

OCR A-Level Chemistry A

Reaction rates and equilibrium

Questions only

All 9 reaction rates and equilibrium questions

Questions

9

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	2018 P1 Q14	1	
2	2018 P3 Q2	13	
3	2022 P1 Q16	10	
4	2024 P1 Q11	1	
5	2024 P1 Q8	1	
6	2025 P1 Q18	14	
7	2025 P1 Q5	1	
8	2020 P1 Q13	1	
9	2020 P1 Q7	1	

Total _____ / 43 Percentage _____ %

Questions from OCR past papers, 2018–2025, reproduced for revision. Practise these topics online, with instant marking:

whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/?topics=reaction-rates-and-equilibrium&len=0

Questions

Reaction rates and equilibrium · 9 questions · 43 marks · time allowed 58 min

Q1 · June 2018 · Paper 1 (Periodic table, elements and physical chemistry) · Q14 · [1 mark]

Which statement(s) explain(s) why reaction rates increase as temperature increases?

- 1 The activation energy is less.
- 2 Collisions between molecules are more frequent.
- 3 A greater proportion of molecules have energy greater than the activation energy.

Tick (✓) one box.

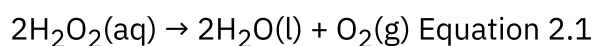
- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1
-

Q2 · June 2018 · Paper 3 (Unified chemistry) · Q2 · [13 marks]

This question also needs Amount of substance, Electrons, bonding and structure, Enthalpy changes and 2 other topics.

This question looks at reactions of hydrogen peroxide and of cobalt(II) ions.

Aqueous hydrogen peroxide decomposes as shown in equation 2.1.



The reaction is catalysed by manganese(IV) oxide, MnO_2 .

A student investigates the decomposition of a hydrogen peroxide solution as outlined below.

- The student adds 50.00 cm^3 of $\text{H}_2\text{O}_2(\text{aq})$ to a conical flask.
- The student adds a small spatula measure of MnO_2 and quickly connects the flask to a gas syringe.
- The student measures the volume of oxygen every 200 seconds.

