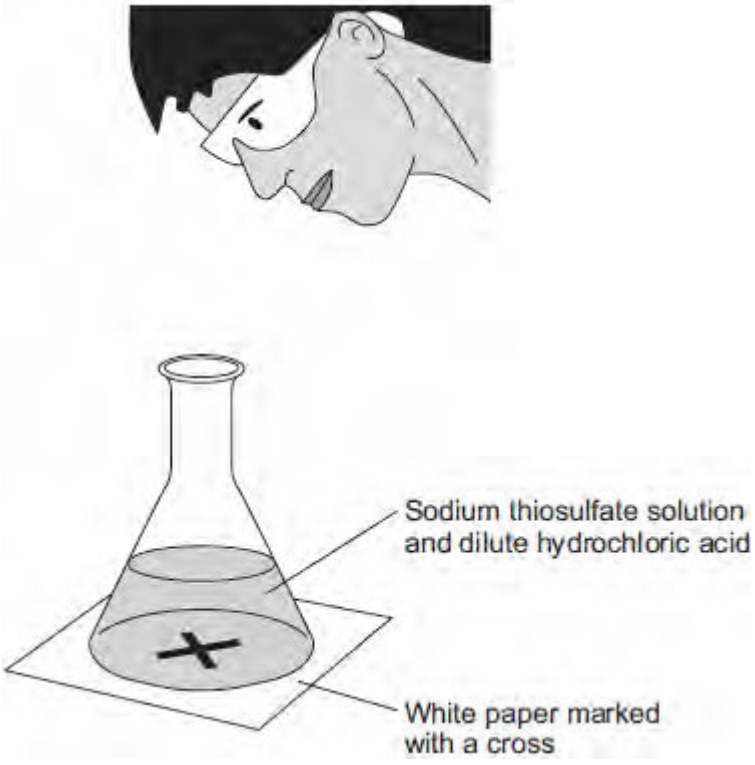
Q1. A student investigated the rate of reaction between sodium thiosulfate solution and dilute hydrochloric acid, as shown in **Figure 1**.

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.

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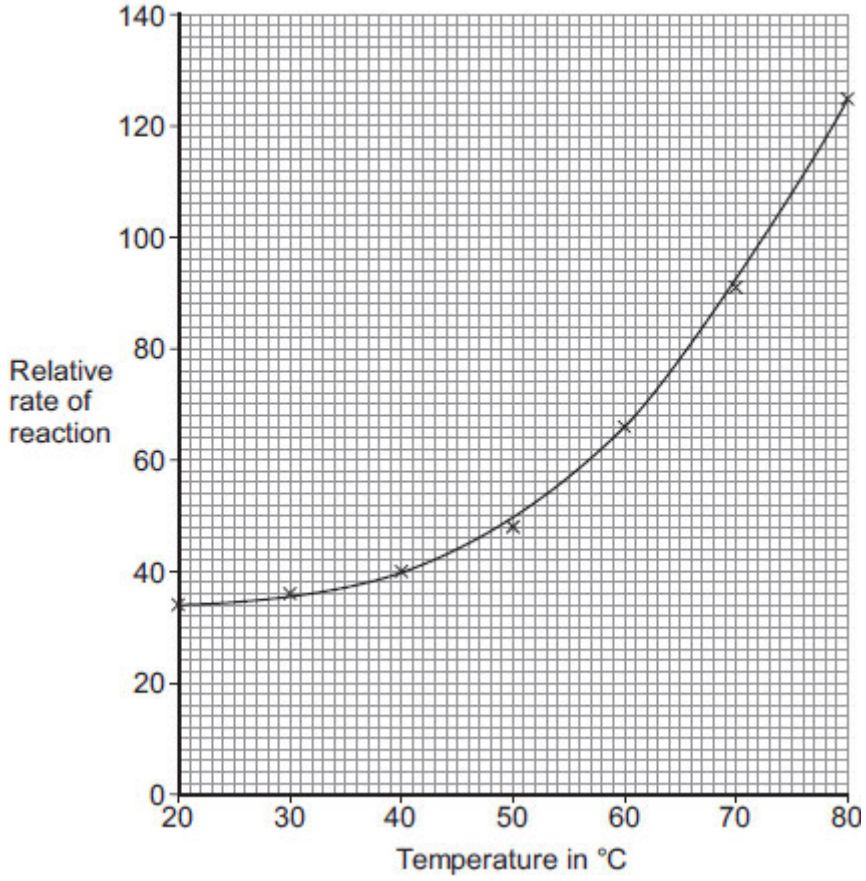
(1)

