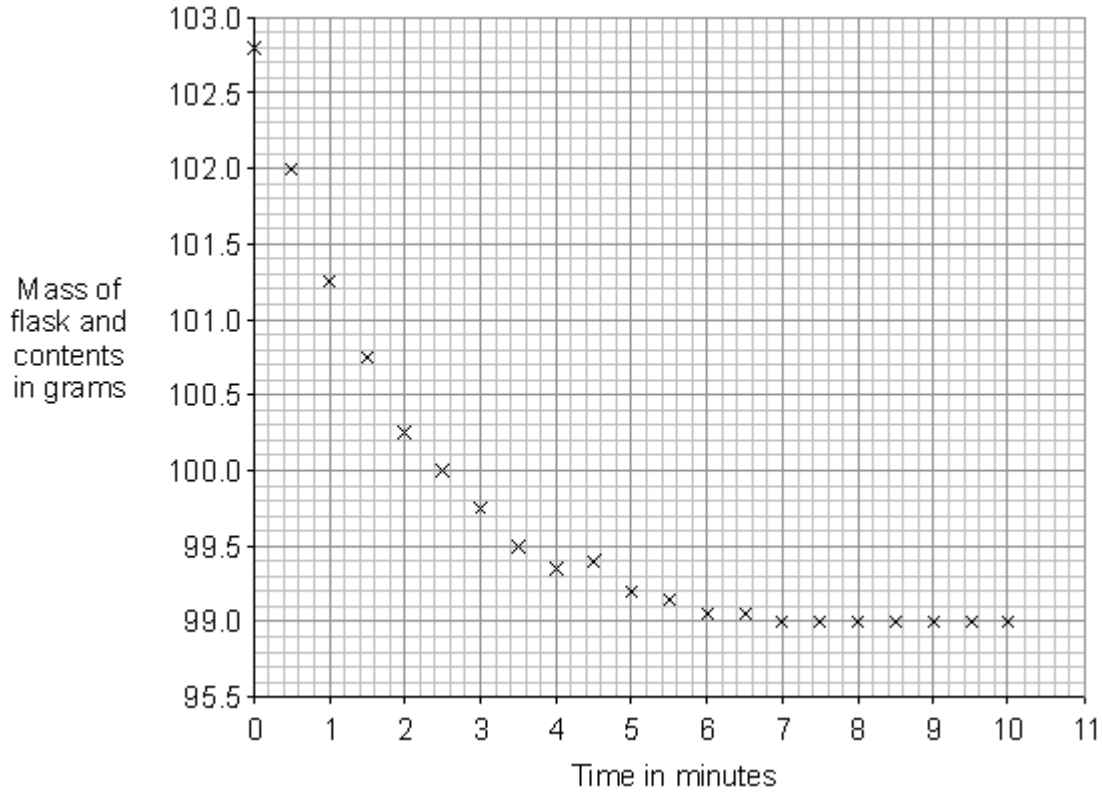
$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The student used the apparatus shown in the diagram.



The student measured the mass of the flask and contents for ten minutes.

The results are shown on the graph. Use the graph to answer the questions.



(a) (i) Complete the graph by drawing a line of best fit.

(1)

(ii) Use the graph to find the mass of the flask and contents after 1.8 minutes.

..... grams

(1)

(iii) The rate of reaction can be measured by the steepness of the graph line.

Describe, as fully as you can, how the rate of reaction changes with time in this experiment.

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.....

(2)

(b) The mass of the flask and contents decreased during the experiment.

Use the equation for this reaction to help you explain why.

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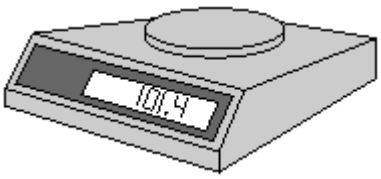
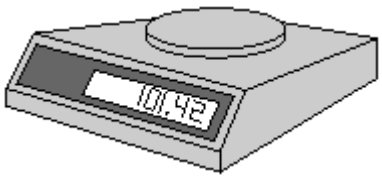
(2)

(c) A balance is used to measure the mass of the apparatus.

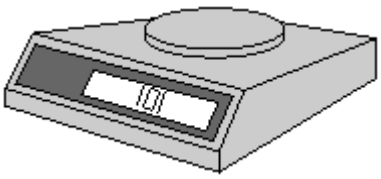
(i) Which balance, **A**, **B**, or **C**, has the highest resolution?



Balance A



Balance B



Balance C

The balance with the highest resolution is balance ☐

(1)

(ii) The balance used for this experiment should have a high resolution.

Explain why.

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(2)

(d) The student repeated the experiment using powdered marble instead of marble chips.

The rate of reaction between the marble and hydrochloric acid particles was much faster with the powder.

Explain why.