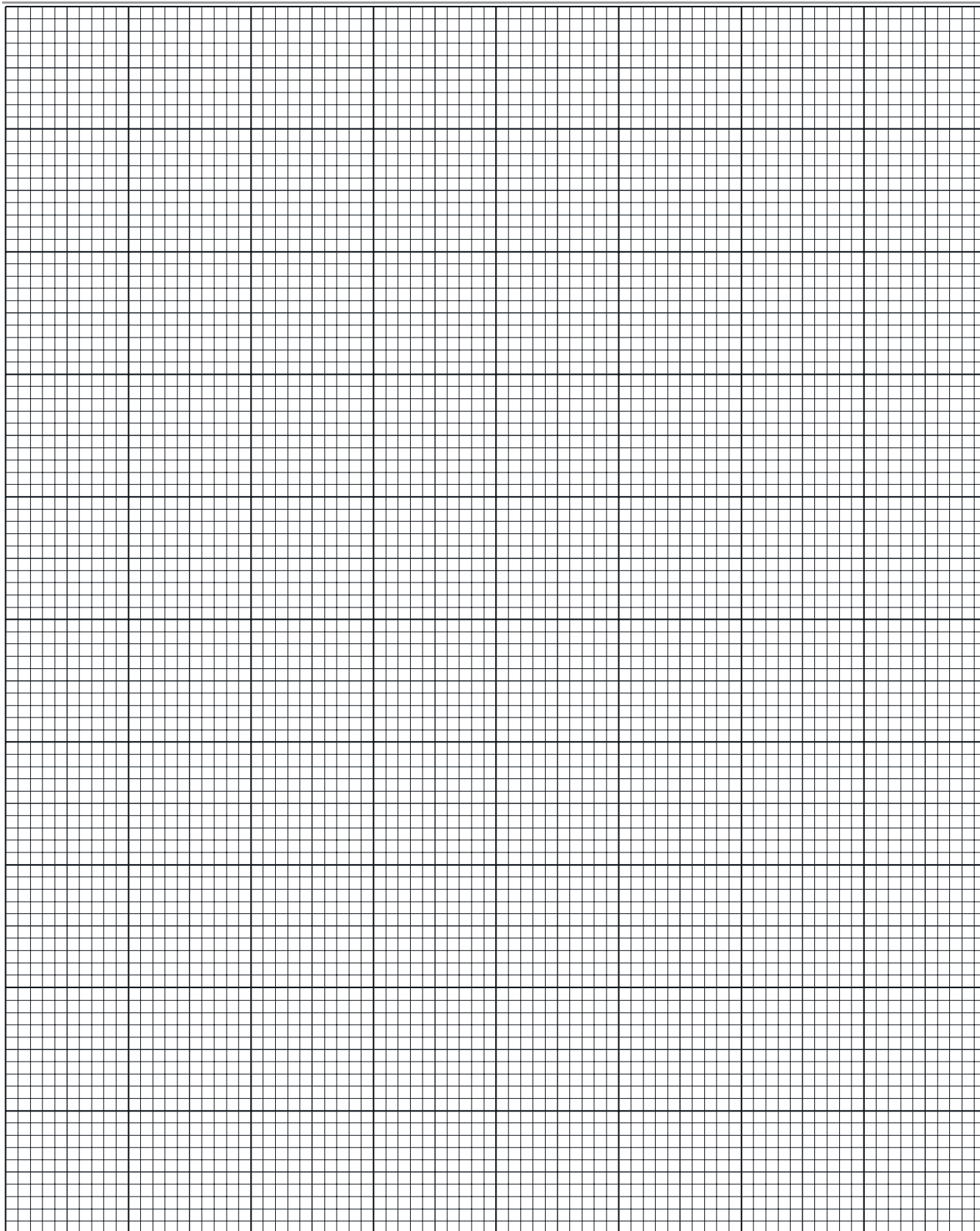
Results

Time/s	Volume of O ₂ /cm ³
0	0
200	15
400	28
600	36
800	41
1000	46
1200	48
1400	50

2(a)(i) Process the results as outlined below.

- On page 5, plot a graph of volume of O₂ against time.
- Use your graph to find the rate of the reaction, in cm³ s⁻¹, at t = 500 s.

Show your working on the graph and in the space below.



$$\text{rate} = \text{cm}^3 \text{ s}^{-1}$$

[5 marks]

Draw your answer on the figure above.

2(a)(ii) The student allows the reaction in equation 2.1 to proceed until no more gas is evolved.

The volume of O_2 in the syringe is now 55 cm^3 , measured at RTP.

Calculate the initial concentration of the H_2O_2 .

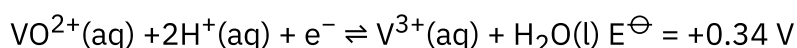
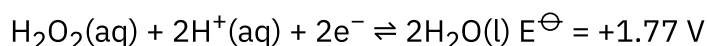
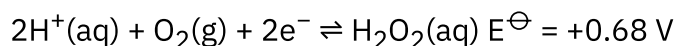
Give your answer to two significant figures.

initial concentration of $H_2O_2 = \text{mol dm}^{-3}$

[3 marks]

2(b) Hydrogen peroxide can act as an oxidising agent or as a reducing agent.

Some standard electrode potentials are shown below.



Use this information to write an equation for a reaction in which hydrogen peroxide acts as a reducing agent.

[2 marks]

Cobalt(II) forms complex ions with water ligands and with chloride ligands.

- With water ligands, cobalt(II) forms a pink octahedral complex ion, $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$.
- With chloride ligands, cobalt(II) forms a blue tetrahedral complex ion.

A student dissolves cobalt(II) sulfate in water in a boiling tube. A pink solution forms.

