Reaction Rates
A Level only

Question Paper 2

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

Time allowed: **42 minutes**

Score: **/31**

Percentage: **/100**

Grade Boundaries:

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

In the presence of acid, $H^+(aq)$, aqueous bromate(V) ions, $BrO_3^-(aq)$, react with aqueous bromide ions, $Br^-(aq)$, to produce bromine, $Br_2(aq)$.

A student carried out an investigation into the kinetics of this reaction.

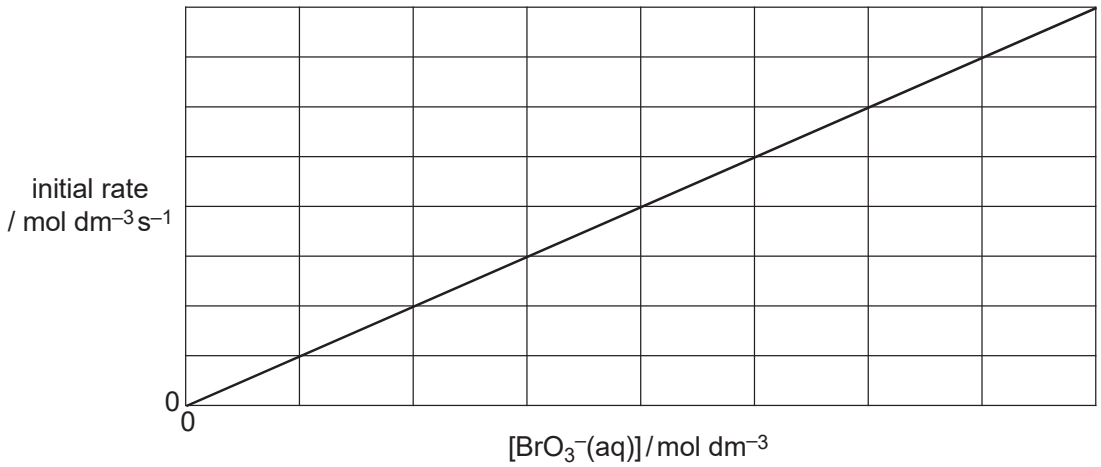
(a) Balance the ionic equation for this reaction.

$$BrO_3^- + \quad Br^- + \quad H^+ \longrightarrow Br_2 + \quad H_2O$$

[1]

(b) The student investigated how different concentrations of $BrO_3^-(aq)$ affect the initial rate of the reaction.

A graph of initial rate against $[BrO_3^-(aq)]$ is shown below.



The student then investigated how different concentrations of $Br^-(aq)$ and $H^+(aq)$ affect the initial rate of the reaction.

The results are shown below.

$[BrO_3^-(aq)]$ /mol dm^{-3}	$[Br^-(aq)]$ /mol dm^{-3}	$[H^+(aq)]$ /mol dm^{-3}	initial rate /mol dm^{-3} s^{-1}
5.0×10^{-2}	1.5×10^{-1}	3.1×10^{-1}	1.19×10^{-5}
5.0×10^{-2}	3.0×10^{-1}	3.1×10^{-1}	2.38×10^{-5}
5.0×10^{-2}	1.5×10^{-1}	6.2×10^{-1}	4.76×10^{-5}

- Using the results from the student's experiments, what conclusions can be drawn about the kinetics of this reaction? Justify your reasoning.

- Calculate the rate constant for this reaction, including the units.

In your answer you should make clear how your conclusions fit with the experimental results. [9]

[Total: 10 Marks]

Hydrogen, H_2, reacts with nitrogen monoxide, NO, as shown in the equation below.

$$2H_2(g) + 2NO(g) \rightarrow N_2(g) + 2H_2O(g)$$

A chemist carries out a series of experiments and determines the rate equation for this reaction:

$$\text{rate} = k[H_2(g)][NO(g)]^2$$

(a) In one of the experiments, the chemist reacts together:

- $1.2 \times 10^{-2}\,\text{mol}\,\text{dm}^{-3}\,H_2(g)$
- $6.0 \times 10^{-3}\,\text{mol}\,\text{dm}^{-3}\,NO(g)$

The initial rate of this reaction is $3.6 \times 10^{-2}\,\text{mol}\,\text{dm}^{-3}\,\text{s}^{-1}$.

Calculate the rate constant, k, for this reaction. State the units, if any. [3]

(b) Predict what would happen to the initial rate of reaction for the following changes in concentrations.

(i) The concentration of $H_2(g)$ is doubled. [1]

(ii) The concentration of NO(g) is halved. [1]

(iii) The concentrations of $H_2(g)$ and NO(g) are **both** increased by four times. [1]

(c) The chemist carries out the reaction between hydrogen and nitrogen monoxide at a higher pressure.

(i) Explain, with a reason, what happens to the initial rate of reaction. [1]

(ii) State what happens to the rate constant. [1]

(d) This overall reaction between hydrogen and nitrogen monoxide takes place by a two-step mechanism. The first step is much slower than the second step.

Suggest a possible two-step mechanism for the overall reaction.

step 1:

step 2: [2]

[Total: 10 Marks]

This question is about reaction rates.

