How Fast? - Rates

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	How Fast? - Rates
Booklet	Question Paper 1

Time Allowed: **46 minutes**

Score: /38

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1   The equation for the reaction between bromate(V) ions and bromide ions in acid

solution is

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \rightarrow 3Br_2(aq) + 3H_2O(l)$$
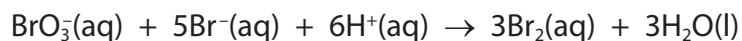
The rate equation for this reaction is
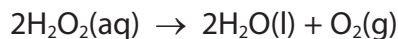
$$rate = k[BrO_3^-][Br^-][H^+]^2$$

When the concentrations of all of the reactants are doubled, the rate increases by a factor of

☒ **A** 2

☒ **B** 4

☒ **C** 8

☒ **D** 16

(Total for Question 1 = 1 mark)

2   The decomposition of hydrogen peroxide is catalysed by iodide ions.

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

The rate equation for this reaction is

$$rate = k[H_2O_2][I^-]$$

This is consistent with a reaction mechanism in which

☒ **A** there is only one step.

☒ **B** the catalyst is used up.

☒ **C** the slowest step is the reaction of two molecules of hydrogen peroxide with an iodide ion.

☒ **D** the slowest step is the reaction of one molecule of hydrogen peroxide with an iodide ion.

(Total for Question 2 = 1 mark)

3 Which of the following sketch graphs shows a reaction that is zero order with respect to reactant Q?

☒ **A**   [Q]

Time

☒ **B**   Rate

[Q]

☒ **C**   [Q]

Time

☒ **D**   Rate

[Q]
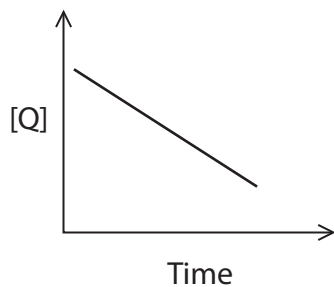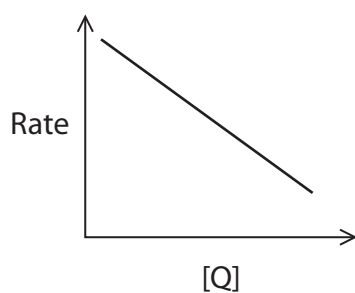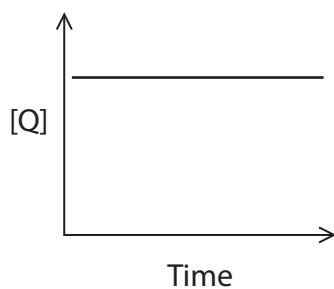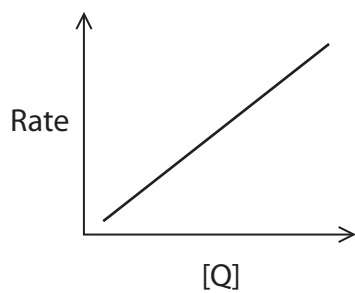
(Total for Question 3 = 1 mark)

4 Typical results of a rate experiment are shown in the sketch graph below.
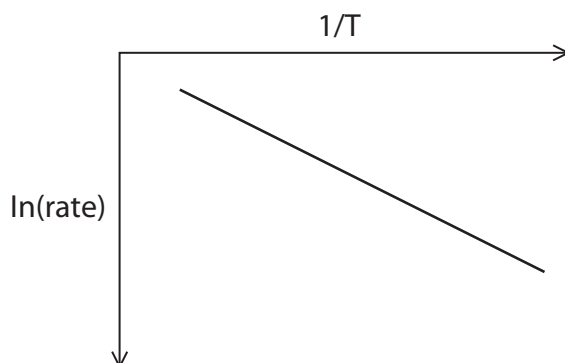
The activation energy, E_a, of a reaction is related to the rate by the equation

$$\ln(\text{rate}) = -\frac{E_a}{R} \times \frac{1}{T} + \text{onstant}$$

For the graph above, E_a is equal to

☒ **A** (−gradient) / R

☒ **B** (−gradient) / RT

☒ **C** (−gradient) × R

☒ **D** (−gradient) × RT

(Total for Question 4 = 1 mark)

5 Sulfuryl chloride, SO_2Cl_2, decomposes in a first order reaction.

The half-life for this reaction is 2300 s.

