AQA – Rate equations – A2 Chemistry P2

1. June/ 2020/Paper_2/No.1

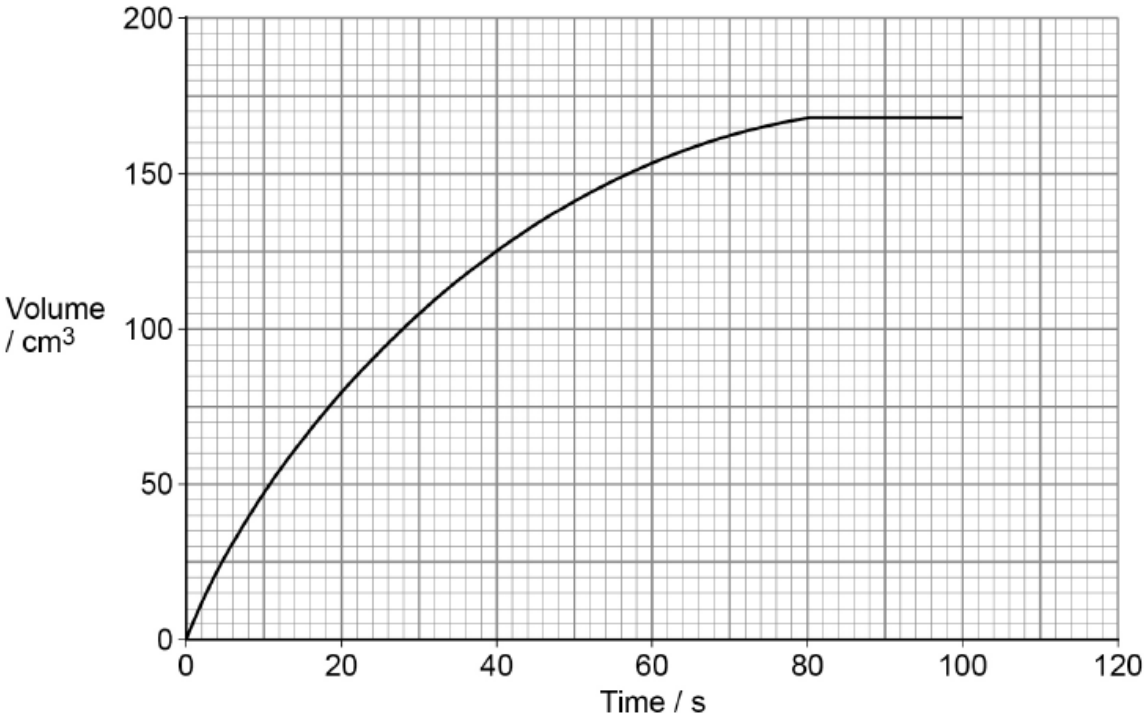
0 1 This question is about rates of reaction.

Phosphinate ions ($H_2PO_2^-$) react with hydroxide ions to produce hydrogen gas as shown.

$$H_2PO_2^- + OH^- \rightarrow HPO_3^{2-} + H_2$$

A student completed an experiment to determine the initial rate of this reaction.
The student used a solution containing phosphinate ions and measured the volume of hydrogen gas collected every 20 seconds at a constant temperature.
Figure 1 shows a graph of the student's results.

Figure 1



0 1 . 1 Use the graph in **Figure 1** to determine the initial rate of reaction for this experiment. State its units. Show your working on the graph.

[3 marks]

Rate _____ Units _____

0 1 . 2 Another student reacted different initial concentrations of phosphinate ions with an excess of hydroxide ions. The student measured the time (t) taken to collect 15 cm^3 of hydrogen gas. Each experiment was carried out at the same temperature. **Table 1** shows the results.

Table 1

Initial $[H_2PO_2^-]$ / mol dm^{-3}	t / s
0.25	64
0.35	32
0.50	16
1.00	4

State the relationship between the initial concentration of phosphinate and time (t).

Deduce the order of the reaction with respect to phosphinate.

[2 marks]

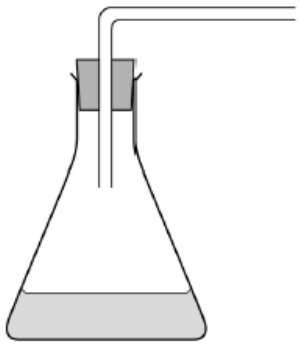
Relationship _____

Order _____

0 1 . 3 Complete the diagram in **Figure 2** to show how the hydrogen gas could be collected and measured in the experiments in Questions **01.1** and **01.2**.

[1 mark]

Figure 2



The rate equation for a different reaction is

$$rate = k\,[\mathrm{L}]\,[\mathrm{M}]^2$$

0 1 . 4 Deduce the overall effect on the rate of reaction when the concentrations of both **L** and **M** are halved.

[1 mark]

0 1 . 5 The rate of reaction is 0.0250 mol dm^{-3} s^{-1} when the concentration of **L** is 0.0155 mol dm^{-3}

Calculate the concentration of **M** if the rate constant is 21.3 mol^{-2} dm^{6} s^{-1}

[3 marks]

Concentration of **M** _____ mol dm^{-3}

0 1 . 6 Define the term overall order of reaction.

