Reaction Rates
AS & A Level

Question Paper 1

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Reaction Rates
Paper	AS & A Level
Booklet	Question Paper 1

Time allowed: **49 minutes**

Score: **/36**

Percentage: **/100**

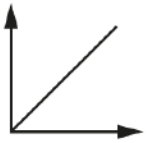
Grade Boundaries:

A*	A	B	C	D	E
>85%	73%	60%	47%	34%	21%

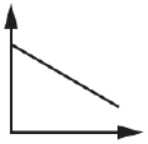
A reaction is first order with respect to a reactant **X**.

Which rate–concentration graph for reactant **X** is the correct shape?

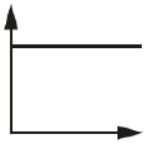
A



B



C



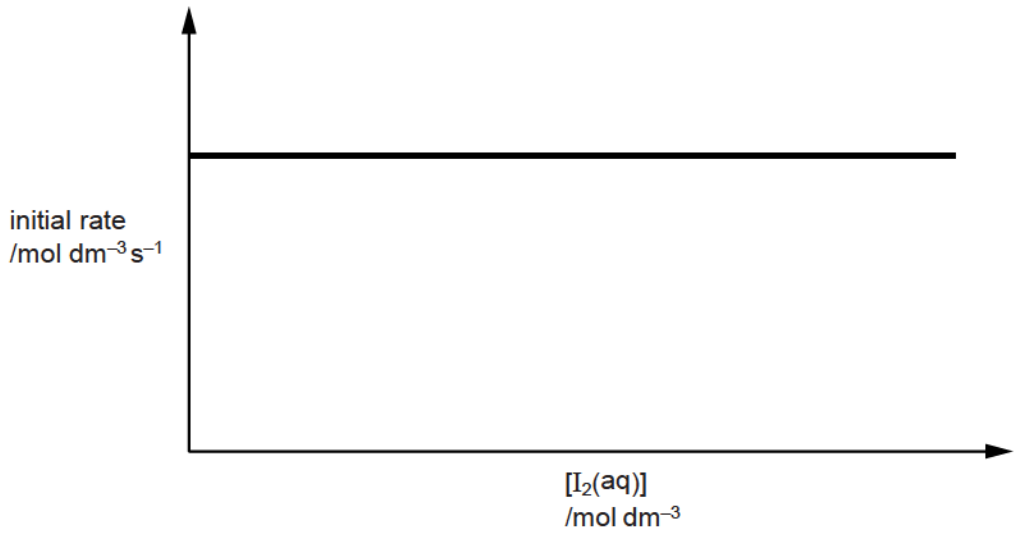
D

[1]

A student investigates the reaction between iodine, I_2, and propanone, $(CH_3)_2CO$, in the presence of aqueous hydrochloric acid, HC*l*(aq).

The results of the investigation are shown below.

Rate–concentration graph



Results of initial rates experiments

experiment	[$(CH_3)_2CO$(aq)] / mol dm^{-3}	[HC*l*(aq)] / mol dm^{-3}	initial rate / mol dm^{-3} s^{-1}
1	1.50×10^{-3}	2.00×10^{-2}	2.10×10^{-9}
2	3.00×10^{-3}	2.00×10^{-2}	4.20×10^{-9}
3	3.00×10^{-3}	5.00×10^{-2}	1.05×10^{-8}

(a) Determine the orders with respect to I_2, $(CH_3)_2CO$ and HC*l*, the rate equation and the rate constant for the reaction.

Explain all of your reasoning. [9]

(b) The student then investigates the reaction of hydrogen, H_2, and iodine monochloride, ICl.

The equation for this reaction is shown below.

$$H_2(g) + 2ICl(g) \rightarrow 2HCl(g) + I_2(g)$$

The rate equation for this reaction is shown below.

$$\text{rate} = k[H_2(g)]\,[ICl(g)]$$

Predict a possible two-step mechanism for this reaction. The first step should be the rate-determining step. [2]

[Total 11 Marks]