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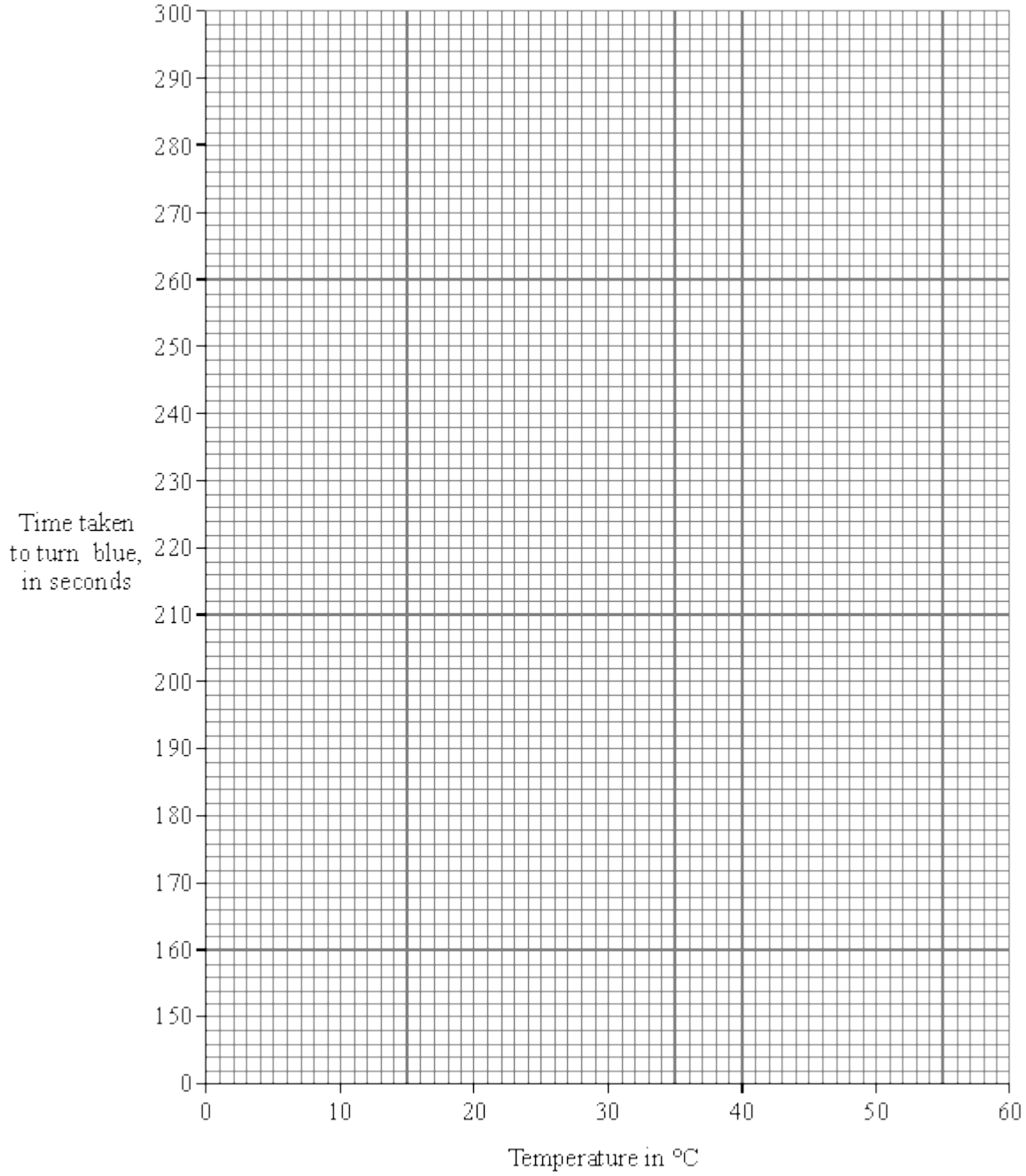
(2)
(Total 11 marks)

10 Solutions **A** and **B** are colourless. When they are mixed, they react and turn blue after a period of time. A student investigated how temperature affected the rate of reaction between solutions **A** and **B**. The rate was measured by timing how long the mixture took to turn blue.

The results are shown in the table.

Temperature in °C	22	25	34	45	51
Time taken to turn blue, in seconds	290	250	200	170	160

(a) (i) Draw a graph for these results.



(3)

(ii) Use your graph to find how long it takes the solution to turn blue at 40°C.

Time = ... s

(1)

(b) (i) How does the rate of reaction change as the temperature is increased?

.....

.....

(1)

(ii) Explain, in terms of particles, why temperature has this effect on the rate of reaction.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

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.....

(3)

(c) State **one** variable that must be kept constant to make this experiment a fair test.

.....

(1)

(Total 9 marks)

11 Hydrogen peroxide slowly decomposes into water and oxygen.

hydrogen peroxide → water + oxygen

The reaction can be speeded up by adding manganese dioxide.

(a) (i) What do we call a substance that speeds up a chemical reaction without being changed itself?

.....

(1)

(ii) Give **two** other ways of increasing the rate of this reaction.