[1 mark]

_____

_____

_____

2. June/ 2019/Paper_2/No.4

0 4 Substances **P** and **Q** react in solution at a constant temperature.
The initial rate of reaction was studied in three experiments by measuring the change in concentration of **P** over the first five seconds of the reaction.
The data obtained are shown in **Table 1**.

Table 1

Experiment	Time after mixing / s	Concentration / mol dm^{-3}	
		P	**Q**
1	0	1.00×10^{-2}	1.25×10^{-2}
	5.0	0.92×10^{-2}	not measured
2	0	2.00×10^{-2}	1.25×10^{-2}
	5.0	1.84×10^{-2}	not measured
3	0	0.50×10^{-2}	2.50×10^{-2}
	5.0	0.34×10^{-2}	not measured

0 4 . 1 Complete **Table 2** to show the initial rate of reaction of **P** in each experiment.

[1 mark]

Table 2

Experiment	Initial rate / mol dm^{-3} s^{-1}
1	1.6×10^{-4}
2	
3	

0 4 . 2 Determine the order of reaction with respect to **P** and the order of reaction with respect to **Q**.

[2 marks]

Order with respect to **P** _____

Order with respect to **Q** _____

0 4 . 3 A reaction between substances **R** and **S** was second order with respect to **R** and second order with respect to **S**.
At a given temperature, the initial rate of reaction was 1.20×10^{-3} mol dm^{-3} s^{-1} when the initial concentration of **R** was 1.00×10^{-2} mol dm^{-3} and the initial concentration of **S** was 2.45×10^{-2} mol dm^{-3}

Calculate a value for the rate constant, k, for the reaction at this temperature.
Give the units for k

[3 marks]

k _____ Units _____

3. June/2021/Paper_2/No.10

1 0 This question is about rates of reaction.
Iodine and propanone react together in an acid-catalysed reaction

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

A student completed a series of experiments to determine the order of reaction with respect to iodine.

Method

- Transfer 25 cm^3 of 1.0 mol dm^{-3} propanone solution into a conical flask.
- Add 10 cm^3 of 1.0 mol dm^{-3} HCl(aq)
- Add 25 cm^3 of 5.0×10^{-3} mol dm^{-3} $I_2(aq)$ and start a timer.
- At intervals of 1 minute, remove a 1.0 cm^3 sample of the mixture and add each sample to a separate beaker containing an excess of $NaHCO_3(aq)$
- Titrate the contents of each beaker with a standard solution of sodium thiosulfate and record the volume of sodium thiosulfate used.

1 0 . 1 Suggest why the 1.0 cm^3 portions of the reaction mixture are added to an excess of $NaHCO_3$ solution.

[2 marks]

1 0 . 2 Suggest why the order of this reaction with respect to propanone can be ignored in this experiment.

[2 marks]

The volume of sodium thiosulfate solution used in each titration is proportional to the concentration of iodine in each beaker.

Table 5 shows the results of the experiment.

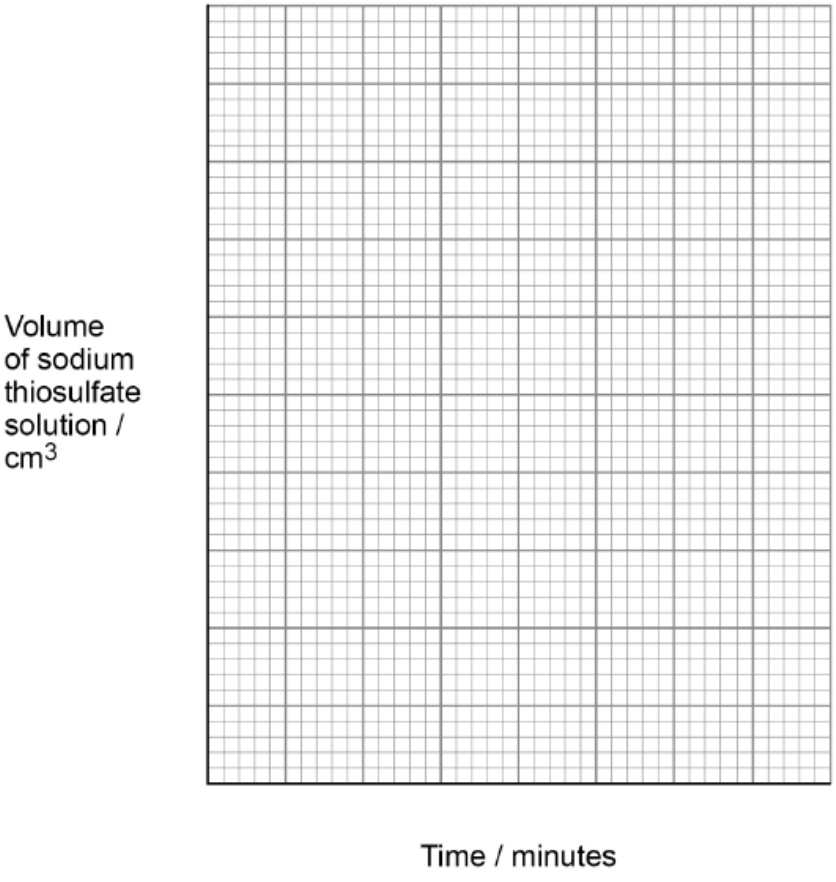
Table 5

Time / minutes	Volume of sodium thiosulfate solution / cm^3
1	41
2	35
3	24
4	22
5	16
6	10

1 0 . 3 Use the results in **Table 5** to draw a graph of volume of sodium thiosulfate solution against time.

