Combined Science Higher Past Paper Practice

5.6 Rate and Extent of Chemical Change

5.6.1 Rate of Reaction			
Demand	**Question**	**Page Number**	**Mark Scheme**
Low	**1**	2	45
	2	5	46
	6	12	53
	7	14	54
	8	16	55
Standard	**9**	19	56
	11	22	58
High	**12**	25	59
	15	31	62
	17	35	64
	20	42	69

5.6.2 Reversible Reactions and Dynamic Equilibrium			
Demand	**Question**	**Page Number**	**Mark Scheme**
Low	**3**	7	48
	5	10	51
High	**13**	28	60
	14	30	61
	16	33	63
	18	39	66
	19	41	67

Q1. This question is about hydrogen peroxide.

(a) The symbol equation for the decomposition of hydrogen peroxide (H_2O_2) is:

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Complete the word equation for the decomposition of hydrogen peroxide.

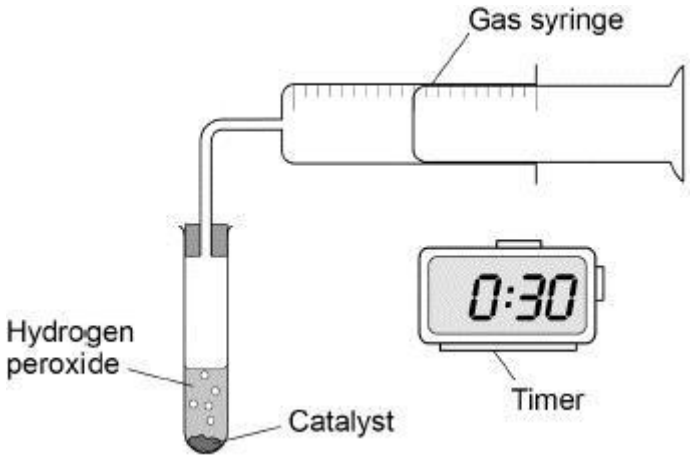
hydrogen peroxide → _____ + _____

(2)

A student investigated the effect of different catalysts on the decomposition of hydrogen peroxide.

The student measured the volume of gas collected every 30 seconds for 5 minutes.

Figure 1 shows the apparatus used.



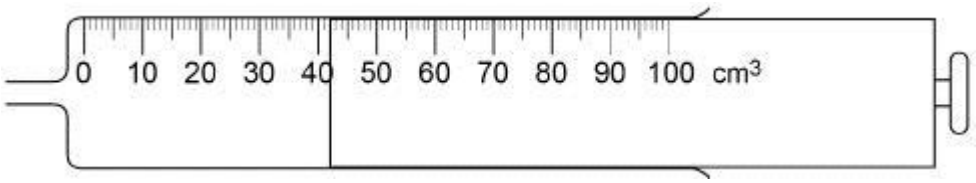
(b) Which **two** variables should the student keep the same to make the investigation a fair test?

Tick (✓) **two** boxes.

- Concentration of hydrogen peroxide ☐
- Mass of catalyst ☐
- Size of gas syringe ☐
- Type of catalyst ☐
- Volume of gas collected ☐

(2)

(c) **Figure 2** shows a gas syringe.



What is the volume of gas in the syringe?

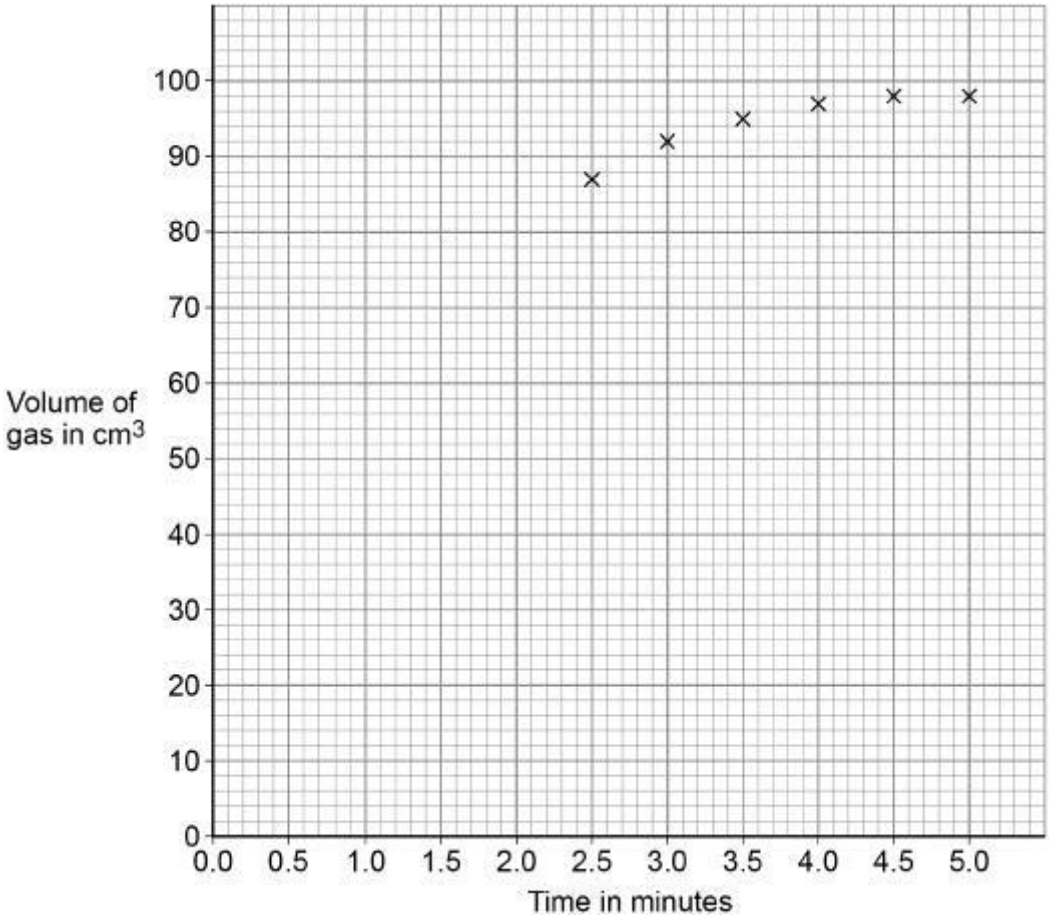
Volume = _____ cm^3

(1)

The table below shows the student's results for one catalyst.

Time in minutes	0.0	0.5	1.0	1.5	2.0
Volume of gas in cm^3	0	34	54	68	78

(d) Six of the other results have been plotted on graph below.



Complete the graph on the grid above.

You should:

- plot the results from the table above.
- draw a line of best fit for all of the results.

(3)

The student repeated the experiment with other catalysts and plotted a graph for each of the catalysts used.

(e) Suggest how the student could use these graphs to identify the best catalyst.

_____

_____

(1)

(f) All the graphs level off at the same volume of gas.

Suggest why.

_____

_____

(1)

(g) In another investigation, a student increased the temperature of the hydrogen peroxide.

Why is the rate of reaction faster when the temperature of the hydrogen peroxide is increased?

Tick (✓) **two** boxes.

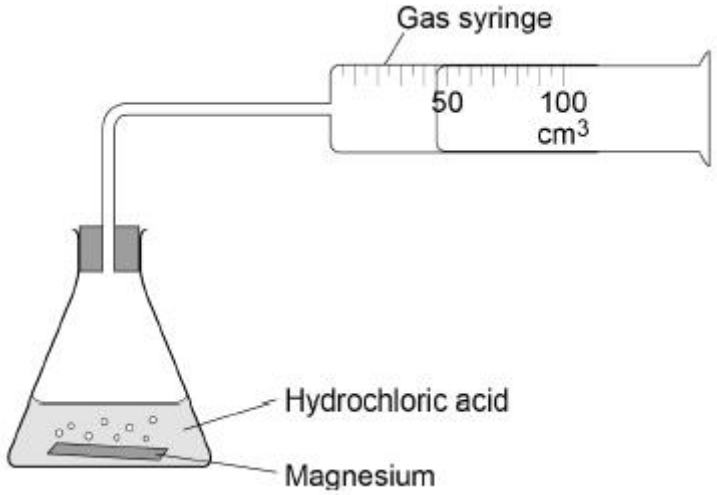
The concentration of hydrogen peroxide decreases.	☐
The particles are moving more slowly.	☐
The particles have more energy.	☐
There are more particle collisions per second.	☐
There are more particles per unit volume.	☐

(2)

(Total 12 marks)

Q2. A student investigated the rate of the reaction between magnesium and hydrochloric acid.

The diagram shows the apparatus the student used.



(a) Balance the equation for the reaction.

$$Mg + \_\_\_\_\_ HCl \rightarrow MgCl_2 + H_2$$

(1)

(b) The student used 50 cm^3 of hydrochloric acid.

Which apparatus would measure 50 cm^3 of hydrochloric acid with the greatest accuracy?

Tick (✓) **one** box.

50 cm^3 beaker ☐

50 cm^3 conical flask ☐

50 cm^3 measuring cylinder ☐

(1)

(c) The student measured the volume of gas produced every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas were:

26 cm^3 38 cm^3 47 cm^3 55 cm^3 59 cm^3 60 cm^3

Complete the table to show these results.

0	0

(4)

(d) The volumes of gas were lower than expected.

Suggest **one** reason.

_____

_____

(1)

(e) The student repeated the experiment using different concentrations of hydrochloric acid.

Give **two** variables the student should keep the same.

1 _____

2 _____

(2)

(f) Complete the sentences.

As the concentration of the hydrochloric acid increased, the

rate of the reaction _____ .

This is because there were more acid _____ in each

cubic centimetre (cm^3).

So the collisions happened more _____ .

(3)

(Total 12 marks)

Q3. (a) What percentage of the Earth's atmosphere is nitrogen?

Tick **one** box.

5% ☐ 20% ☐ 50% ☐ 80% ☐

(1)

(b) During the first billion years of the Earth's existence the amount of nitrogen in the atmosphere increased.

Give **one** source of this nitrogen.

_____

(1)

(c) Nitrogen is used to make ammonia.

The word equation for the reaction is:

nitrogen + hydrogen _____ ammonia

Write the correct symbol in the equation to show that it is a reversible reaction.

(1)

(d) A reversible reaction can reach equilibrium.

Complete the sentence.

Equilibrium is reached when the forward reaction and the reverse reaction happen at the same _____ .

(1)

(e) Fertilisers are formulations containing nitrogen.

What is a formulation?

_____

_____

(1)

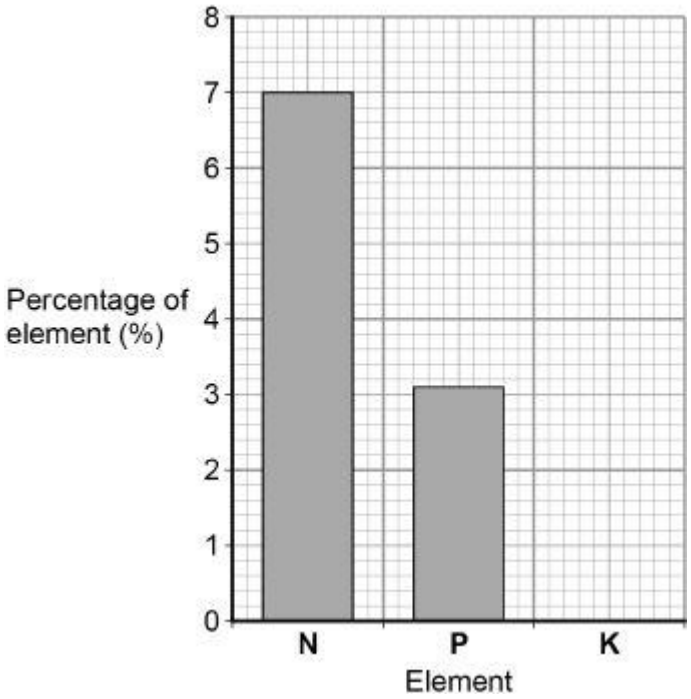
(f) The table below shows percentages of chemical elements in a fertiliser.

