

OCR A-Level Chemistry A

Rate equations

Questions only

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

Questions

11

Total marks

43

Time allowed

58 min

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 OCR Data Sheet.
- Print the separate mark scheme when you are ready to mark your answers.

For marking

Q	Source	Marks	Score
1	2019 P1 Q21	6	
2	2022 P1 Q8	1	
3	2022 P3 Q4	8	
4	2023 P1 Q17	6	
5	2024 P1 Q10	1	
6	2024 P1 Q17	7	
7	2024 P1 Q9	1	
8	2025 P1 Q12	1	
9	2025 P1 Q9	1	
10	2020 P1 Q8	1	
11	2021 P1 Q21	10	

Total _____ / 43 Percentage _____ %

Questions from OCR past papers, 2019–2025, reproduced for revision. Practise these topics online, with instant marking:
whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=rate-equations&len=0

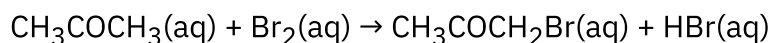
Questions

Rate equations · 11 questions · 43 marks · time allowed 58 min

Q1 · June 2019 · Paper 1 (Periodic table, elements and physical chemistry) · Q21 · [6 marks]

This question also needs Amount of substance.

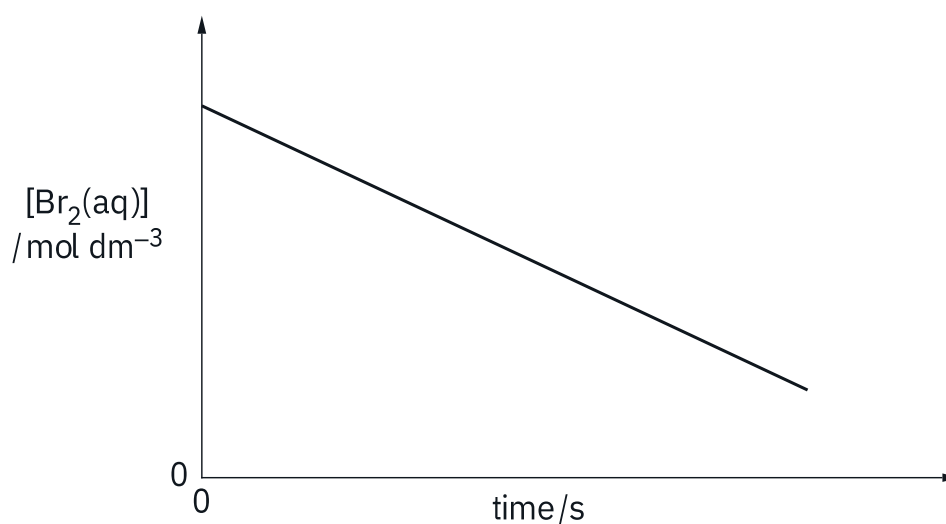
21 Three students carry out a rates investigation on the reaction between bromine and propanone in the presence of hydrochloric acid.



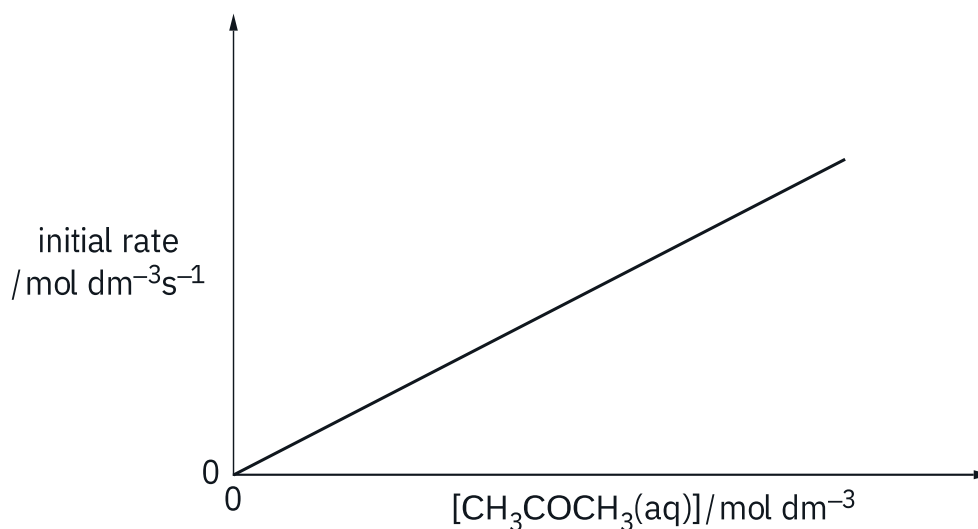
Each student investigates the effect of changing the concentration of one of the reactants whilst keeping the other concentrations constant.

