How Fast? - Rates

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	How Fast? - Rates
Booklet	Question Paper 2

Time Allowed: **39 minutes**

Score: **/32**

Percentage: **/100**

Grade Boundaries:

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

1 (a) Iodine reacts with propanone, CH_3COCH_3, in the presence of a catalyst of dilute hydrochloric acid.

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

Students carried out a rate investigation of this reaction. In each set of experiments, the initial concentration of one substance was varied and the initial concentrations of the other two substances were kept constant.

First set of experiments

The initial concentration of propanone was varied.

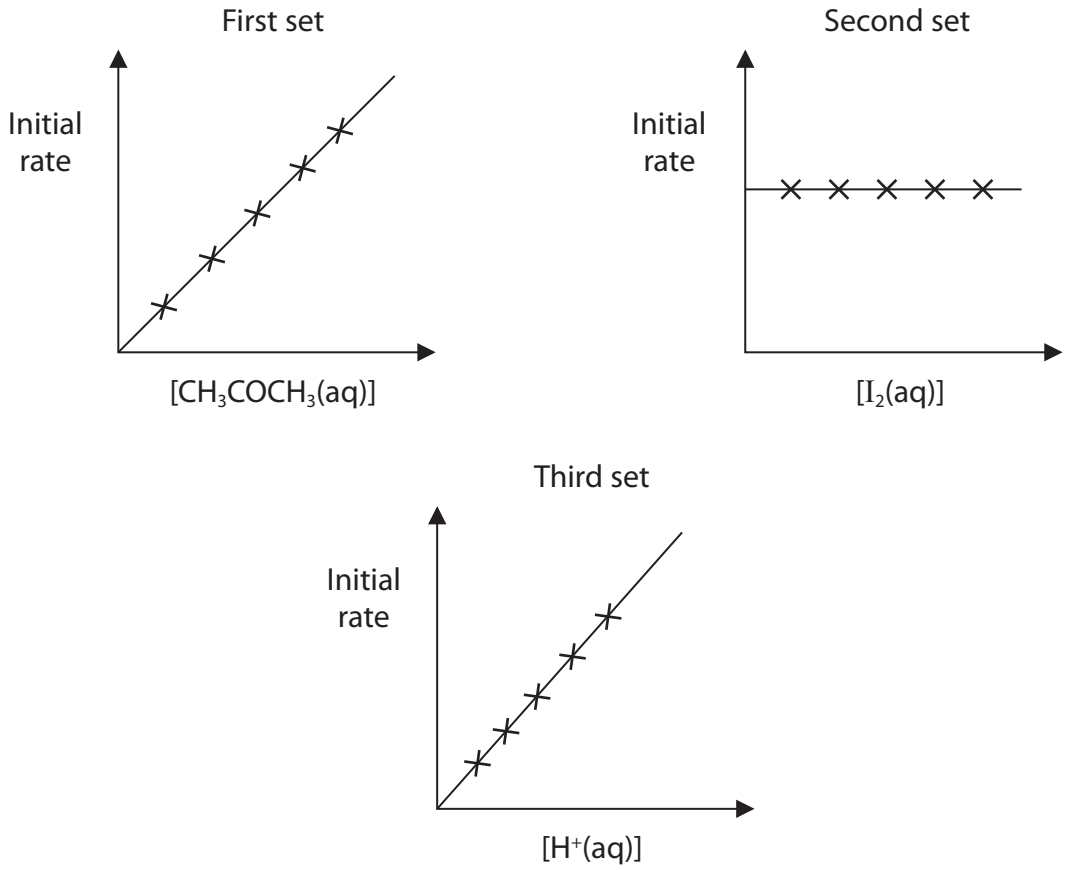
Second set of experiments

The initial concentration of iodine was varied.

Third set of experiments

The initial concentration of hydrochloric acid was varied.

The results of each set of experiments are shown in the graphs below.



(i) For the second set of experiments, state a practical method for following the progress of this reaction. Indicate which substance is being monitored by your method.

(2)

*(ii) Use the graphs to deduce the orders of reaction with respect to propanone, iodine and H^+ ions. Explain your reasoning.

(4)

(iii) Write the rate equation for the reaction.

(1)

(iv) In one of the experiments, the following data were collected:

$[CH_3COCH_3(aq)] = 0.667$ mol dm^{-3}

$[I_2(aq)] = 1.67$ $^{-3}$ mol dm^{-3}

$[H^+(aq)] = 0.667$ m $^{-3}$

Initial rate $= 8.80 \times 10^{-6}$ mol dm^{-3} s^{-1}

Use the data to calculate the value for the rate constant.
Include units in your answer.

(2)

(v) Use the rate equation to suggest a possible rate-determining step in the mechanism for the reaction between iodine and propanone in the presence of dilute hydrochloric acid.