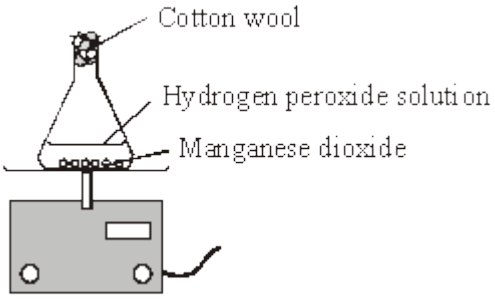
1 .....

2 .....

(2)

(b) The diagram shows how the rate of this reaction can be measured.

As the hydrogen peroxide decomposes, the mass of the flask and its contents decreases.



Why does this decrease in mass take place?

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.....

(1)
(Total 4 marks)

12 This item appeared in the Wolverhampton *Express and Star* on October 31st, 1997. Read the passage and answer the questions that follow.

Fumes scare at factory

Workers were forced to flee a factory after a chemical alert. The building was evacuated when a toxic gas filled the factory.
It happened when nitric acid spilled on to the floor and mixed with magnesium metal powder.

(a) The equation which represents the reaction between magnesium and nitric acid is:

$Mg_{(s)} + 4HNO_{3(aq)} \rightarrow Mg(NO_3)_{2(aq)} + 2H_2O_{(1)} + 2NO_{2(g)}$

Give the formula of the toxic gas that was produced.

.....

(1)

(b) Explain, in terms of particles, how the toxic gas was able to fill the factory quickly.

.....

.....

.....

(2)

(c) The reaction of nitric acid with magnesium metal powder is more dangerous than if the acid had fallen on to the same mass of magnesium bars. Explain why.

.....

.....

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(1)

(d) (i) Water was sprayed on to the magnesium and nitric acid to slow down the reaction. Explain, in terms of particles, why the reaction would slow down.

.....

.....

.....

(2)

(ii) Explain why it is better to add alkali, rather than just add water to the spillage.

.....

.....

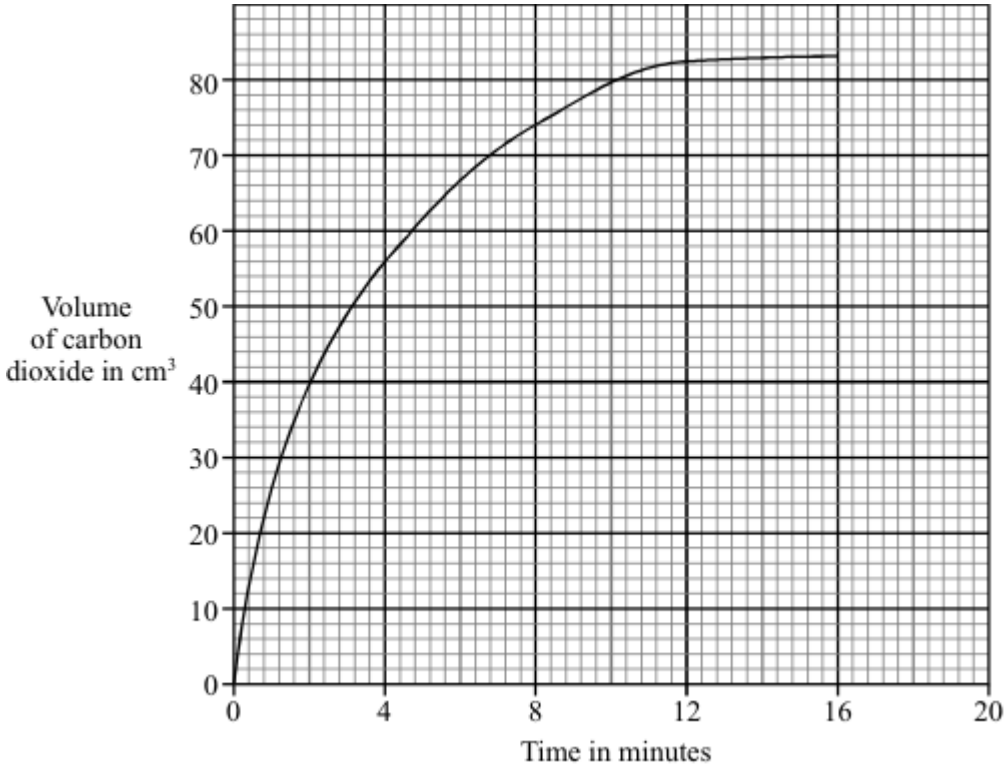
(1)

(Total 7 marks)

13 Calcium carbonate reacts with nitric acid to produce carbon dioxide.

$$CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + H_2O + CO_2$$

A 10 g lump of calcium carbonate was reacted with 20 cm^3 of dilute nitric acid. When the reaction was finished, some of the calcium carbonate was left unreacted. The graph shows the volume of carbon dioxide made in each minute for sixteen minutes.



(a) The volume of carbon dioxide made in each minute decreases until it remains steady at 83 cm^3.
Explain why.

.....

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.....

(2)

(b) Draw a graph line, on the axes above, for an experiment where 20 cm^3 of the same dilute nitric acid was reacted with 10 g of **powdered** calcium carbonate.