Element	**Percentage (%)**
Nitrogen (N)	7.0
Phosphorus (P)	3.1
Potassium (K)	5.8

Draw the bar for potassium on **Figure 1**

Use the information in the table above.

Figure 1



(1)

(g) A fertiliser contains 0.225 g of iron per 3.0 g of fertiliser.

Which calculation gives the percentage of iron in the fertiliser?

Tick **one** box.

$\frac{0.225}{3.0 \times 100}$ ☐

$\frac{3.0 \times 100}{0.225}$ ☐

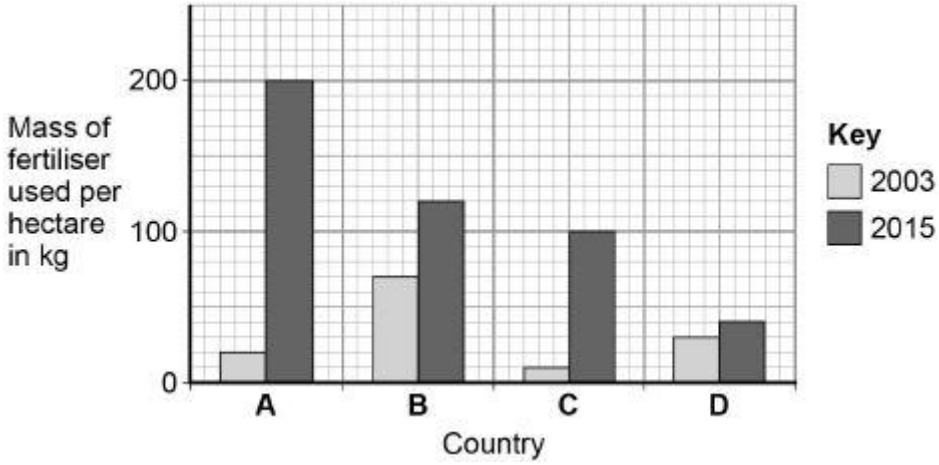
$\frac{0.225 \times 3.0}{100}$ ☐

$\frac{0.225 \times 100}{3.0}$ ☐

(1)

(h) **Figure 2** shows the use of fertiliser in four different countries, **A**, **B**, **C** and **D**, in 2003 and 2015

Figure 2



A student said:

'**much** more fertiliser was used in 2015 than in 2003'

Is the student correct?

Use data from **Figure 2** to justify your answer.

_____

_____

_____

_____

_____

(3)

(Total 10 marks)

Q5. (a) This question is about gases.

Draw **one** line from each substance to the description of the substance.

Substance	Description of substance
	Compound
Air	Element
Carbon dioxide	Hydrocarbon
Oxygen	Metal
	Mixture

(3)

(c) Give **two** reasons why the percentage of carbon dioxide in the air has decreased in the last 2.7 billion years.

Tick (✓) **two** boxes.

- Combustion ☐
- Dissolved in oceans ☐
- Intense volcanic activity ☐
- Photosynthesis ☐
- Respiration ☐

(2)

Oxygen reacts with sulfur dioxide.

The reaction is reversible.

(d) What is the symbol for a reversible reaction?

_____

(1)

(e) Complete the sentence.

In a reversible reaction the forward reaction is exothermic, so the

reverse reaction is _____ .

(1)

(f) A reversible reaction happens in apparatus which stops the escape of reactants and products.

Complete the sentence.

Equilibrium is reached when the forward and reverse reactions happen at

exactly the same _____ .

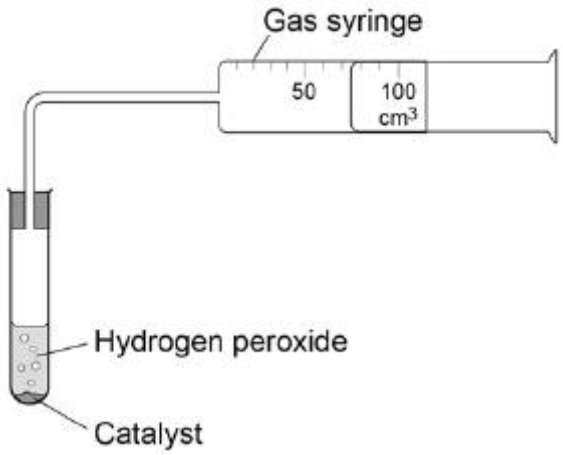
(1)

(Total 10 marks)

Q6. A student investigated the effect of different catalysts on the decomposition of hydrogen peroxide.

Figure 1 shows the apparatus the student used.

Figure 1



(a) Oxygen gas is produced.

Table 1 shows the student's observations.

Table 1

Catalyst	**Observation**
Manganese dioxide	A lot of gas and hydrogen peroxide bubbles up into gas syringe
Potato	Steady bubbles of gas
Copper oxide	Few bubbles of gas
Sodium chloride	Very few bubbles of gas

Which is the most useful catalyst?

Explain your answer.

_____

_____

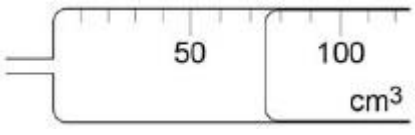
_____

_____

(2)

(b) **Figure 2** shows the gas syringe during the investigation.

Figure 2



What is the volume of gas?

Tick **one** box.

52 cm^3 ☐ 55 cm^3 ☐ 70 cm^3 ☐ 75 cm^3 ☐

(1)

(c) For one of the catalysts the student measures the volume of gas given off every 20 seconds for 2 minutes.

The volume of gas was zero at the start of the experiment.

The measured volumes of gas are:

23 cm^3 42 cm^3 59 cm^3 72 cm^3 80 cm^3 88 cm^3

Complete **Table 2** to show these results.

Table 2

(4)

(d) Suggest why the readings might be lower than expected.

_____

_____

(1)

(e) The student did the experiment with four different catalysts.

Give **two** variables the student should keep constant.

1. _____

2. _____

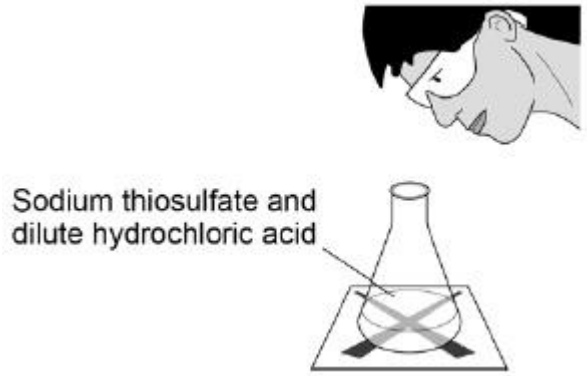
(2)

(Total 10 marks)

Q7. A student investigated the effect of concentration on the rate of the reaction between sodium thiosulfate and dilute hydrochloric acid.

Figure 1 shows the apparatus the student used.

Figure 1



(a) The symbol equation for the reaction is:

$$Na_2S_2O_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O + S$$

Complete the word equation for the reaction.

sodium thiosulphate + hydrochloric acid → _____ + sulfur dioxide + water + sulfur

_____

(1)

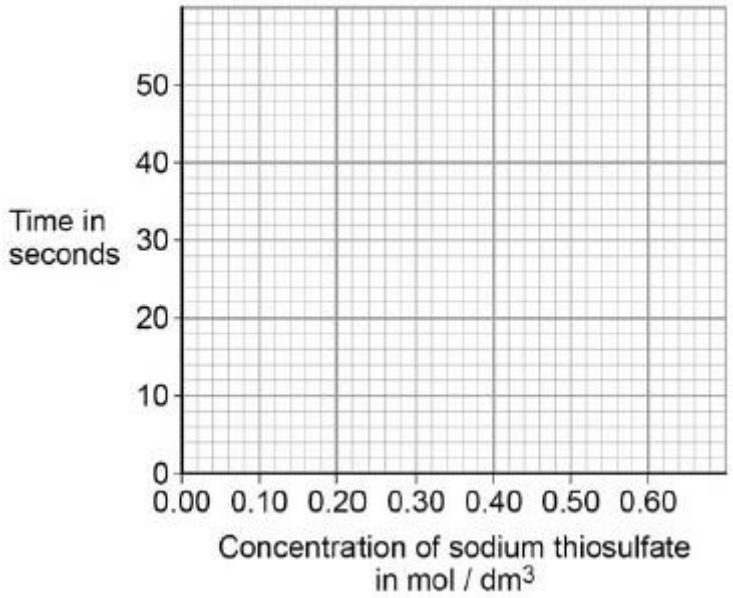
(b) The table shows the results.

Concentration of sodium thiosulfate in mol/dm³	**Time for student to no longer see the cross in seconds**
0.10	41
0.20	21
0.30	20
0.40	10
0.50	8

Plot the data from the table on **Figure 2**.

Draw a line of best fit.

Figure 2



(3)

(c) The student determined the time for a concentration of 0.15 mol/dm^3

What is the concentration when the reaction is 20 seconds faster?

You should show your working on **Figure 2**.

_____

Concentration = _____ mol/dm^3

(2)

(d) Estimate the time taken for the reaction when the concentration of sodium thiosulfate is 0.60 mol/dm^3

_____

Time taken = _____ s

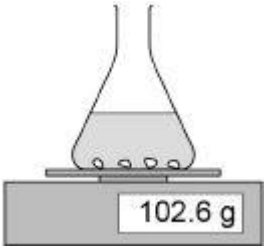
(1)

(Total 7 marks)

Q8. A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10.0 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid and start a timer.
3. Record the mass lost from the flask every 10 seconds.
4. Repeat steps 1 to 3 with different sizes of marble chips.



(a) Draw **one** line from each type of variable to the correct example of the variable.

Type of variable	**Example of variable**
	Mass lost from flask
Independent	Size of flask
	Size of marble chips
Control	Time taken
	Volume of acid

(2)

(b) The equation for the reaction is:

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

Name the **three** products.

1. _____

2. _____

3. _____

(2)

(c) Another student suggests putting some cotton wool in the top of the flask.

Suggest why this improves the investigation.

_____

_____

(1)

(d) The reaction produces 1.6 g of gas in 30 seconds.

Calculate the mean rate of the reaction in the first 30 seconds.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{mass of product produced in grams}}{\text{time in seconds}}$$

_____

_____

Mean rate of reaction = _____

(1)

(e) What is the unit for the mean rate of reaction calculated in part **(d)**?