In an experiment, the initial concentration of sulfuryl chloride is 1.0 mol dm^{-3}.

What is the concentration, in mol dm^{-3}, of sulfuryl chloride after 4600 s?

☒ **A** 0.75

☒ **B** 0.50

☒ **C** 0.25

☒ **D** 0.125

(Total for Question 5 = 1 mark)

6 A halogenoalkane reacts with hydroxide ions to form an alcohol.
Which of the following statements is true if the reaction is first order?

☒ **A** Increasing the concentration of hydroxide ions increases the rate of the reaction.

☒ **B** The rate equation for the reaction is rate = [halogenoalkane].

☒ **C** The reaction mechanism is S_N1.

☒ **D** The reaction involves the formation of a transition state.

(Total for Question 6 = 1 mark)

7   The rate equation for the oxidation of bromide ions by bromate(V) ions in acid solution is shown below.

$$\text{Rate} = k[BrO_3^-(aq)][Br^-(aq)][H^+(aq)]^2$$
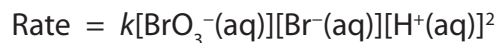
If the concentrations of all three reactants double, the rate will increase by a factor of

☒ **A**   2

☒ **B**   4

☒ **C**   8

☒ **D**   16

(Total for Question 7 = 1 mark)

8   The gaseous first order reaction, A → B + C, was found to have a half-life of 20 s when the initial pressure of A was 2 atm.

When the initial pressure of A is increased to 4 atm, the half-life is

☒ **A**   10 s

☒ **B**   20 s

☒ **C**   40 s

☒ **D**   400 s

(Total for Question 8 = 1 mark)

9 Bromine reacts with methanoic acid as shown below.

$$HCOOH(aq) + Br_2(aq) \rightarrow 2H^+(aq) + 2Br^-(aq) + CO_2(g)$$
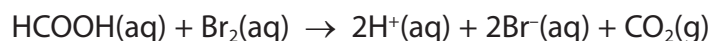
The kinetics of the reaction can be investigated by various methods.

(a) For two different named substances, identify a method of following the progress of the reaction. The methods given should be different for each substance and should **not** involve taking samples from the reaction mixture.

(2)

Substance 1

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Method

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Substance 2

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Method

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(b) In an investigation of the kinetics of the reaction, a large excess of methanoic acid was used.

(i) Use the data shown on page 12 to plot a graph that can be used to determine the order of reaction with respect to bromine.

(2)

