

AQA A-Level Chemistry

Rate equations

Questions only

The newest questions, about an hour. All 19 are in the exam generator.

Questions

10

Total marks

46

Time allowed

1 h

Name

Class or teacher

Date

Instructions

- Answer all questions in the spaces provided.
- Use black ink. Show your working for every calculation.
- You may use a scientific calculator and the AQA Data Sheet.
- Print the separate mark scheme when you are ready to mark your answers.

For marking

Q	Source	Marks	Score
1	2017 A-level P3 Q27	1	
2	2018 A-level P3 Q12	1	
3	2018 A-level P3 Q13	1	
4	2019 A-level P3 Q10	1	
5	2025 A-level P2 Q9	11	
6	2025 A-level P3 Q2	15	
7	2025 A-level P3 Q4	9	
8	2020 A-level P3 Q33	1	
9	2023 A-level P2 Q2	5	
10	2020 A-level P3 Q12	1	

Total _____ / 46 Percentage _____ %

Questions from AQA past papers, 2017–2025, reproduced for revision. Practise these topics online, with instant marking:
whiteboardchemistry.com/revision/aqa-a-level-chemistry/exam-questions?topics=rate-equations&len=0

Questions

Rate equations · 10 questions · 46 marks · time allowed 1 h

Q1 · June 2017 · Paper 3 · Q27 · [1 mark]

This question also needs Acids and bases.

The rate equation for the acid-catalysed reaction between iodine and propanone is: $\text{rate} = k [\text{H}^+] [\text{C}_3\text{H}_6\text{O}]$

The rate of reaction was measured for a mixture of iodine, propanone and sulfuric acid at $\text{pH} = 0.70$

In a second mixture the concentration of the sulfuric acid was different but the concentrations of iodine and propanone were unchanged. The new rate of reaction was a quarter of the original rate.

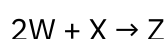
What was the pH of the second mixture?

Tick (✓) one box.

- ☐ **A** 1.00
- ☐ **B** 1.30
- ☐ **C** 1.40
- ☐ **D** 2.80
-

Q2 · June 2018 · Paper 3 · Q12 · [1 mark]

Solutions of two compounds, W and X, react together in the presence of a soluble catalyst, Y, as shown in the equation



When the concentrations of W, X and Y are all doubled, the rate of reaction increases by a factor of four.

Which is a possible rate equation for this reaction?

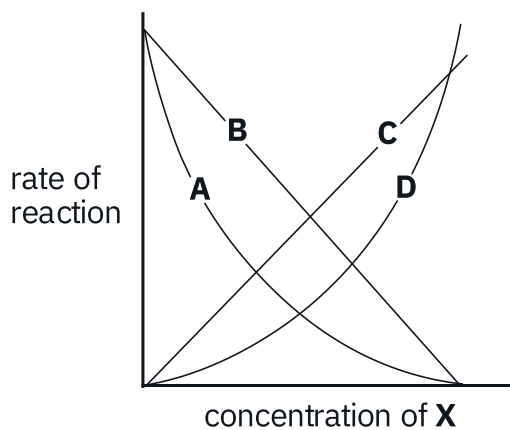
Tick (✓) one box.

- ☐ **A** $\text{rate} = k [\text{W}]^2 [\text{X}]$
- ☐ **B** $\text{rate} = k [\text{W}]^2 [\text{Y}]$
- ☐ **C** $\text{rate} = k [\text{X}] [\text{Y}]$
- ☐ **D** $\text{rate} = k [\text{X}] [\text{Z}]$

Q3 · June 2018 · Paper 3 · Q13 · [1 mark]

A series of experiments was carried out to find the order of reaction with respect to reactant X. In these experiments, only the concentration of X was changed.

Which graph would show that the reaction is second-order with respect to X?



Tick (✓) one box.

☐ **A** A

☐ **B** B

☐ **C** C

☐ **D** D

Q4 • June 2019 • Paper 3 • Q10 • [1 mark]

The results of an investigation of the reaction between P and Q are shown in this table.

Initial [P] Initial [Q] Initial rate

Experiment

/ mol dm⁻³ / mol dm⁻³ / mol dm⁻³ s⁻¹

1	0.200	0.500	0.400
2	0.600	To be calculated	0.800

The rate equation is: rate = k [P] [Q]²

What is the initial concentration of Q in experiment 2?

Tick (✓) one box.

☐ **A** 0.167

☐ **B** 0.333

☐ **C** 0.408

☐ **D** 0.612

Q5 • June 2025 • Paper 2 • Q9 • [11 marks]

This question also needs Halogenoalkanes.

This question is about rates of reaction.

The rate of hydrolysis of a bromoalkane (RBr) is investigated using this method.