Tick **one** box.

g ☐ g/s ☐ s ☐ s/g ☐

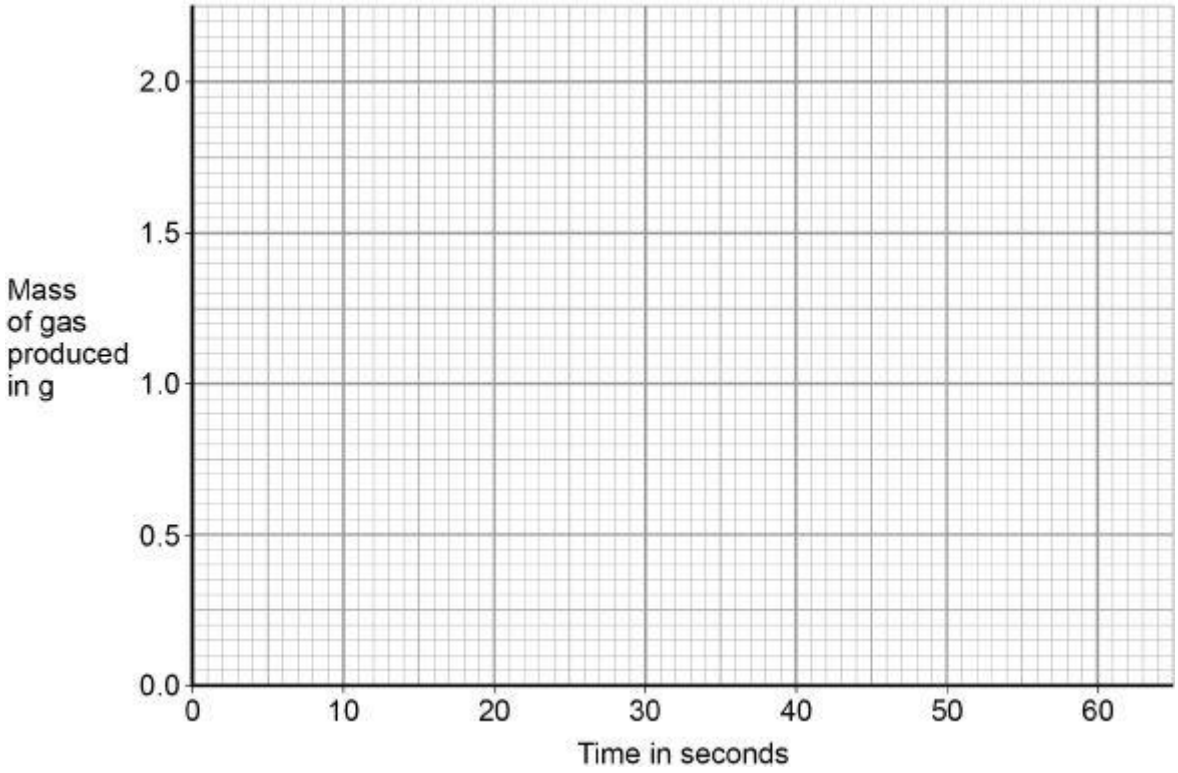
(1)

(f) The table below shows the student's results.

Time in seconds	**Mass of gas produced in g**
0	0.0
10	0.8
20	0.6
30	1.6
40	1.8
50	2.0
60	2.0

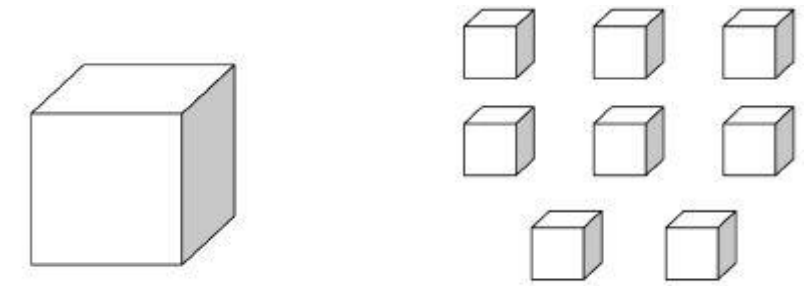
Plot the data from the table above on **Figure 2** (next page)

Draw a line of best fit.



(3)

(g) **Figure 3** shows a large marble chip and eight small marble chips.



Large marble chip **Eight small marble chips**

The large marble chip has the same total volume as the eight small marble chips, but a different surface area.

Why do the eight small marble chips react faster than the large marble chip?

Tick **one** box.

- The eight small marble chips have a larger surface area, so less frequent collisions. ☐
- The eight small marble chips have a larger surface area, so more frequent collisions. ☐
- The eight small marble chips have a smaller surface area, so less frequent collisions. ☐
- The eight small marble chips have a smaller surface area, so more frequent collisions. ☐

(1)

Q9. Some students investigated the effect of temperature on the rate of reaction.

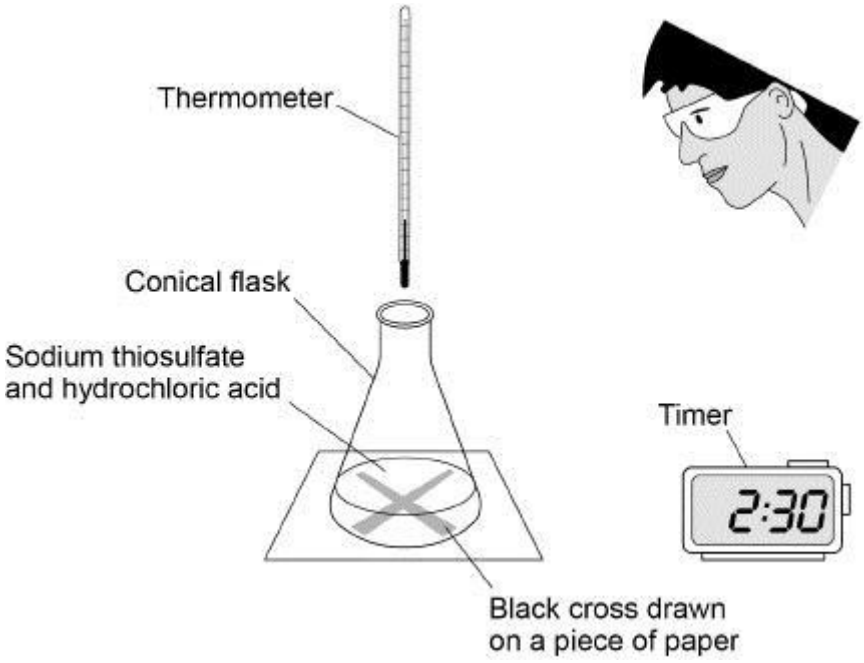
(a) The students reacted sodium thiosulfate solution with hydrochloric acid.

This is the method used.

1. Use a beaker to measure 50 cm^3 of heated sodium thiosulfate solution into a conical flask.
2. Measure the temperature of the room.
3. Put the conical flask on a black cross drawn on a piece of paper.
4. Start a timer.
5. Use the same beaker to measure 10 cm^3 of hydrochloric acid into the conical flask.
6. Stop the timer when the cross is no longer visible.

The students repeated the experiment at a different room temperature.

The diagram below shows the apparatus.



The method contains errors and does **not** produce accurate results.

Describe a method the students should use to produce accurate results.

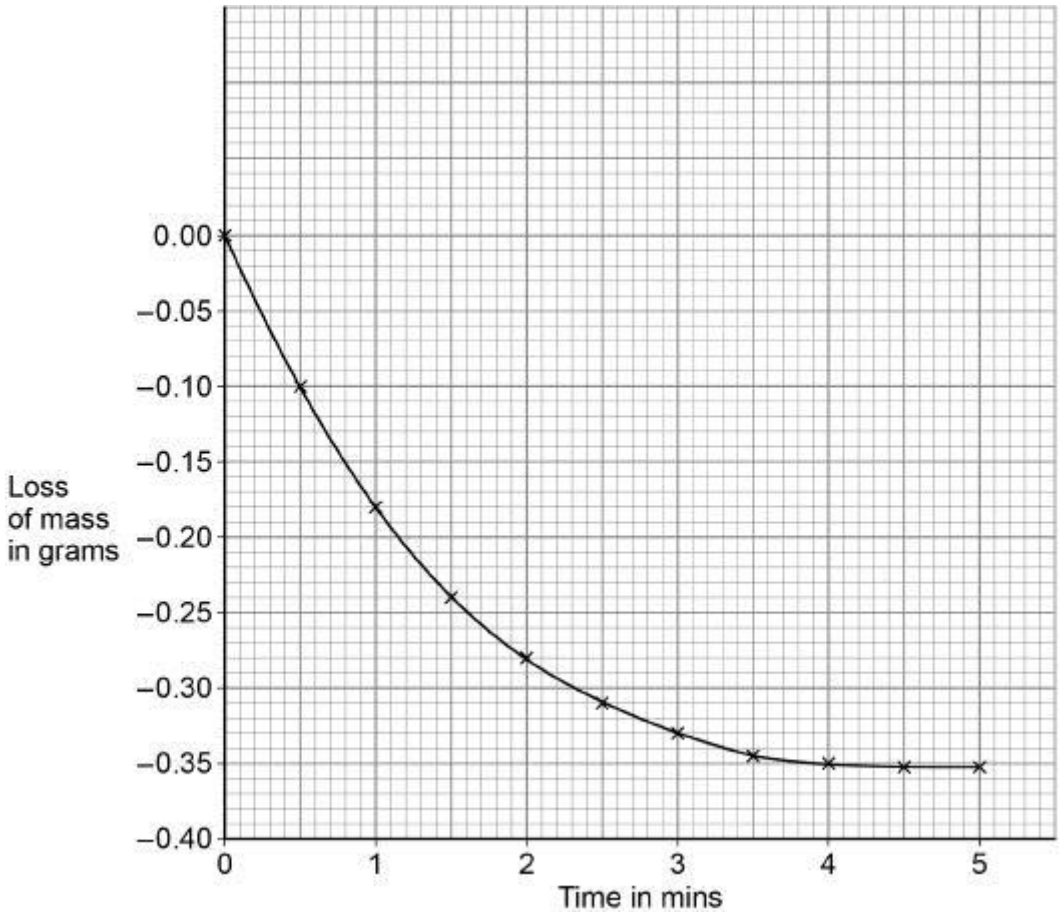
You do **not** need to write about safety precautions.

(6)

Some students investigated the effect of temperature on the rate of a different reaction.

They recorded the loss of mass from their apparatus at 40 °C

The graph below shows the results.



(b) Calculate the mean rate of reaction between 1 minute and 3 minutes at 40 °C

Use the graph above and the equation:

$$\text{Mean rate of reaction} = \frac{\text{change in mass of gas in g}}{\text{time in mins}}$$

Mean rate of reaction = _____ g/min

(3)

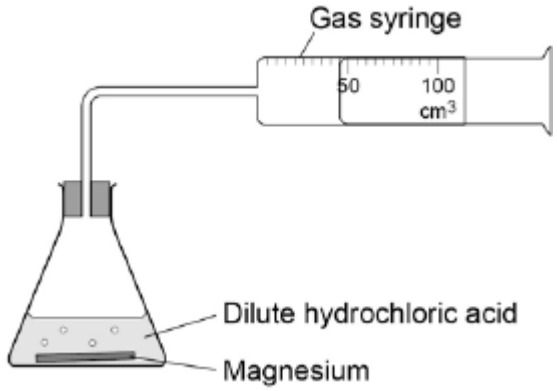
(c) Draw a curve on the graph above for the results you would expect at a temperature of 50 °C instead of 40 °C

(2)

(Total 11 marks)

Q11. A student investigated the rate of the reaction between magnesium and dilute hydrochloric acid.

