Rates of Reaction 3

Name: _____

Class: _____

Date: _____

Time: **76 minutes**

Marks: **70 marks**

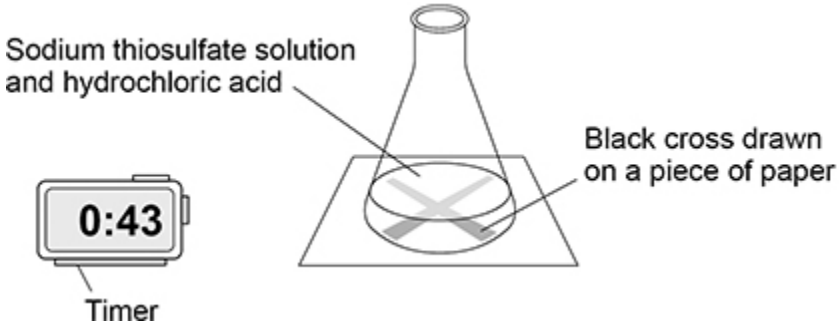
Comments:

1. A student investigates the effect of concentration on the rate of the reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 1 shows the experiment.

The experiment was done in a fume cupboard.

Figure 1



This is the method used.

1. Pour 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Pour 10 cm^3 of hydrochloric acid into the conical flask and start a timer.

4. Stop the timer when the cross can no longer be seen.

5. Repeat the experiment with different concentrations of sodium thiosulfate solution.

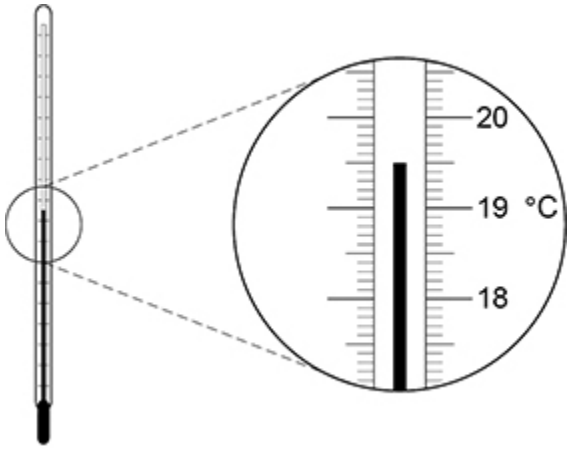
(a) Draw **one** line from each type of variable to the correct example of the variable in this investigation.

Type of variable	Example of variable
	Concentration of sodium thiosulfate solution
Dependent	Temperature of reaction mixture
	Time taken for the cross to no longer be seen
Independent	Volume of acid
	Volume of the flask

(2)

(b) The experiment is done at room temperature.

Figure 2



What is the temperature shown on the thermometer in **Figure 2**?

Temperature = _____ °C

(1)

Table 1 shows the student's results.