Experiment 1

The student places the boiling tube in a water bath at 100 °C.

Concentrated hydrochloric acid is added dropwise.

The colour of the solution changes from pink to blue.

Experiment 2

The student places the boiling tube from experiment 1 in an ice/water bath at 0 °C.

The colour of the solution changes from blue to pink.

2(c)(i) Write the equilibrium equation for the reaction that takes place when the colour of the solution changes.

[1 mark]

2(c)(ii) Explain the observations and predict whether the formation of the blue colour is exothermic or endothermic.

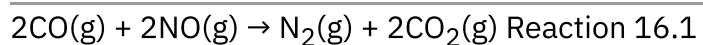
[2 marks]

Q3 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q16 · [10 marks]

This question also needs Rate equations.

A catalytic converter in a car removes nitrogen monoxide, NO, and carbon monoxide, CO, from the exhaust gases.

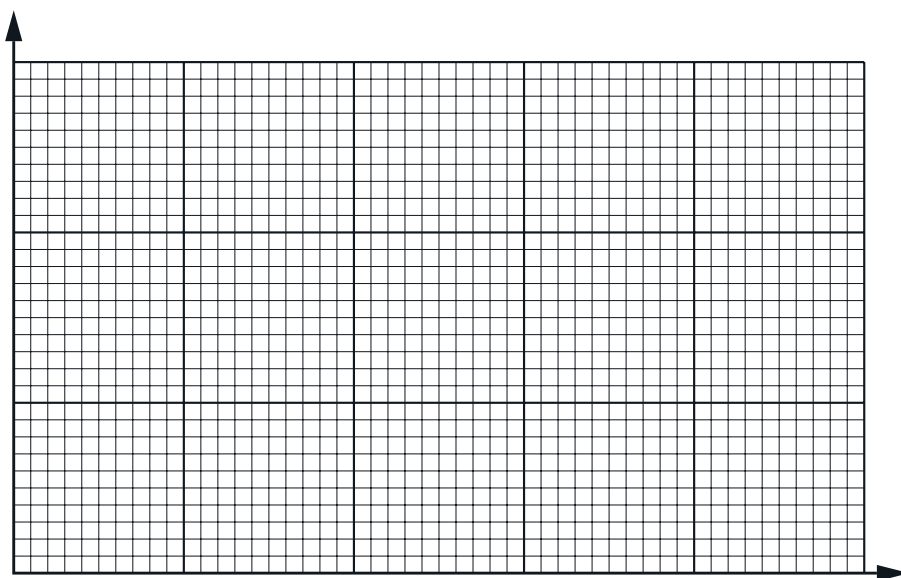
One reaction that happens in a catalytic converter is shown below.



16(a)(i) Explain how increasing the temperature increases the rate of Reaction 16.1.

Include a labelled sketch, using Boltzmann distributions, on the grid below.

Label the axes.



[3 marks]

Draw your answer on the figure above.

16(a)(ii) The rate of Reaction 16.1 is investigated by carrying out three experiments at the same temperature. The results are shown below.

Experiment	[NO(g)] / mol dm ⁻³	[CO(g)] / mol dm ⁻³	Initial rate / mol dm ⁻³ s ⁻¹
1	2.75×10^{-4}	7.25×10^{-4}	1.85×10^{-4}
2	5.50×10^{-4}	7.25×10^{-4}	7.40×10^{-4}
3	1.10×10^{-3}	2.90×10^{-3}	1.18×10^{-2}

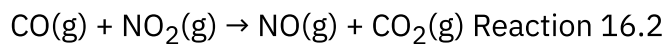
Determine the orders with respect to NO and CO, the rate equation, and the rate constant, k, including units.

Explain your reasoning.

k = units

[5 marks]

16(b) Carbon monoxide also reacts with nitrogen dioxide as shown in Reaction 16.2.