The student used the apparatus shown in **Figure 1** to collect the gas produced.



(a) Outline a plan to investigate how the rate of this reaction changed when the concentration of the hydrochloric acid was changed.

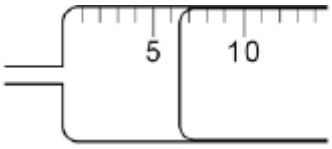
- Describe how you would do the investigation and the measurements you would make.
- Describe how you would make it a fair test.

You do **not** need to write about safety precautions.

(6)

(b) **Figure 2** shows the gas syringe during one of the experiments.

Figure 2



What is the volume of gas collected?

Tick **one** box.

5.3 cm^3 ☐

6.0 cm^3 ☐

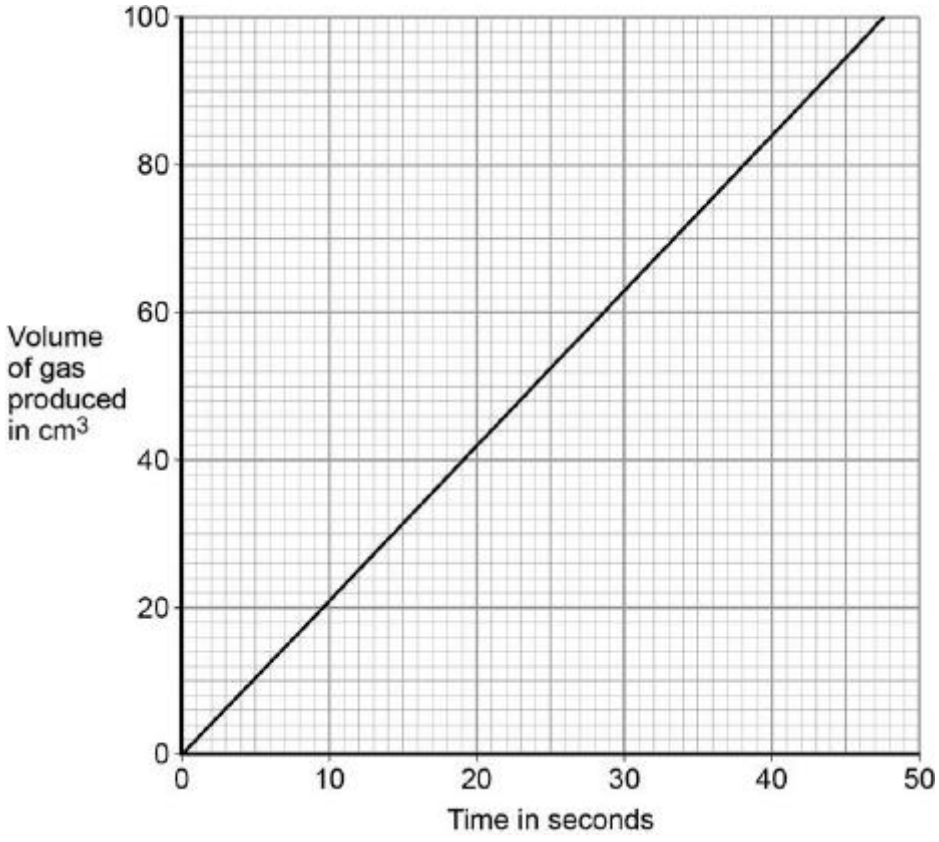
6.5 cm^3 ☐

7.0 cm^3 ☐

(1)

(c) **Figure 3** shows the student's results for one concentration of hydrochloric acid.

Figure 3



The table below shows the student's results when the concentration was two times greater than the results on **Figure 3**

Time in seconds	Volume of gas produced in cm^3
0	0
10	35
15	52
20	80
30	87

Plot the results in the table above on the grid in **Figure 3**.
Draw a line of best fit.

(3)

(d) Give **one** conclusion about how the rate of reaction changed when the concentration of hydrochloric acid was changed.

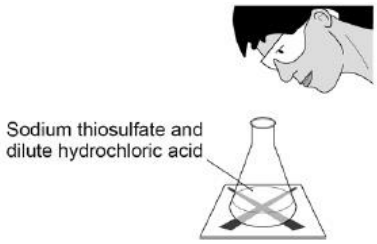
_____

_____

(1)

(Total 11 marks)

Q12. A student investigated the rate of the reaction between sodium thiosulfate solution and dilute hydrochloric acid.

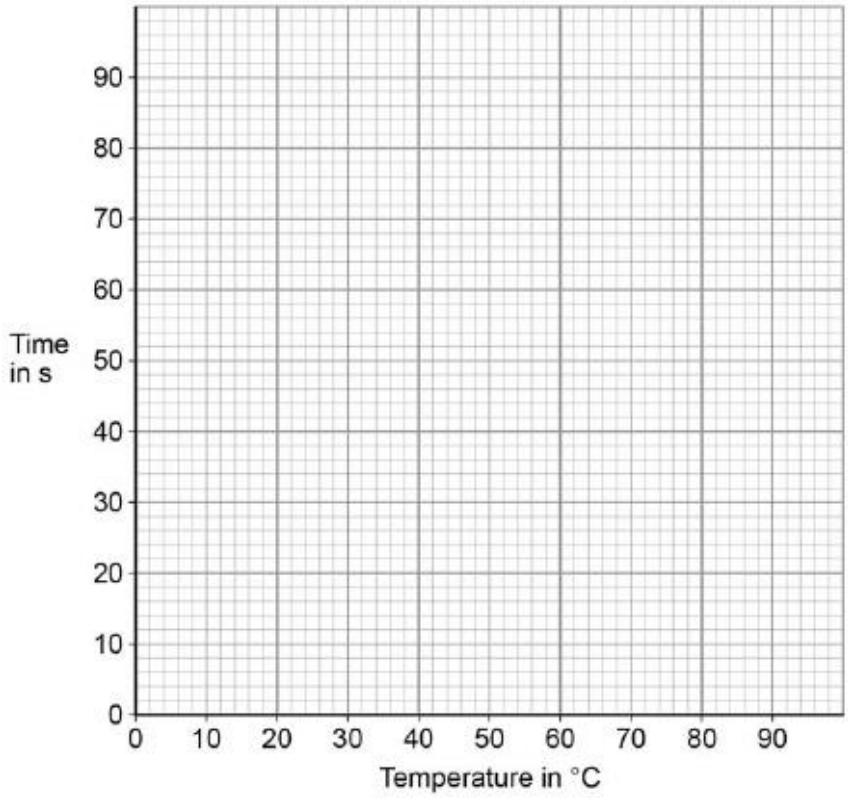


The table shows the time taken for the student to no longer see the cross at different temperatures.

Temperature in °C	**Time in seconds**
25	89
32	62
44	33
55	17
64	8
75	5
85	4

(a) Plot the data from the table on **Figure 2**.

Draw a line of best fit.



(3)

(b) Describe the trend in **Figure 2**.

Use values from **Figure 2**.

_____

_____

_____

_____

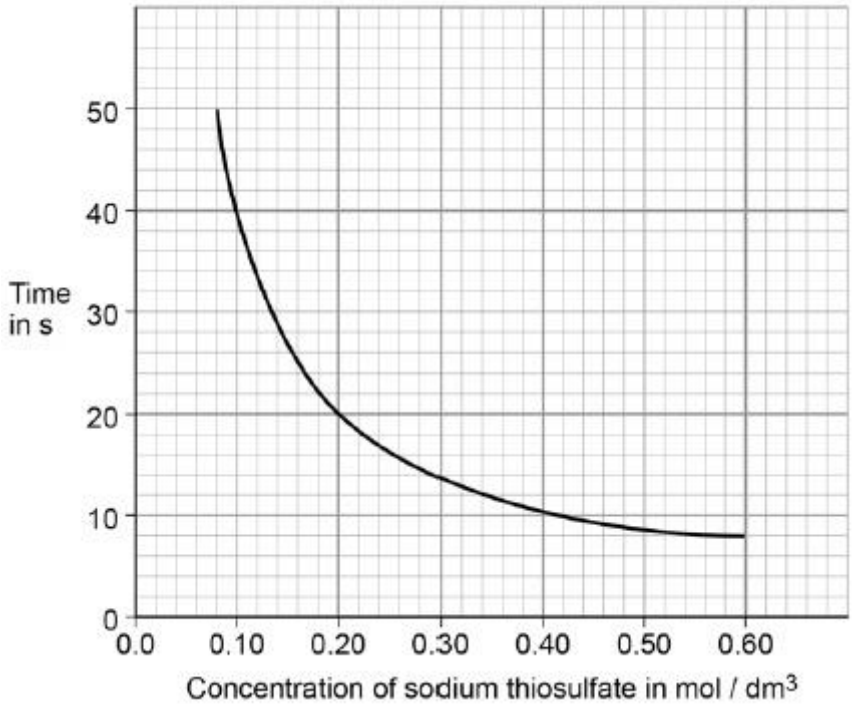
_____

(3)

(c) The student also investigated the effect of concentration on the time taken for the reaction.

Figure 3 shows the student's results.

Figure 3



Draw a tangent to the curve at 0.20 mol/dm^3

Calculate the gradient (slope) of the tangent at 0.20 mol/dm^3 and give the unit.

_____

_____

_____

_____

Gradient = _____ Unit _____

(4)

(d) Explain why the rate decreases during a reaction between sodium thiosulfate and dilute hydrochloric acid.

Write about particles in your answer.

_____

_____

_____

_____

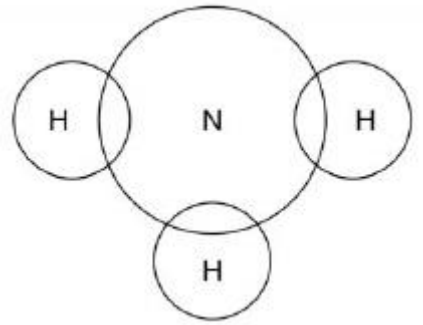
(2)

(Total 12 marks)

Q13. This question is about ammonia (NH_3).

(a) Complete the diagram to show the bonding electrons in ammonia.

Show the outer electrons only.



(2)

Ammonia is produced from nitrogen and hydrogen.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

(b) A low pressure is used.

Explain the effect on the yield of ammonia.

_____

_____

_____

_____

(2)

(c) A high temperature is used.

Explain the effect on the yield of ammonia.

_____

_____

_____

_____

(2)

(d) Ammonia is removed from the reaction mixture.

Explain the effect on the position of equilibrium.

_____

_____

_____

_____

(2)

(Total 8 marks)

Q14. Sulfur dioxide (SO_2) is used to manufacture sulfuric acid.

(a) Explain why sulfur dioxide has a low boiling point.

(3)

(b) The equation shows one stage in the manufacture of sulfuric acid from sulfur dioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction is exothermic in the forward direction.

Use Le Chatelier's Principle to predict the effect of increasing the temperature on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

(2)

(c) Use Le Chatelier's Principle to predict the effect of increasing the pressure on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

(2)

(Total 7 marks)

Q15. This question is about catalysts.

(a) Why are catalysts used in reactions?