Their results are shown below.

Results of student 1



Results of student 2



Results of student 3

Experiment	$[\text{Br}_2(\text{aq})]$ / mol dm^{-3}	$[\text{CH}_3\text{COCH}_3(\text{aq})]$ / mol dm^{-3}	$[\text{H}^+(\text{aq})]$ / mol dm^{-3}	Initial rate / $10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$
1	0.004	1.60	0.20	1.25
2	0.004	1.60	0.40	2.50

Explain how the reaction orders can be determined from the students' results, and determine the rate equation and rate constant.

[6 marks]

Q2 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

The half-life for a first order reaction is 80 s.

What is the rate constant k , in s^{-1} , for this reaction?

Tick (✓) one box.

☐ **A** 8.66×10^{-3}

☐ **B** 0.0125

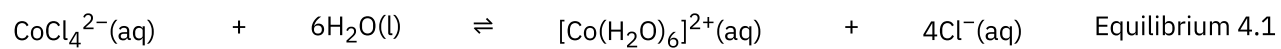
☐ **C** 55.5

☐ **D** 115

Q3 · June 2022 · Paper 3 (Unified chemistry) · Q4 · [8 marks]

This question also needs Reaction rates and equilibrium.

Two students plan to investigate Equilibrium 4.1, shown below.



blue

pink

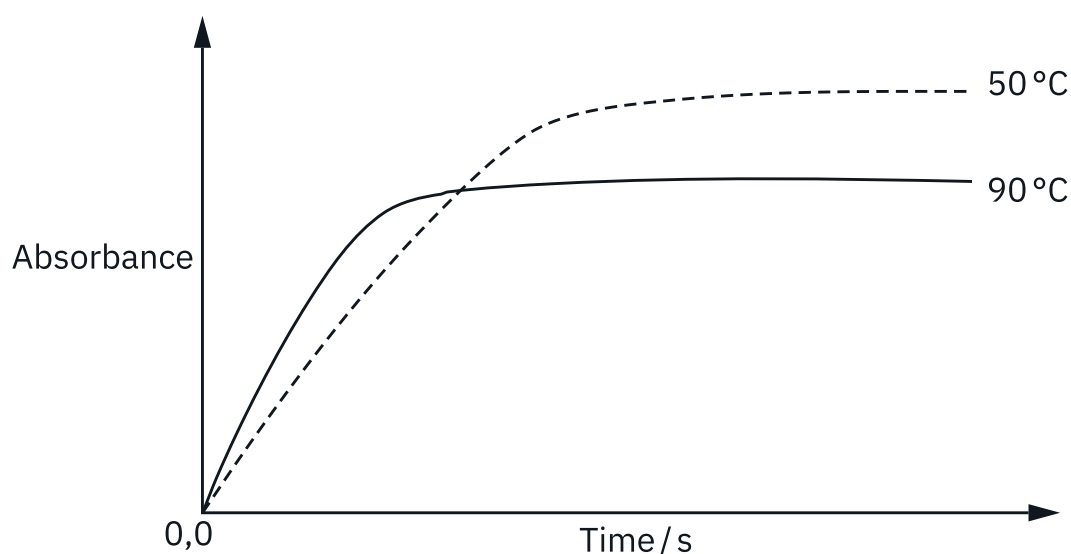
4(a) The students are supplied with the equilibrium mixture in Equilibrium 4.1 at room temperature.