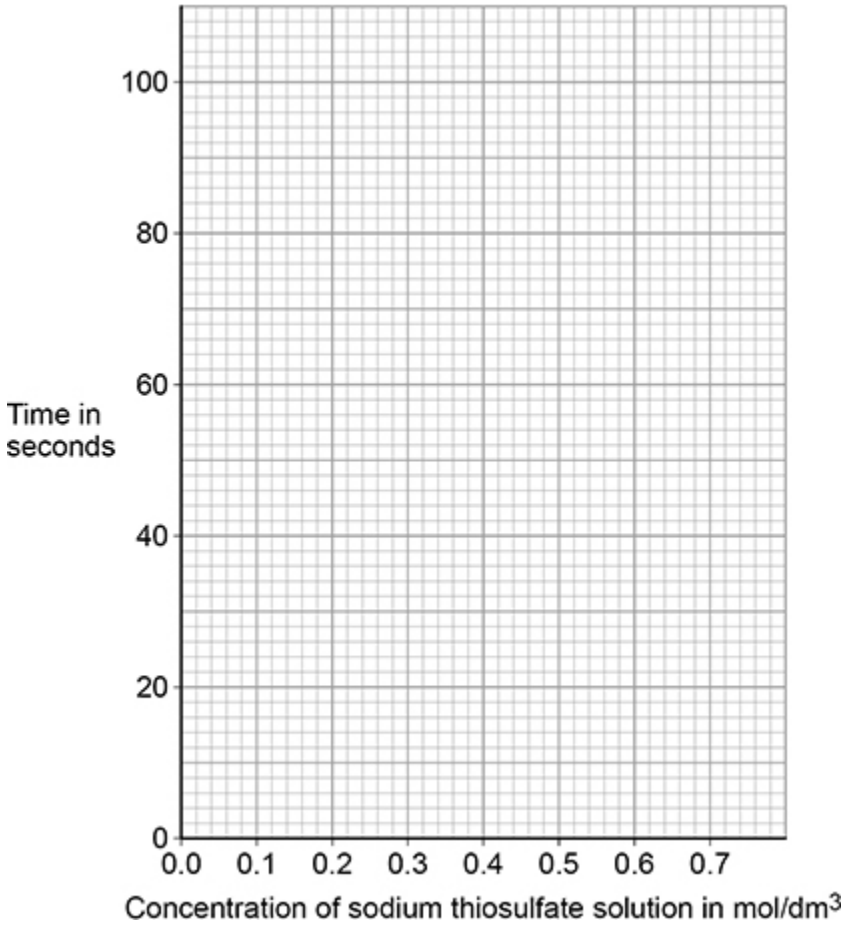
Table 1

Concentration of sodium thiosulfate solution in mol/dm^3	Time in seconds
0.1	82
0.2	40
0.3	20
0.4	13
0.5	10
0.6	8

(c) Plot the data from **Table 1** on **Figure 3**.

Draw a line of best fit.

Figure 3



(3)

(d) Predict the time taken for the cross to no longer be seen at a concentration of 0.7 mol/dm^3

Use your graph in **Figure 3**.

Time = _____ s

(1)

(e) Complete the sentence.

As the concentration of sodium thiosulfate solution increases, the time taken for the cross to no longer be seen _____.

(1)

(f) In one experiment 0.725 g of sulfur is produced in 20 seconds.

Calculate the mean rate of the reaction from 0 to 20 seconds.

Use the equation:

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

_____

_____

Mean rate of reaction = _____

(2)

(g) What is the unit for the mean rate of reaction calculated in part (f)?

Tick (✓) **one** box.

g ☐ g/s ☐ s ☐ s/g ☐

(1)

(h) The student did the experiment with 0.15 mol/dm^3 sodium thiosulfate solution and repeated the experiment three more times.

Table 2 shows the results.

Table 2

	Test 1	**Test 2**	**Test 3**	**Test 4**
Time in seconds for the cross to no longer be seen	60.5	63.2	82.3	65.7

Calculate the mean time for this reaction.

Do **not** include the anomalous result in your calculation.

Give your answer to 3 significant figures.

Mean time for the reaction (3 significant figures) = _____ s

(3)

(Total 14 marks)

2. This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

The equation for the reaction is:

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

(a) The mass of the conical flask and contents was greater at the start of the reaction than at the end.

Explain why.

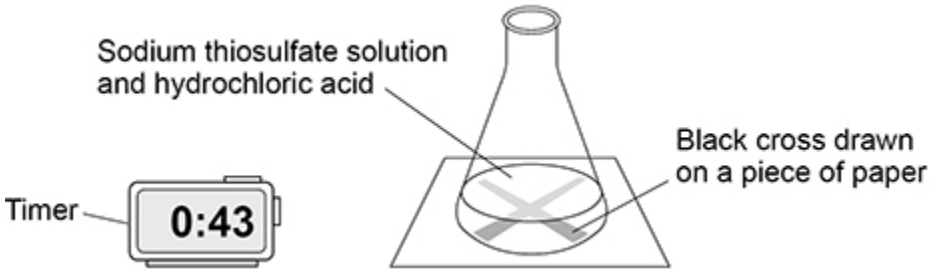
(2)

A teacher demonstrated the reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 1 shows the experiment.