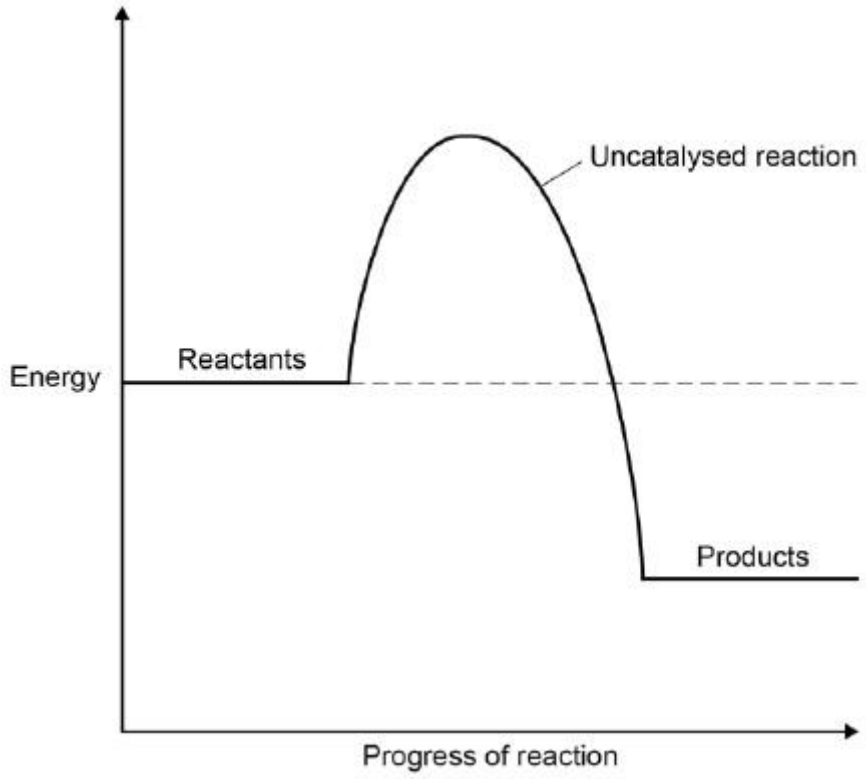
_____

_____

(1)

Figure 1 shows the reaction profile for a reaction without a catalyst.

Figure 1



(b) Label the activation energy (E_A) for the reaction on **Figure 1**.

(1)

(c) Label the energy change for the reaction on **Figure 1**.

(1)

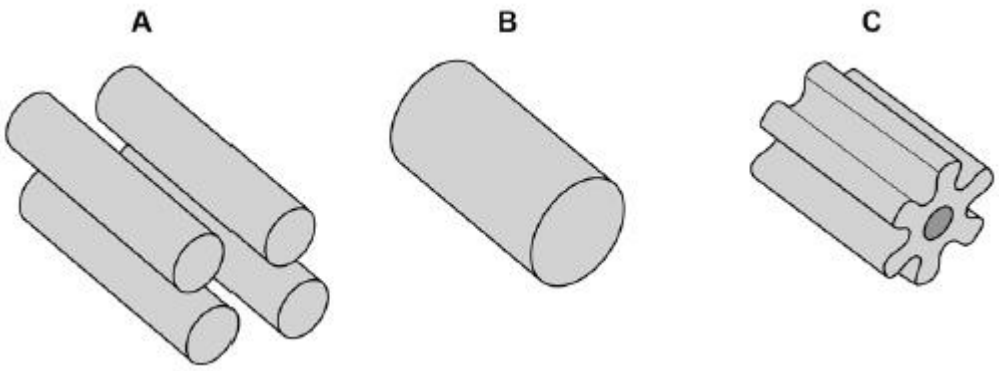
(d) Draw the reaction profile for the reaction **with a catalyst** on **Figure 1**.

(2)

(e) **Figure 2** shows three different shapes of the same catalyst.

Each catalyst has the same volume.

Figure 2



Evaluate the effectiveness of the shapes of the catalyst in **Figure 2**.

(3)

(Total 8 marks)

Q16. Bleach is a solution of sodium hypochlorite (NaClO).

Chlorine gas is produced when bleach reacts with hydrochloric acid.

$$NaClO(aq) + 2HCl\ (aq) \rightleftharpoons NaCl(aq) + H_2O(l) + Cl_2(g)$$

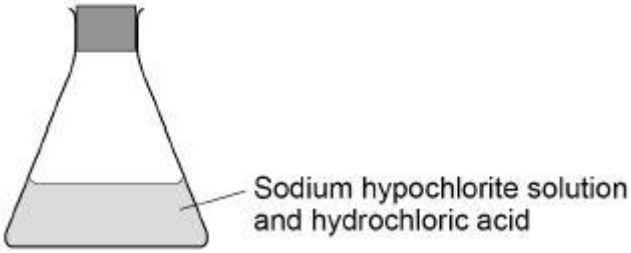
(a) Give the test and result for chlorine gas.

_____

_____

(2)

The diagram below shows a sealed flask of sodium hypochlorite and hydrochloric acid at equilibrium.



(b) Explain why equilibrium is reached in this reaction.

_____

_____

_____

_____

_____

_____

(2)

(c) The stopper in the diagram above is removed and hydrochloric acid is added.

The stopper is replaced.

Explain what happens to the equilibrium.

_____

_____

_____

_____

_____

_____

_____

(4)

Chlorine gas is also produced when hydrogen chloride decomposes.

$$2HCl(g) \rightleftharpoons H_2(g) + Cl_2(g)$$

The forward reaction is endothermic.

(d) Predict the effect of increasing the temperature on the amount of chlorine gas produced at equilibrium.

Explain your answer using Le Chatelier's Principle.

_____

_____

_____

_____

(2)

(e) Explain the effect of increasing the pressure on this equilibrium.

_____

_____

_____

_____

(2)

(Total 12 marks)

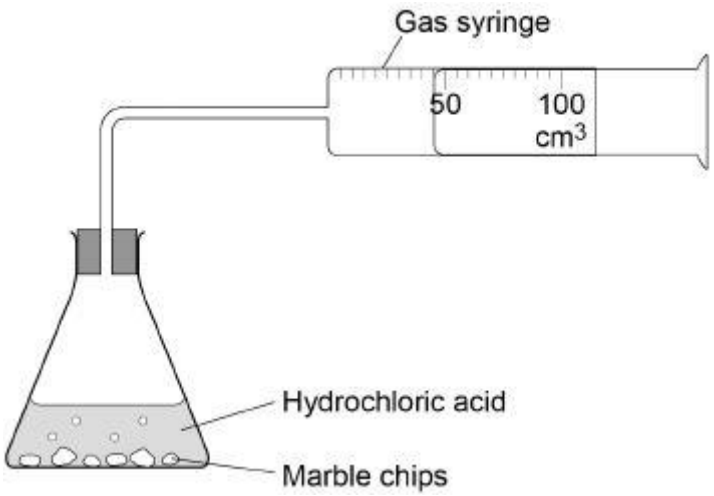
Q17. A student investigated the effect of the size of marble chips on the rate of the reaction between marble chips and hydrochloric acid.

This is the method used.

1. Add 10 g of marble chips into the flask.
2. Add 50 cm^3 of hydrochloric acid, connect the gas syringe and start a timer.
3. Record the volume of gas produced every 10 seconds.

Figure 1 shows the apparatus.

Figure 1



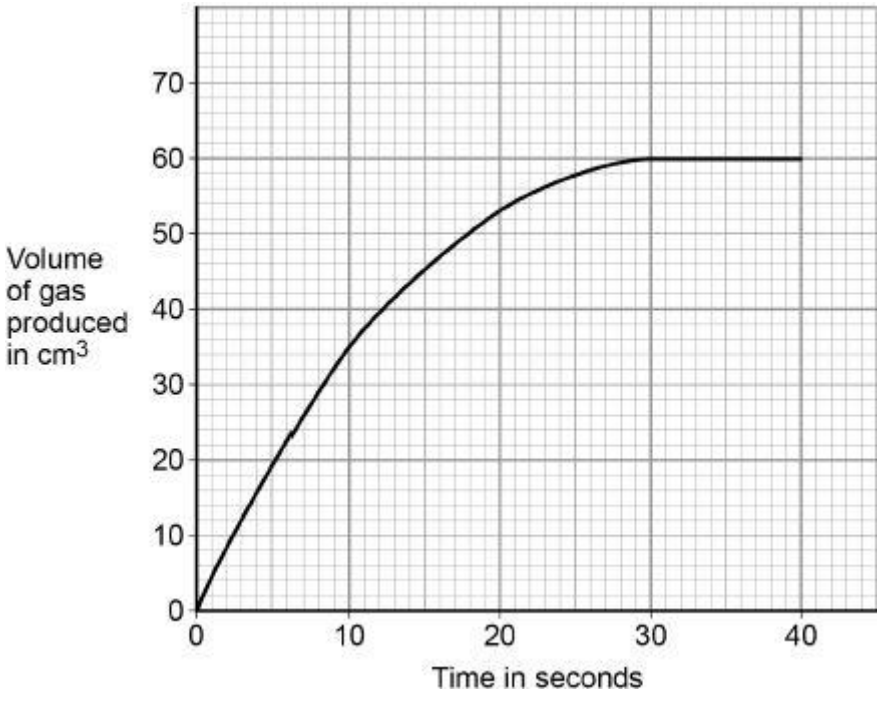
(a) Complete the equation for the reaction.

$CaCO_3 +$ _____ $HCl \rightarrow$ _____

(2)

Figure 2 shows the student's results.

Figure 2



(b) Describe the trend shown in **Figure 2**

Use values in your answer.

(3)

(c) Describe how you would use **Figure 2** to find the rate of the reaction at 15 seconds.

You do **not** need to do a calculation.

(2)

(d) Give the units for the rate of this reaction.

(1)

The table below shows the results of the investigation.

Relative size of marble chips	**Volume of gas produced in cm^3 after given time in seconds**					
	10 s	**20 s**	**30 s**	**40 s**	**50 s**	**60 s**
Small	35	53	60	60	60	60
Medium	21	39	51	58	60	60
Large	14	29	39	48	58	60

(e) Give **one** conclusion about how the size of the marble chips affects the rate of the reaction.

(1)

(f) Suggest why all three sizes of marble chips produce a maximum volume of 60 cm^3 of gas.

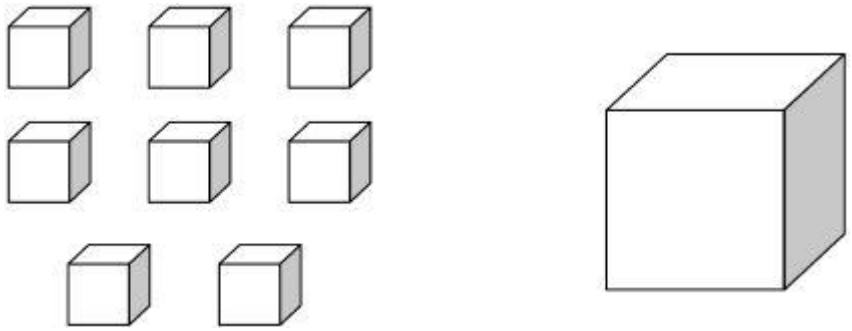
_____

_____

(1)

(g) **Figure 3** shows eight small cubes, each 1 cm × 1 cm × 1 cm, and one large cube, 2 cm × 2 cm × 2 cm

Figure 3



Total volume of small cubes = 8 cm^3

Volume of large cube = 8 cm^3

Total surface area of small cubes = 48 cm^2

Calculate the surface area of the large cube.