(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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(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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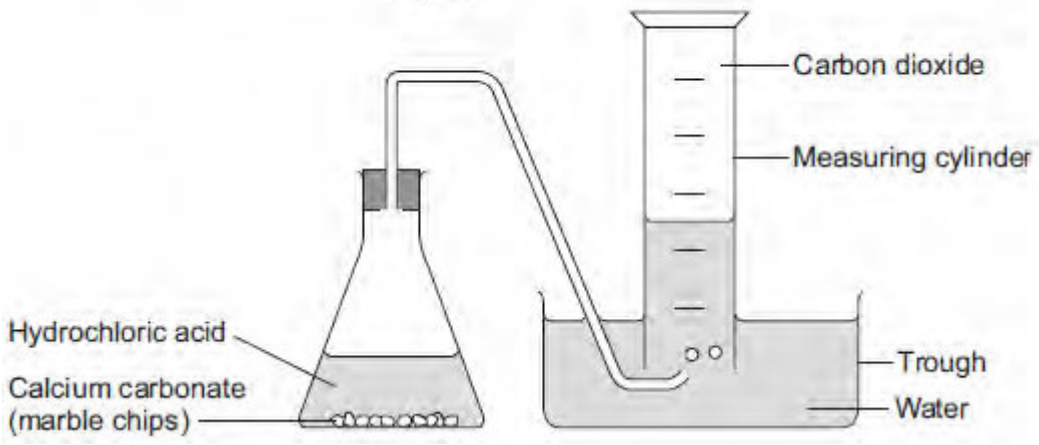
(3)
(Total 8 marks)

Q2. 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.

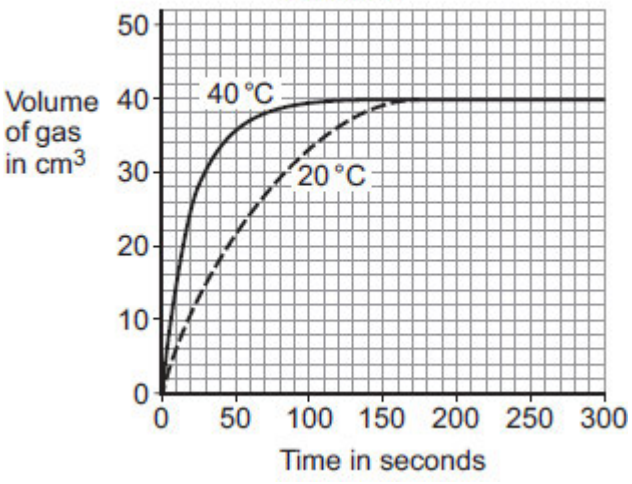
The equation for the reaction is:

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

(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.

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(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.

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.....

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)

Q3. Lead nitrate solution reacts with potassium iodide solution.

The reaction produces a solid.

Figure 1 shows the reaction occurring.

Figure 1

Lead Iodide By Der Kreole (own work) (CC-BY-3.0) via Wikimedia Commons

(a) (i) Give the name of this type of reaction.

Tick (✓) **one** box.

Combustion ☐

Neutralisation ☐

Precipitation ☐

(1)

(ii) Write the missing state symbols in the chemical equation.

$Pb(NO_3)_2$(aq) + 2KI(.....) ⟶ PbI_2(.....) + $2KNO_3$(aq)

(2)

(iii) Complete the word equation for the reaction.

lead nitrate + ... ⟶ lead iodide + ...

(2)

(iv) How is solid lead iodide separated from the solution?

Draw a ring around the correct answer.

Distillation **Electrolysis** **Filtration**

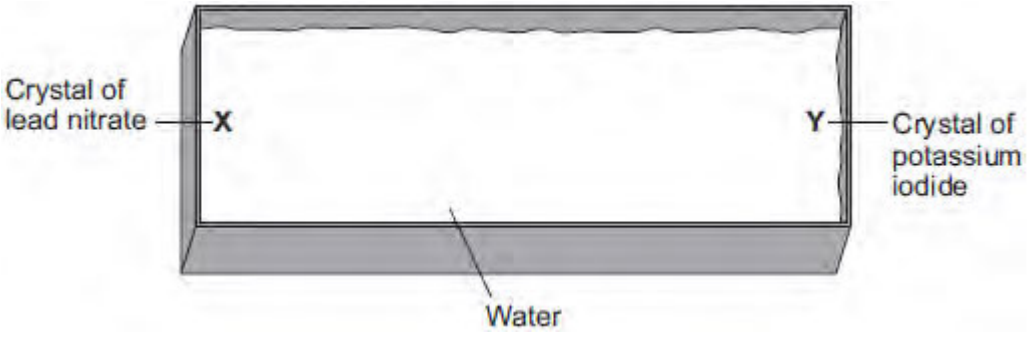
(1)

(b) A group of students investigated the movement of particles.