- One student heats 20 cm³ of the mixture to 50 °C.
- The other student heats 20 cm³ of the mixture to 90 °C.

The students use colorimetry to observe how the colour of the equilibrium mixture changes over time.

- The colorimeter is set up so that the greater the absorbance, the greater the concentration of $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.
- The initial absorbance is set to zero.
- The absorbance is recorded every 30 seconds.

The students plot the graph below from the results of the experiment.



Use the graph and relevant chemical theory to answer the following. Include all reasoning:

- Explain the different initial rates at 50 °C and 90 °C.

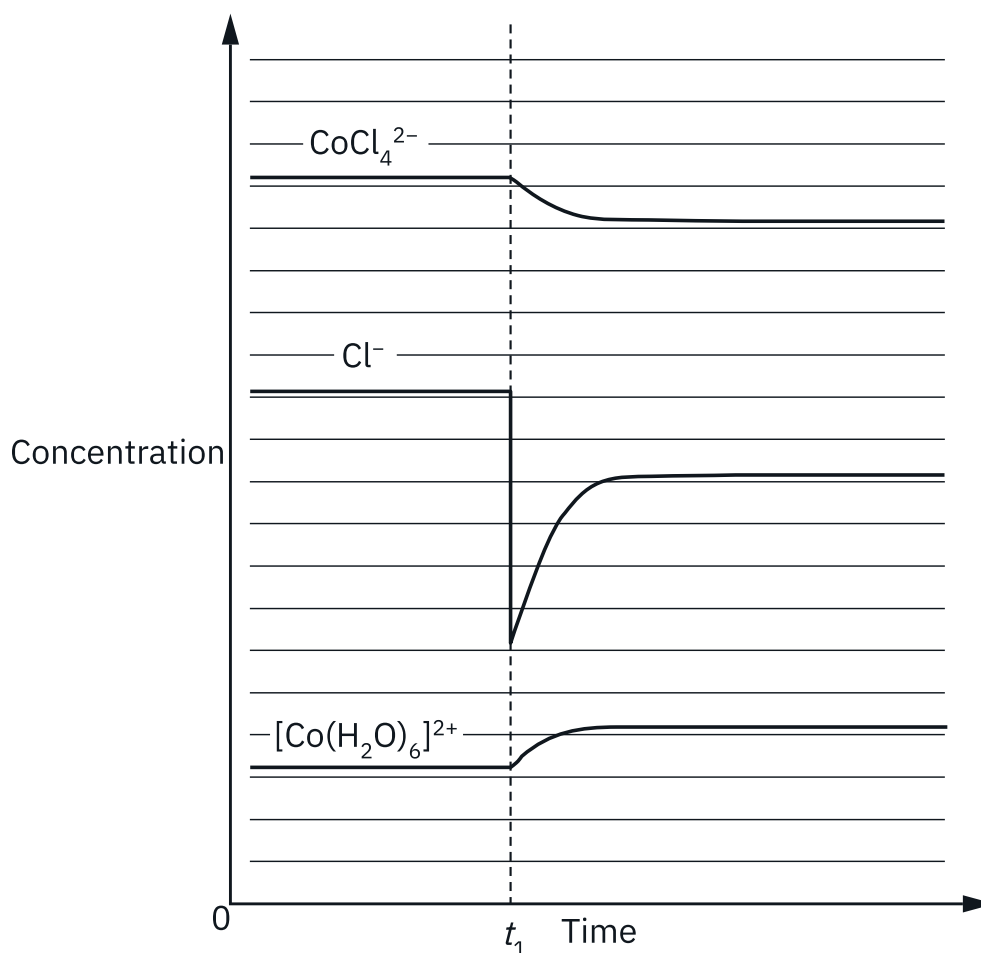
- Predict the sign of ΔH for the forward reaction in Equilibrium 4.1.

[4 marks]

The students investigate how addition of aqueous silver nitrate, $\text{AgNO}_3(\text{aq})$, affects the equilibrium position in Equilibrium 4.1.