_____

_____

_____

_____

Surface area of the large cube = _____ cm^2

(2)

(h) Explain why the size of the marble chips affects the rate of the reaction.

Give your answer in terms of 'collision theory'.

_____

_____

_____

_____

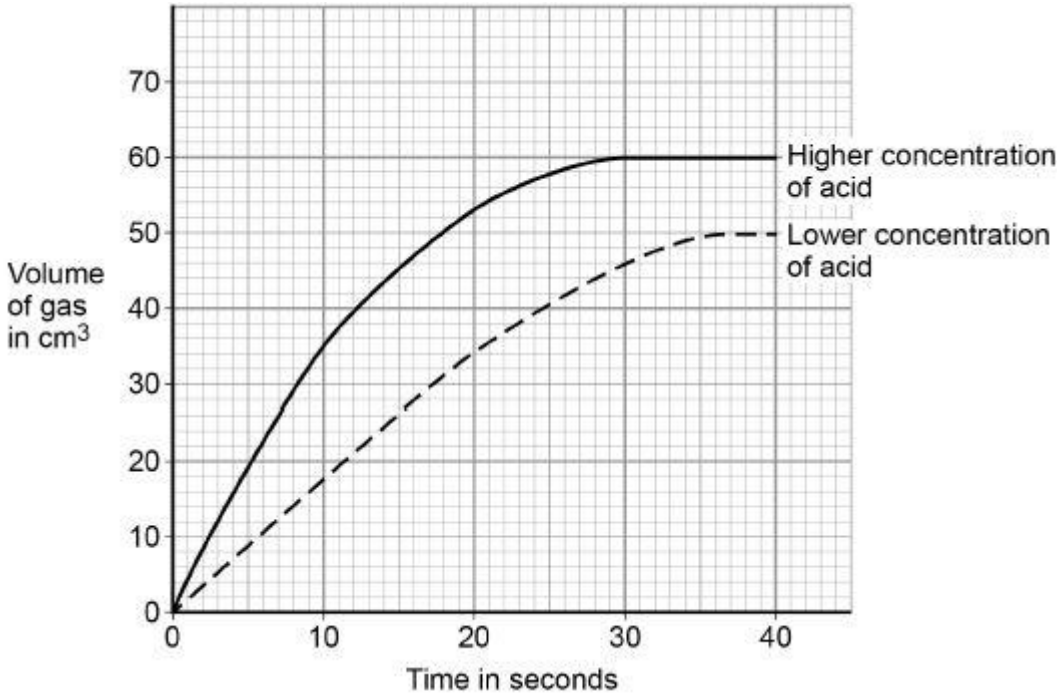
_____

(2)

(i) The student repeated the investigation with small marble chips using hydrochloric acid with a lower concentration.

Figure 4 shows the volume of gas produced during the first 40 seconds.

Figure 4



Explain why the results for the lower concentration of acid are different from the results for the higher concentration of acid.

_____

_____

_____

_____

_____

_____

(3)

(Total 17 marks)

Q18. This question is about equilibrium.

(a) Describe how a reaction reaches equilibrium.

(2)

Nitrogen dioxide gas reacts to form dinitrogen tetraoxide gas.

The reaction is reversible.

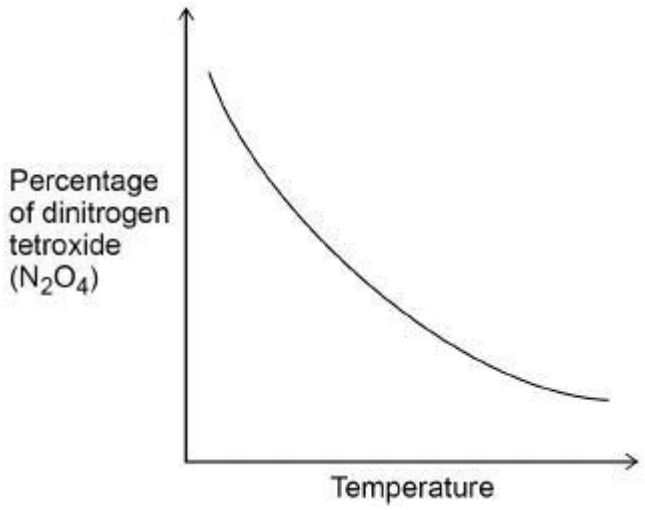
The equation for the reaction is:

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

(b) Explain the effect on the equilibrium position of increasing the pressure.

(2)

(c) The graph below shows the change in the percentage of dinitrogen tetroxide (N_2O_4) in the equilibrium mixture as the temperature of the equilibrium mixture is changed.



Explain the effect on the equilibrium position of increasing the temperature.

Use the graph above.

(3)

(Total 7 marks)

Q19. This question is about oxygen (O_2) and sulfur dioxide (SO_2).

(a) Give the test and result for oxygen gas.

Test _____

Result _____

(2)

(b) The reaction between oxygen and sulfur dioxide is at equilibrium.

$$O_2(g) + 2\ SO_2(g) \rightleftharpoons 2\ SO_3(g)$$

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

_____

_____

_____

_____

(2)

(c) Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \longrightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

_____

_____

_____

_____

_____

_____

_____

_____

Mass of calcium sulfite produced = _____ g

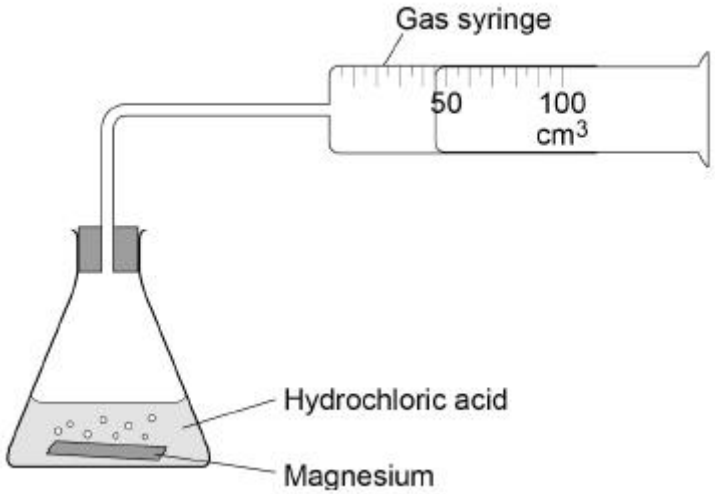
(4)

(Total 8 marks)

Q20. This question is about magnesium.

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

Figure 1 shows the apparatus.



(a) Which is the correct ionic equation for the reaction?

Tick (✓) **one** box.

$Mg + 2\ H^+ \longrightarrow Mg^{2+} + H_2$ ☐

$Mg^{2+} + 2\ Cl^- \longrightarrow MgCl_2$ ☐

$Mg + 2\ HCl \longrightarrow MgCl_2 + H_2$ ☐

$Mg^+ + Cl^- \longrightarrow MgCl$ ☐

(1)

(b) What happens in the reaction between magnesium and hydrochloric acid?

Tick (✓) **one** box.

Electron sharing ☐

Electron transfer ☐

Proton transfer ☐

(1)

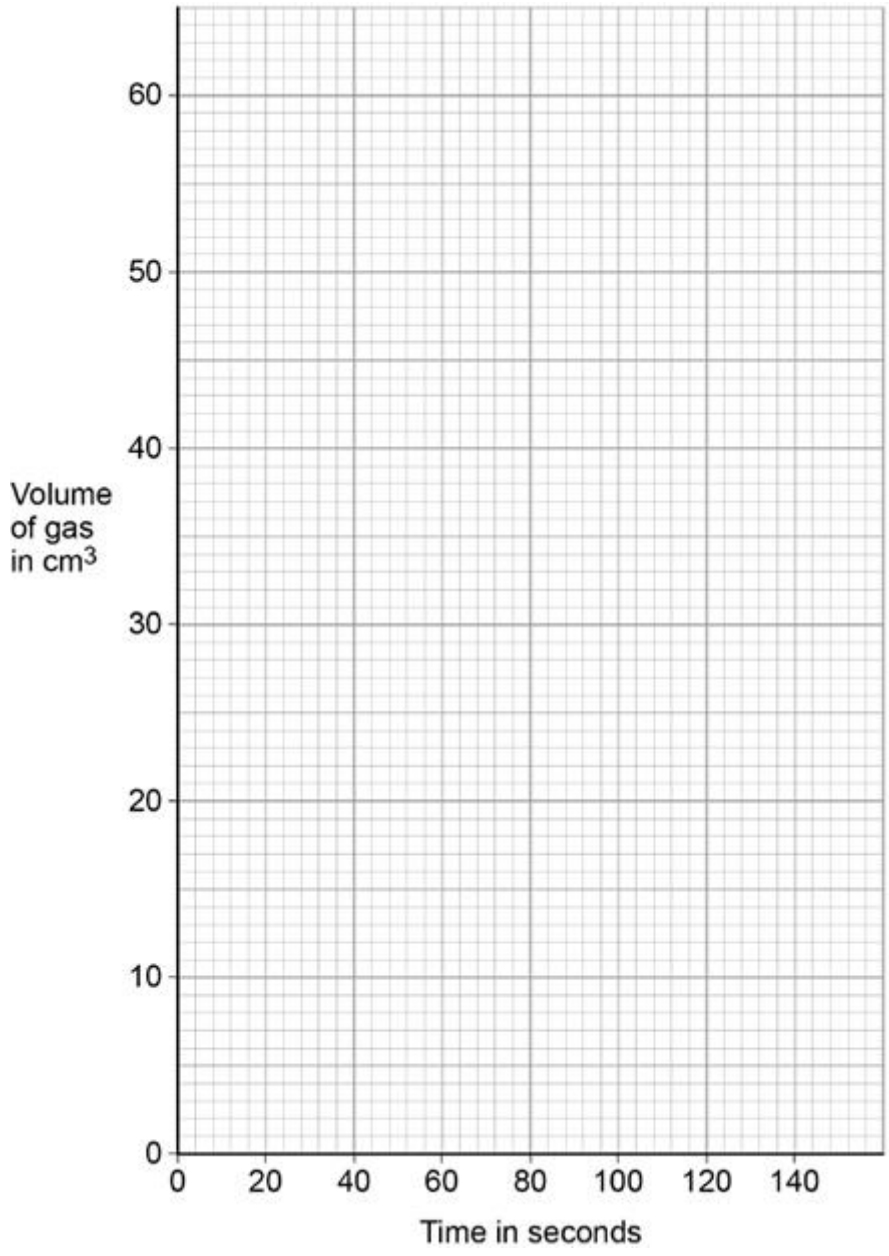
(c) The table shows the student's results.

Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm²	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from the table on **Figure 2**.

Draw a line of best fit.

Figure 2



(3)

(d) Describe the changes in the rate of this reaction.

(3)

(e) Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

(3)

(Total 11 marks)

Q1.