(2)

(c) Give **one** way of changing the rate of this reaction (other than using powdered calcium carbonate).

.....

.....

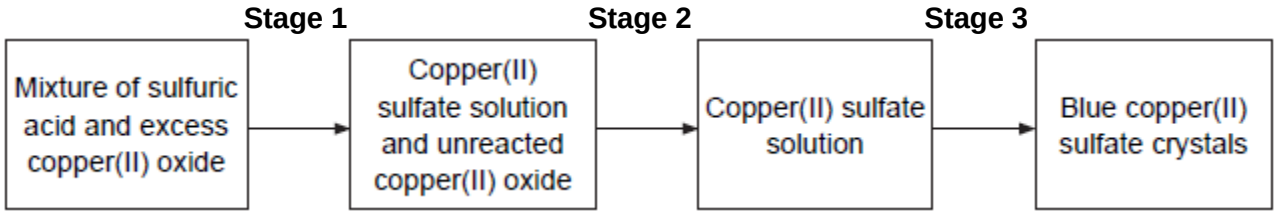
(1)

(Total 5 marks)

14 This question is about compounds of copper.

(a) A student made some copper(II) sulfate crystals.

The flow diagram shows the stages of the preparation of copper(II) sulfate crystals.



(i) The reaction mixture is heated in **Stage 1**.

Suggest why.

.....

.....

(1)

(ii) Complete the equation for this reaction.

CuO + ... → $CuSO_4$ + ...

(2)

(iii) How would the student remove the unreacted copper(II) oxide in **Stage 2**?

.....

.....

(1)

(iv) How would the student obtain copper(II) sulfate crystals from the copper(II) sulfate solution in **Stage 3**?

.....

(1)

(v) The mass of crystals obtained was less than the student had calculated.

Suggest **one** reason why.

.....

.....

(1)

(b) The student heated the blue copper(II) sulfate crystals.

The word equation for the reaction is shown below.

hydrated copper(II) sulfate $\rightleftharpoons$ anhydrous copper(II) sulfate + water

blue white

(i) What does the symbol $\rightleftharpoons$ mean ?

.....

(1)

(ii) 300 J of energy are taken in when some blue copper(II) sulfate crystals are heated.

What is the energy change when an excess of water is added to the anhydrous copper(II) sulfate produced?

.....

.....

(2)

(c) A sample of copper nitride contains 3.81 g of copper and 0.28 g of nitrogen.

Calculate the empirical formula.

You **must** show all your working to get full marks.

Relative atomic masses (A_r): N = 14; Cu = 63.5.

.....

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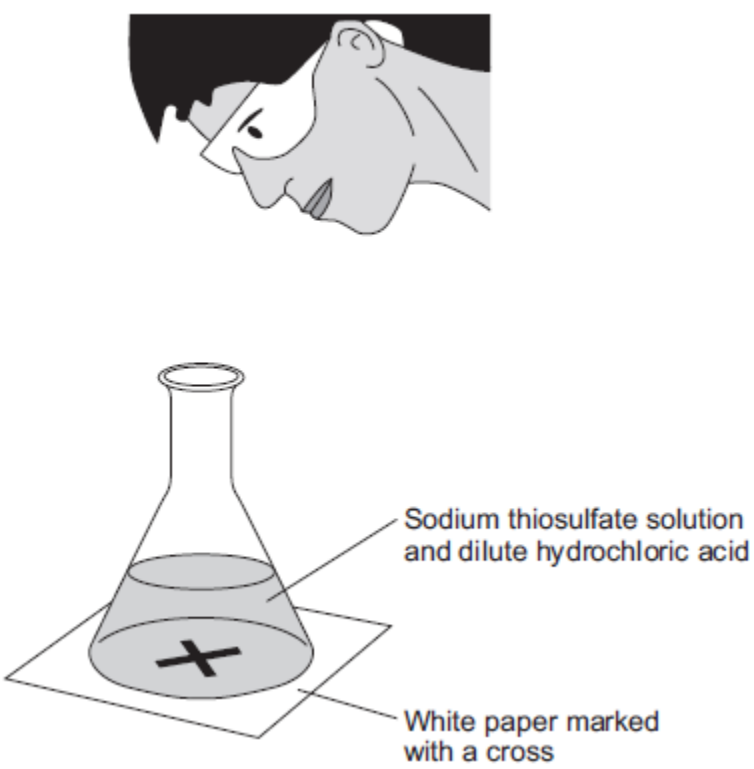
Empirical formula = ...

(4)
(Total 13 marks)

15 A student investigated the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid, as shown in **Figure 1**.

Figure 1



The reaction produced a precipitate, which made the mixture turn cloudy.

The student timed how long it took until she could no longer see the cross.

She calculated the rate of the reaction.

(a) The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\ HCl(aq) \longrightarrow 2\ NaCl(aq) + S(s) + SO_2(g) + H_2O(l)$$

Name the product that made the mixture go cloudy.

