Q1. When iodine molecules are dissolved in aqueous solutions containing iodide ions, they react to form triiodide ions (I_3^-).

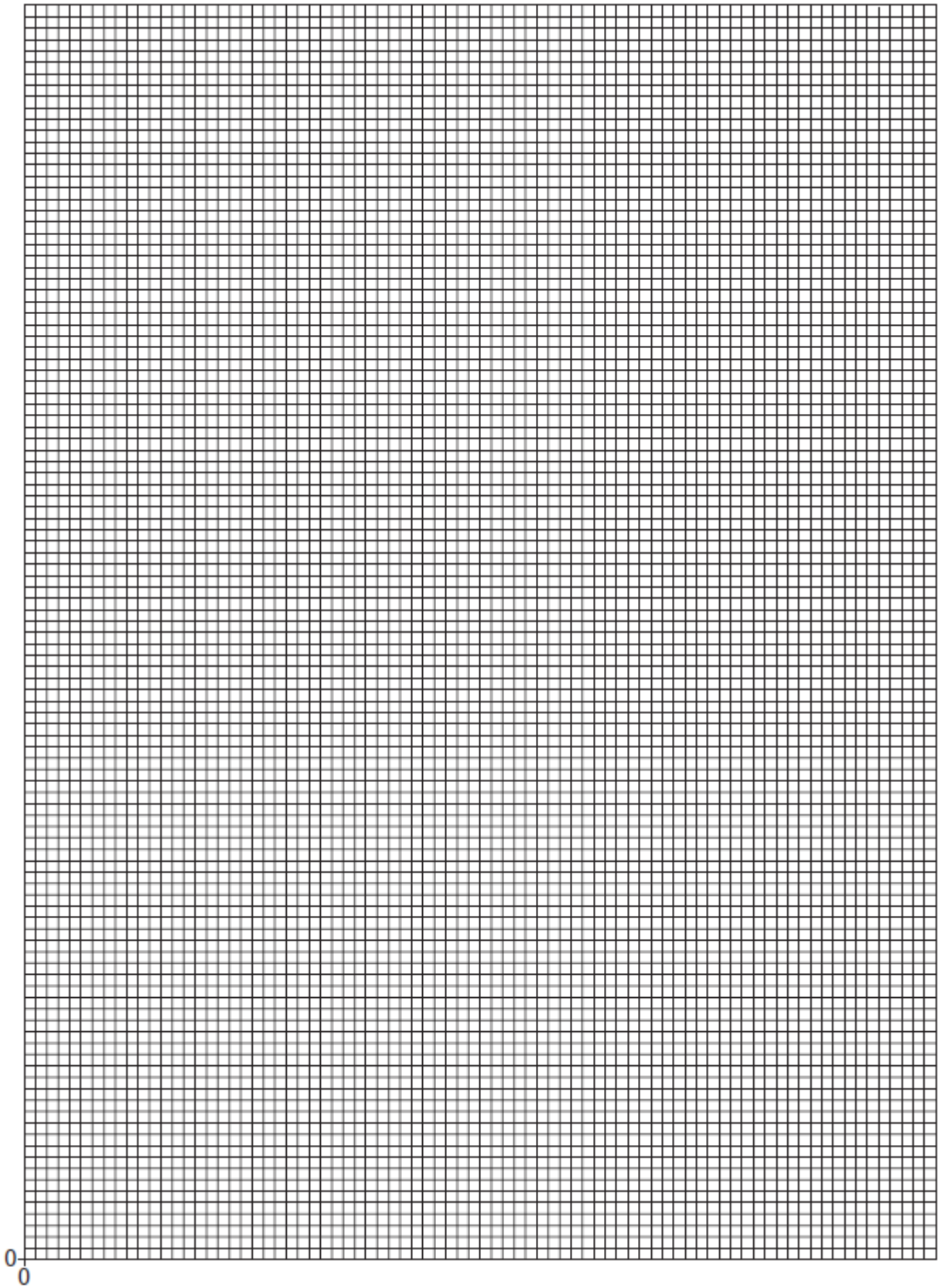
$$I_2 + I^- \longrightarrow I_3^-$$

The rate of the oxidation of iodide ions to iodine by peroxodisulfate(VI) ions ($S_2O_8^{2-}$) was studied by measuring the concentration of the I_3^- ions at different times, starting at time = 0, when the reactants were mixed together. The concentration of the I_3^- ions was determined by measuring the absorption of light using a spectrometer.