The experiment was done in a fume cupboard.

Figure 1



This is the method the teacher used.

1. Pour 50 cm^3 of sodium thiosulfate solution into a conical flask.

2. Put the conical flask on a black cross drawn on a piece of paper.

3. Pour 10 cm^3 of hydrochloric acid into the conical flask and start a timer.

4. Stop the timer when the cross can no longer be seen.

5. Repeat the experiment at different temperatures.

(b) What type of variable is time in this reaction?

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

(1)

(c) The table below shows the results.

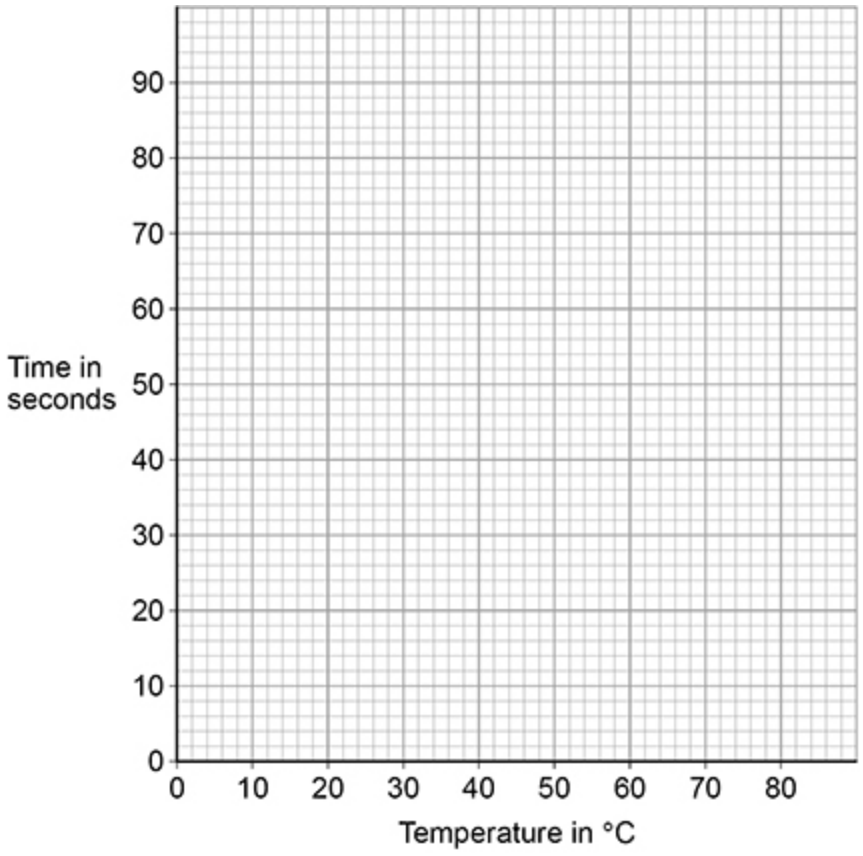
Temperature in °C	Time in seconds
19	82
32	48
45	43
52	15
63	7
73	3

Complete **Figure 2**.

You should:

- plot the data from the table above on **Figure 2**
- draw a line of best fit.