The rate equation for Reaction 16.2 is shown below:

$$\text{rate} = k [\text{NO}_2\text{(g)}]^2$$

Suggest a possible two-step mechanism for Reaction 16.2.

The first step is much slower than the second step.

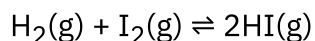
[2 marks]

step 1

step 2

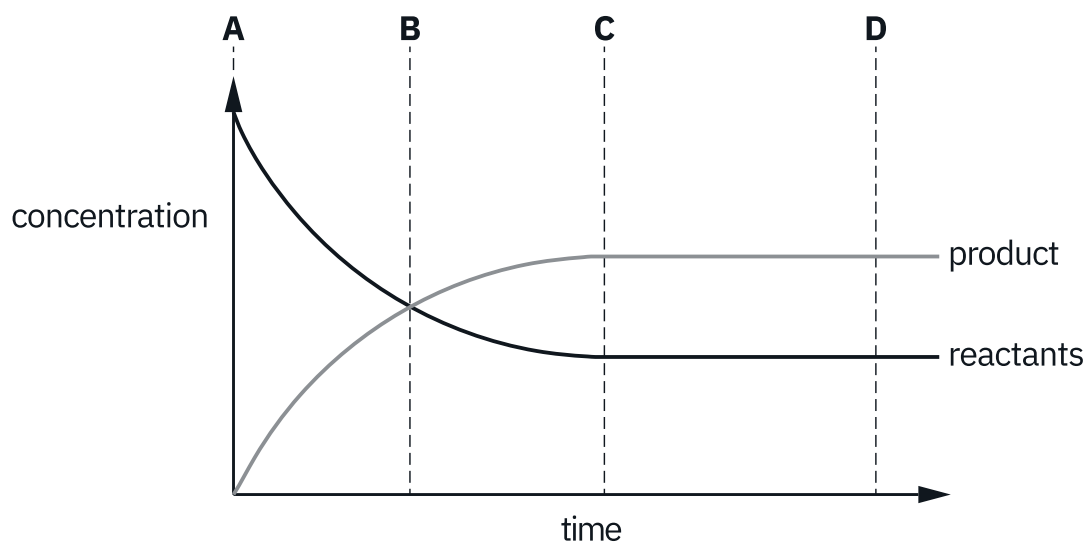
Q4 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q11 · [1 mark]

The reversible reaction between hydrogen and iodine to form hydrogen iodide is



The graph shows how the concentrations of the reactants and product change as the reaction reaches a dynamic equilibrium.

At which point on the graph is the equilibrium reached?



Tick (✓) one box.

☐ **A** A

☐ **B** B

☐ **C** C

☐ **D** D

Q5 · June 2024 · Paper 1 (Periodic table, elements and physical chemistry) · Q8 · [1 mark]

Which row in the table explains how a catalyst affects the activation energy (E_a) and the proportion of molecules with energy $> E_a$?

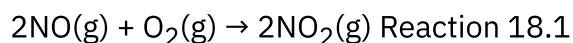
Tick (✓) one box.

- ☐ **A** How the activation energy changes: decreases · Proportion of molecules with energy $> E_a$: decreases
- ☐ **B** How the activation energy changes: decreases · Proportion of molecules with energy $> E_a$: increases
- ☐ **C** How the activation energy changes: increases · Proportion of molecules with energy $> E_a$: decreases
- ☐ **D** How the activation energy changes: increases · Proportion of molecules with energy $> E_a$: increases

Q6 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q18 · [14 marks]

This question also needs Rate equations.

Nitrogen monoxide, NO, reacts with oxygen to form nitrogen dioxide, NO₂.