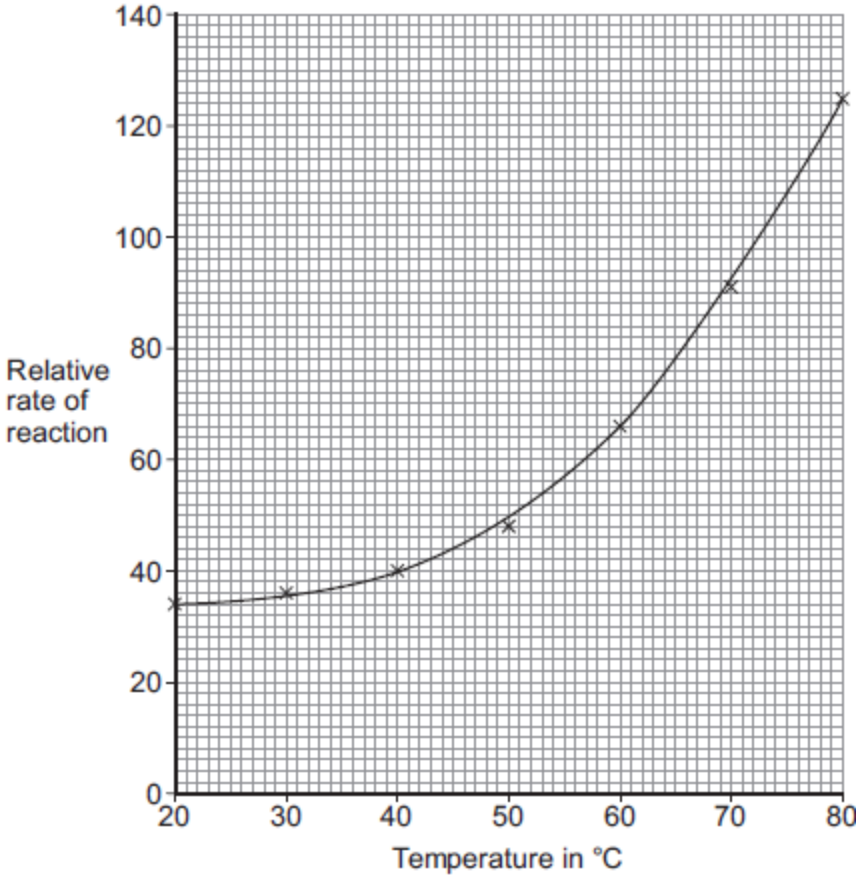
.....

(1)

(b) The student investigated the effect of changing the temperature of the sodium thiosulfate solution on the rate of reaction.

She plotted her results on a graph, as shown in **Figure 2**.

Figure 2



Describe the trends shown in the student's results.

.....

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.....

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(2)

(c) The student then investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

(i) Suggest **two** variables the student would need to control to make sure that her results were valid.

.....

.....

.....

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(2)

(ii) From this investigation the student correctly concluded:

'As the concentration of sodium thiosulfate solution doubles, the rate of reaction doubles.'

Explain the student's conclusion in terms of particles.

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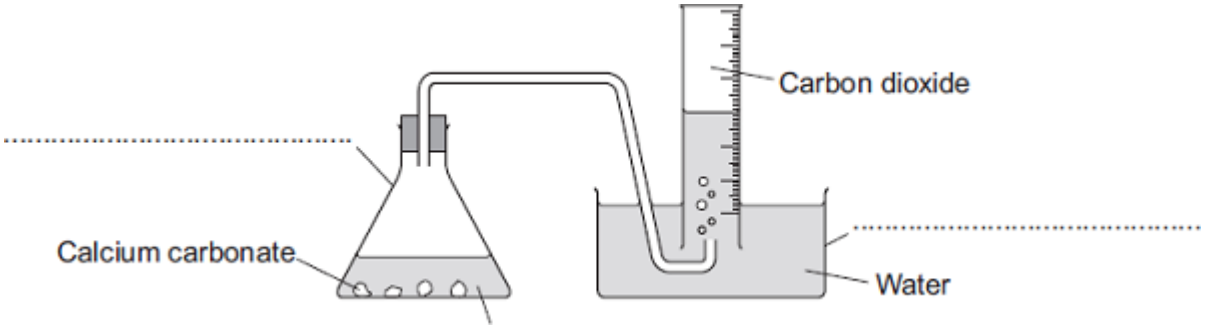
(3)
(Total 8 marks)

16 Some students were investigating the rate at which carbon dioxide gas is produced when metal carbonates react with an acid.

One student reacted 1.00 g of calcium carbonate with 50 cm^3, an excess, of dilute hydrochloric acid.

The apparatus used is shown in **Diagram 1**.

Diagram 1



(a) Complete the **two** labels for the apparatus on the diagram.

(2)

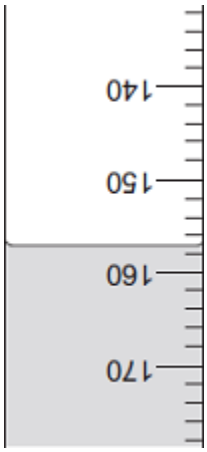
(b) The student measured the volume of gas collected every 30 seconds.