Figure 2

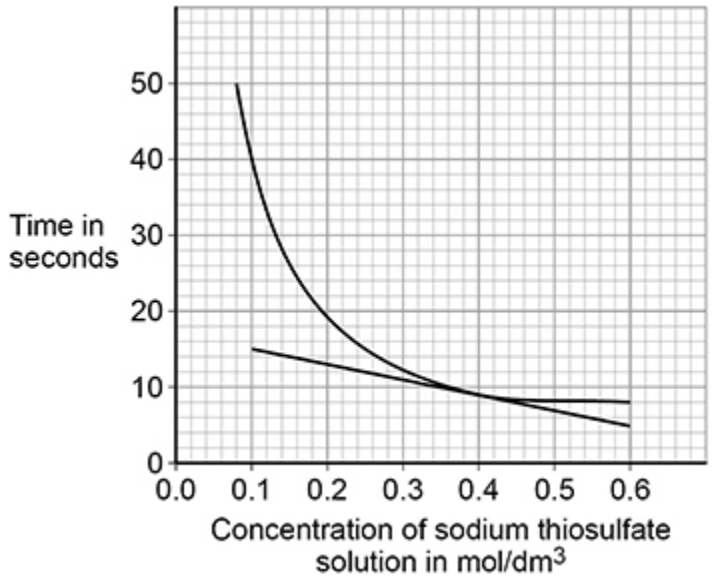


(3)

(d) A student investigated the effect of concentration of sodium thiosulfate on the time taken for the reaction at room temperature.

Figure 3 shows the results with a tangent drawn at 0.4 mol/dm^3

Figure 3



Calculate the gradient (slope) of the tangent at 0.4 mol/dm^3

Give the unit.

Gradient = _____

Unit = _____

(4)

(e) The student determined the **rate** of the reaction at regular time intervals during an experiment.

Explain why the **rate** decreased during the reaction.

You should give your answer in terms of particles.

_____

_____

_____

_____

(2)

(Total 12 marks)

3. This question is about catalysts and equilibrium.

(a) What type of substance is a catalyst in biological systems?

Tick (✓) **one** box.

Algae	☐
Alkene	☐
Enzyme	☐
Formulation	☐

(1)

(b) Explain how a catalyst increases the rate of a reaction.

_____

_____

_____

_____

(2)

The reversible reaction for the production of ammonia is:

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

(c) What can scientists predict using Le Chatelier's Principle?

_____

_____

(1)

(d) Describe how a reversible chemical reaction is able to reach equilibrium.

_____

_____

_____

_____

(2)

(e) Explain the effect of increasing the pressure on the yield of ammonia.

_____

_____

_____

_____

(2)

(f) The forward reaction to produce ammonia is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia.

_____

_____

_____

_____

(2)

(Total 10 marks)

4. Fresh water contains low levels of dissolved salts.

Water reacts with anhydrous copper sulfate in a reversible reaction.

The word equation for the reaction is:

water + anhydrous copper sulfate ⇌ hydrated copper sulfate

(a) How does the equation show that the reaction is reversible?

_____

_____

(1)

(b) Complete the sentences.

Choose answers from the box.

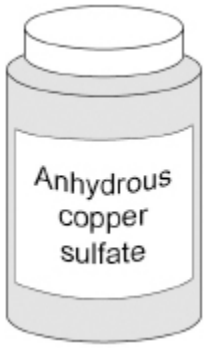
blue	**green**	**orange**	**white**	**yellow**

The colour of anhydrous copper sulfate is _____.

The colour of hydrated copper sulfate is _____.

(2)

(c) The figure below shows anhydrous copper sulfate in a sealed container.



Suggest **one** reason why anhydrous copper sulfate is kept in a sealed container.

_____

_____

(1)

Sodium chloride dissolves in water to form sodium chloride solution.

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

Substance	Description of substance
	Compound
Sodium chloride solution	Element
Water	Hydrocarbon
	Mixture

(2)

(e) Name the process used to obtain solid sodium chloride from sodium chloride solution.

_____

(1)

(f) Two processes used to obtain potable water from fresh water are:

- filtering
- sterilising.

Give **one** reason why each process is used.

Filtering _____

_____

Sterilising _____

_____

(2)

(g) Which type of water is the easiest to obtain potable water from?

Tick (✓) **one** box.

Ground water ☐

Salt water ☐

Waste water ☐

(1)

(h) Which of the following is the first stage of waste water treatment?

Tick (✓) **one** box.

