Reaction Rates
AS & A Level
Question Paper 2

Level	A Level
Subject	Chemistry
Exam Board	OCR
Module	Physical Chemistry & Transition Elements
Topic	Reaction Rates
Paper	AS & A Level
Booklet	Question Paper 2

Time allowed: **41 minutes**

Score: **/30**

Percentage: **/100**

Grade Boundaries:

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

Hydrogen peroxide reacts with iodide ions in acid conditions, as shown below.

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

A student investigates the rate of this reaction by carrying out four experiments at the same temperature. The student's results are shown below.

Experiment	$[H_2O_2(aq)]$ /mol dm^{-3}	$[I^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ /mol dm^{-3}	Initial rate /mol dm^{-3} s^{-1}
1	0.0010	0.20	0.10	5.70×10^{-6}
2	0.0020	0.20	0.10	1.14×10^{-5}
3	0.0020	0.20	0.20	1.14×10^{-5}
4	0.0040	0.40	0.10	4.56×10^{-5}

(a) The rate equation is: $rate = k\,[H_2O_2(aq)]\,[I^-(aq)]$

- Show that the student's results support this rate equation.
- Calculate the rate constant, *k*, for this reaction.

  Give your answer to **two** significant figures, in standard form and with units.

In your answer you should make clear how the experimental results provide evidence for the rate equation. [6]

(b) The student concluded that $H^+(aq)$ ions act as a catalyst.

Explain why the student's conclusion is **not** correct. [1]

(c) A four-step mechanism has been proposed for this reaction.
The rate-determining step is the first step.

(i) State what is meant by the term *rate-determining step*. [1]

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(ii) The equation for **Step 3** in the four-step mechanism is shown below.

Suggest equations for the other three steps.
State symbols are **not** required.

Step 1:

Step 2:

Step 3: $HIO + I^- \rightarrow I_2 + OH^-$

Step 4:

[3]

[Total: 11 Marks]

Iodide ions, I^-, react with $S_2O_8^{2-}$ ions as shown in the equation below.

$$2I^-(aq) + S_2O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$$

A student investigates the rate of this reaction using the initial rates method.

The student measures the time taken for a certain amount of iodine to be produced.

(a) Outline a series of experiments that the student could have carried out using the initial rates method.

How could the results be used to show that the reaction is first-order with respect to both I^- and $S_2O_8^{2-}$?

In your answer you should make clear how the results are related to the initial rates. [4]

(b) In one of the experiments, the student reacts together:

- 8.0×10^{-2} mol dm^{-3} $I^-(aq)$
- 4.0×10^{-3} mol dm^{-3} $S_2O_8^{2-}(aq)$.

The initial rate of this reaction is 1.2×10^{-3} mol dm^{-3} s^{-1}.

The reaction is first-order with respect to I^- and first-order with respect to $S_2O_8^{2-}$.

Calculate the rate constant, k, for this reaction.
State the units, if any.

[3]

(c) This reaction between I^- ions and $S_2O_8^{2-}$ ions can be catalysed by either $Fe^{2+}(aq)$ ions or $Fe^{3+}(aq)$ ions.

Standard electrode potentials are shown below.

$S_2O_8^{2-}(aq) + 2e^-$	$\rightleftharpoons$	$2SO_4^{2-}(aq)$	$E^\ominus = +2.01V$
$Fe^{3+}(aq) + e^-$	$\rightleftharpoons$	$Fe^{2+}(aq)$	$E^\ominus = +0.77V$
$I_2(aq) + 2e^-$	$\rightleftharpoons$	$2I^-(aq)$	$E^\ominus = +0.54V$

(i) Using this information, write two equations to show how the reaction of I^- ions and $S_2O_8^{2-}$ ions can be catalysed by **Fe^{2+}** ions. [2]

(ii) Suggest why the reaction of I^- ions and $S_2O_8^{2-}$ ions is also catalysed by **Fe^{3+}** ions. [1]