The graph shows the changes in the equilibrium concentrations of CoCl_4^{2-} , Cl^- and $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ after addition of the $\text{AgNO}_3(\text{aq})$.

The $\text{AgNO}_3(\text{aq})$ is added at time = t_1 .



4(b)(i) Explain why the Cl^- concentration drops sharply at time = t_1 .

[1 mark]

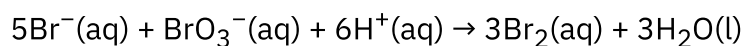
4(b)(ii) Explain the changes in concentration of CoCl_4^{2-} , Cl^- and $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$ after time = t_1 .

Refer to Equilibrium 4.1 in your answer.

[3 marks]

Q4 · June 2023 · Paper 1 (Periodic table, elements and physical chemistry) · Q17 · [6 marks]

17 Bromine, Br₂, can be produced by the reaction:



A student investigates the rate of this reaction by carrying out four experiments at the same temperature. The student's results are shown below.

Experiment	[Br ⁻] / mol dm ⁻³	[BrO ₃ ⁻] / mol dm ⁻³	[H ⁺] / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	2.00 × 10 ⁻²	1.20 × 10 ⁻¹	8.00 × 10 ⁻²	2.52 × 10 ⁻⁴
2	6.00 × 10 ⁻²	1.20 × 10 ⁻¹	8.00 × 10 ⁻²	7.56 × 10 ⁻⁴
3	4.00 × 10 ⁻²	6.00 × 10 ⁻²	8.00 × 10 ⁻²	2.52 × 10 ⁻⁴
4	2.00 × 10 ⁻²	6.00 × 10 ⁻²	4.00 × 10 ⁻¹	3.15 × 10 ⁻³

Explain how the reaction orders can be determined from the student's results, and determine the rate equation and rate constant for this reaction.

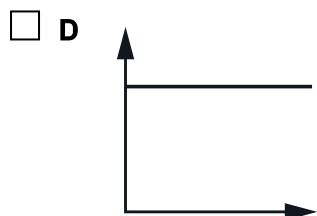
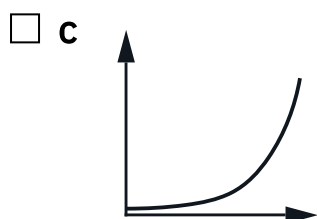
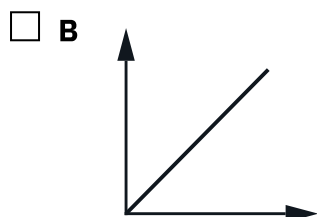
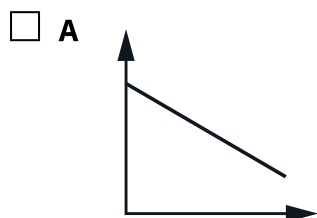
[6 marks]

Q5 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q10 · [1 mark]

A reaction is zero order with respect to a reactant.

Which rate–concentration graph for the reactant is the correct shape?

Tick (✓) one box.