Aerobic biological treatment of effluent ☐

Anaerobic digestion of sewage sludge ☐

Screening and removal of grit ☐

(1)

(Total 11 marks)

5. 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 → _____ + _____

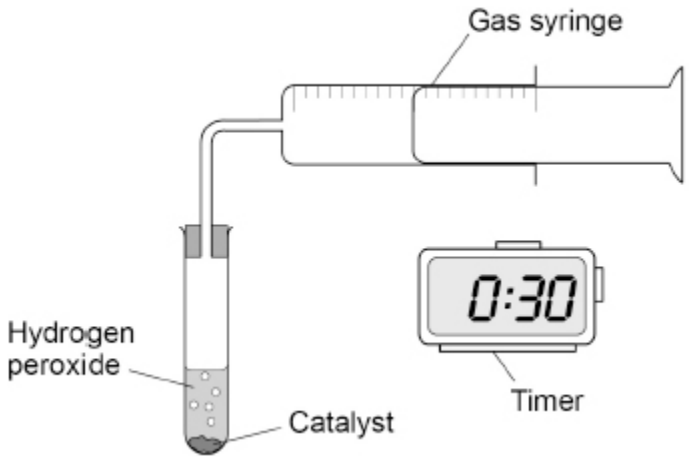
(2)

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.

Figure 1



(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 ☐

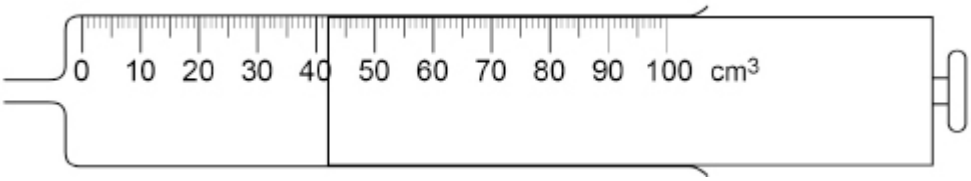
Type of catalyst ☐

Volume of gas collected ☐

(2)

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

Figure 2



What is the volume of gas in the syringe?