The table below shows the results.

Time / s	**Concentration of I_3^- / mol dm^{-3}**
10	0.23
20	0.34
30	0.39
40	0.42
50	0.47
60	0.44
70	0.45

(a) Plot the values of the concentration of I_3^- (y-axis) against time on the grid below.



(2)

(b) A graph of these results should include an additional point. On the grid, draw a ring

around this additional point.

(1)

(c) Draw a best-fit curve on the grid, **including the extra point from part (b)**.

(2)

(d) Draw a tangent to your curve at time = 30 seconds. Calculate the slope (gradient) of this tangent and hence the rate of reaction at 30 seconds. Include units with your final answer.
Show your working.

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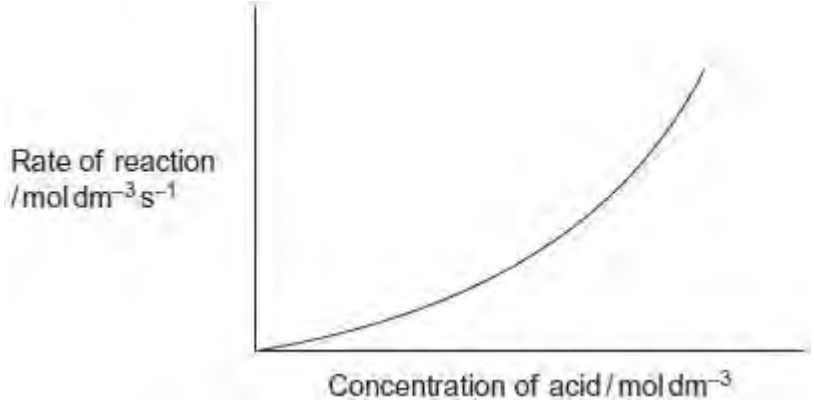
(4)
(Total 9 marks)

Q2.(a) In an investigation of the rate of reaction between hydrochloric acid and pure magnesium, a student obtained the following curve.



The reaction of magnesium with dilute hydrochloric acid is exothermic.

Use your understanding of collision theory to explain why the student did **not** obtain a straight line.

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(3)

(b) The magnesium used in a laboratory experiment was supplied as a ribbon. The ribbon was stored in an open plastic bag exposed to the air.

Explain why it is important to clean the surface of this magnesium ribbon when investigating the rate of its reaction with hydrochloric acid.

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(2)

(c) Magnesium ribbon reacts with hot water. Heated magnesium ribbon reacts with steam. State **two** differences between these reactions.

Difference 1 .....

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Difference 2 .....

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(2)

(d) Pure magnesium reacts completely with an excess of dilute sulfuric acid.
The reaction of pure calcium with an excess of dilute sulfuric acid is very rapid initially.
This reaction slows down and stops before all of the calcium has reacted.

Use your knowledge of the solubilities of Group 2 sulfates to explain why these reactions of magnesium and calcium with dilute sulfuric acid are so different.

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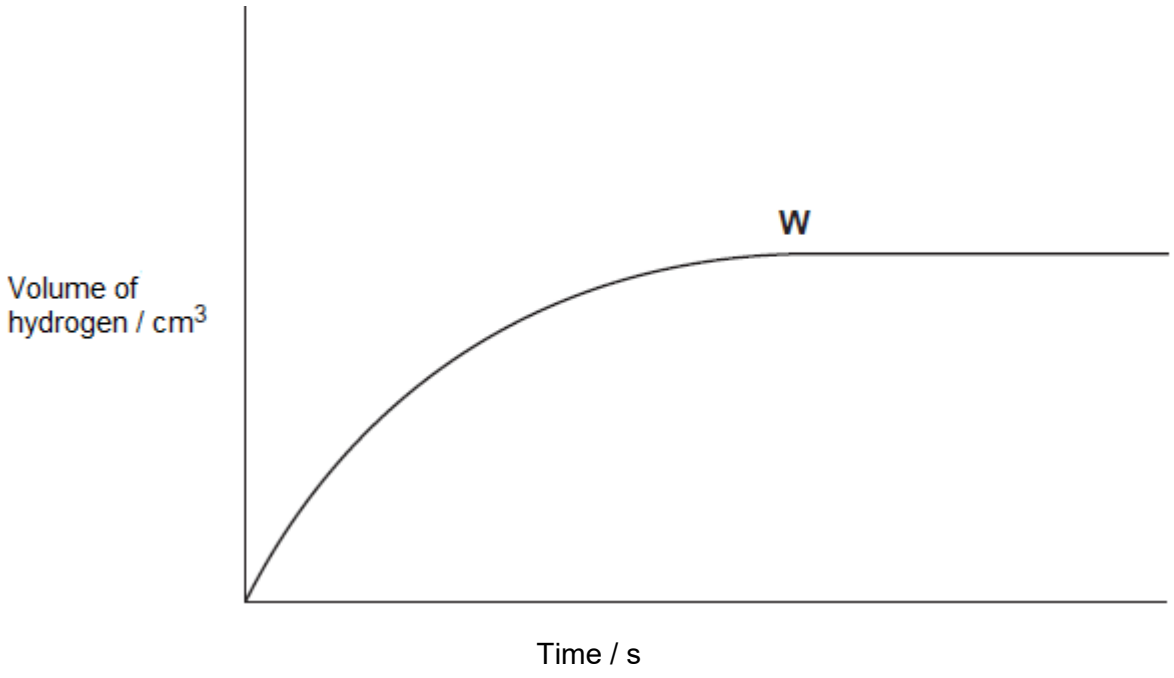
(3)
(Total 10 marks)