The students filled a container with water.

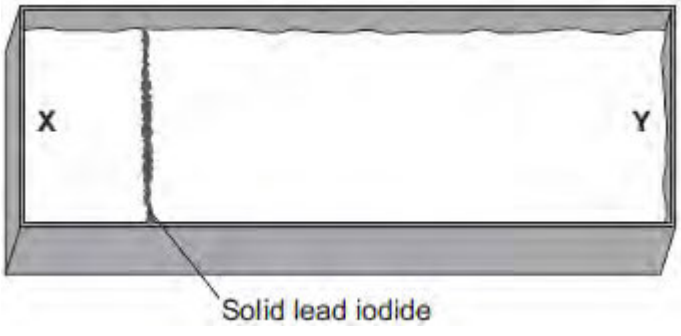
The students added a crystal of lead nitrate at position **X** and a crystal of potassium iodide at position **Y**, as shown in **Figure 2**.

Figure 2 – view from above



After 3 minutes solid lead iodide started to form at the position shown in **Figure 3**.

Figure 3 – view from above



(i) Tick (✓) the correct box to complete the sentence.

Lead ions and iodide ions move through the water by

diffusion. ☐

evaporation. ☐

neutralisation. ☐

(1)

(ii) What conclusion can you make about the speed of movement of lead ions compared with iodide ions?

Give a reason for your answer.

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(2)

(iii) The students repeated the experiment at a higher temperature.

The solid lead iodide formed after a shorter period of time.

Explain why, in terms of particles.

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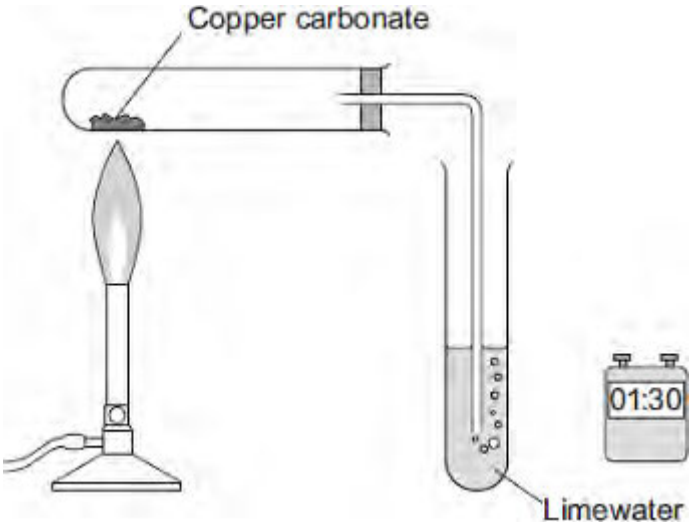
(2)

(Total 11 marks)

Q4. Carbon dioxide is produced when copper carbonate is heated.

A student investigated heating copper carbonate.
The student used the apparatus to measure how long it took for carbon dioxide to be produced.
The student also noted what happened during each minute for three minutes.



(a) The student used changes to the limewater to measure how long it took for carbon dioxide to be produced.

Describe how.

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(2)

(b) The student wrote down her observations.

Time interval in minutes	**Observations**
Between 0 and 1	A slow release of gas bubbles. The limewater did not change. The solid in the test tube was green.
Between 1 and 2	A fast release of gas bubbles.

	The limewater changed at 1 minute 10 seconds.
Between 2 and 3	No release of gas bubbles. The solid in the test tube was black.

(i) Suggest the reason for the student's observations between 0 and 1 minute.

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(2)

(ii) Explain the student's observations between 1 and 2 minutes.

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(2)

(iii) Explain the student's observations between 2 and 3 minutes.

