Practice Question Set For A-Level
Subject : Chemistry
Paper-2 Topic: Rate Equations

Name of the Student:_____
Max. Marks : 22 Marks **Time : 22 Minutes**

Q1.

Hydrogen peroxide solution decomposes to form water and oxygen.

$$2\ H_2O_2(aq) \rightarrow 2\ H_2O(l) + O_2(g)$$

The reaction is catalysed by manganese(IV) oxide.

A student determines the order of this reaction with respect to hydrogen peroxide. The student uses a continuous monitoring method in the experiment.

The student places hydrogen peroxide solution in a conical flask with the catalyst and uses a gas syringe to collect the oxygen formed. The student records the volume of oxygen every 10 seconds for 100 seconds.

(a) Explain why the reaction is fastest at the start.

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_____

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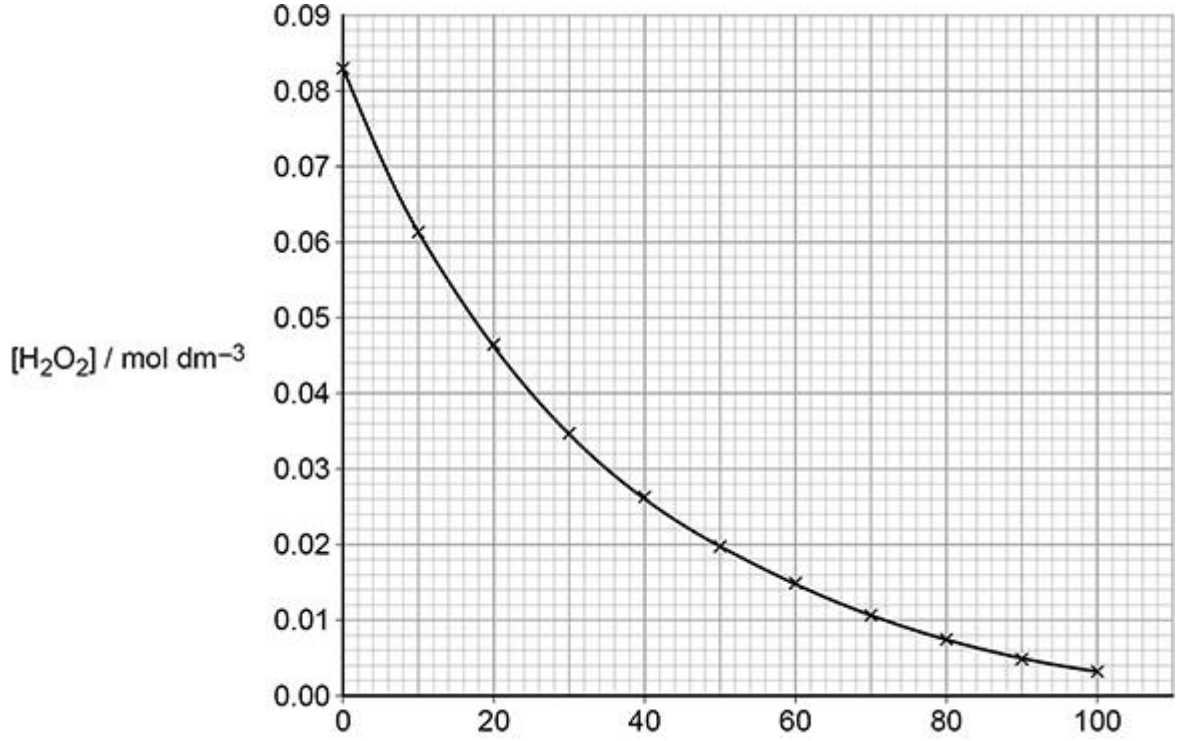
(2)

(b) The graph in **Figure 1** shows how the concentration of hydrogen peroxide changes with time in this experiment.

Figure 1



Tangents to the curve in **Figure 1** can be used to determine rates of reaction.

Draw a tangent to the curve when the concentration of hydrogen peroxide solution is 0.05 mol dm^{-3}

Use your tangent to calculate the gradient of the curve at this point.