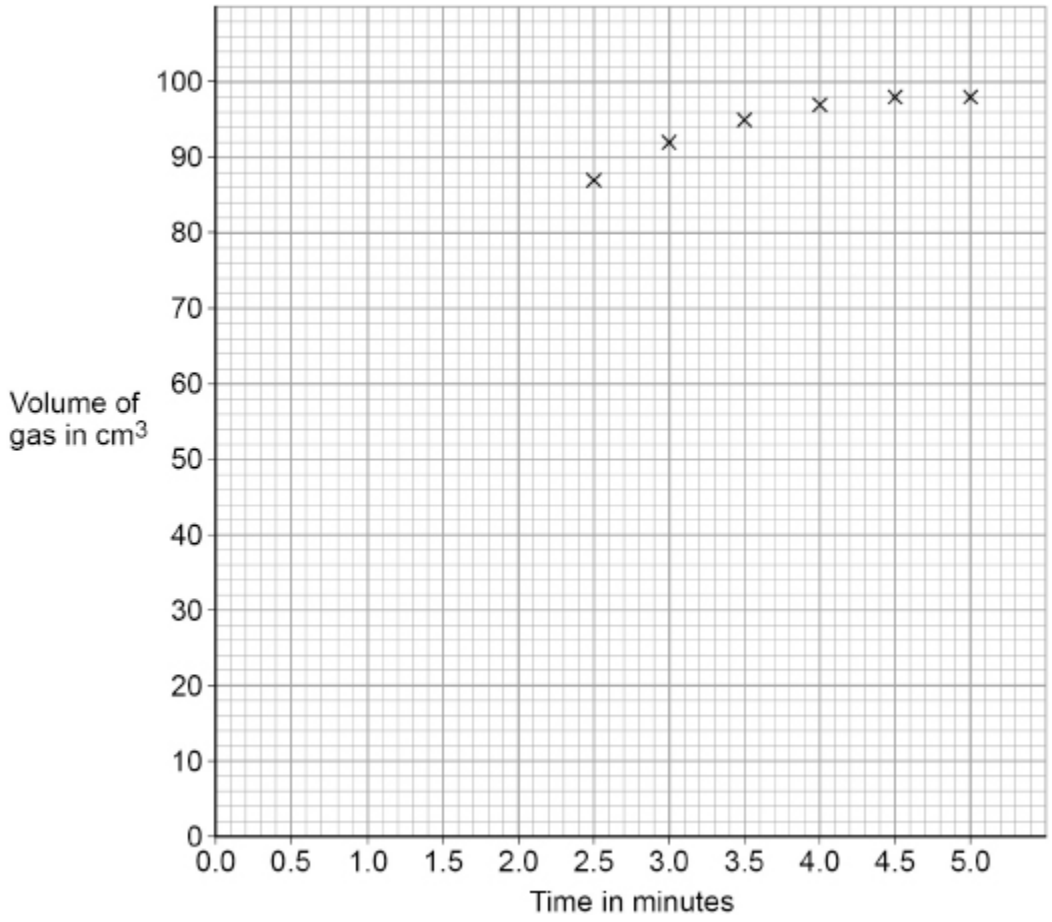
Volume = _____ cm^3

(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)

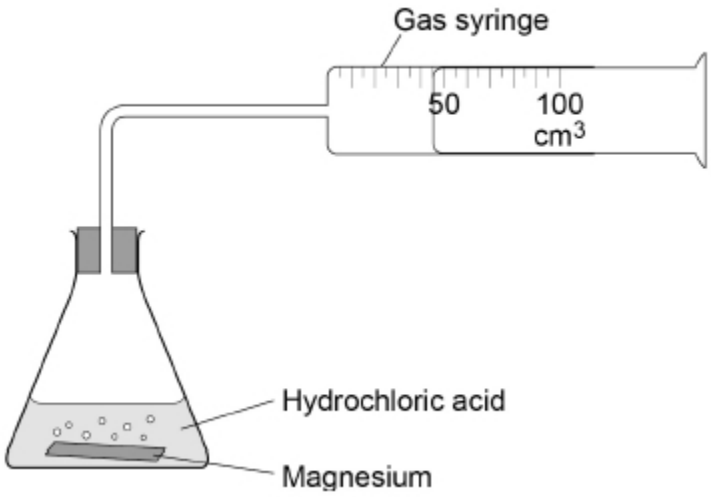
(Total 12 marks)

6. This question is about magnesium.

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

Figure 1 shows the apparatus.

Figure 1



(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)