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(2)

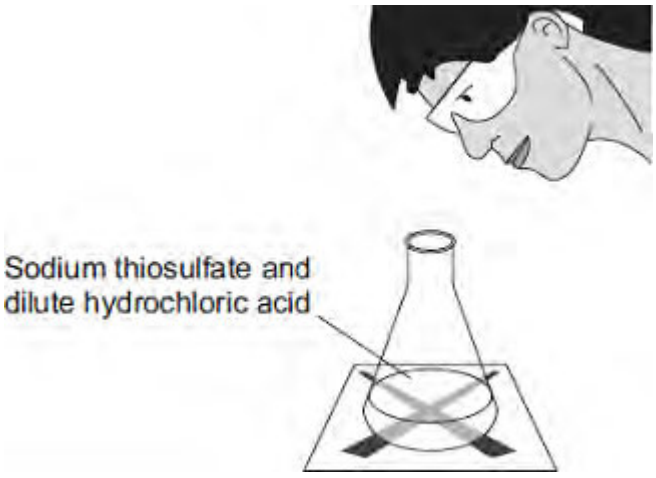
Q5. A student investigated the rate of reaction between sodium thiosulfate and dilute hydrochloric acid.

The student placed a conical flask over a cross on a piece of paper.

The student mixed the solutions in the flask.

The solution slowly went cloudy.

The student timed how long it took until the cross could not be seen.



The equation for the reaction is:

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

sodium thiosulfate + hydrochloric acid → sodium chloride + water + sulfur dioxide + sulfur

(a) Explain why the solution goes cloudy.

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(2)

(b) The student repeated the experiment with different concentrations of sodium thiosulfate.

Concentration of	**Time taken until the cross could not be**

sodium thiosulfate in moles per dm^3	seen in seconds			
	Trial 1	**Trial 2**	**Trial 3**	**Mean**
0.040	71	67	69	69
0.060	42	45	45	44
0.080	31	41	33	

(i) Calculate the mean time for 0.080 moles per dm^3 of sodium thiosulfate.

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Mean = ... seconds

(2)

(ii) Describe and explain, in terms of particles and collisions, the effect that increasing the concentration of sodium thiosulfate has on the rate of the reaction.

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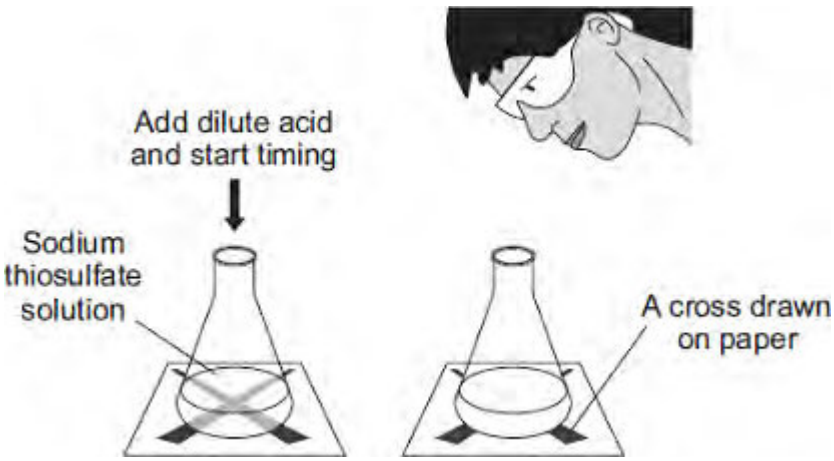
(3)
(Total 7 marks)

Q6. 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 study how changing the concentration of the sodium thiosulfate solution alters the rate of this reaction.

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

The results of the experiments 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.

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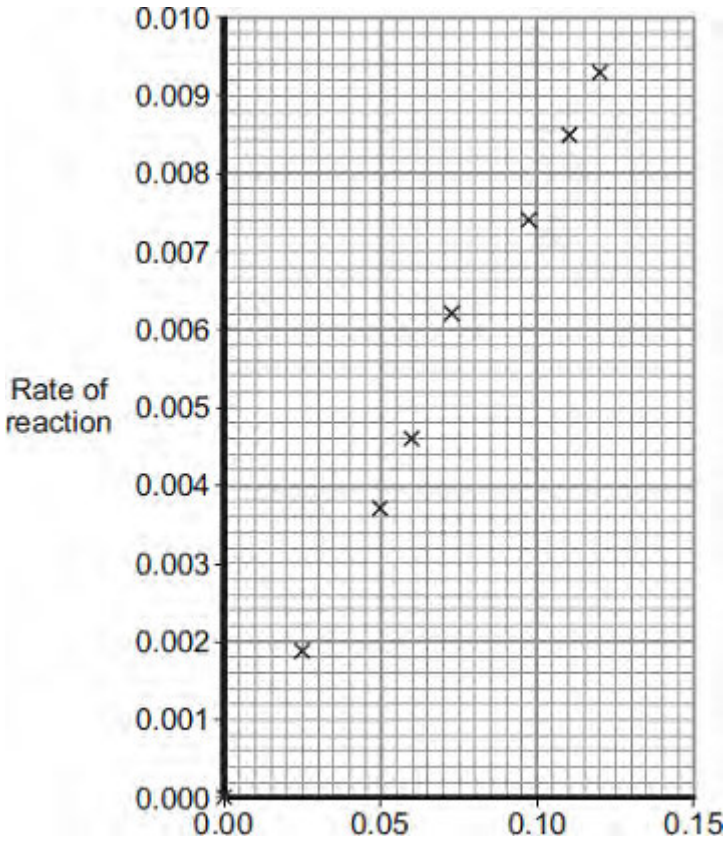
(2)