Gradient _____ mol dm^{-3} s^{-1}

(2)

(c) The concentration of hydrogen peroxide solution at time *t* during the experiment can be calculated using this expression.

$$[H_2O_2]_t = [H_2O_2]_{initial}\left(\frac{V_{max} - V_t}{V_{max}}\right)$$

$[H_2O_2]_t$ = concentration of hydrogen peroxide solution at time *t* / mol dm^{-3}

$[H_2O_2]_{initial}$ = concentration of hydrogen peroxide solution at the start / mol dm^{-3}

V_{max} = total volume of oxygen gas collected during the whole experiment / cm^3

V_t = volume of oxygen gas collected at time *t* / cm^3

In this experiment, V_{max} = 100 cm^3

Use **Figure 1** and the expression to calculate $[H_2O_2]_t$ when 20 cm^3 of oxygen has been collected.

$[H_2O_2]_t$ _____ mol dm^{-3}

(2)

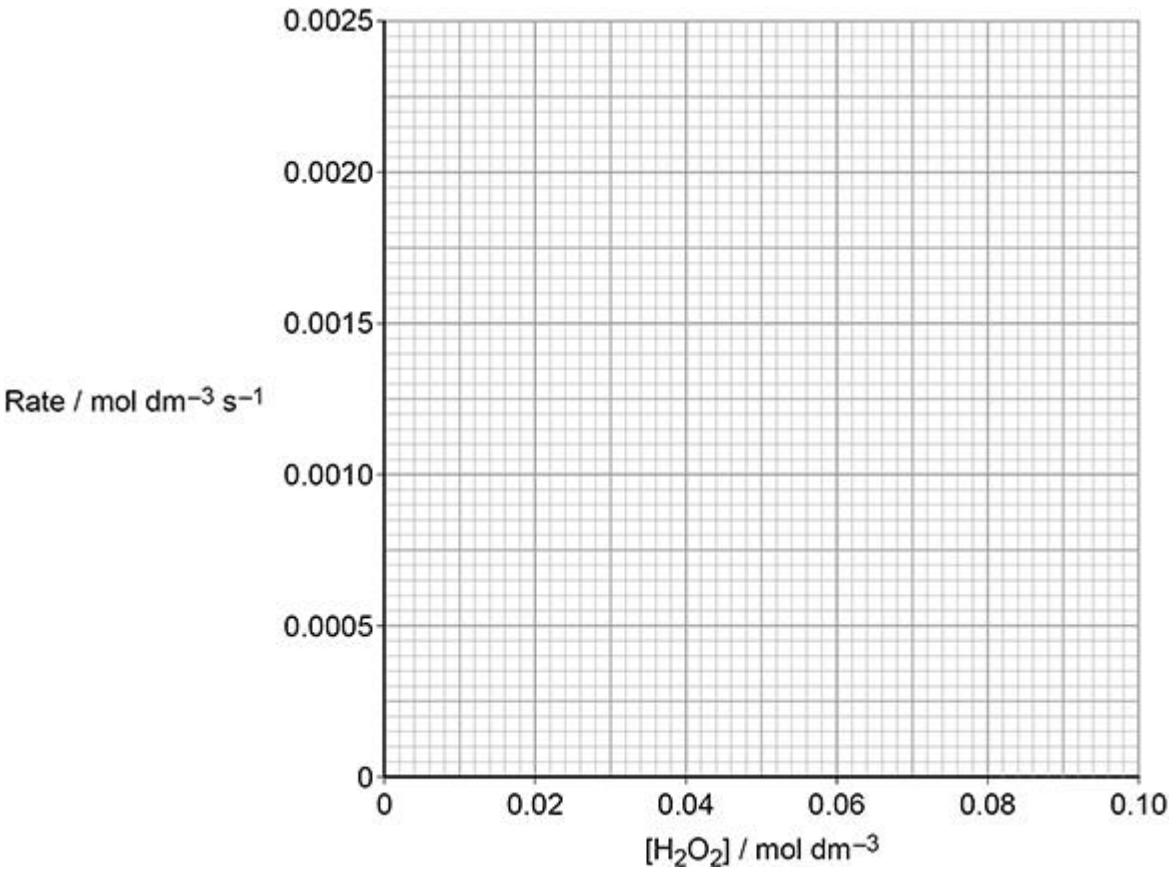
The table below shows data from a similar experiment.

$[H_2O_2]$ / mol dm^{-3}	0.02	0.03	0.05	0.07	0.09
Rate / mol dm^{-3} s^{-1}	0.00049	0.00073	0.00124	0.00168	0.00219

(d) Plot the data from the table above on the grid in **Figure 2**.