Time / s	0	60	120	180	240	300	420	600	700
[Br_2(aq)] / mol dm^{-3}	0.0100	0.0082	0.0066	0.0053	0.0043	0.0034	0.0021	0.0011	0.0007
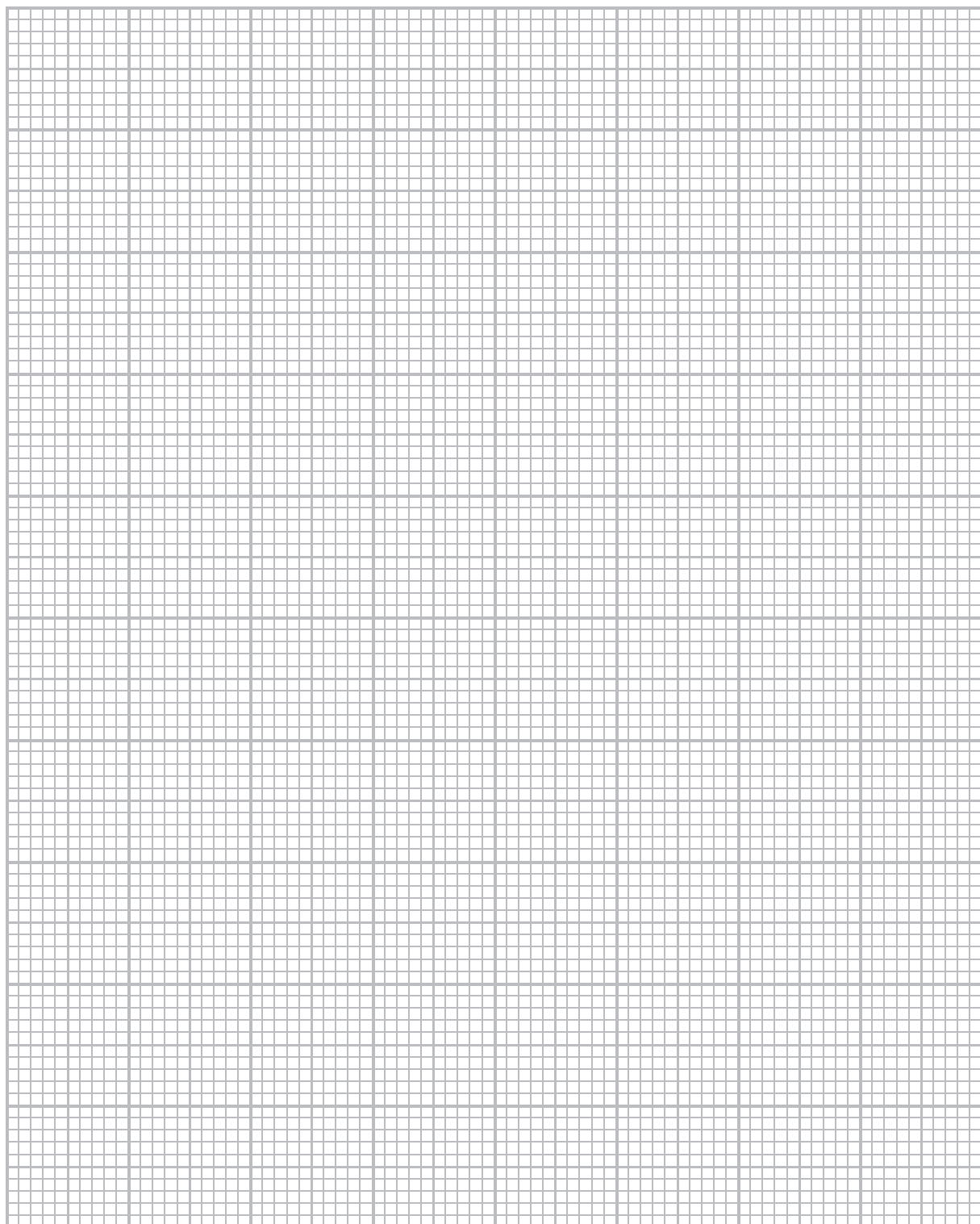
(ii) Use the graph to confirm that the reaction is first order with respect to bromine.

Show on the graph the measurements you use to confirm this and explain how the order is deduced.

(3)

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(iii) Under the conditions of the experiment, the order of reaction with respect to methanoic acid appears to be zero.

Explain why this is the case.

(1)

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(iv) Further experiments show that the reaction is actually first order with respect to methanoic acid.

Write the rate equation for the reaction.

(1)

(v) The initial rate of the reaction carried out in part (b)(i) was found to be 4.54×10^{-5} mol dm^{-3} s^{-1}.

The initial concentration of methanoic acid was 0.500 mol dm^{-3} and that of bromine was 0.0100 mol dm^{-3}.

Use these values, and your rate equation in part (b)(iv), to calculate the rate constant for the reaction.

Give the units of the rate constant.

(2)

(Total for Question 9 = 11 marks)

10 The kinetics of the reaction below was investigated in a series of experiments.

$$A + B \xrightarrow{\text{catalyst } X} C + D \quad \Delta H \text{ is positive}$$

(a) Compound **C** is a gas, whereas compounds **A**, **B** and **D** are in solution. Outline a method that could be used to investigate the rate of the reaction. You may wish to draw a diagram.