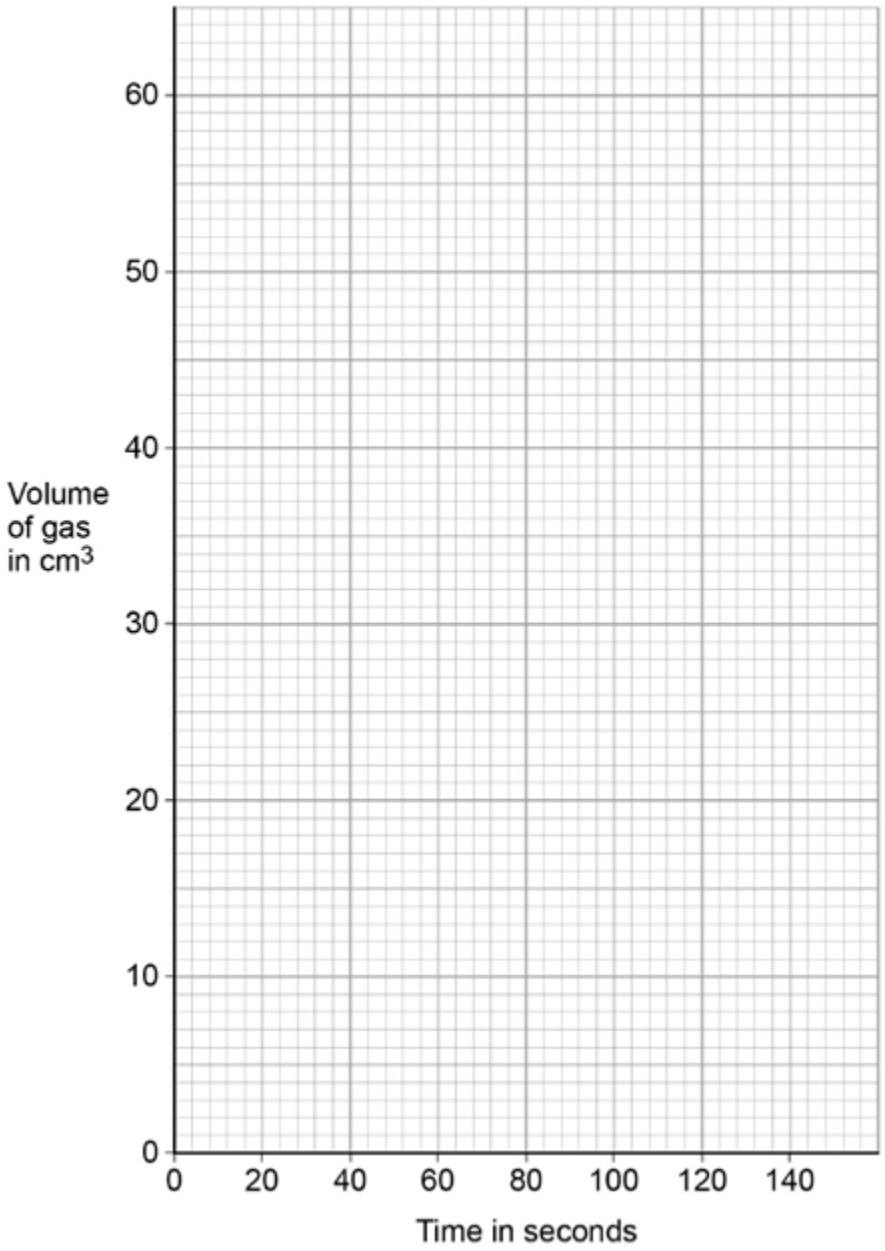
(c) The table shows the student's results.

Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^2	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)

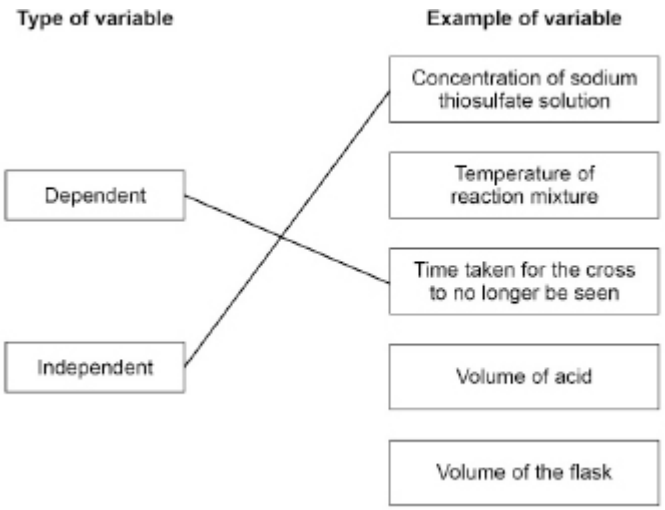
(e) Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

(3)

(Total 11 marks)

1. (a)



*do **not** accept more than one line from a box on the left*

2

(b) 19.5 (°C)

1

(c) all points correctly plotted

allow a tolerance of ± ½ a small square

*allow **1** mark for 3 / 4 / 5 points correctly plotted*

2

line of best fit

1

(d) 7 (s)