- A boiling tube has a cross drawn onto it.
- An aqueous solution of silver nitrate is added to an ethanolic solution of RBr in the boiling tube in a warm water bath.
- The time is recorded for the cross on the boiling tube to become invisible.

The method is repeated at different temperatures.

09.1 State why the cross on the boiling tube becomes invisible.

[1 mark]

09.2 The volume and concentration of each substance used at each temperature is kept constant.

Identify one other variable that should be kept constant to ensure that the investigation is fair.

[1 mark]

09.3 The reaction between the bromoalkane RBr and an aqueous solution of KOH is investigated.

The rate constant k for this reaction is determined at a series of temperatures T .

The Arrhenius equation can be written in this form.

$$\ln k = - (E_a)/(RT) + \ln A$$

Table 2 shows an incomplete set of results for this investigation.

Table 2

$T / ^\circ\text{C}$	$(1)/(T) / \text{K}^{-1}$	$k / \text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$	$\ln k$
39.5	3.20×10^{-3}	0.432	-0.84
44.5	3.15×10^{-3}	0.741	-0.30
52.2		1.65	0.50
60.3	3.00×10^{-3}	3.74	1.32
71.8	2.90×10^{-3}	10.8	2.38

Complete Table 2.

[1 mark]

09.4 The results in Table 2 can be used to plot a graph to determine the activation energy

E_a for this reaction.

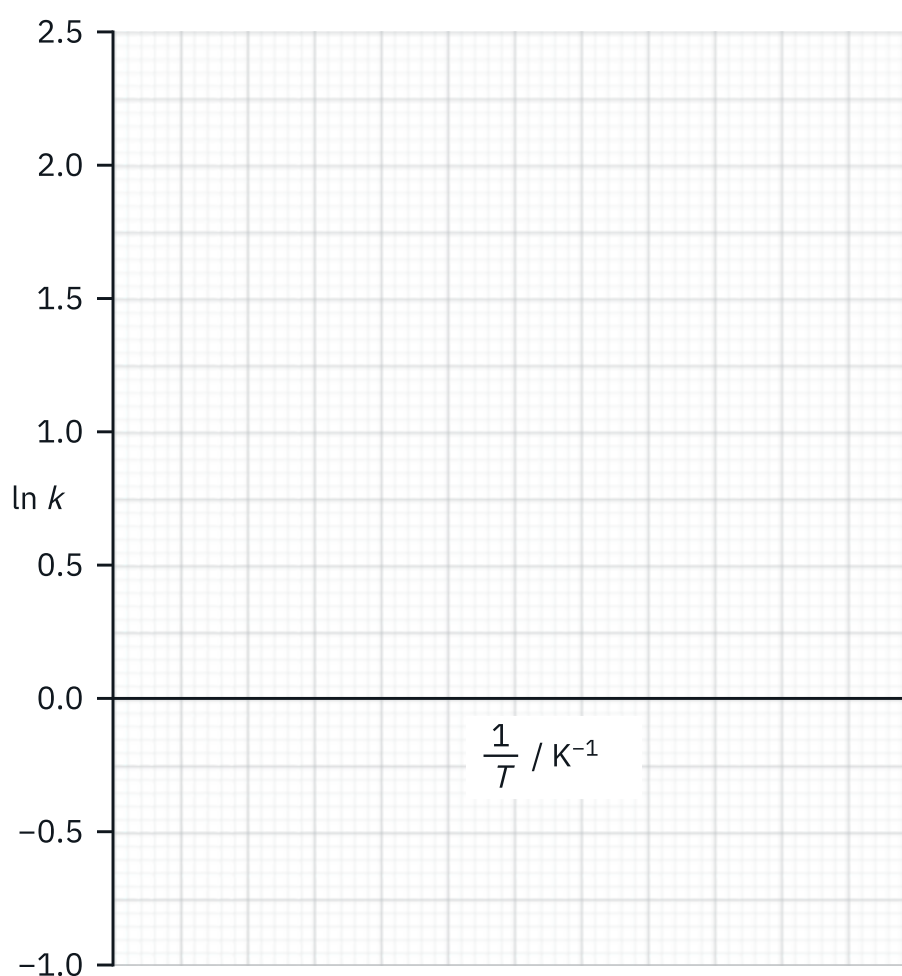
Complete the x-axis in Figure 10 by adding an appropriate scale.

Plot the graph on the grid in Figure 10.