Draw a line of best fit.

[3 marks]



1 0 . 4 Explain how the graph shows that the reaction is zero-order with respect to iodine in the reaction between propanone and iodine.

[2 marks]

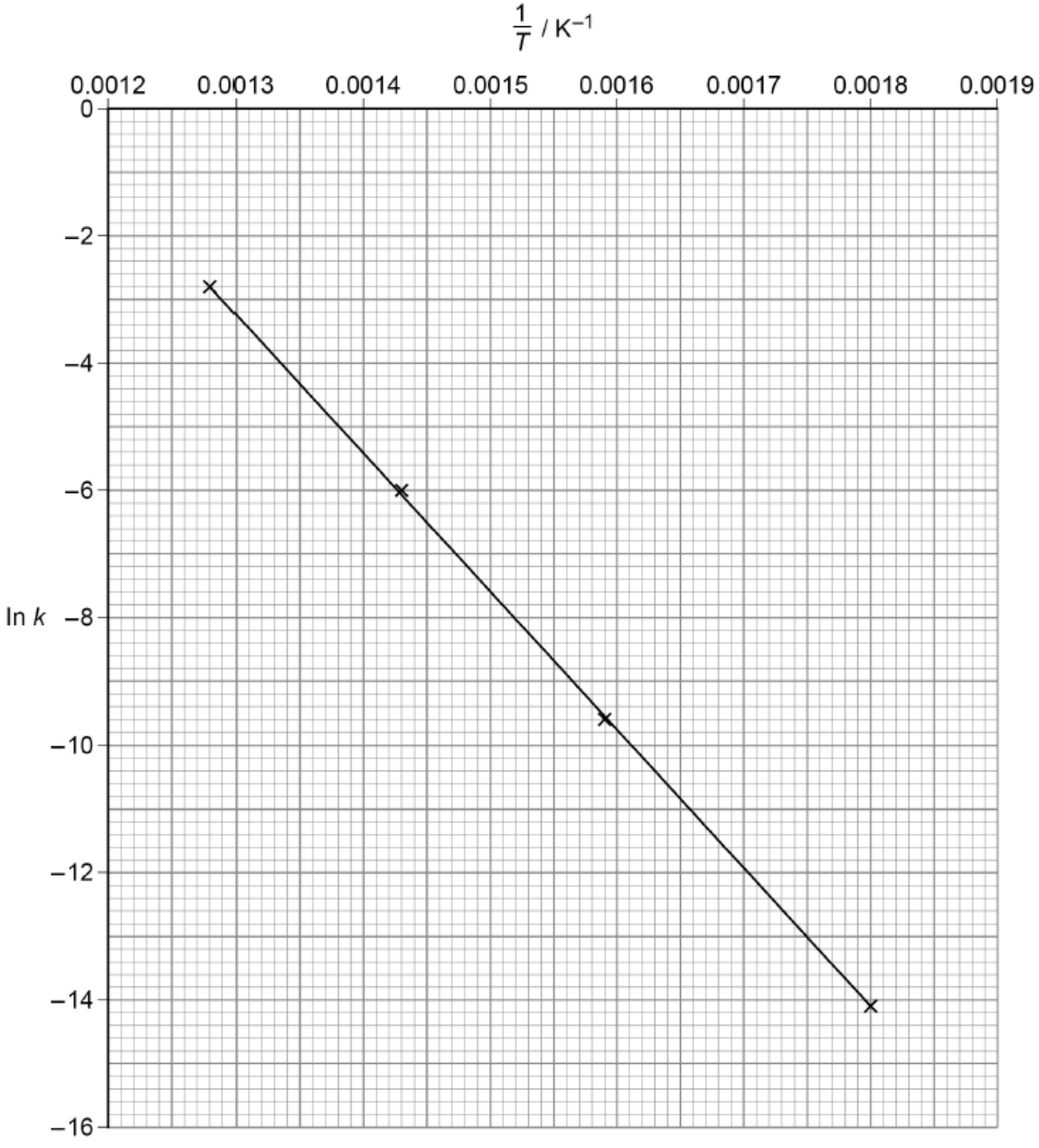
1 0 . 5 The Arrhenius equation can be written as

$$\ln k = \frac{-E_a}{RT} + \ln A$$

Figure 8 shows a graph of $\ln k$ against $\frac{1}{T}$ for the reaction

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

Figure 8



Use **Figure 8** to calculate a value for the activation energy (E_a), in kJ mol^{-1}, for this reaction.

The gas constant R = 8.31 J K^{-1} mol^{-1}

[3 marks

E_a _____ kJ mol^{-1}