The table shows the student's results.

Time in seconds	**Volume of carbon dioxide collected in cm^3**
30	104
60	
90	198
120	221
150	232
180	238
210	240
240	240

(i) **Diagram 2** shows what the student saw at 60 seconds.

Diagram 2



What is the volume of gas collected?

Volume of gas = ... cm^3

(1)

(ii) Why did the volume of gas stop changing after 210 seconds?

.....

.....

(1)

(c) Another student placed a conical flask containing 1.00 g of a Group 1 carbonate (M_2CO_3) on a balance.

He then added 50 cm^3, an excess, of dilute hydrochloric acid to the flask and measured the mass of carbon dioxide given off.

The equation for the reaction is:

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

The final mass of carbon dioxide given off was 0.32 g.

(i) Calculate the amount, in moles, of carbon dioxide in 0.32 g carbon dioxide.

Relative atomic masses (A_r): C = 12; O = 16

.....

.....

.....

Moles of carbon dioxide = ... moles

(2)

(ii) How many moles of the metal carbonate are needed to make this number of moles of carbon dioxide?

.....

.....

Moles of metal carbonate = ... moles

(1)

(iii) The mass of metal carbonate used was 1.00 g.

Use this information, and your answer to part **(c) (ii)**, to calculate the relative formula mass (M_r) of the metal carbonate.

If you could not answer part **(c) (ii)**, use 0.00943 as the number of moles of metal carbonate. This is **not** the answer to part **(c) (ii)**.

.....

.....

Relative formula mass (M_r) of metal carbonate = ...

(1)

(iv) Use your answer to part **(c) (iii)** to calculate the relative atomic mass (A_r) of the metal in the metal carbonate (M_2CO_3) and so identify the Group 1 metal in the metal carbonate.

If you could not answer part **(c) (iii)**, use 230 as the relative formula mass of the metal carbonate. This is **not** the answer to part **(c) (iii)**.

To gain full marks, you must show your working.

.....

.....

.....

.....

Relative atomic mass of metal is .....

Identity of metal .....

(3)

(d) Two other students repeated the experiment in part **(c)**.

(i) When the first student did the experiment some acid sprayed out of the flask as the metal carbonate reacted.

Explain the effect this mistake would have on the calculated relative atomic mass of the metal.

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) The second student used 100 cm^3 of dilute hydrochloric acid instead of 50 cm^3.

Explain the effect, if any, this mistake would have on the calculated relative atomic mass of the metal.

.....

.....

.....

.....

.....

.....

.....

(3)
(Total 17 marks)

1

(a) any **two** from:

- increases
  owtte allow 'goes up'
- until reaches maximum / levels off
  owtte
- quickly at first
  owtte
- then more slowly / rate decreases
  allow reaction finished
  ignore rate increases

2

(b) use a more concentrated acid
list principle applies

use zinc powder

2

[4]

2

(a) reversible

1

(b) (from blue) to pink
*do **not** accept*
incorrect initial colour

1

(c) sensible answers such as:

- stop water reaching papers
  accept stop entry of moisture / wet / dampness / condensation
- water (vapour) in air
  ignore references to toxicity of cobalt chloride

1

[3]

3 (a) oxidising

1

(b) (i) oxygen

ignore any numbers

1

(ii) (catalyst) speeds up a (chemical reaction)

accept changes the rate (of reaction)

1

[3]

4 (a) (i) oxygen, sulfur trioxide

both needed for mark

1

(ii) compound

1

(b) increases

accept (goes) higher / (goes) up / (is) faster) / (are) more frequent

1

(c) activation

1

(d) catalyst **or** increase temperature

1

[5]

5 (a) (i) a continuous straight line missing anomalous point

allow a line which does not start at zero / origin

1

(ii) any **two** sensible errors eg

- timing errors and / or example(*)
- measurement errors and / or example(*)
- apparatus errors and / or example(*)
- human / experimental / random error and / or example
  or 'did not do it right'(*)
  *(*)could be two from **same** category eg two timing errors – watch not started at the same time plus difficulty in deciding when the cross has disappeared.*
- temperature fluctuation
- anomalous point
  accept outlier / wrong result
- results not recorded correctly
- plotting error
- rate calculated incorrectly
  ignore 'not repeated'
  *ignore systematic / zero error / weighing error **or** error unqualified*

2

(b) (i) straight line

or

as concentration increases the rate goes up **or** converse

accept numerical example
accept positive correlation
accept same gradient
ignore 'most points near / on line of best fit'

1

(ii) more collisions

accept greater chance of collisions

accept collide more successfully

accept alternative versions of collide eg 'bump / hit'

ignore references to energy / speed of particles / surface area

1

more particles (in each volume of solution)(i.e. an attempt at defining concentration)

accept 'particles are closer together'

allow ions / atoms / molecules for particles ignore reactants

*accept greater frequency of collisions **or** greater number of collisions per second for **2** marks*

1

[6]

6 (a) (must be possible for the gas to enter and displace the water) **or** other suitable apparatus

