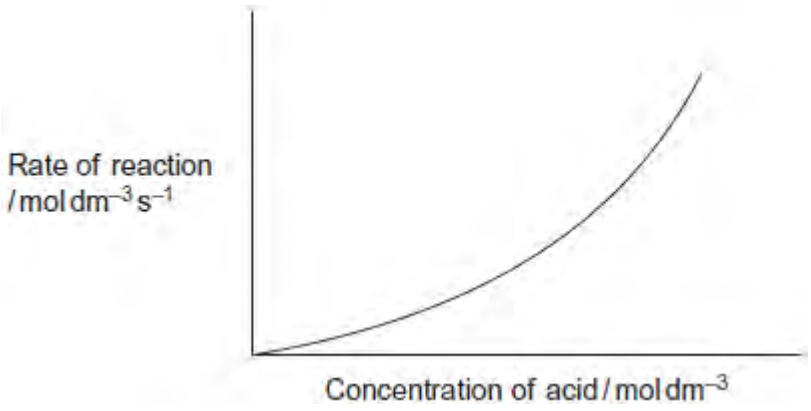
Q1.(a) In an investigation of the rate of reaction between hydrochloric acid and pure magnesium, a student obtained the following curve.



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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(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.

.....

.....

.....

.....

(2)

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

Difference 1 .....

.....

Difference 2 .....

.....

(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.

.....

.....

.....

.....

.....

.....

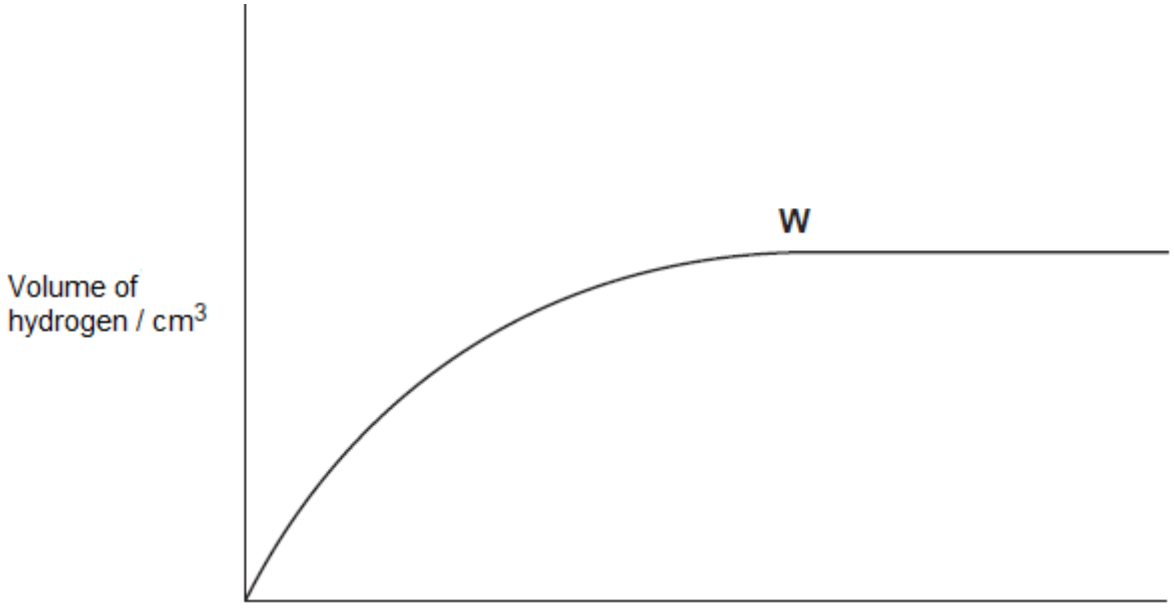
.....

(3)
(Total 10 marks)

Q2.(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*.

.....

.....

.....

(1)

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

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

.....

(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*.