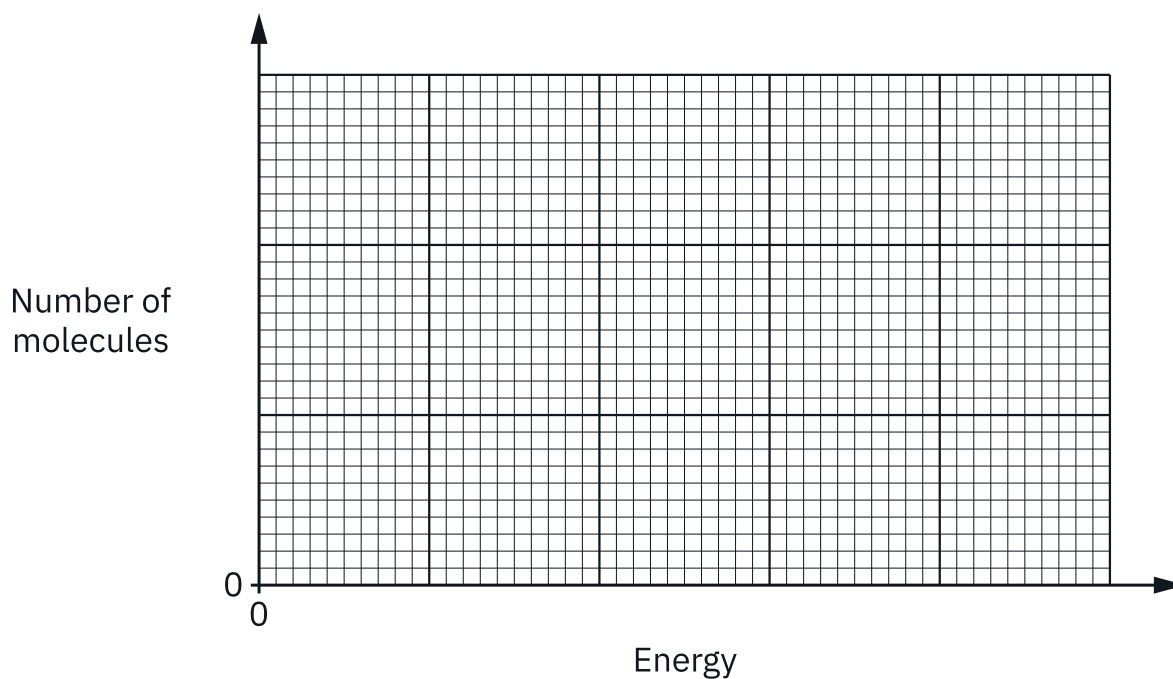
The rate of reaction increases in the presence of a heterogeneous platinum catalyst.

18(a)(i) Explain why platinum is an example of a heterogeneous catalyst for Reaction 18.1.

[1 mark]

18(a)(ii) Explain how the platinum catalyst increases the rate of reaction.

Include a labelled sketch of the Boltzmann distribution on the grid.



[2 marks]

Draw your answer on the figure above.

18(a)(iii) In industry, catalysts have great economic importance and benefits for increased sustainability.

Explain how the use of catalysts is beneficial to the environment.

[1 mark]

18(b) The following data was obtained in a series of experiments on the rate of the reaction for Reaction 18.1 at a constant temperature.

Experiment	[NO] / mol dm ⁻³	[O ₂] / mol dm ⁻³	rate / mol dm ⁻³ s ⁻¹
1	0.040	0.035	7.45×10^{-4}
2	0.040	0.070	1.49×10^{-3}
3	0.060	0.035	1.68×10^{-3}

Determine the orders with respect to NO and O₂. Explain your reasoning.

Determine the rate equation and calculate the rate constant, k, including units.

k = units

[5 marks]

The rate constant varies with temperature, according to the Arrhenius equation.

A technician determines the activation energy for Reaction 18.1 by determining the rate constant, k , at different temperatures.

The table shows the technician's results.