(a) water

ignore H_2O

1

oxygen

ignore O_2

1

(b) concentration of hydrogen peroxide

1

mass of catalyst

1

(c) 42 (cm^3)

1

(d) all five points correctly plotted

allow a tolerance of ± ½ a small square

*allow **1** mark for 3 **/** 4 points correctly plotted*

2

line of best fit drawn

1

(e) (for the best catalyst) curve is steepest (at the beginning)
or
highest (initial) gradient
or
greatest volume of gas in stated time

1

(f) same volume / concentration of hydrogen peroxide (used)

ignore amount

allow catalyst does not affect volume

1

(g) the particles have more energy

1

there are more particle collisions per second

1

[12]

Q2.

(a) 2

allow multiples of whole equation

1

(b) 50 cm^3 measuring cylinder

1

(c) headings: time **and** volume (of gas)

allow in either column

1

units: s **and** cm^3

allow any units of time and volume placed in relevant column

1

time values correct (and match units)

1

volume values match time values

ignore incorrect representation of time values

*if no other marks awarded allow **1** mark for time with correct units*
or
volume with correct units

1

(d) any **one** from:

- concentration of the acid was lower (than expected)
- some (gas) escaped
- impure magnesium
- temperature lower (than expected)

answers must relate to the diagram

ignore answers relating to amount or surface area or time

1

(e) any **two** from:

- length of magnesium
- or
- surface area of magnesium

allow mass of magnesium

allow same form of magnesium

allow same size of magnesium

- volume of acid

ignore concentration of hydrochloric acid

- temperature (of acid)

ignore room temperature

2

(f) increased

allow went up

allow got bigger

1

particles

allow ions or molecules

ignore concentration

1

frequently

allow often

1

[12]

Q3.

(a) 80

1

(b) volcanoes

allow ammonia
allow meteorites

1

(c) ⇌

ignore any extra words

1

(d) rate

allow speed
allow pace

*do **not** accept time*
*do **not** accept amount*
*do **not** accept level*
*do **not** accept point*

1

(e) a mixture designed as a useful product

1

(f) bar for K to 5.8%

allow ± ½ a small square

1

(g) $\frac{0.225 \times 100}{3.0}$

1

(h) use has increased

1

(increase is) less in country B
or (increase is) less in country D

allow (increase is) more in country A
***or** (increase is) more in country C*

1

example of data

1

[10]

Q4.

(a) 3.50 %

1

(b) correct bar to 2.1 (%)

allow a tolerance of ± $\frac{1}{2}$ *a small square*

1

(c)

*an answer of 227 (kg) scores **2** marks*

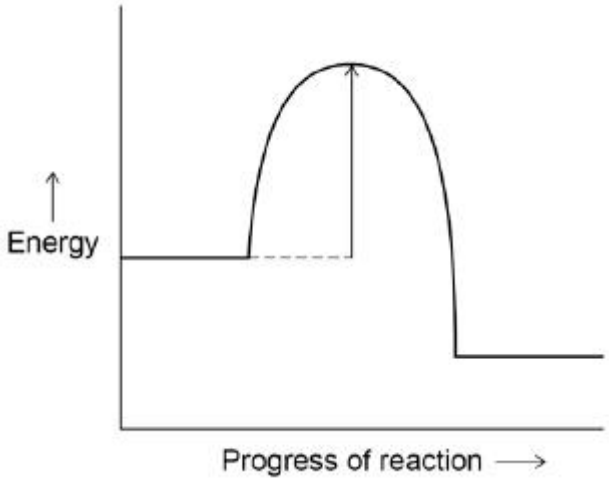
(617 + 258) − 648
or
875 − 648

1

= 227 (kg)

1

(d)



ignore arrow heads

1

(e) (curve) starts and ends at same energy levels as existing curve

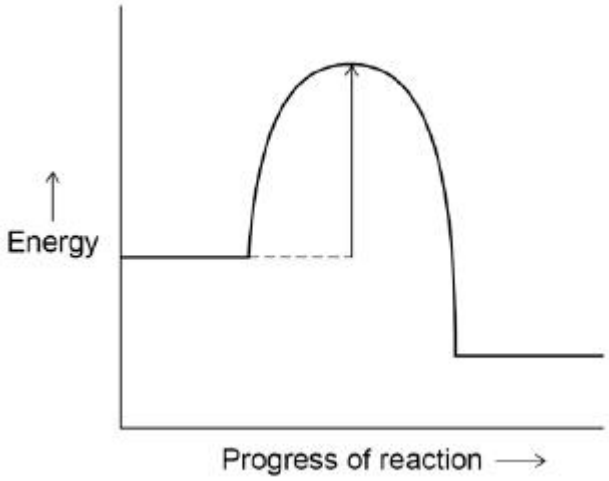
1

maximum of curve below
maximum of existing curve

only award if MP1 correct

1

an answer of



scores 2 marks
ignore references to activation energy

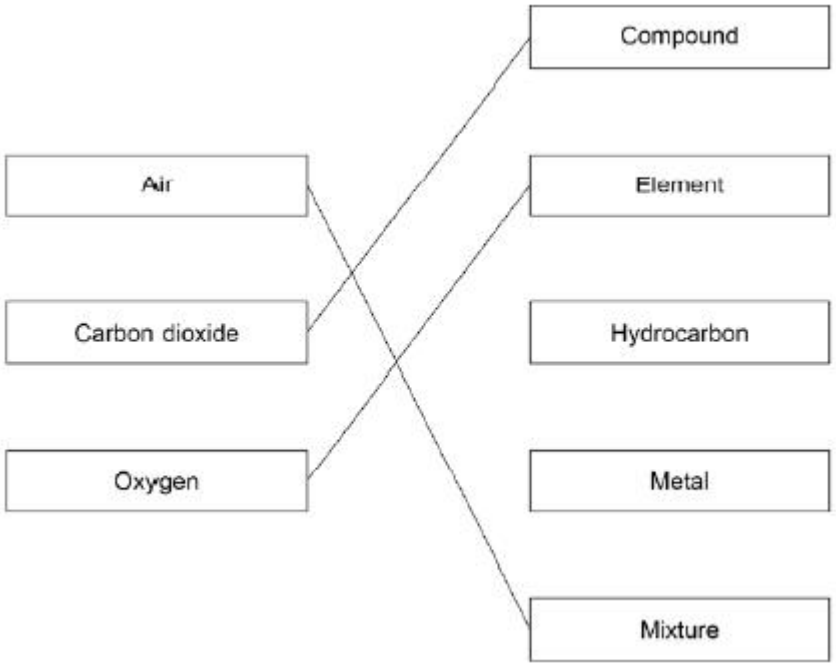
(f) enzymes

1

[8]

Q5.

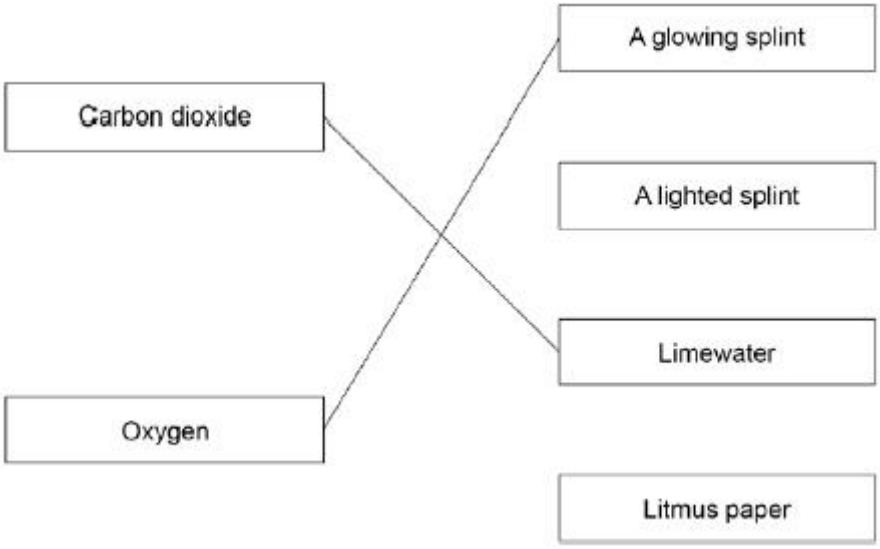
(a)



If more than one line is drawn from any one substance and not crossed out, no mark is given for that substance. The other marks can be awarded.

1
1
1

(b)



If more than one line is drawn from any one gas and not crossed out, no mark is awarded for that gas.

The other mark can be awarded.

1
1

(c) dissolved in oceans

1

photosynthesis

1

(d) ⇌

ignore any other words, formulae or symbols

1

(e) endothermic (reaction)

spelling must be correct

*do **not** accept exothermic*

1

(f) rate (of reaction)

allow speed or velocity

*do **not** accept any other response*

1

[10]

Q6.

(a) potato

1

effective, but manageable and safe

*allow **1** for manganese dioxide is effective*

1

(b) 75 cm^3

1

(c) headings: time, volume

1

units: s or seconds, cm^3

1

correct values for times, including 0

1

correct values for volumes

Time in seconds	Volume in cm^3
0	0
20	23
40	42
60	59
80	72
100	80
120	88

1

(d) any **one** from:

- gas escaped
- leak
- slow to put on bung
- systematic error

1

(e) any **two** from:

- concentration of peroxide
- volume of peroxide
- temperature
- mass of catalyst
- surface area of catalyst

2

[10]

Q7.

(a) sodium chloride

1

(b) points correctly plotted

*allow **1** mark if 4 correct*

2

correct line of best fit

*do **not** accept straight line*

1

(c) 0.38–0.50

*allow for **1** mark for working shown on graph*

2

(d) ≥5 seconds and <8 seconds

1

[7]

Q8.

(a) lines from:

- independent to size of marble chips

1

- control to volume of acid

1

ignore arrowheads

*do **not** accept if more than one line from one box*

(b) calcium chloride

carbon dioxide

*do **not** accept carbon oxide*

water

*do **not** accept hydrogen oxide*

2

*all three needed for **2** marks*
*allow **1** mark if two correct*

(c) stops loss of acid

allow stops loss of water / liquid
allow to ensure that only the gas escapes

*do **not** accept stops acid evaporating*

*do **not** accept stops gas / CO_2 / water vapour escaping*

1

(d) 0.053

allow 0.05
allow 0.053333…

*do **not** accept 0.052*
ignore units

1

(e) g/s

1

(f) all points correctly plotted

*allow **1** mark for 5 points correctly plotted*
allow ± ½ a small square

2

line of best fit

should be a curve nearer to (10,0.8) than the anomaly (20, 0.6) and through all other points

if plotting incorrect allow 1 mark for appropriate line of best fit through student's points

1

(g) the eight small marble chips have a larger surface area, so more frequent collisions

1

[11]

Q9.

(a) **Level 3:** The method would lead to the production of a valid outcome. All key steps are identified and logically sequenced.

5–6

Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the plan is not fully logically sequenced.

3–4

Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.