Use your graph to determine a value, in kJ mol^{-1} , for the activation energy E_a

The gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

Figure 10



$E_a \text{ kJ mol}^{-1}$

[5 marks]

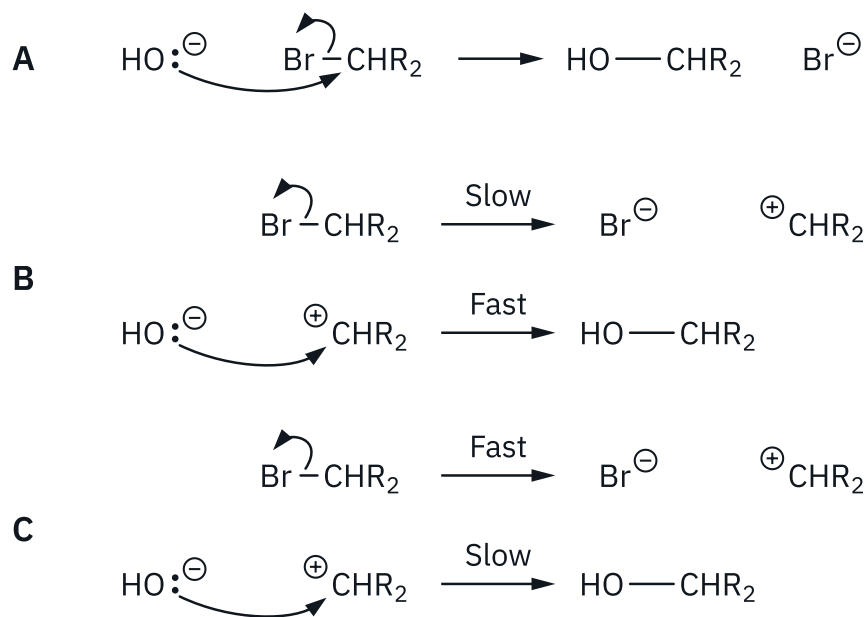
Draw your answer on the figure above.

09.5 The rate equation for the reaction between a different bromoalkane (R_2CHBr) and an aqueous solution of KOH is

$$\text{rate} = k [R_2CHBr]$$

Which of these is a correct mechanism for the reaction between R_2CHBr and KOH?

Tick (✓) one box.



[1 mark]

A

B

C

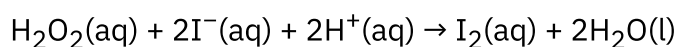
09.6 Explain, in terms of bond polarity, why R_2CHBr and KOH react together.

[2 marks]

Q6 • June 2025 • Paper 3 • Q2 • [15 marks]

The effect of reactant concentrations on the rate of a reaction is investigated.

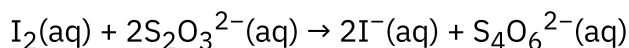
The equation for the reaction is shown.



The experiment is done five times in the presence of thiosulfate ions and starch.

The reactant concentrations are varied by changing the volume of each reactant in the mixture.

The thiosulfate ions react with the iodine as it is produced, until all the thiosulfate has reacted.



After all the thiosulfate has reacted, the iodine produced in the mixture then reacts with the starch and the solution turns blue-black.

The time taken for the solution to turn blue-black is recorded.

If the amount of thiosulfate is the same in each experiment, the time recorded represents the time to produce the same amount of iodine in each experiment.

Table 3 shows the results of the investigation.

Table 3

$[H_2O_2]$ $[I^-]$ $[H^+]$ Time for reaction mixture

Experiment

/ mol dm^{-3} / mol dm^{-3} / mol dm^{-3} to turn blue-black / s

Experiment	[H ₂ O ₂] / mol dm ⁻³	[I ⁻] / mol dm ⁻³	[H ⁺] / mol dm ⁻³	Time for reaction mixture to turn blue-black / s
1	0.010	0.010	0.10	60
2	0.020	0.010	0.10	30
3	0.030	0.010	0.10	20
4	0.030	0.020	0.10	10
5	0.030	0.020	0.20	10

02.1 The amount of thiosulfate is the same in each experiment. To allow the order of reaction with respect to each reactant to be calculated, several other variables need to be controlled.

Identify three other control variables.

[3 marks]

Control variable 1

Control variable 2

Control variable 3

02.2 Deduce the order of reaction with respect to each reactant.

Explain how you deduced the order of reaction with respect to iodide ions.

[3 marks]

Order with respect to H_2O_2

Order with respect to I^-

Order with respect to H^+

Explanation

02.3 Give the rate equation for the reaction.

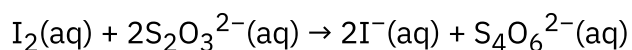
Determine the units of the rate constant.

[2 marks]

Rate equation

Units of rate constant

02.4 In each experiment, 1.00 cm^3 of $1.00 \times 10^{-3} \text{ mol dm}^{-3}$ sodium thiosulfate solution is used to react with the iodine initially produced.