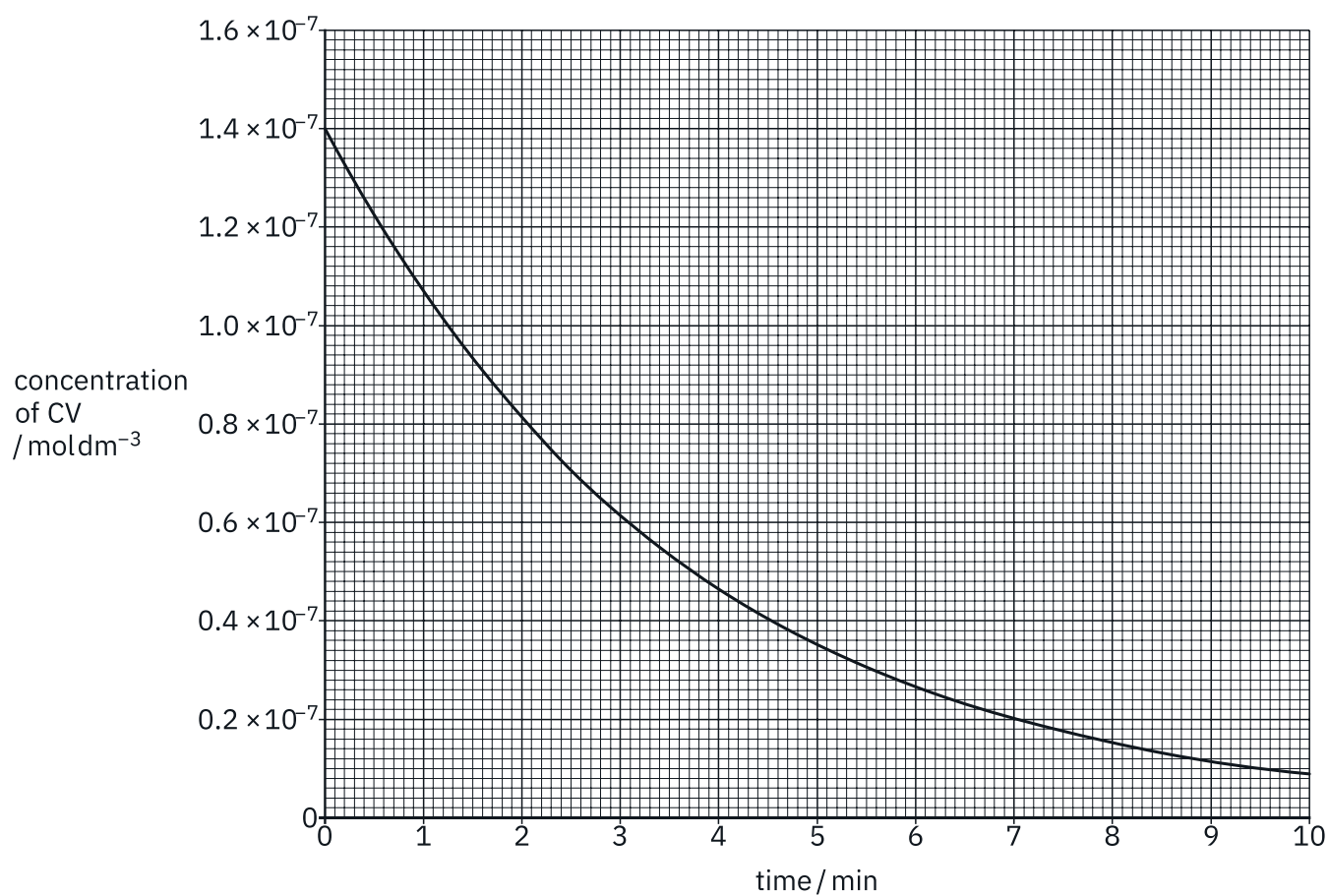
**Q6 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q17 · [7 marks]**

Crystal violet (CV) is a purple dye. In the presence of an alkali, CV reacts to form a colourless product.

A student uses a colorimeter to investigate the rate of the reaction between CV and sodium hydroxide, NaOH.

- The student mixes 10.0 cm^3 of $2.8 \times 10^{-7} \text{ mol dm}^{-3}$ CV with 10.0 cm^3 of $0.016 \text{ mol dm}^{-3}$ NaOH.
- A large excess of NaOH is used, so that the reaction is effectively zero-order with respect to OH^- ions.
- The student places a sample of the reaction mixture in a colorimeter and measures the absorbance over time.

The student uses the absorbance readings to calculate the concentration of CV and plots a graph of concentration of CV against time, as shown below.



17(a) Using collision theory, explain why the gradient decreases over time.

[1 mark]

17(b) Use the graph to determine the order of reaction with respect to CV, the rate of the reaction at three minutes and the rate constant, k.

Your answer must show full working on the graph and on the lines below.

[6 marks]

Q7 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

A graph of $\ln(k)$ is plotted against $1/T$ for a reaction.

(k = rate constant, T = temperature in K.)

The gradient has the numerical value of $-16\,000$.