Draw a line of best fit.

Figure 2



(2)

(e) Use **Figure 2** to determine the order of reaction with respect to H_2O_2

State how the graph shows this order.

Order _____

How the graph shows this order _____

_____

_____

(2)

(Total 10 marks)

Q2.

This question is about rates of reaction.
Iodine and propanone react together in an acid-catalysed reaction

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

A student completed a series of experiments to determine the order of reaction with respect to iodine.

Method

- Transfer 25 cm^3 of 1.0 mol dm^{-3} propanone solution into a conical flask.
- Add 10 cm^3 of 1.0 mol dm^{-3} HCl(aq)
- Add 25 cm^3 of 5.0×10^{-3} mol dm^{-3} I_2(aq) and start a timer.
- At intervals of 1 minute, remove a 1.0 cm^3 sample of the mixture and add each sample to a separate beaker containing an excess of $NaHCO_3$(aq)
- Titrate the contents of each beaker with a standard solution of sodium thiosulfate and record the volume of sodium thiosulfate used.

(a) Suggest why the 1.0 cm^3 portions of the reaction mixture are added to an excess of $NaHCO_3$ solution.

_____

_____

_____

_____

(2)

(b) Suggest why the order of this reaction with respect to propanone can be ignored in this experiment.

_____

_____

_____

_____

_____

_____

(2)

The volume of sodium thiosulfate solution used in each titration is proportional to the concentration of iodine in each beaker.

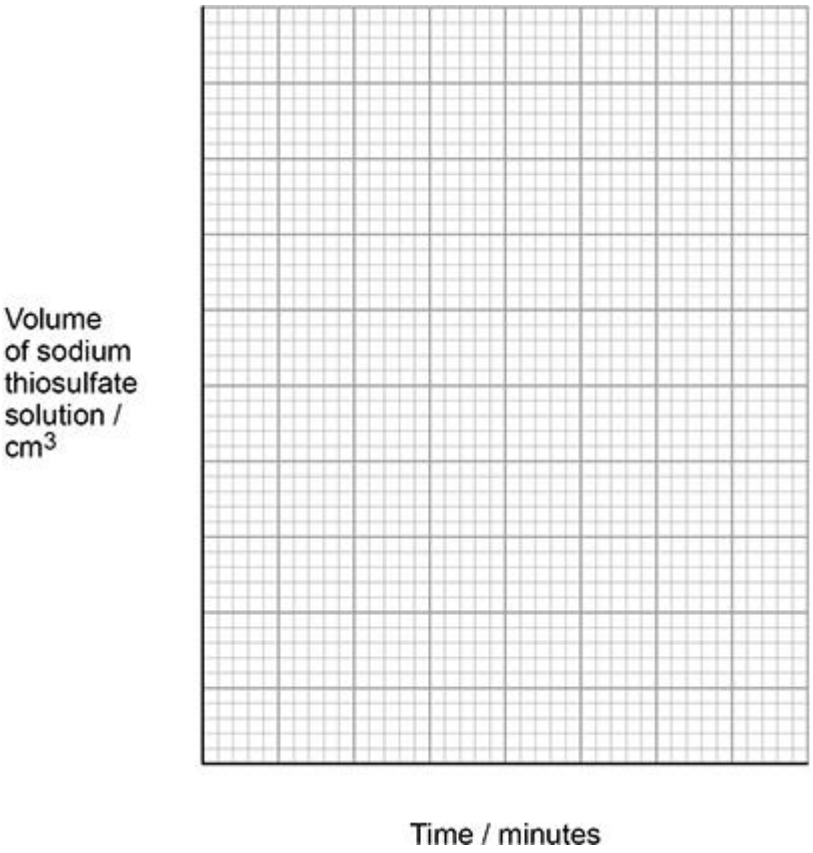
The table below shows the results of the experiment.

Time / minutes	**Volume of sodium thiosulfate solution / cm^3**
1	41
2	35
3	24

4	22
5	16
6	10

(c) Use the results in the table above to draw a graph of volume of sodium thiosulfate solution against time.

Draw a line of best fit.



(3)

(d) Explain how the graph shows that the reaction is zero-order with respect to iodine in the reaction between propanone and iodine.