Q3.(a) **Figure 1** shows the volume of hydrogen gas collected when a sample of magnesium reacted with an excess of dilute hydrochloric acid.

The rate of this reaction can be studied by measuring the time it takes for a given volume of hydrogen to be collected.

Figure 1



(i) State the meaning of the term *rate of reaction*.

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(1)

(ii) State and explain what has happened to the rate of this reaction at point **W** in **Figure 1**.

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(2)

(iii) In terms of collision theory explain why, at a fixed temperature, the rate of this reaction doubles when the concentration of the hydrochloric acid doubles.

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(2)

(b) In a study of the reaction in part (a), a student referred to activation energy.

(i) State the meaning of the term *activation energy*.

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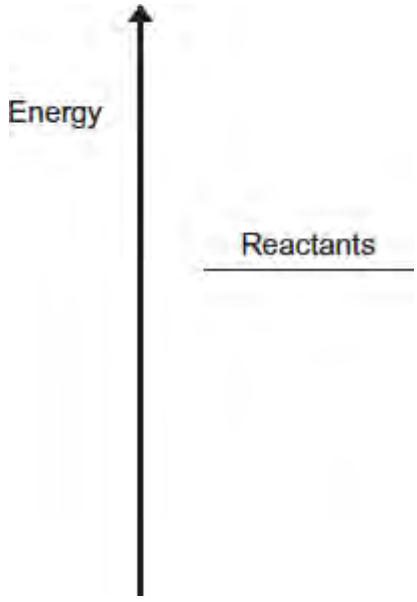
(1)

(ii) Complete **Figure 2** by drawing the shape of the reaction profile from reactants to products for an exothermic reaction.
Show the position of the products. Show and label the activation energy.

Figure 2



(2)

(c) Barium metal reacts very quickly with dilute hydrochloric acid, but it reacts more slowly with water.

(i) Write an equation for the reaction of barium with water.

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(1)

(ii) A solution containing barium ions can be used to show the presence of sulfate ions in an aqueous solution of sodium sulfate.

Write the **simplest ionic** equation for the reaction that occurs and state what is observed.

Simplest ionic equation

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Observation

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(2)

(iii) State **one** use of barium sulfate in medicine.
Explain why this use is possible, given that solutions containing barium ions are poisonous.

Use .....

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Explanation .....

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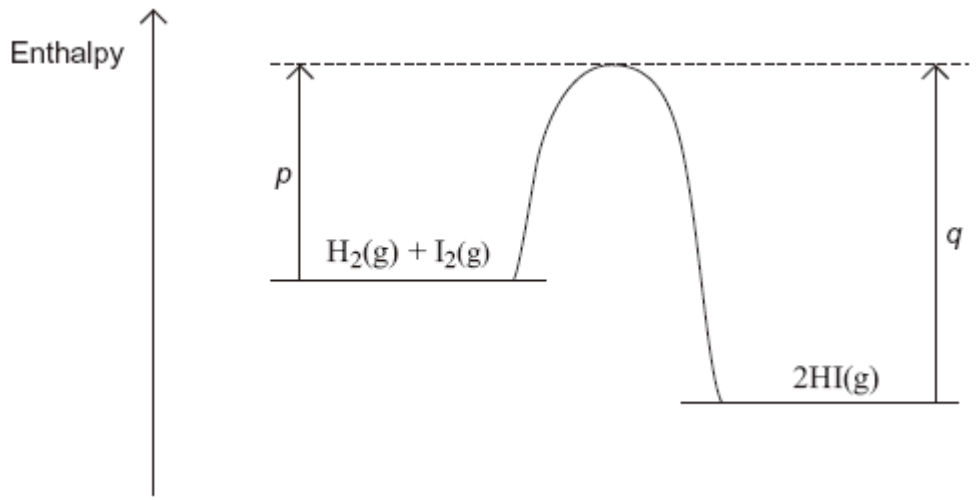
(2)
(Total 13 marks)