- apparatus to collect the gas correctly assembled

  for 1 mark

- **calibrated** collection vessel (award even if diagram is wrong)

  for 1 mark

2

(b) (i) at the start / in the first 1/2 minutes (or any time within this range)

for 1 mark

1

(ii) increase the temperature / use smaller pieces of metal / use more metal / increase the surface area of the metal / add a catalyst / shake the flask / increase the concentration / strength of the acid

for 1 mark

1

(c) (i) 48

for 1 mark

1

(ii) increase the amount of magnesium used

for 1 mark

(do not allow increase the amount of acid used)

1

[6]

7 (a) (i) the higher the temperature, the greater the rate

or

at 40 °C rate is faster than at 20 °C

accept the higher the temperature, the faster the reaction

1

(ii) 40 °C curve is steeper

accept the 40 °C line becomes horizontal sooner

accept at higher temperatures the reaction finishes sooner

accept reaction finishes sooner at 40 °C

accept at higher temperatures the gas is produced faster

or

correct comparison of data from the graph

1

(iii) 2

1

(b) (i) Concentration of acid

Mass of marble chips

2

(ii) increases rate

*incorrect reference to energy = max **1***

1

(because of) more frequent collisions (between particles)

accept particles are more likely to collide

ignore more collisions

ignore more successful collisions

1

(c) any **one** from:

- increases rate of reaction
- reduces energy required
- lower temperature can be used
- catalyst is not used up.

1

[8]

8 (a) any **two** from:

- effervescence / bubbles / fizzing

  allow gas / hydrogen is given off
  allow volume of gas
  allow magnesium floats

- magnesium disappears / dissolves

  allow change in mass of magnesium

- heat given off / exothermic

  allow temperature change
  *do **not** accept temperature decreases*

- change in pH

  *do **not** accept pH decreases*

2

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance.

0 marks
No relevant content.

Level 1 (1-2 marks)
A simple plan without reference to changing any variable but should include an attempt at measuring rate **or** an attempt at fair testing

Level 2 (3-4 marks)
A plan including change of concentration / 'volume' of acid **and** should include an attempt at measuring rate **and / or** an attempt at fair testing

Level 3 (5-6 marks)
A workable plan including change of concentration **and** measurement of rate **and** fair testing

Examples of chemistry points made in the response could include:

Plan:

- add magnesium to acid
- time reaction / 'count bubbles' / measure volume of gas
- change concentration / 'volume' of acid

Control Variables:

- amount / mass / length / same 'size' of magnesium
- volume / amount of acid

6

[8]

9

(a) (i) curve missing anomalous point

1

(ii) answer in the range of 100.35 to 100.5

1

(iii) reaction goes quickly at first

accept reaction slows down

1

reaction stops

1

(b) because carbon dioxide is produced

accept gas is produced

1

carbon dioxide / gas escapes, therefore the mass of the flask and contents decreases

1

(c) (i) balance B

1

(ii) because during the experiment a gas / carbon dioxide escapes from the flask

1

therefore the balance needs a high resolution to measure the small changes in the mass

1

(d) the (marble) powder has a larger surface area than the (marble) chips

1

therefore there would be more collisions with the acid particles (within the same amount of time)

1

[11]

10

(a) (i) accurate plotting of points ($\pm \frac{1}{2}$ square)

2 *marks for all points*
1 *mark for 3 or 4 points*

2

sensible smooth curve

reasonable attempt
*do **not** accept double lines **or** dot to dot*

1

(ii) accurately read from <u>their</u> graph to $\pm \frac{1}{2}$ square

1

(b) (i) (as temperature increases) rate <u>increases</u>

accept speeds up, gets faster, gets quicker
accept higher speed
*do **not** accept gets bigger / higher unqualified*
*do **not** accept answers about time on its own*

1

(ii) **Quality of Written Communication**
The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme.

maximum 2 marks if ideas not expressed well

any **three** from:

for converse maximum 2 marks

particles have more energy

higher kinetic energy

particles move faster

*do **not** accept move more or vibrate more*

3

more collisions

accept greater rate of collisions

more energetic / successful / harder collisions

more particles have activation energy

(c) concentration (of solutions) **or** volume (of solutions)

accept 'how much of'
accept references to intensity of colour
accept same endpoint
accept rate of stirring / shaking
*do **not** accept reference to solids **or** catalysts etc*
ignore containers
*do **not** accept pH*

1

[9]

11 (a) (i) catalyst / enzyme

1

(ii) any **two** from

do not accept increase volume of peroxide

- heat
- stir / shake
- increase concentration of peroxide / catalyst

2

(b) oxygen lost

do not allow incorrect gas

1

[4]

12 (a) NO_2 / $2NO_{2(g)}$ / Nitrogen dioxide

for one mark

1

(b) particles of gas move / they move

reject spread out
particles move randomly / mix / go between air molecules / diffusion

any two for 1 mark each

2

(c) faster reaction / more surface area (*not* smaller pieces)

for one mark

1

(d) (i) **either** lower temperature / particles move slower
fewer collisions (owtte) / less energetic collisions / owtte
or acid diluted (owtte)
fewer collisions (owtte)

for 1 mark each

2

(ii) alkali neutralises the acid / stops the reaction
or water will only slow the reaction not stop it

either for 1 mark

1

[7]