The total volume of the reaction mixture in experiment 3 is 40.0 cm^3

Calculate the initial rate of production of iodine, in $\text{mol dm}^{-3} \text{ s}^{-1}$, for experiment 3.

Initial rate $\text{mol dm}^{-3} \text{ s}^{-1}$

[3 marks]

02.5 The total uncertainty in the times recorded for each experiment is $\pm 0.5 \text{ s}$ but the stopwatch used has a measurement uncertainty of $\pm 0.01 \text{ s}$

Suggest why, in each experiment, the uncertainty in the times recorded is greater than the measurement uncertainty of the stopwatch.

[1 mark]

02.6 Calculate the percentage uncertainty in the time recorded in experiment 3.

Percentage uncertainty

[1 mark]

02.7 The five experiments are repeated with the same stopwatch and the same concentrations and volumes of H_2O_2 , I^- and H^+

Suggest and explain how the method can be changed to decrease the percentage uncertainty in the times recorded.

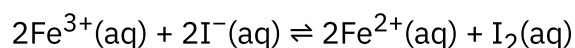
[2 marks]

Q7 • June 2025 • Paper 3 • Q4 • [9 marks]

50.0 cm^3 of $0.015 \text{ mol dm}^{-3} \text{ Fe}_2(\text{SO}_4)_3(\text{aq})$ are mixed with 50.0 cm^3 of

$0.015 \text{ mol dm}^{-3} \text{ KI}(\text{aq})$ at a temperature of 40°C

The mixture is left for several hours until equilibrium is reached.



A sample of the equilibrium mixture is titrated to determine the amount of $\text{I}^{-}(\text{aq})$ in the equilibrium mixture.

04.1 Give the expression for the equilibrium constant, K_c , for the equilibrium.

K_c

[1 mark]

04.2 Before the titration, the sample is 'quenched' by adding 50 cm^3 of ice-cold water.

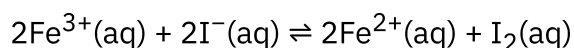
Suggest why the sample is 'quenched' in this way before the titration.

Explain your answer.

[2 marks]

04.3 The amount of $\text{I}^-(\text{aq})$ in the equilibrium mixture is found to be $3.00 \times 10^{-4} \text{ mol}$

Calculate the value of K_c at 40°C for the equilibrium.



Give the units of K_c

Assume that the total volume of the mixture remains constant at 100 cm^3

[6 marks]

K_c

Units of K_c

Q8 • November 2020 • Paper 3 • Q33 • [1 mark]

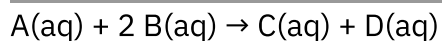
What are the units of the rate constant for a third order reaction?

Tick (✓) one box.

- ☐ **A** $\text{mol dm}^{-3} \text{ s}^{-1}$
- ☐ **B** $\text{mol}^{-1} \text{ dm}^3 \text{ s}^{-1}$
- ☐ **C** $\text{mol}^2 \text{ dm}^{-6} \text{ s}^{-1}$
- ☐ **D** $\text{mol}^{-2} \text{ dm}^6 \text{ s}^{-1}$

Q9 • June 2023 • Paper 2 • Q2 • [5 marks]

A and B react together in the presence of an acid catalyst.



The rate equation for this reaction is

$$\text{rate} = k[\text{B}]^2[\text{H}^+]$$

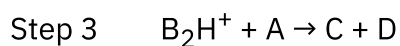
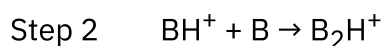
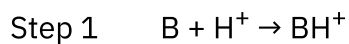
The table below shows how the values of the relative initial rate vary with different concentrations of each reagent at the same temperature.

Experiment	[A] / mol dm ⁻³	[B] / mol dm ⁻³	[H ⁺] / mol dm ⁻³	Relative initial rate
1	0.40	0.20	0.10	1.00
2	0.50	0.20	0.10	
3	0.40		0.10	0.64
4	0.50	0.30	0.06	

(a) Complete the table by calculating the missing values.

[3 marks]

(b) A suggested mechanism for the reaction is shown.



Deduce the rate-determining step for this reaction.

Give a reason for your answer.

[2 marks]

Rate-determining step

Reason

Q10 • November 2020 • Paper 3 • Q12 • [1 mark]

The rate expression for the reaction between X and Y is $\text{rate} = k [X]^2 [Y]$ Which statement is correct?

Tick (✓) one box.

- ☐ **A** The rate constant has units $\text{mol}^{-1} \text{dm}^3 \text{s}^{-1}$
- ☐ **B** The rate of the reaction is halved if the concentration of X is halved and the concentration of Y is doubled.
- ☐ **C** The rate increases by a factor of 16 if the concentration of X is tripled and the concentration of Y is doubled.
- ☐ **D** The rate constant is independent of temperature.

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Mark scheme:

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