Q4. An equation for the equilibrium reaction between hydrogen, iodine and hydrogen iodide is shown below.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(a) The curve in the diagram below illustrates the reaction profile for this equilibrium reaction without a catalyst.



(i) Draw on the diagram a curve to illustrate the reaction profile for this equilibrium reaction **with** a catalyst.

(2)

(ii) Use the diagram to deduce whether the formation of hydrogen iodide from hydrogen and iodine is exothermic or endothermic.

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(1)

(iii) State what the diagram suggests about the sum of the bond enthalpies for the reactant molecules compared with the product molecules.

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(1)

(iv) In terms of *p* and *q*, identify the following for this equilibrium without a catalyst.

A value for the activation energy for the forward reaction .....

A value for the overall enthalpy change for the forward reaction

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(2)

(b) A mixture of $H_2(g)$ and $I_2(g)$ was allowed to reach equilibrium.

(i) State the effect of a catalyst on the rate of attainment of this equilibrium.

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(1)

(ii) State and explain the effect of an increase in total pressure on the rate of attainment of this equilibrium.

Effect of an increase in pressure on rate .....

Explanation .....

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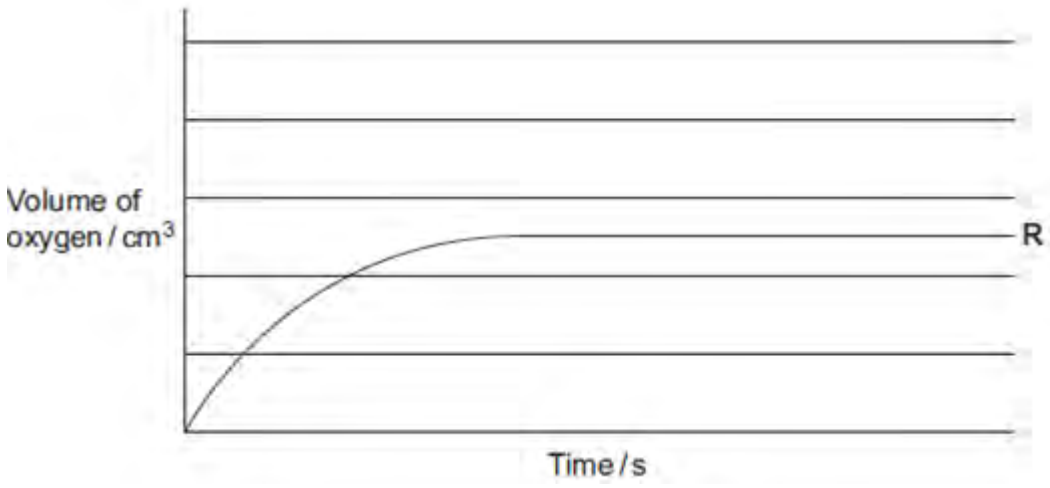
(3)
(Total 10 marks)

Q5. A student carried out an experiment to determine the rate of decomposition of hydrogen peroxide into water and oxygen gas.

The student used 100 cm^3 of a 1.0 mol dm^{-3} solution of hydrogen peroxide at 298 K and measured the volume of oxygen collected.
Curve **R**, in each of **Figures 1**, **2** and **3**, shows how the total volume of oxygen collected changed with time under these conditions.

(a) Draw a curve on **Figure 1** to show how the total volume of oxygen collected will change with time if the experiment is repeated at 298 K using 100 cm^3 of a 2.0 mol dm^{-3} solution of hydrogen peroxide.