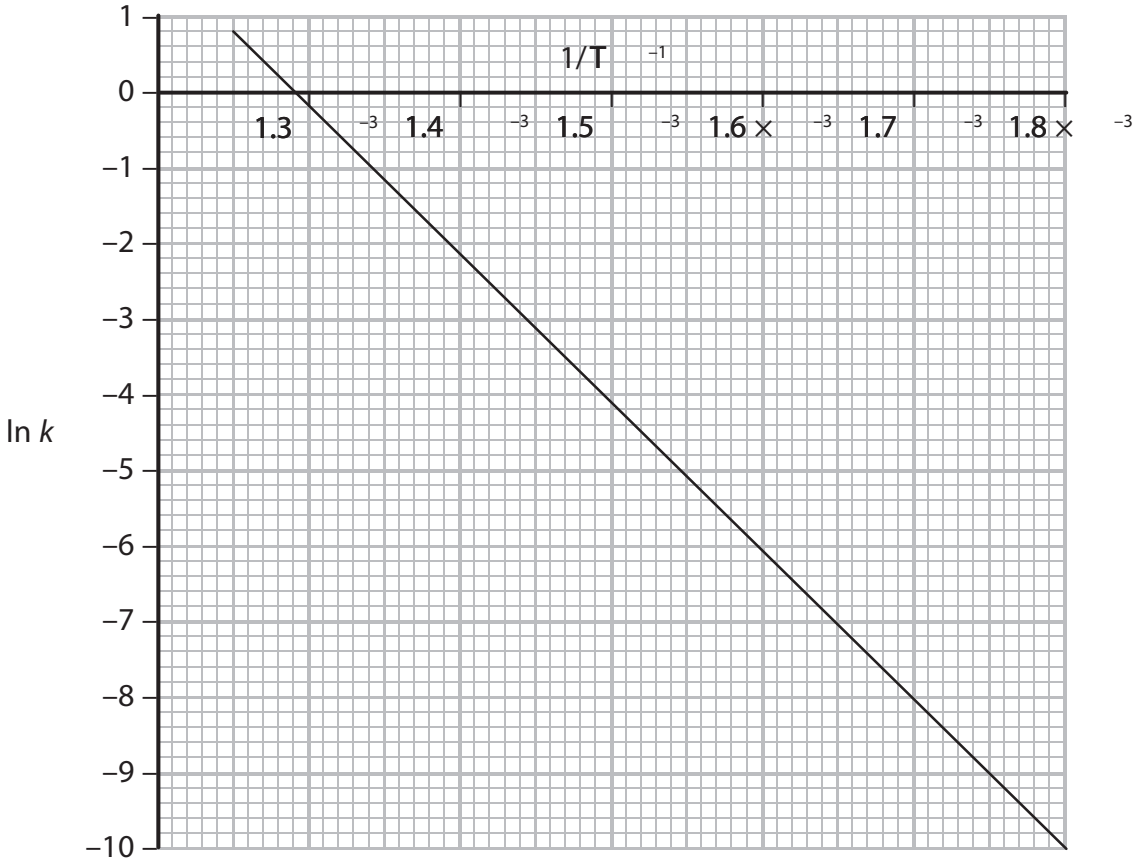
Explain your reasoning.

(2)

(b) Iodine also forms hydrogen iodide by direct reaction with hydrogen.

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

A graph of ln *k* against 1/T for this reaction is shown below.



(i) Calculate the gradient of the graph. Include a sign and units in your answer.

(2)

(ii) Use your value for the gradient of the graph to calculate the activation energy, E_a. Include units and give your answer to **three** significant figures.

The Arrhenius equation is

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + a \quad \text{onstant}$$

[Gas constant, $R = 8.31$ J mol^{-1} K^{-1}]

(2)

(Total for Question 1 = 15 marks)

2 The decomposition of dinitrogen pentoxide in a suitable solvent produces nitrogen dioxide, which remains in solution, and oxygen gas which is given off.

The overall equation for the reaction is:

$$N_2O_5 \rightarrow 2NO_2 + \tfrac{1}{2}O_2$$

(a) Draw a diagram of the apparatus you would use to follow the rate of this reaction and give the measurements you would make.

(3)

(b) (i) The rate equation for this reaction is:

$$\text{Rate} = k[N_2O_5]$$

What are the units of the rate constant, *k*?

(1)

*(ii) A suggested mechanism for the reaction is:

1st Step $N_2O_5 \rightarrow NO_2 + NO_3$ .....

2nd Step $_2 + NO_3 \rightarrow NO + O_2 + NO_2$ .....

3rd Step N $+ N_2O_5 \rightarrow 3NO_2$ .....

Label these reactions, fast or slow, and explain how your labelling is consistent with the rate equation for the reaction.

(3)

(c) The rate constant, *k*, was calculated at different temperatures.

(i) Suggest a practical method for keeping the temperature constant.

(1)

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(ii) The table shows the measurements of the rate constant, *k*, at different temperatures. Some of the corresponding values for reciprocal of temperature and ln *k* are also shown.