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

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

How does the graph support this conclusion?

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(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)

Q7. The symbol equation for the decomposition of hydrogen peroxide is:

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

(a) This reaction is *exothermic*.

What is an *exothermic* reaction?

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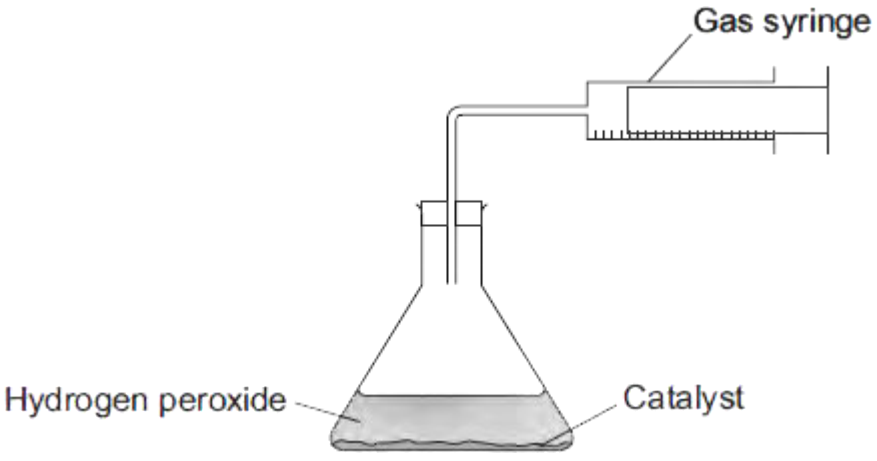
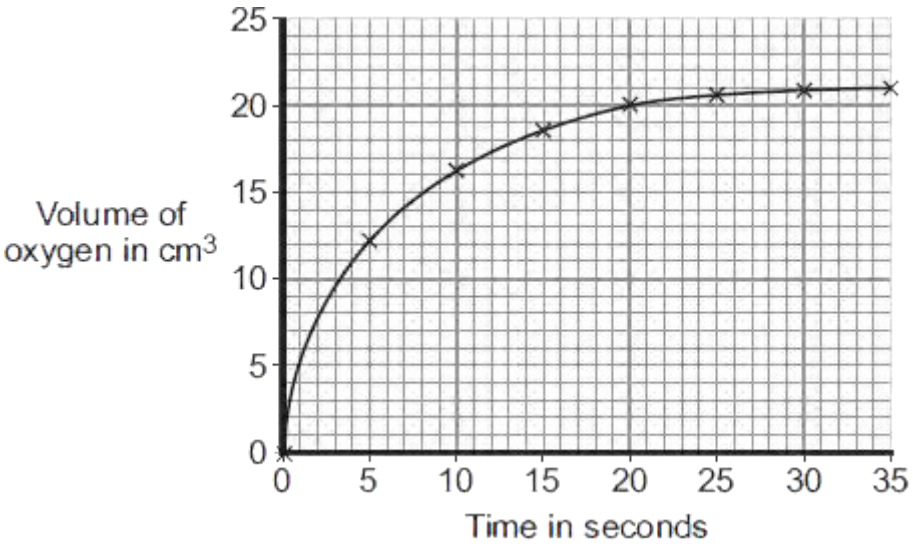
(1)

(b) A student measured the volume of oxygen produced by 50 cm^3 of hydrogen peroxide.



The graph shows the results.



(i) Use the graph to describe the changes in the rate of the reaction from 0 to 35 seconds.

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(3)

(ii) What was the total volume of oxygen gas collected?

..... cm^3

(1)

(iii) The student had calculated that the hydrogen peroxide used should produce 25 cm^3 of oxygen.

Calculate the percentage yield of oxygen.

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Answer = ... %

(2)

(c) An increase in the temperature of the hydrogen peroxide increases the rate of the reaction.

Use your knowledge of particles to explain why.

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(3)
(Total 10 marks)