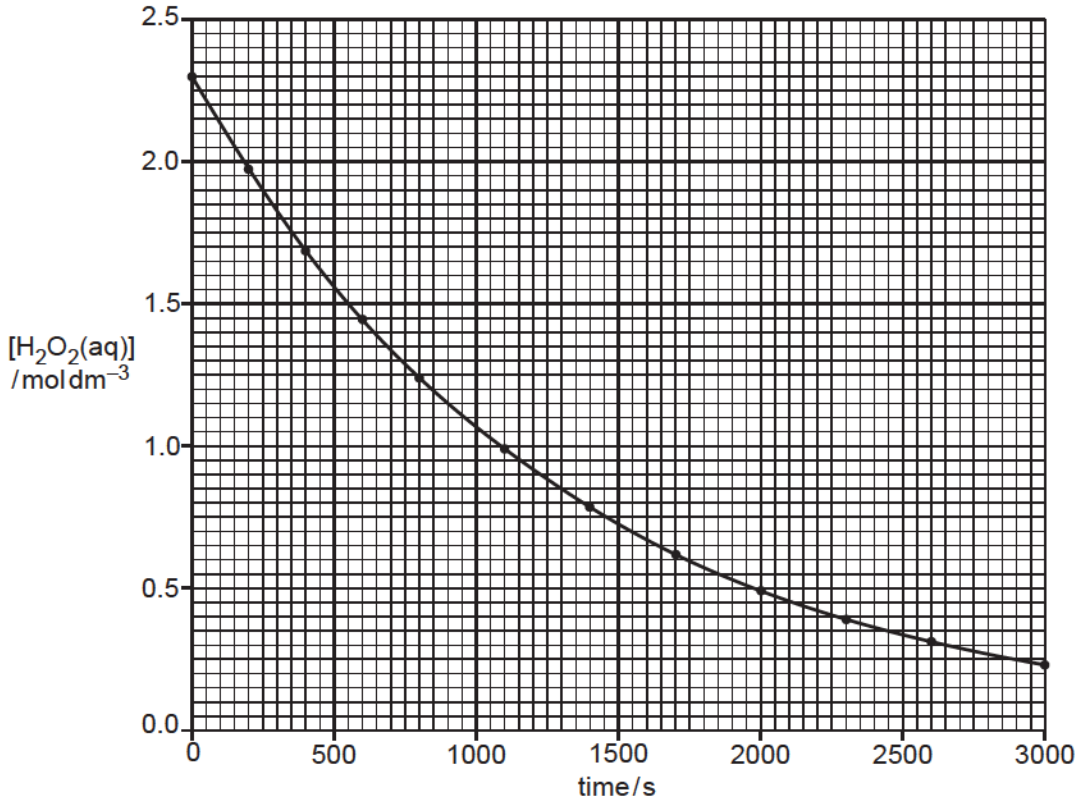
Aqueous solutions of hydrogen peroxide, $H_2O_2(aq)$, decompose as in the equation below.

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

A student investigates the decomposition of $H_2O_2(aq)$ by measuring the volume of oxygen gas produced over time. All gas volumes are measured at room temperature and pressure.

The student uses 25.0 cm^3 of 2.30 mol dm^{-3} H_2O_2.

From the results, the student determines the concentration of $H_2O_2(aq)$ at each time. The student then plots a concentration–time graph.



(a) Determine the total volume of oxygen, measured at room temperature and pressure, that the student should be prepared to collect in this investigation.

Suggest apparatus that would allow this gas volume to be collected, indicating clearly the scale of working.

[3]

(b) Suggest a different experimental method that would allow the rate of this reaction to be followed over time.

[1]

(c)* Determine the initial rate of reaction, the order with respect to H_2O_2, and the rate constant.

Your answer must show full working on the graph and on the lines below.

[6]

(Total 10 marks)

This question is about reactions of hydrogen peroxide, H_2O_2.

(a) Hydrogen peroxide, H_2O_2, iodide ions, I^-, and acid, H^+, react as shown in the equation below.

$$H_2O_2(aq) + 2I^-(aq) + 2H^+(aq) \rightarrow I_2(aq) + 2H_2O(l)$$

A student carries out several experiments at the same temperature, using the initial rates method, to determine the rate constant, *k*, for this reaction.

The results are shown below.

Experiment	Initial concentrations			Rate $/10^{-6}$ mol dm^{-3} s^{-1}
	$[H_2O_2(aq)]$ /mol dm^{-3}	$[I^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ /mol dm^{-3}	
1	0.0100	0.0100	0.100	2.00
2	0.0100	0.0200	0.100	4.00
3	0.0200	0.0100	0.100	4.00
4	0.0200	0.0100	0.200	4.00

(i) Determine the rate equation and calculate the rate constant, *k*, including units.

[3]

(ii) The rate constant, *k*, for this reaction is determined at different temperatures, *T*.

Explain how the student could determine the activation energy, E_a, for the reaction graphically using values of *k* and *T*.

[3]

(b) Solutions of hydrogen peroxide decompose slowly into water and oxygen:

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

This reaction is catalysed by manganese dioxide, $MnO_2(s)$.

Standard electrode potentials are shown below.

$O_2(g) + 2H^+(aq) + 2e^-$	$\rightleftharpoons$	$H_2O_2(aq)$	$E^{\ominus} = +0.70\,V$
$MnO_2(s) + 4H^+(aq) + 2e^-$	$\rightleftharpoons$	$Mn^{2+}(aq) + 2H_2O(l)$	$E^{\ominus} = +1.51\,V$
$H_2O_2(g) + 2H^+(aq) + 2e^-$	$\rightleftharpoons$	$2H_2O(l)$	$E^{\ominus} = +1.78\,V$

Using the electrode potentials, explain how MnO_2 is able to act as a catalyst for the decomposition of hydrogen peroxide.

You answer should include relevant equations.

[4]

(c) Peroxycarboxylic acids are organic compounds with the COOOH functional group.

Peroxyethanoic acid, CH_3COOOH, is used as a disinfectant.

(i) Suggest the structure for CH_3COOOH.

The COOOH functional group must be clearly displayed.

[1]

(ii) Peroxyethanoic acid can be prepared by reacting hydrogen peroxide with ethanoic acid. This is a heterogeneous equilibrium.

$$H_2O_2(aq) + CH_3COOH(aq) \rightleftharpoons CH_3COOOH(aq) + H_2O(l) \quad K_c = 0.37\,dm^3\,mol^{-1}$$

A 250 cm^3 equilibrium mixture contains concentrations of 0.500 mol dm^{-3} $H_2O_2(aq)$ and 0.500 moldm^{-3} $CH_3COOH(aq)$.

Calculate the amount, in mol, of peroxyethanoic acid in the equilibrium mixture.

[3]

(Total 14 marks)