

Name of the Student: _____

Max. Marks : 27 Marks

Time : 27 Minutes

Q1.

An equation for the decomposition of hydrogen peroxide is



- (a) The rate of reaction can be determined by collecting the oxygen formed and measuring its volume at regular intervals.

Draw a diagram to show the apparatus that you would use to collect and measure the volume of the oxygen formed.

(2)

- (b) Explain how you could use your results from the experiment in part (a) to determine the initial rate of this reaction.

(2)

- (c) The rate of decomposition of hydrogen peroxide is increased by the addition of cobalt(II) ions.

Outline the essential features of an additional experiment to show that the rate of

decomposition is increased by the addition of cobalt(II) chloride. Use the same method and the same apparatus as in part (a).

(2)

(Total 6 marks)

Q2.

A study of equilibrium is important for understanding chemical reactions.

(a) State Le Chatelier's principle.

(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)

(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.

			$\Delta H^\circ / \text{kJ mol}^{-1}$
P	$\text{H}_2(\text{g}) + \text{I}_2(\text{g})$	$\rightleftharpoons$	$2\text{HI}(\text{g})$ -10
Q	$\text{CO}_2(\text{g}) + 3\text{H}_2(\text{g})$	$\rightleftharpoons$	$\text{CH}_3\text{OH}(\text{g}) + \text{H}_2\text{O}(\text{g})$ -49
R	$\text{N}_2\text{O}_4(\text{g})$	$\rightleftharpoons$	$2\text{NO}_2(\text{g})$ +58
S	$\text{N}_2(\text{g}) + 3\text{H}_2(\text{g})$	$\rightleftharpoons$	$2\text{NH}_3(\text{g})$ -92
T	$\text{C}_2\text{H}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$	$\rightleftharpoons$	$\text{CH}_3\text{CH}_2\text{OH}(\text{g})$ -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)

Q3.

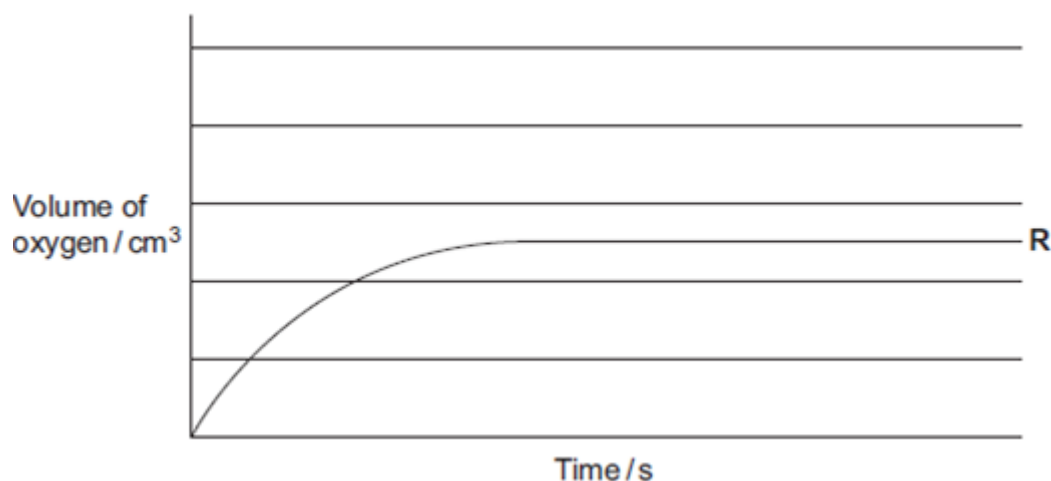
A student carried out an experiment to determine the rate of decomposition of hydrogen peroxide into water and oxygen gas.

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.

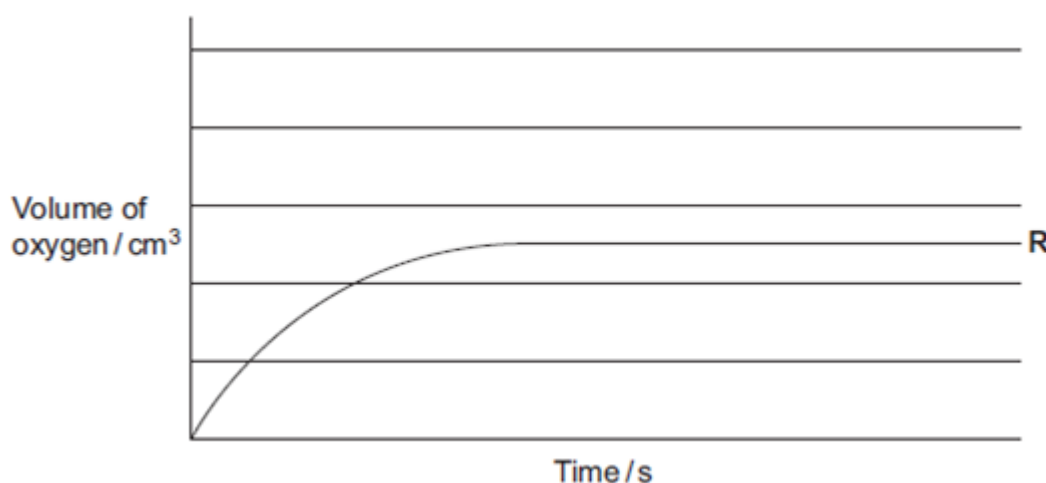
Figure 1



(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.

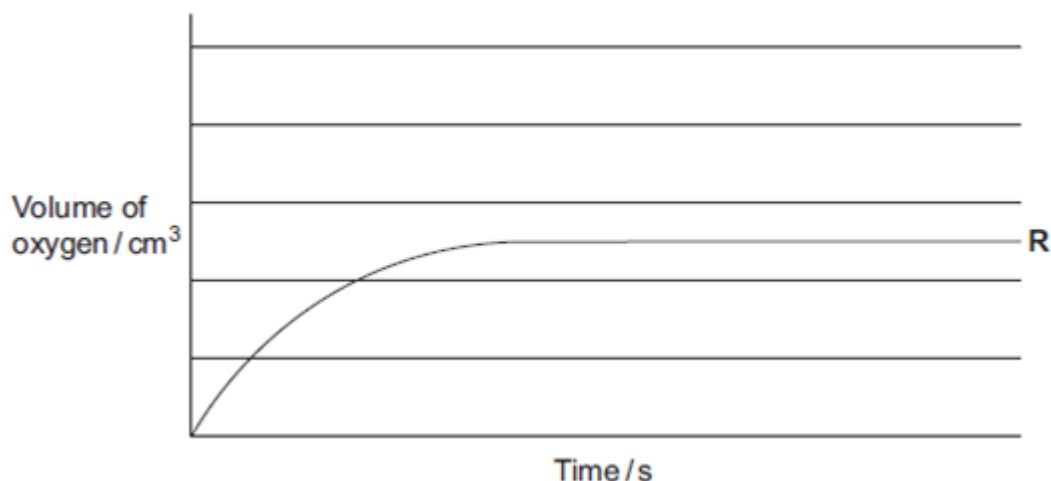
Figure 2



(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

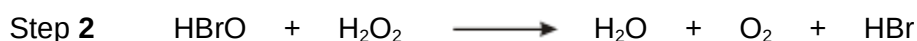


(2)

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

(2)

- (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.



- (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)

(Total 10 marks)