Aqueous iron(III) ions, $Fe^{3+}(aq)$, react with aqueous iodide ions, $I^-(aq)$, as shown below.

$$2Fe^{3+}(aq) + 2I^-(aq) \rightarrow 2Fe^{2+}(aq) + I_2(aq)$$

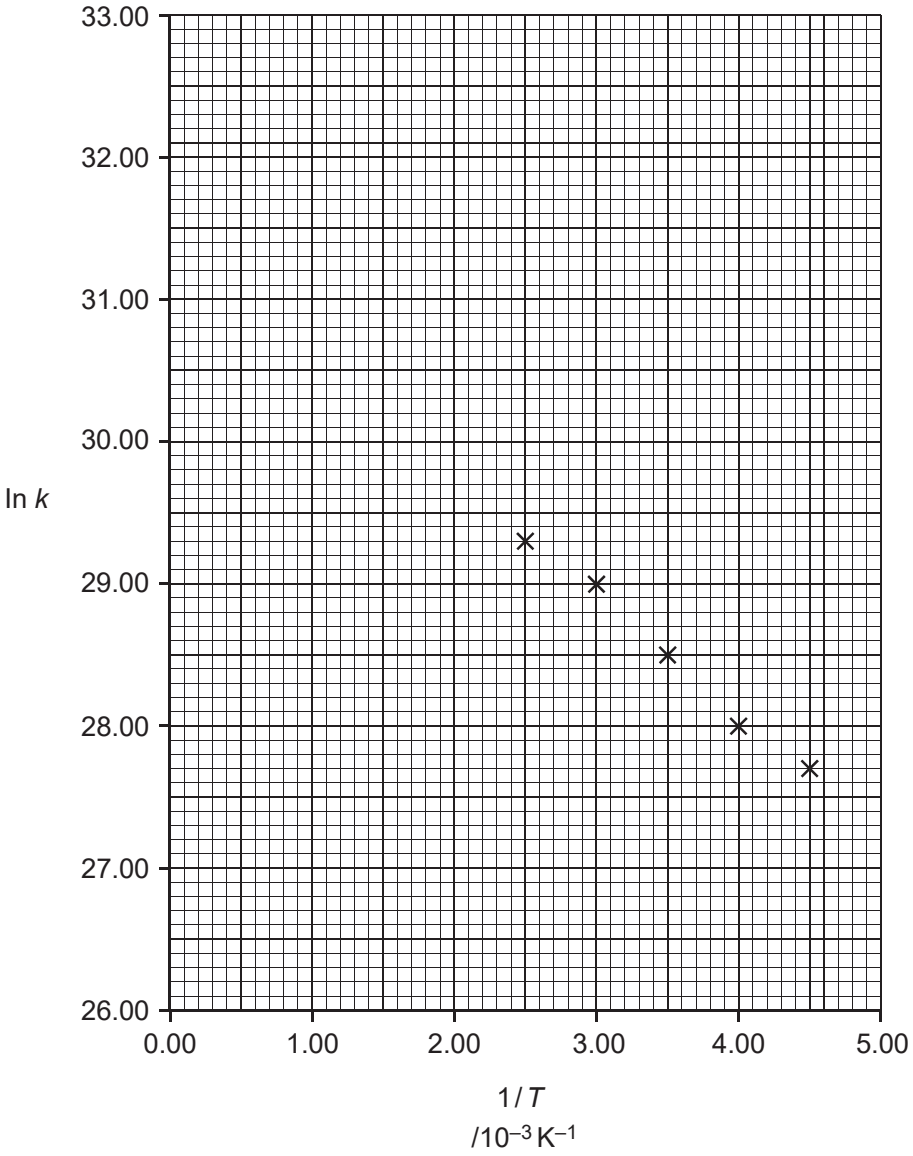
A student carries out three experiments to investigate how different concentrations of $Fe^{3+}(aq)$ and $I^-(aq)$ affect the initial rate of this reaction. The results are shown below.

Experiment	$[Fe^{3+}(aq)]$ / mol dm^{-3}	$[I^-(aq)]$ / mol dm^{-3}	Initial rate / mol dm^{-3} s^{-1}
1	4.00×10^{-2}	3.00×10^{-2}	8.10×10^{-4}
2	8.00×10^{-2}	3.00×10^{-2}	1.62×10^{-3}
3	4.00×10^{-2}	6.00×10^{-2}	3.24×10^{-3}

(a)* Determine the rate constant and a possible two-step mechanism for this reaction that are consistent with these results. **[6]**

(b) A student carries out an investigation to find the activation energy, E_a, and the pre-exponential factor, A, of a reaction.

The student determines the rate constant, k, at different temperatures, T.
The student then plots a graph of $\ln k$ against $1/T$ as shown below.



(i) Draw a best-fit straight line and calculate the activation energy, in $J\,mol^{-1}$.
Give your answer to **three** significant figures.

Show your working. **[3]**

(ii) Use the graph to calculate the value of the pre-exponential factor, *A*.

Show your working.

[2]

(Total 11 marks)