Temperature / K	$1/T / \text{K}^{-1}$	k	$\ln k$
1500	6.7×10^{-4}	1.81×10^3	7.50
1750	5.7×10^{-4}	8.51×10^4	
2000	5.0×10^{-4}	2.79×10^5	12.5
2250	4.4×10^{-4}	1.47×10^6	14.2
2500	4.0×10^{-4}	5.70×10^6	15.6

18(c)(i) Complete the table by adding the missing value of $\ln k$.

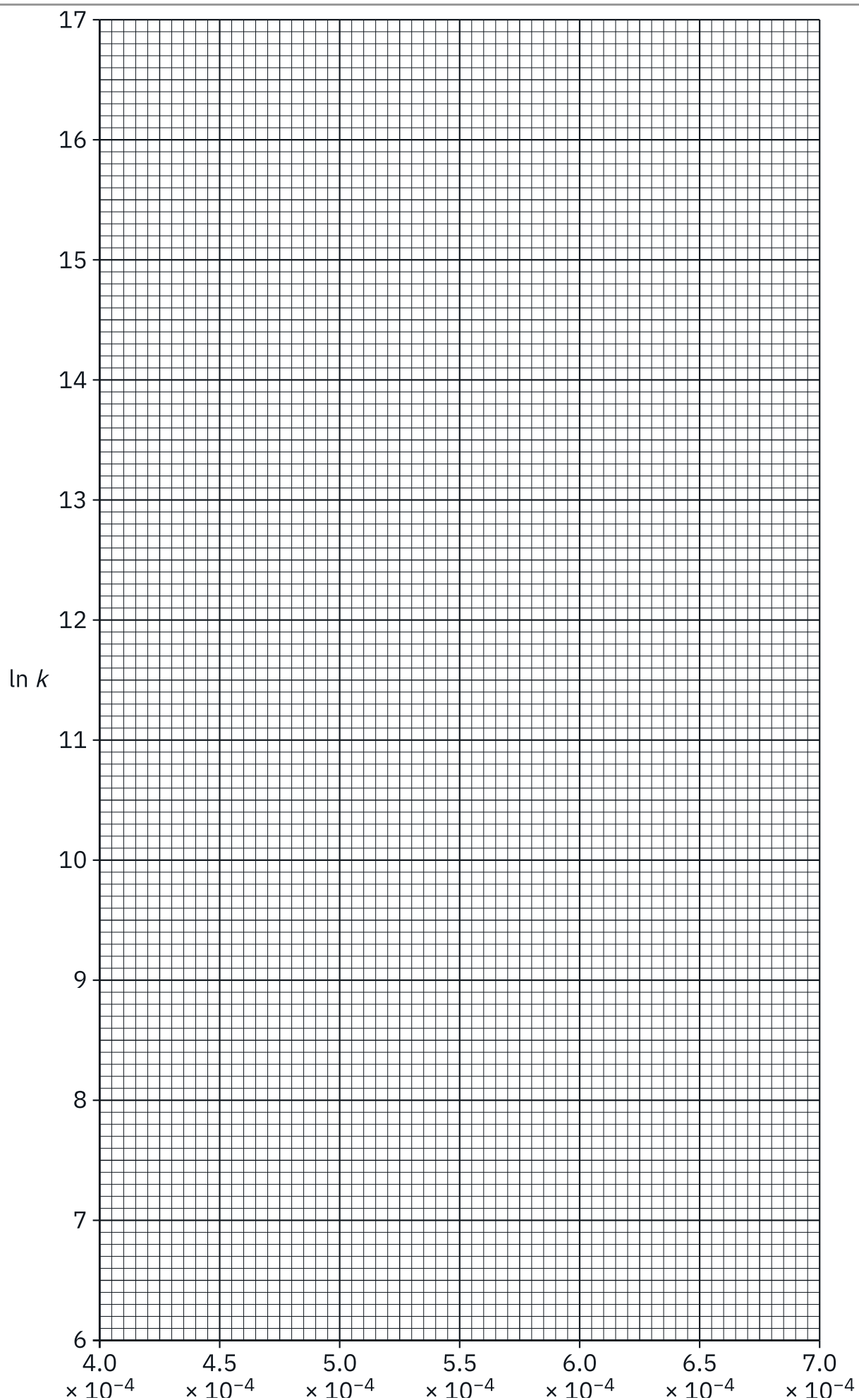
[1 mark]

18(c)(ii) Plot a graph of $\ln k$ against $1/T$ on the grid opposite.