Complete the table by calculating the missing values.

(2)

T/K	*k*	$\frac{1}{T}$ / K^{-1}	ln *k*
280	3.80×10^{-6}	3.57×10^{-3}	−12.5
290	1.65×10^{-5}	3.45×10^{-3}	−11.0
300	6.87×10^{-5}	3.33×10^{-3}	−9.6
310	2.48×10^{-4}	3.23×10^{-3}	−8.3
320	8.65×10^{-4}		

*(iii) Plot a graph of ln *k* on the vertical axis against 1/T on the horizontal axis.

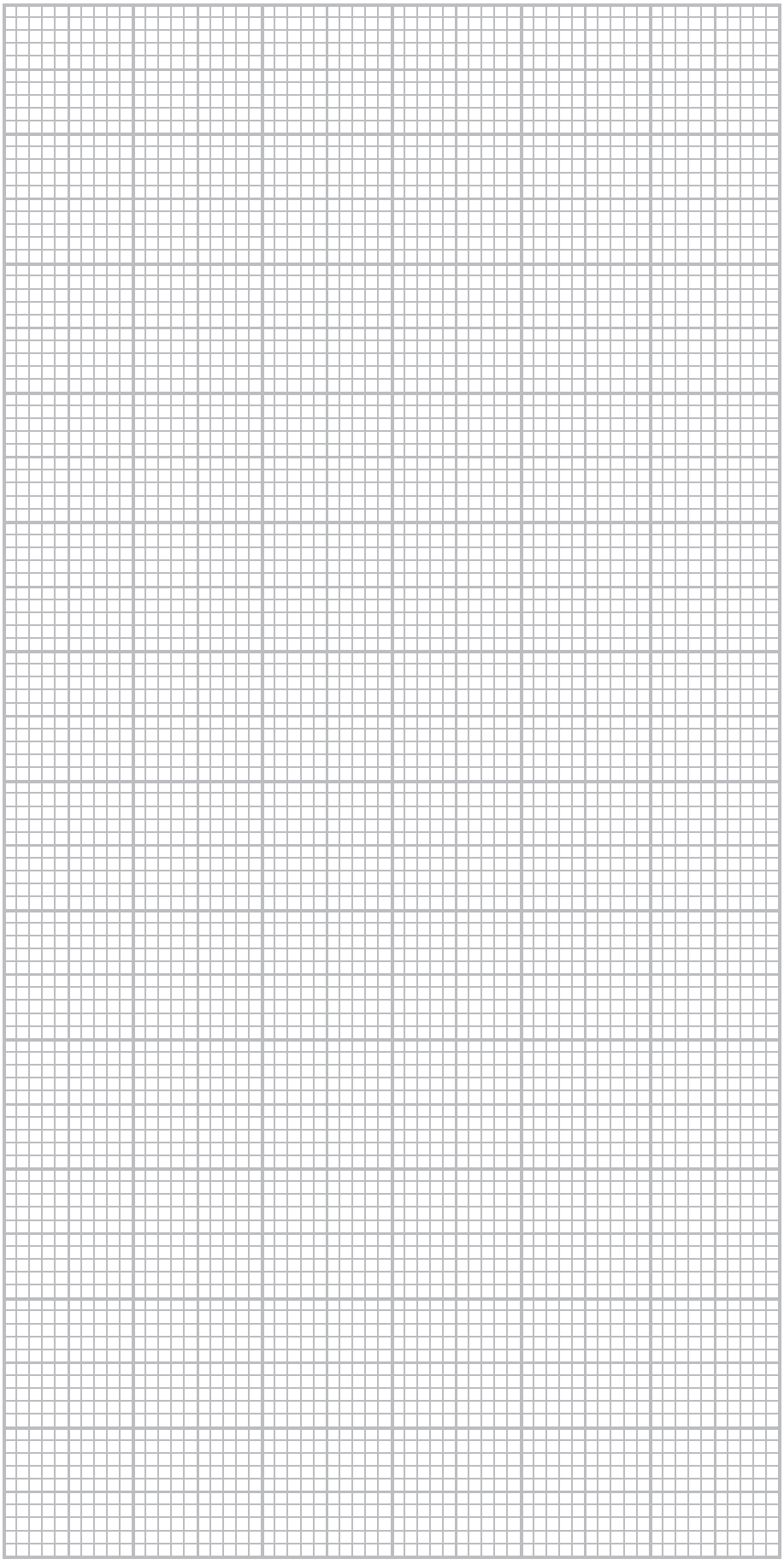
Calculate the gradient of your graph and use this to calculate the activation energy, E_a. Remember to include units with your answer, which should be given to three significant figures.

The Arrhenius equation can be expressed as

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + a \quad \text{onstant}$$

[Gas constant , $R = 8.31$ J K^{-1} mol^{-1}]

(7)



(Total for Question 2 = 17 marks)