(3)

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(b) The rate of the reaction was measured at several different initial concentrations of **A** in the presence of a large excess of compound **B** and a constant amount of catalyst **X**, to find the order of reaction with respect to **A**. The results are shown on the graph below.
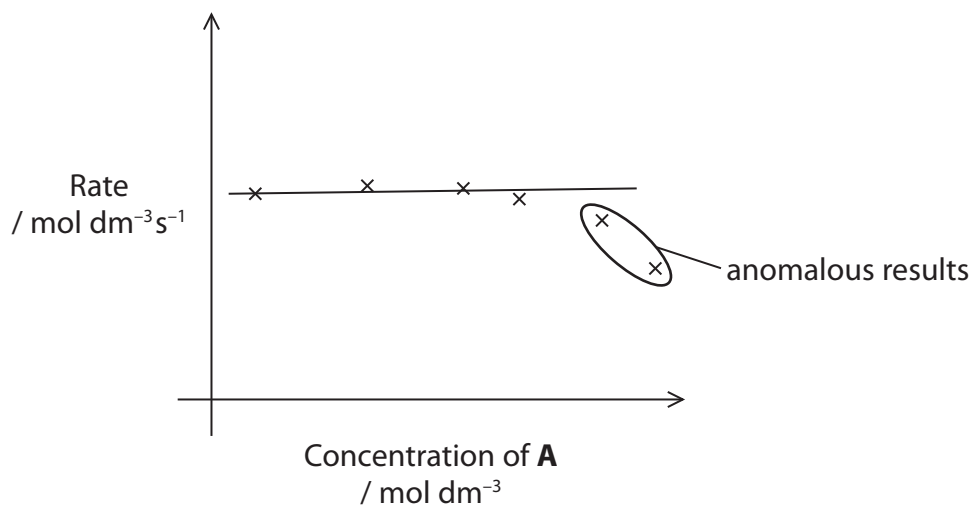
(i) Suggest an explanation, other than experimental error, for the two anomalous results ringed.

(2)

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(ii) What is the order of reaction with respect to **A**? Justify your answer.

(2)

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(c) In a second series of experiments, further data were collected using a different method. These results are summarised in the table below.

Experiment	Initial concentration / mol dm^{-3}			Rate / mol dm^{-3} s^{-1}
	A	**B**	**X**	
1	0.010	0.025	0.100	0.0025
2	0.010	0.075	0.100	0.0225
3	0.010	0.100	0.200	0.0800
4	0.020	0.100	0.200	0.0800

(i) Give **one** reason why obtaining these further data may be considered useful.

(1)

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(ii) State the order with respect to **B** and hence deduce the order with respect to **X**. Explain how you arrived at your answers. Include appropriate experiment numbers in your explanation.

(4)

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(iii) Use your answers to (b)(ii) and (c)(ii) to give the rate equation for the reaction.

(1)

(iv) Use your answer from (c)(iii) and appropriate data from **Experiment 3** in the table, to calculate the value of the rate constant, *k*.
Include units in your answer.

(2)

(d) A student carried out an investigation into the kinetics of the reaction between 1-bromopropane and hydroxide ions. A summary of the student's findings is shown below.
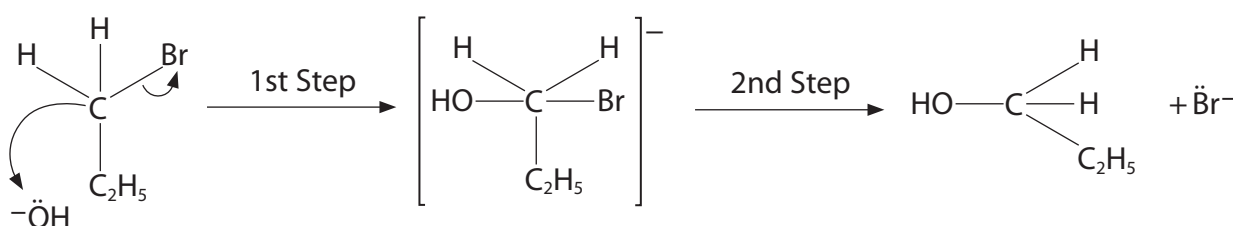
Kinetics Investigation - Summary of Key Findings

Reaction is second order overall and is known as S_N2.
Both 1-bromopropane and the hydroxide ions are involved in the slow step of this two-part reaction.

Suggested Mechanism

The hydroxide ions react with the 1-bromopropane as below.

Use your knowledge of the mechanism of nucleophilic substitution reactions to suggest **two** features of the summary, including the student's mechanism, that you think are correct and **two** features you think are incorrect.

(4)

Two features you think are correct.

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Two features you think are incorrect.

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(Total for Question 10 = 19 marks)