13 (a) the concentration of the (nitric) acid is decreasing

*accept the number of acid particles is decreasing **or** there are fewer collisions*

1

(the volume of carbon dioxide remains at 83 cm^3)
when the concentration of the (nitric) acid is zero

*accept no acid remains **or** all the acid is used up **or** no acid particles*

1

(b) line starts at origin is steeper **and** remains to the left of the original line

1

graph line levels off at 83 cm^3 **and** before 12 minutes

tolerance ± square

1

(c) change the temperature

*accept increase **or** decrease the temperature*
*accept change (increase **or** decrease) the concentration (of the nitric acid)*
*ignore amounts of reactants **or** changes in pressure **or** stirring **or** use of catalyst*

1

[5]

14 (a) (i) to increase the rate of reaction

1

(ii) H_2SO_4 on the left hand side

1

H_2O on right hand side

1

(iii) filtration

*allow centrifuging **or** decanting*

ignore evaporation if after filtration

1

(iv) crystallisation

ignore reference to filtration
unless given as an alternative

or

evaporation / heating / boiling / cooling

1

(v) any **one** from:

- because of an incomplete reaction

  accept not all acid reacted
  accept impure reactants
  accept unexpected reaction
  ignore reversible reaction

- because some (copper sulfate) lost on filtering **or** when poured into evaporating basin **or** boiled over **or** left in apparatus

  must specify when lost

  *accept some (copper sulfate **or** acid) spilt*

- weighing error (of copper sulfate)

1

(b) (i) reversible (reaction)

1

(ii) 300(J)

allow the same

1

(energy) given out / released

accept exothermic / –

*ignore increasing **or** decreasing energy*

1

(c)

$\frac{3.81}{63.5}$ $\frac{0.28}{14}$

1 *mark for dividing mass by A_r (max **2** if A_r divided by mass)*

1

= 0.06 = 0.02

1 *mark for correct proportions*

1

3 1

1 *mark for correct whole number ratio (allow multiples). Can be awarded from formula*

1

Cu_3N

ecf *allowed from **step 2 to step 3** and **step 3 to step 4** if sensible attempt at step **1***

*correct formula gains **1** mark*

1

[13]

15 (a) sulfur / sulphur / S / S(s)

1

(b) as the temperature increases, the rate of reaction increases

allow two correct values for rate quoted (from graph) at different temperatures

1

the rate of increase increases **or** there is an exponential relationship

*accept the rate of reaction increases slowly (from 20 °C to 50 °C) then increases more rapidly for **2** marks*

answer MUST be based on rate / speed of reaction

1

(c) (i) any **two** from:

- temperature (of the reactants)
- concentration of hydrochloric acid
- volume of hydrochloric acid
- volume of sodium thiosulfate
- the (size / darkness / thickness of the) cross
- total volume of solution.

*if no other marks gained, allow **1** mark for:*

rate of stirring

OR

amount of hydrochloric acid / sodium thiosulfate

OR

volume of solution

2

(ii) (because as the concentration increases) the number of particles per unit volume increases **or** particles are closer together.

idea of more particles in a given space is required for the first mark.

ignore references to area.

1

(therefore) the frequency of (successful) collisions increases

allow increased chance / probability of collisions

number of collisions increases is insufficient here.

***must** mention per unit time or frequency.*

ignore speed of collisions.

if reference to space and time missing from M1 and M2 but they are otherwise correct, then award 1 mark.

1

so the number of particles (per unit volume) doubles **or** (the frequency of) collisions doubles.

*students can score **2** marks for a qualitative explanation; the third mark is for a quantitative explanation.*

1

[8]

16 (a) left hand: (conical) flask

*do **not** accept round bottomed*
flask or container which is not a flask

1

right hand: beaker / trough

accept plastic box

1

(b) (i) 157

1

(ii) all calcium carbonate used up **or** reaction stopped

*do **not** accept all acid used up*

1

(c) (i) 0.007(272727…)

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow (0.32 / 44) for **1** mark*

2

(ii) 0.007(272727…)

*allow ecf from **(c)(i)***

1

(iii) (M_r = mass / moles = 1 / 0.00727…) = 137.5 or 138

*allow ecf from **(c)(ii)***

if use 0.00943 moles then = 106

if use 0.007 allow 143 (142.857)

1

(iv) (138) – 60 (= 78)

23 / 85

1

(78 / 2) = 39

1

potassium

sodium / rubidium

*identity of metal ecf on A_r, but **must** be Group 1*

*If no working max **1** mark*

1

(d) (i) (relative atomic mass) would decrease

1

because the mass lost greater

1

so moles carbon dioxide larger **or** moles metal carbonate greater

1

(ii) no change

1

because the acid (already) in excess

1

so the amount carbon dioxide lost is the same

1

[17]