Use your graph to calculate the value of the activation energy, E_a , in kJ mol^{-1} .

Give your answer to **2** significant figures.

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



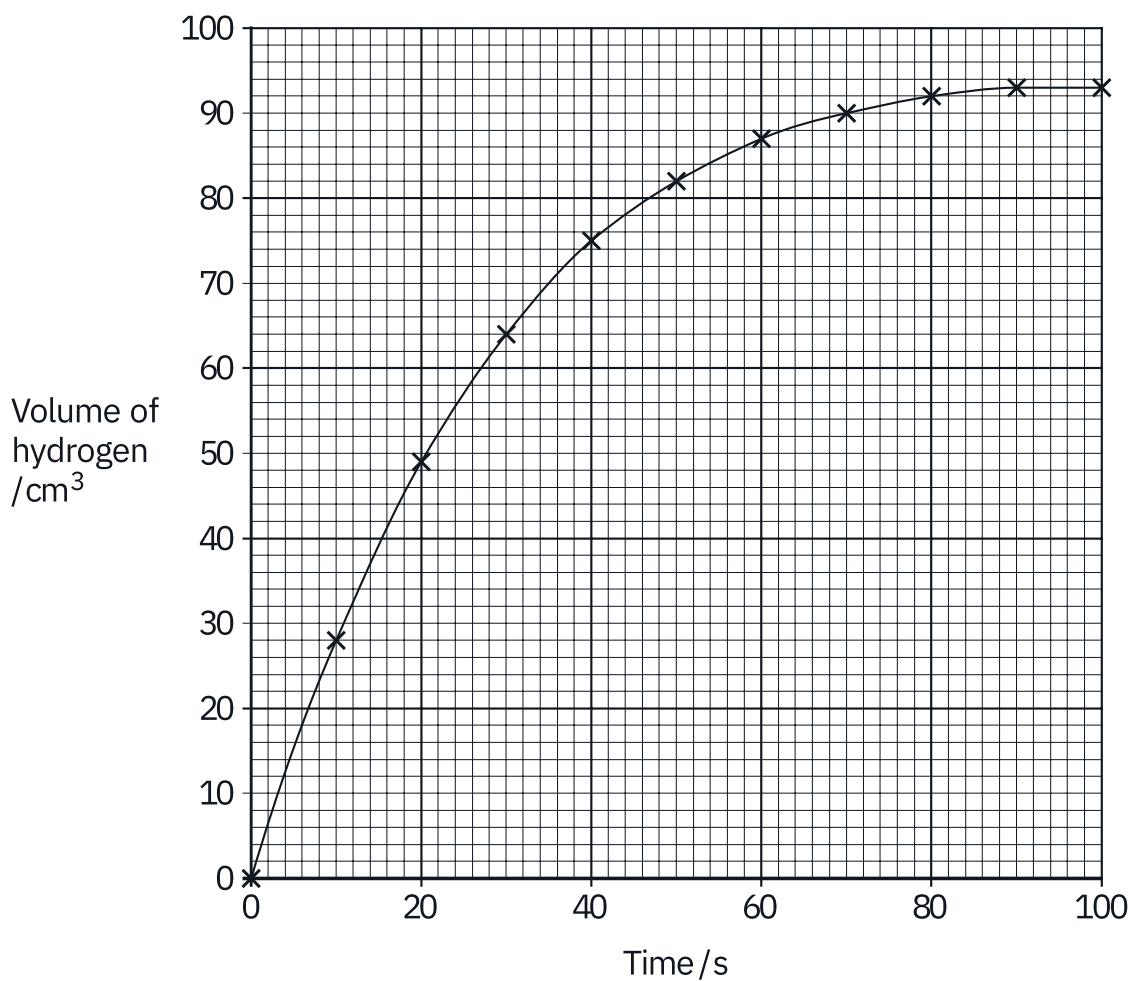
$$\frac{1}{T} / \text{K}^{-1}$$

[4 marks]

Draw your answer on the figure above.