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_____

_____

_____

_____

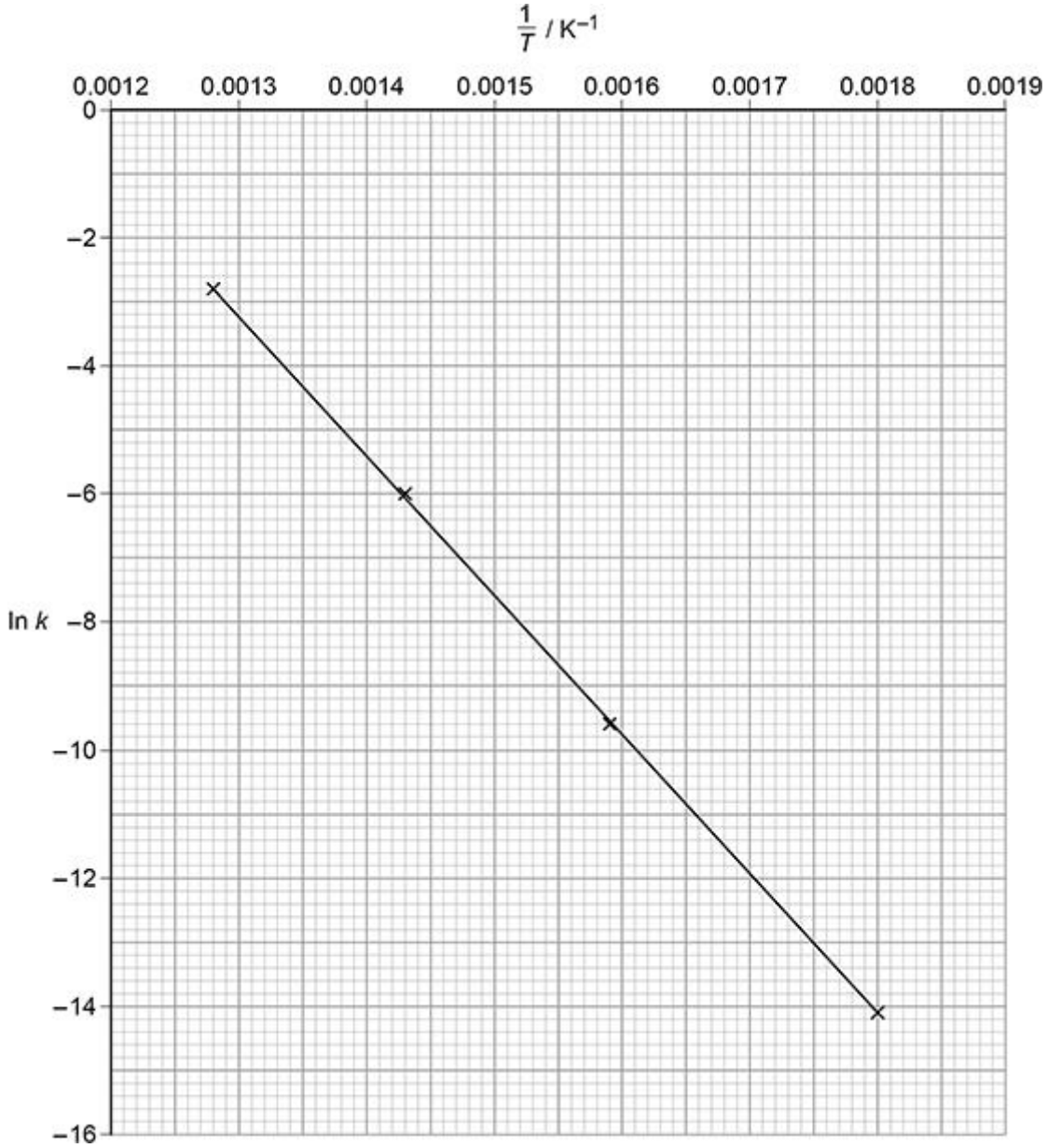
(2)

(e) The Arrhenius equation can be written as

$$\ln k = \frac{-E_a}{RT} + \ln A$$

The figure below shows a graph of ln k against $\frac{1}{T}$ for the reaction

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



Use the figure above to calculate a value for the activation energy (E_a), in kJ mol^{-1}, for this reaction.

The gas constant R = 8.31 J K^{-1} mol^{-1}

E_a _____ kJ mol^{-1}

(3)

(Total 12 marks)