1–2

No relevant content

0

Indicative content:

- use a measuring cylinder / pipette / burette to measure 50 cm^3 of sodium thiosulfate
- use a different measuring cylinder / pipette / burette to measure 10 cm^3 of hydrochloric acid
- start the timer when the acid is added
- record the temperature of the solution after the acid is added
- stop the timer when the cross is no longer visible
- record the temperature of the solution at the end of the reaction
- calculate the mean temperature of the reaction
- repeat the experiment at different temperatures
- use the same concentration of sodium thiosulfate and same concentration of hydrochloric acid
- use the same volume of sodium thiosulfate and the same volume of hydrochloric acid
- describe how to heat the thiosulfate / acid solutions

(b) *ignore signs*

(change in mass of gas =) 0.15
and
(time =) 2

1

(rate of reaction =) $\frac{0.15}{2}$

allow correct use of incorrectly determined values for mass and / or time

1

0.075 (g/min)

1

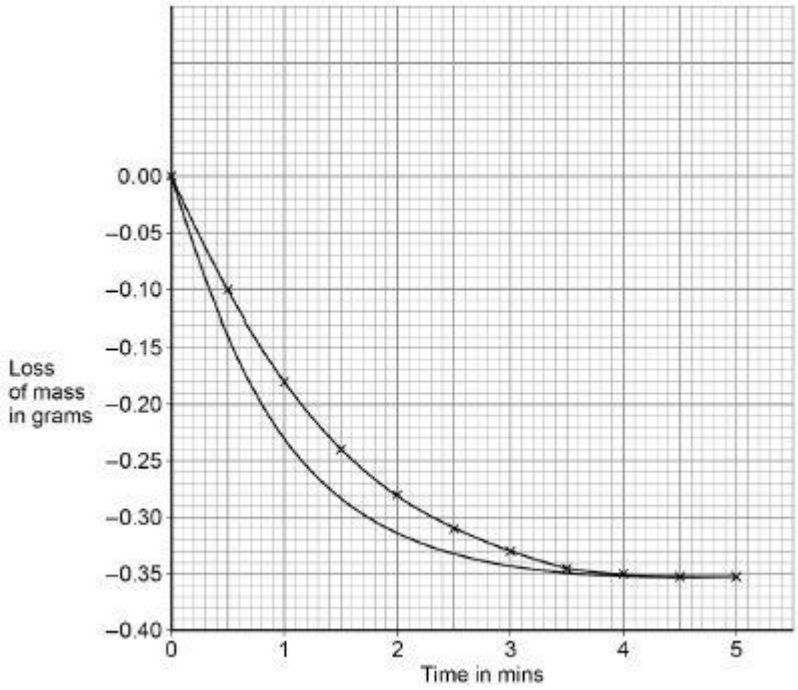
(c) curve starts at same point, to the left and steeper

1

line levels at − 0.35 g

1

the curve below can be awarded 2 marks


Loss
of mass
in grams
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
−0.30
−0.35
−0.40
0
1
2
3
4
5
Time in mins

[11]

Q11.

(a) **Level 3 (5–6 marks):**
A coherent method is described with relevant detail, which demonstrates a broad understanding of the relevant scientific techniques and procedures. The steps in the method are logically ordered with the dependent and control variables correctly identified. The method would lead to the production of valid results.

Level 2 (3–4 marks):
The bulk of a method is described with mostly relevant detail, which demonstrates a reasonable understanding of the relevant scientific techniques and procedures. The method may not be in a completely logical sequence and may be missing some detail.

Level 1 (1–2 marks):
Simple statements are made which demonstrate some understanding of some of the relevant scientific techniques and procedures. The response may lack a logical structure and would not lead to the production of valid results.

0 marks:
No relevant content

Indicative content

- remove bung and add magnesium
- start stopclock / timer
- measure volume of gas at fixed time intervals
- repeat with different concentrations of acid
- control volume of acid
- control initial temperature of acid
- control amount / mass / length / particle size of magnesium

6

(b) 6.5 cm^3

1

(c) all points plotted correctly

*allow **1** mark for 4 points plotted correctly*

2

best fit straight line drawn

1

(d) when the concentration of acid increased the rate of reaction increased or vice versa

answer must use the terms 'rate of reaction' linked to 'concentration'

1

[11]

Q12.

(a) all points correctly plotted

*allow **1** mark for 5 points correctly plotted*

2

line of best fit

1

(b) time decreases as temperature increases

1

rate of change decreases

1

comparison of two values from graph

1

(c) correctly drawn tangent

1

values correctly read from graph

1

calculation

1

unit: s / (mol /dm^3)

allow seconds per mol per dm^3

1

(d) fewer particles per unit volume

1

decreased frequency of collisions

1

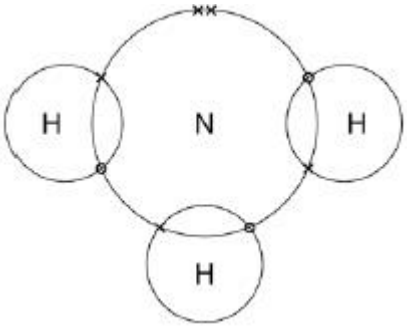
[12]

Q13.

(a) 3 × bonding pairs of electrons

1

2 × unbonded electrons on nitrogen



2

(b) decreases yield

1

more moles on left hand side

1

(c) decreases yield

1

exothermic reaction

1

(d) moves to right hand side

or

more ammonia produced

1

to replace the ammonia

1

[8]

Q14.

(a) small molecules

1

with weak intermolecular forces

1

(so) only a small amount of energy is needed to separate the molecules

any reference to bonds being weak or being broken negates the second and third mark unless they are stated to be intermolecular bonds or bonds between molecules

1

(b) decreases

1

because the equilibrium shifts in the endothermic direction

allow reverse reaction favoured if forward reaction is exothermic

1

(c) increases

1

because there are more molecules of gas on the left-hand side

or converse

1

[7]

Q15.

(a) changes the rate
or
speeds up the reaction

1

(b) correct label from reactants level to top of curve

1

(c) correct label from reactants level to products level

1

(d) starts at reactant level, ends at products level

1

curves upwards underneath existing curve

1

(e) greater surface area increases catalytic effectiveness

1

plus any **two** from:
- smaller pellets give higher surface area to volume ratio
- hole increases surface area
- ridges increase surface area

2

[8]

Q16.

(a) damp / moist litmus paper

ignore colour of litmus paper

1

bleaches / goes white

1

(b) forward and reverse rates equal

1

because no escape of reactants or products

allow closed system
allow particles for reactants or products

1

(c) equilibrium shifts

allow no longer in equilibrium

1

to right-hand side

allow in favour of forward reaction

1

to produce more of any products
or
to reduce any reactants

allow correct references to Le Chatelier's Principle

1

(new) equilibrium will be established

1

(d) amount of chlorine gas increases

1

(because) system shifts to counteract the change

allow (because) system shifts to take in energy
allow (because) system shifts in endothermic direction

1

(e) no change

1

because equal numbers of molecules
or
moles (of gas) on each side

1

[12]

Q17.

(a) $CaCl_2 + CO_2 + H_2O$

products in any order

1

balancing: **2** (HCl)

dependent on correct formulae for products

1

(b) value from graph used to show volume increase

must include a time or volume value

1

values from graph used to show the volume increases less rapidly

must include time interval or volume increment

1

volume **or** time stated when graph line levels off

*allow levels off at 60 (cm^3) **or** 28 to 30 s*
allow descriptions in terms of rate of reaction

1

values must be approximately correct

(c) draw tangent at <u>15 s</u>

allow draw a straight line on the curve at <u>15 s</u>

1

calculate gradient

allow correct description of gradient calculation
ignore calculations if given

1

(d) centimetres cubed per second

*allow cm^3/s **or** $cm^3\ s^{-1}$ (all lower case)*
allow mixture of abbreviations and words, e.g. centimetres cubed/s

*do **not** accept non-SI abbreviations (e.g. sec for s)*

1

(e) (rate) increases as chips get smaller

allow converse

1

(f) same amount of acid

or

same number of moles of acid

allow same volume of acid
allow same concentration of acid
allow same mass of $CaCO_3$ / marble chips
allow one reactant is the limiting factor

1

(g) (surface area of each face = 2 × 2 =) 4

1

(6 × 4 =) 24 (cm^2)

allow 6 × student's value from step 1

1

*an answer of 24 (cm^2) scores **2** marks*

(h) small(er) chips have large(r) surface area (for the same volume)

allow converse

1

so more frequent collisions

allow more chance of collisions
allow more likely to collide

*do **not** accept reference to speed of particles or energy of collisions*

ignore more collisions
ignore more successful collisions

1

(i) (sloping part is less steep because) reaction is slower

1

due to less frequent collisions

*do **not** accept reference to speed of particles or energy of collisions*
ignore fewer collisions

1

fewer acid particles (in same volume)

ignore weaker acid

1

or

(sloping part is less steep because) reaction is slower (1)

there are fewer acid particles (in same volume) (1)

(graph levels off lower) so less gas is produced (1)

allow converse for more concentrated acid

[17]

Q18.

(a) when a reversible reaction occurs in apparatus which prevents the escape of reactants and products

allow when a reversible reaction occurs in a sealed system

1

(equilibrium is reached) when the forward and reverse reactions occur at (exactly) the same rate

1

(b) (as pressure increases) the equilibrium position shifts to the right hand side

allow (as pressure increases) the percentage of product / dinitrogen tetroxide / N_2O_4 increases

1

(because) there are less moles / molecules (of dinitrogen tetroxide) on right hand side

allow (because) there are more moles / molecules (of nitrogen dioxide) on left hand side

1

(c) (as temperature increases) equilibrium position shifts to left hand side

1

(because the forward) reaction is exothermic
or
(because) the backward reaction is endothermic

1

(so) the percentage of product / dinitrogen tetroxide / N_2O_4 decreases

1

[7]

Q19.

(a) glowing splint

1

relights

1

(b) equilibrium shifts to right-hand side

allow towards the products

allow in favour of the forward reaction

1

(because) concentration of SO_3 decreases

this marking point is dependent on first marking point being awarded

allow pressure decreases

allow to increase the concentration of SO_3 allow to re-establish equilibrium

1

(c) (M_r CaO =) 56

1

(M_r $CaSO_3$ =) 120

1

$\frac{7}{56} \times 120$

1

= 15(.0 g)

*an answer of 15(.0 g) scores **4** marks*

in all approaches allow a correct calculation using an incorrectly calculated M_r

alternative approach A

(M_r CaO =) 56 (1)

$\frac{7}{56}$ = 0.125 (moles) (1)

(mass $CaSO_3$ =) 0.125 × 120 (1)

= 15(.0 g) (1)

1

alternative approach B

M_r CaO =) 56 (1)

$\frac{56}{7}$ = 8 (factor) (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{8}$ = 15(.0 g) (1)

alternative approach C

M_r CaO =) 56 (1)

M_r $CaSO_3$ =) 120 (1)

$\frac{120}{56}$ *= 2.14235714 (factor) (1)*

2.14235714 × 7 = 15(.0 g) (1)

[8]

Q20.

(a) $Mg + 2H^+ \longrightarrow Mg^{2+} + H_2$

1

(b) electron transfer

1

(c) all points correctly plotted

allow a tolerance of ± 1/2 a small square

*allow **1** mark for at least 4 points correctly plotted*

2

line of best fit

1

(d) (rate) decreases

allow (rate is) fastest at the beginning

1

(rate decrease) more slowly as time increases (in rate)

1

(rate) becomes zero at time read from graph

allow reaction stops at time read from graph

1

(e) (rate decreases because) fewer particles (of acid / magnesium) as reaction progresses

allow (rate decreases because) concentration of acid decreases as reaction progresses

1

(so) less frequent collisions

allow collisions less likely

ignore less / fewer collisions

1

reaction stops due to limiting factor / reagent

allow reaction stops because a reactant is used up

1

*Incorrect reference to energy scores **max. 1***

[11]