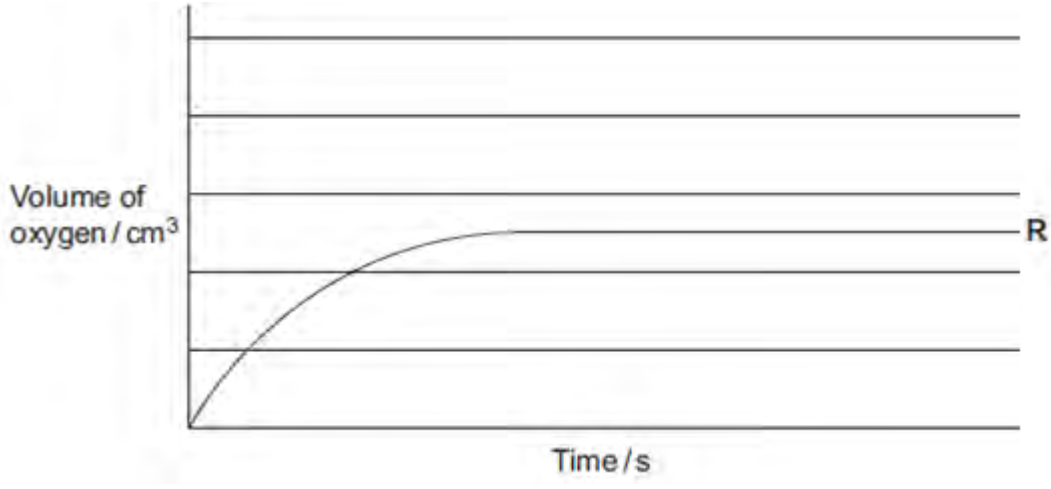
Figure 1



(2)

(b) Draw a curve on **Figure 2** to show how the total volume of oxygen collected will change with time if the experiment is repeated at 298 K using 100 cm^3 of a 0.4 mol dm^{-3} solution of hydrogen peroxide.

Figure 2

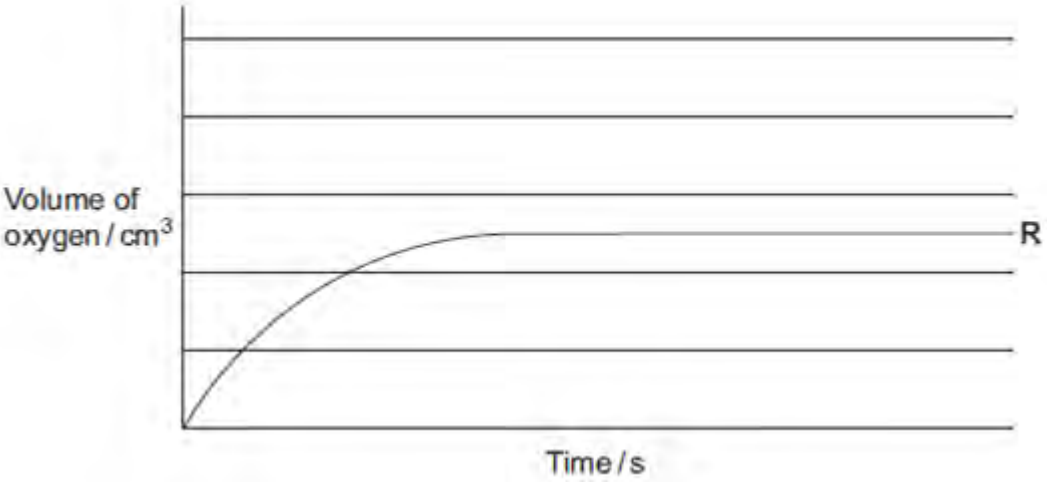


(2)

(c) Draw a curve on **Figure 3** to show how the total volume of oxygen collected will

change with time if the **original** experiment is repeated at a temperature higher than 298 K.
You should assume that the gas is collected at a temperature of 298 K.

Figure 3



(2)

(d) Explain why the slope (gradient) of curve **R** decreases as time increases.

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(Extra space) .....

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(e) The student discovered that hydrogen peroxide decomposes at a faster rate when a few drops of aqueous hydrogen bromide are added to the solution.
The student found on the Internet that this decomposition is thought to proceed in two steps as shown by the following equations.

Step **1** $H_2O_2 + HBr \longrightarrow HBrO + H_2O$

Step **2** $HBrO + H_2O_2 \longrightarrow H_2O + O_2 + HBr$

(i) Write an equation for the overall reaction.

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(1)

(ii) Give **one** reason, other than the increase in rate of reaction, why the student was able to deduce that hydrogen bromide behaves as a catalyst in this two-step reaction.

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(1)