What is the activation energy, in kJ mol^{-1} , for this reaction?

Tick (✓) one box.

- ☐ **A** +1.92
- ☐ **B** +133
- ☐ **C** +1920
- ☐ **D** +133 000

Q8 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q12 · [1 mark]

The rate constant, k , for a first order reaction is $6.19 \times 10^{-3} \text{ s}^{-1}$.

What is the half-life, in s, for the reaction?

Tick (✓) one box.

☐ **A** 4.29×10^{-3}

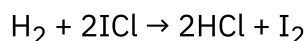
☐ **B** 49

☐ **C** 112

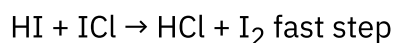
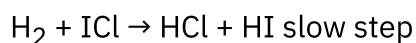
☐ **D** 323

Q9 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

Hydrogen reacts with iodine monochloride, ICl, as shown in the equation:



The mechanism for the reaction is:



What is the rate equation for the reaction between H_2 and ICl?

Tick (✓) one box.

☐ **A** $\text{rate} = k[\text{HI}][\text{ICl}]$

☐ **B** $\text{rate} = k[\text{H}_2][\text{ICl}]$

☐ **C** $\text{rate} = k[\text{H}_2][\text{ICl}]^2$

☐ **D** $\text{rate} = k[\text{H}_2][\text{HI}][\text{ICl}]^2$

Q10 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

This question also needs Reaction rates and equilibrium.

A graph is plotted of $\ln(k)$ against $1/T$.

(k = rate constant, T = temperature in K)

The gradient has the numerical value of $-55\,000$.

What is the activation energy, in kJ mol^{-1} ?

Tick (✓) one box.

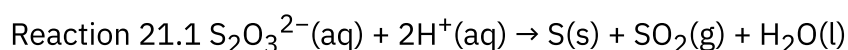
- ☐ **A** $+1.5 \times 10^{-7}$
- ☐ **B** $+2.22 \times 10^{-6}$
- ☐ **C** $+6.62$
- ☐ **D** $+457$

Q11 · November 2021 · Paper 1 (Periodic table, elements and physical chemistry) · Q21 · [10 marks]

This question also needs Reaction rates and equilibrium and Redox and electrode potentials.

This question is about how the rate of reaction is affected by changes in conditions.

A student carries out two investigations using the reaction between aqueous thiosulfate ions, $\text{S}_2\text{O}_3^{2-}(\text{aq})$, and aqueous hydrogen ions, $\text{H}^+(\text{aq})$.



In Investigation 1, the student determines how the rate of Reaction 21.1 is affected by changes in concentration.

The results are shown in the table.

Experiment	$[\text{S}_2\text{O}_3^{2-}(\text{aq})] / \text{mol dm}^{-3}$	$[\text{H}^+(\text{aq})] / \text{mol dm}^{-3}$	initial rate / $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.16	1.00	0.0120
2	0.08	1.00	0.0060
3	0.02	0.50	0.0015

From the results, the student concludes that the rate equation is

$$\text{rate} = k [\text{S}_2\text{O}_3^{2-}(\text{aq})]$$

21(a)(i) Explain how the student's results support this rate equation.

[2 marks]

21(a)(ii) Predict a possible two-step mechanism for Reaction 21.1.

The first step is the rate-determining step.