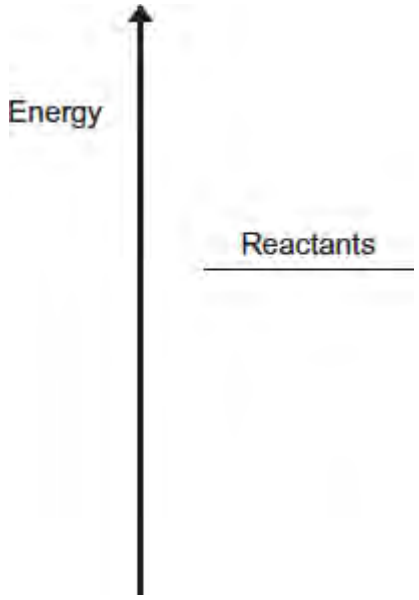
.....

.....

(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.

.....

(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

.....

Observation

.....

(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 .....

.....

Explanation .....

.....

.....

(2)
(Total 13 marks)

Q3.A study of equilibrium is important for understanding chemical reactions.

(a) State le Chatelier's principle.

.....

.....

.....

.....

(Extra space) .....

.....

(1)

(b) Catalysts play an important role in many reactions.

(i) State the meaning of the term *catalyst*.
Explain, in general terms, how catalysts work.

Meaning of the term *catalyst* .....

.....

.....

How catalysts work .....

.....

.....

.....

(3)

(Extra space) .....

.....

(ii) State the effect, if any, of a catalyst on the time taken to reach equilibrium.

.....

(1)

(iii) State the effect, if any, of a catalyst on the position of an equilibrium.

.....

(1)

(c) Consider the following equilibrium reactions.

				$\Delta H^{\ominus}$ / kJ mol^{-1}
P	$H_2(g) + I_2(g)$	$\rightleftharpoons$	$2HI(g)$	−10
Q	$CO_2(g) + 3H_2(g)$	$\rightleftharpoons$	$CH_3OH(g) + H_2O(g)$	−49
R	$N_2O_4(g)$	$\rightleftharpoons$	$2NO_2(g)$	+58

S	$N_2(g) + 3H_2(g)$	$\rightleftharpoons$	$2NH_3(g)$	−92
T	$C_2H_4(g) + H_2O(g)$	$\rightleftharpoons$	$CH_3CH_2OH(g)$	−42

In each of parts (c)(i) to (c)(v), you should record in the box one of the letters, **P, Q, R, S** or **T**, that corresponds to the equilibrium that best fits the information provided. You may use each letter once, more than once or not at all.

(i) A decrease in temperature at constant pressure shifts the position of this equilibrium from right to left.

(1)

(ii) This equilibrium uses concentrated phosphoric acid as a catalyst in a hydration reaction.

(1)

(iii) A decrease in pressure at constant temperature shifts the position of this equilibrium from left to right.

(1)

(iv) There is no change in the position of this equilibrium when the pressure is increased at constant temperature.

(1)

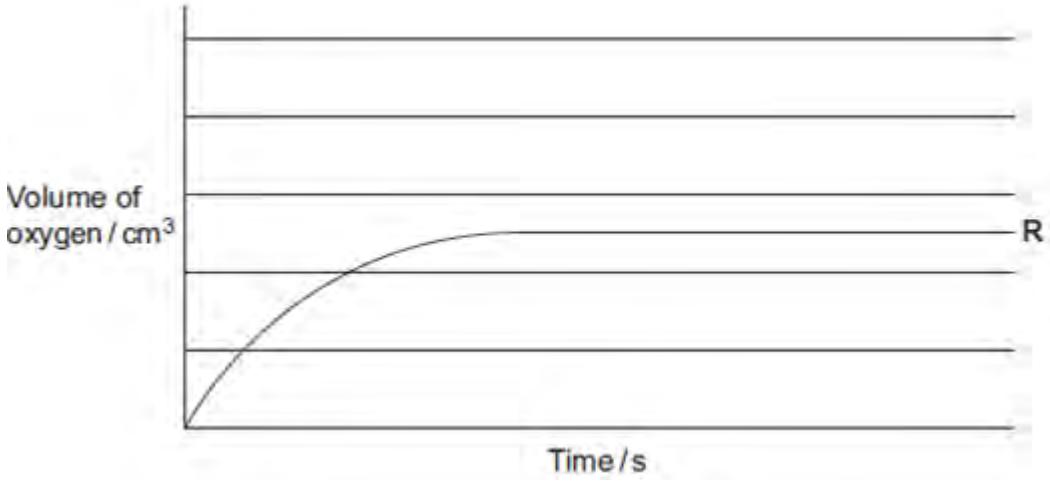
(v) An increase in the concentration of steam at constant temperature and constant pressure shifts the position of this equilibrium from right to left.