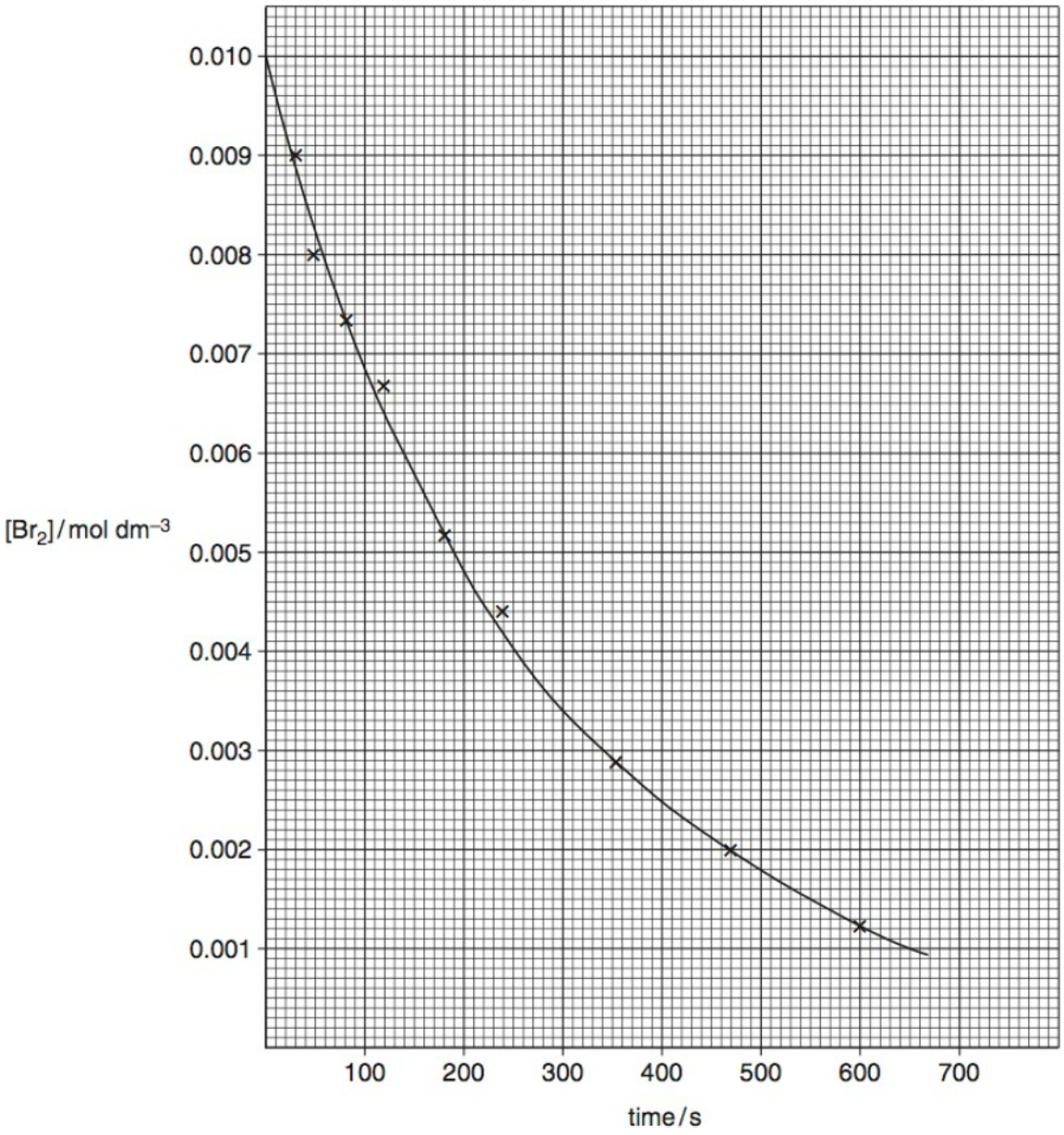
[Total 10 Marks]

Methanoic acid and bromine react as in the equation below.

$$Br_2(aq) + HCOOH(aq) \rightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$

A student investigates the rate of this reaction by monitoring the concentration of bromine over time. The student uses a large excess of HCOOH to ensure that the order with respect to HCOOH will be effectively zero.

From the experimental results, the student plots the graph below.



(a) Suggest how the concentration of the bromine could have been monitored.

[1]

(b) Suggest a different experimental method that would allow the rate of this reaction to be followed over time. **[1]**

(c) Why would use of excess HCOOH ensure that the order with respect to HCOOH is effectively zero? **[1]**

(d)* Using the graph, determine

- the initial rate of reaction
- the rate constant.

Your answer must show full working using the graph and the lines below as appropriate. **[6]**

[Total: 9 Marks]