Q7 · June 2025 · Paper 1 (Periodic table, elements and physical chemistry) · Q5 · [1 mark]

The graph shows the volume of hydrogen released over time in a chemical reaction.



What is the rate of reaction, in $\text{cm}^3 \text{s}^{-1}$, at 30 seconds?

Tick (✓) one box.

- ☐ **A** 0.8
- ☐ **B** 1.2
- ☐ **C** 2.1
- ☐ **D** 2.4

Q8 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q13 · [1 mark]

This question also needs Equilibrium constants K_c and K_p .

Which statement(s) is/are correct when a catalyst is added to a system in dynamic equilibrium?

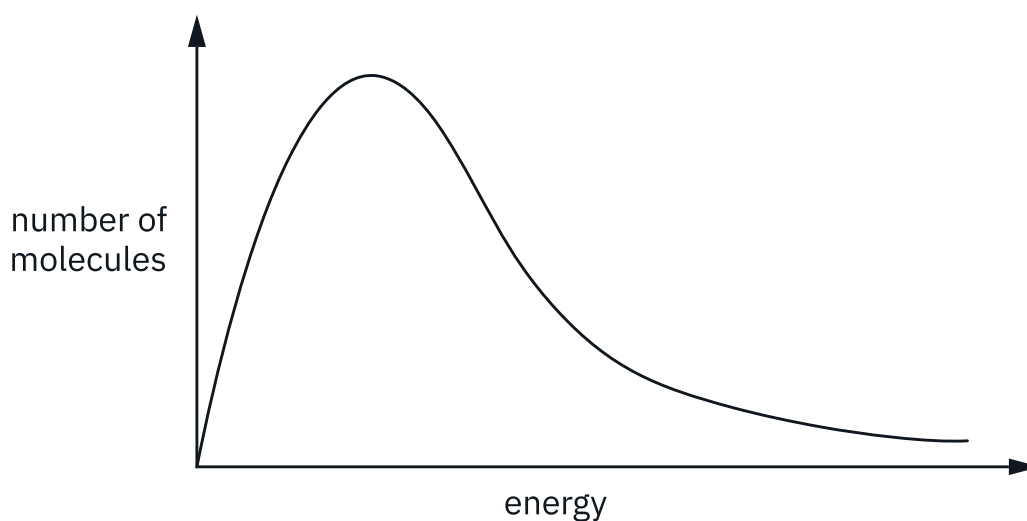
- 1 The rates of the forward and reverse reactions increase by the same amount.
- 2 The concentrations of the reactants and products do not change.
- 3 The value of K_c increases.

Tick (✓) one box.

- ☐ **A** 1, 2 and 3
- ☐ **B** Only 1 and 2
- ☐ **C** Only 2 and 3
- ☐ **D** Only 1

Q9 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q7 · [1 mark]

The diagram represents a Boltzmann distribution curve of molecules at a given temperature.



Which statement for this Boltzmann distribution curve is correct at a higher temperature?

Tick (✓) one box.

- ☐ **A** The peak increases in height and moves to the left.
- ☐ **B** The peak increases in height and moves to the right.
- ☐ **C** The peak decreases in height and moves to the left.
- ☐ **D** The peak decreases in height and moves to the right.

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Mark scheme:

whiteboardchemistry.com/revision/exam-questions/ocr-a-level-chemistry/pdf/reaction-rates-and-equilibrium-mark-scheme.pdf