(1)
(Total 11 marks)

Q4. 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.

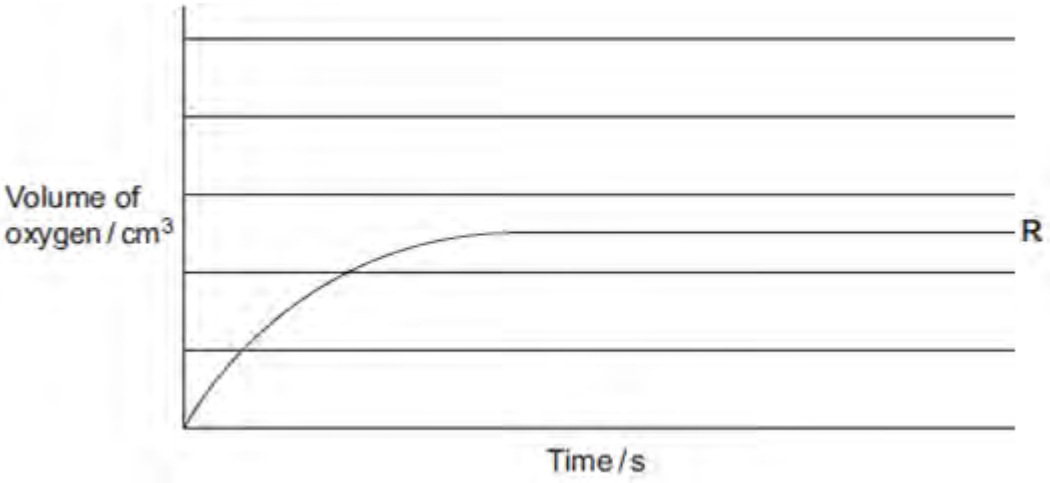
Figure 1



(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.

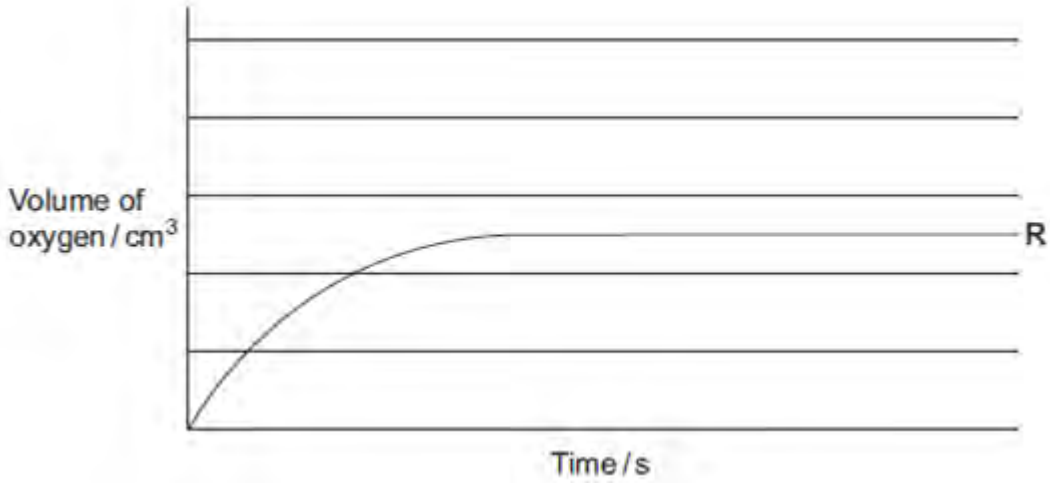
Figure 2



(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.

.....

.....

.....

.....

(Extra space) .....

.....

(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.

.....

(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.

.....

.....

.....

(1)