*allow ecf from part **(c)***

allow a tolerance of ± ½ a small square

1

(e) decreases

1

(f) (mean =) $\frac{0.725}{20}$

1

= 0.03625

ignore units

1

(g) g/s

1

(h) (mean =) $\frac{60.5 + 63.2 + 65.7}{3}$

*allow for **1** mark*

$\frac{60.5 + 63.2 + 65.7 + 82.3}{4} = 67.925$

1

= 63.13333 (s)

1

= 63.1 (s)

allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses the values in the question

1

[14]

2. (a) sulfur dioxide produced

allow a gas is produced

1

(which) escapes from the (conical) flask

1

(b) dependent

1

(c) all points correctly plotted

*allow **1** mark for 3, 4 or 5 points correctly plotted*

allow a tolerance of ± ½ a small square

2

line of best fit

1

(d) correct values for *x* step **and** *y* step from tangent

1

$(\text{rate} =) \frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$

allow correct use of an incorrectly determined value from tangent for x step and/or y step

1

correct calculation of rate

1

s dm^3 / mol

1

(e) (as reaction proceeds) fewer (sodium thiosulfate) particles per unit volume

allow (as reaction proceeds) concentration (of sodium thiosulfate) decreases

1

(so) frequency of (particle) collisions decreases

allow (so) probability of collision decreases

1

[12]

3.

(a) enzyme

1

(b) provides a different reaction pathway

1

(which) has a lower activation energy

1

(c) the effects of changing conditions on the position of an equilibrium (in a closed system)

allow the effects of changing conditions on the yield of an equilibrium reaction (in a closed system)

1

(d) (when) the forward and reverse reactions have the same rate

1

in apparatus which prevents the escape of reactants and products

allow in a closed system

1

(e) yield increases

1

(because) there are more moles (of gas) on the left hand side

allow (because) there are fewer moles (of gas) on the right hand side

1

(f) yield decreases

1

(because) the system shifts in the endothermic direction

1

[10]

4.

(a) (the symbol) ⇌

allow description of reversible sign

1

(b) white

must be in this order

1

blue

1

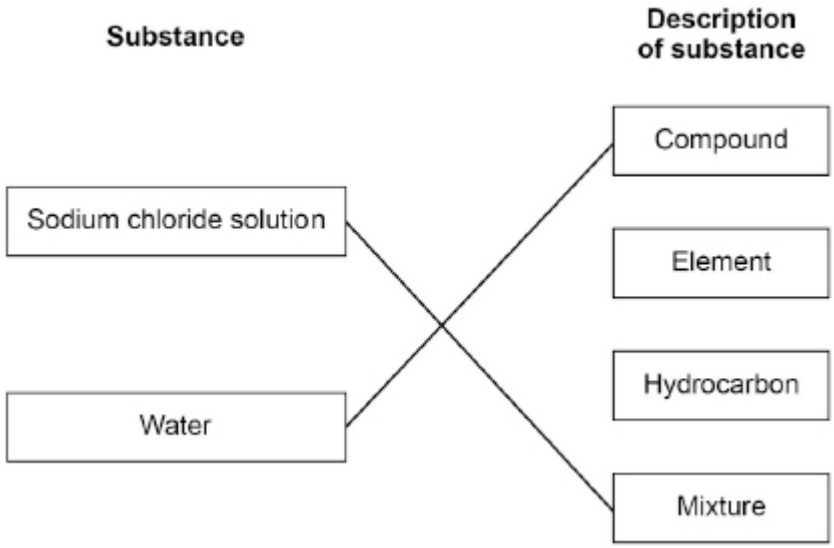
(c) to prevent reaction with water vapour (in the air)

allow to prevent reaction with moisture

allow to keep water out

1

(d)



do **not** accept more than one line from a box on the left

1

1

(e) evaporation

or

crystallisation

1

(f) (filtering) to remove solids

1

(sterilising) to kill bacteria

allow to kill microbes

1

(g) ground water

1

(h) screening and removal of grit

1

[11]

5. (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]

6. (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]