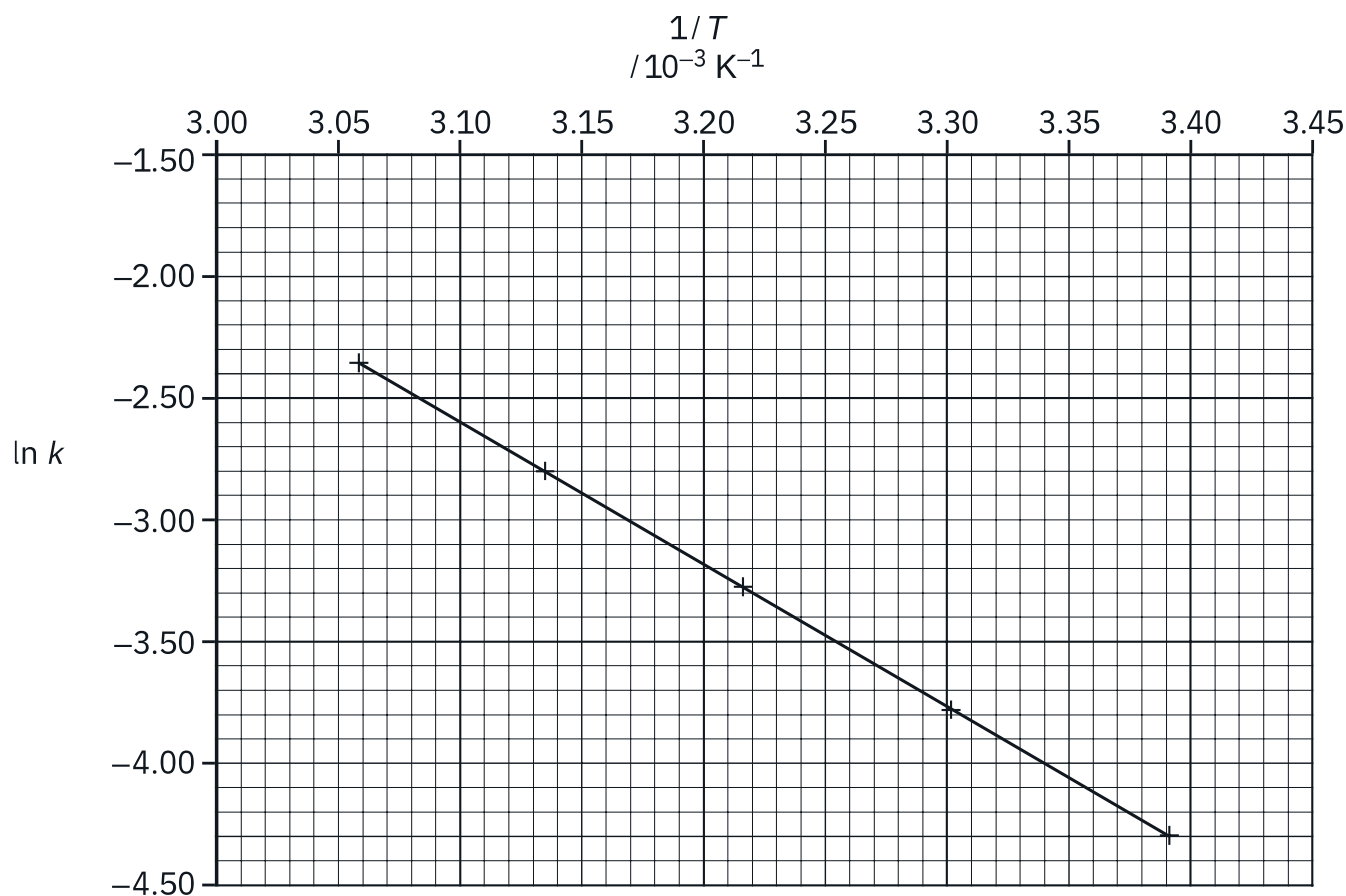
[2 marks]

Step 1

Step 2

In Investigation 2 the student determines the rate constant k of Reaction 21.1 at different temperatures, T .

From the results, the student plots a graph of $\ln k$ against $1/T$ as shown below.



Graph 21.2

21(b)(i) Calculate the activation energy, E_a , for Reaction 21.1, in kJ mol^{-1} .

Give your answer to 3 significant figures.

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

[3 marks]

21(b)(ii) From the graph the student estimates the value of $\ln A$ as -2.00 .

(A is the pre-exponential factor.)

Explain what mistake the student has made.

[1 mark]

21(b)(iii) The student calculates the value of k in Investigation 1 as 0.075 s^{-1} .

Using Graph 21.2, determine the temperature, in $^{\circ}\text{C}$, at which Investigation 1 was carried out.

temperature = $^{\circ}\text{C}$

[2 marks]

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Mark scheme:

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