

OCR A-Level Chemistry A

Equilibrium constants K_c and K_p

Questions only

The newest questions, about an hour. All 12 are in the exam generator.

Questions

7

Total marks

42

Time allowed

57 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	2017 P1 Q13	1	
2	2018 P1 Q9	1	
3	2022 P1 Q20	8	
4	2025 P3 Q3	11	
5	2020 P1 Q9	1	
6	2020 P3 Q5	9	
7	2021 P1 Q20	11	

Total _____ / 42 Percentage _____ %

Questions from OCR past papers, 2017–2025, reproduced for revision. Practise these topics online, with instant marking:

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

Questions

Equilibrium constants Kc and Kp · 7 questions · 42 marks · time allowed 57 min

Q1 · June 2017 · Paper 1 (Periodic table, elements and physical chemistry) · Q13 · [1 mark]

This question also needs Amount of substance.

A mixture of N₂ and O₂ gases has a total pressure of 1.42 atm.

The mole fraction of N₂ is 0.700.

What is the partial pressure, in atm, of O₂ in the mixture?

Tick (✓) one box.

☐ **A** 0.211

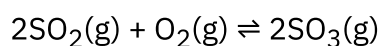
☐ **B** 0.426

☐ **C** 0.493

☐ **D** 0.994

Q2 · June 2018 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

The reversible reaction of sulfur dioxide and oxygen to form sulfur trioxide is shown below.



An equilibrium mixture contains 2.4 mol SO₂, 1.2 mol O₂ and 0.4 mol SO₃.

The total pressure is 250 atm.

What is the partial pressure of SO₃?

Tick (✓) one box.

☐ **A** 15 atm

☐ **B** 25 atm

☐ **C** 100 atm

☐ **D** 200 atm

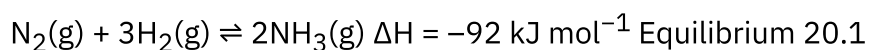
Q3 · June 2022 · Paper 1 (Periodic table, elements and physical chemistry) · Q20 · [8 marks]

This question also needs Reaction rates and equilibrium.

This question is about equilibria involving hydrogen.

20(a) Hydrogen is used industrially to manufacture ammonia.

The equilibrium is shown below.



1.20 mol N₂(g) is mixed with 3.60 mol H₂(g) in a 8.00 dm³ container.

The mixture is heated to 550 °C with an iron catalyst and allowed to reach equilibrium.

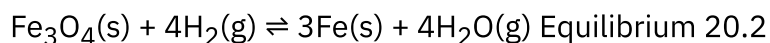
The equilibrium mixture contains 0.160 mol of NH₃.

Determine the equilibrium constant K_c for Equilibrium 20.1, and explain why the operational conditions used by industry may be different from those required for a maximum equilibrium yield of ammonia.

[6 marks]

In industry, hydrogen is also used to reduce the iron oxide Fe_3O_4 as shown in Equilibrium 20.2.

The reaction is carried out at 500 °C.



20(b)(i) When the temperature is decreased, the value of K_p decreases.

Determine whether the forward reaction is exothermic or endothermic.

Explain your answer.

[1 mark]

20(b)(ii) Two students are discussing the effect of pressure on the equilibrium position of Equilibrium 20.2.

Student 1 says:

“There are more moles of products than reactants, so increasing the pressure will shift the equilibrium to the left hand side.”

Student 2 disagrees.

Determine which student is correct. Justify your answer.

[1 mark]

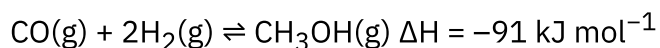
Q4 · June 2025 · Paper 3 (Unified chemistry) · Q3 · [11 marks]

This question also needs Rate equations.

This question is about equilibrium and rates.

3(a) Methanol, CH₃OH, can be made industrially by the reaction of carbon monoxide, CO, with hydrogen, H₂, in the presence of a catalyst. This is a reversible reaction.

The equilibrium below is set up.



The concentrations of CO(g) and CH₃OH(g) in the equilibrium mixture are shown in the table below.

	CO(g)	CH ₃ OH(g)
equilibrium concentration / mol dm ⁻³	0.27	0.11

The value of the equilibrium constant, K_c, for this reaction is 1.8 dm⁶ mol⁻².

- Explain the conditions of pressure and temperature that would give the maximum equilibrium yield of CH₃OH(g).
- Calculate the concentration of H₂(g) in the equilibrium mixture to an **appropriate** number of significant figures.

[5 marks]

3(b) A reaction takes place when aqueous solutions of propanone, $\text{CH}_3\text{COCH}_3(\text{aq})$, and bromine, $\text{Br}_2(\text{aq})$, are mixed in the presence of dilute acid, $\text{H}^+(\text{aq})$.

The overall equation for this reaction is shown below.



- A student carries out three experiments to investigate the rate of this reaction.
- In each experiment, the student investigates the effect of changing the concentration of one of the three chemicals whilst keeping the concentrations of the other chemicals constant.

The student's results are shown below.

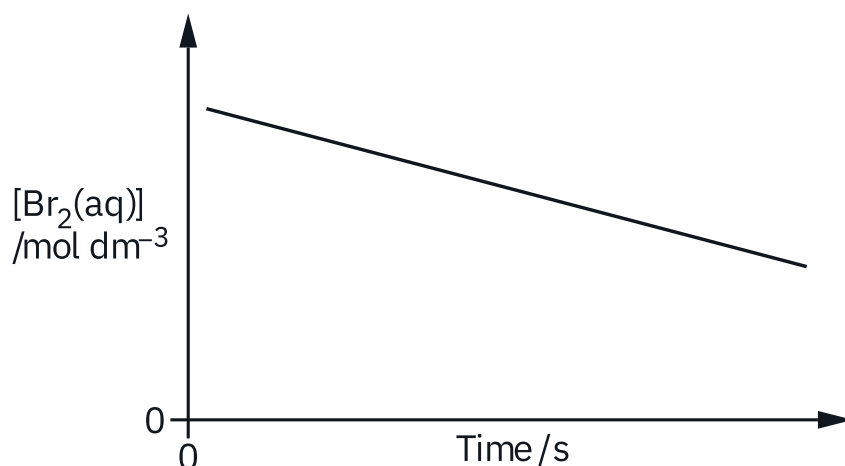
Experiment 1

Only $[\text{CH}_3\text{COCH}_3(\text{aq})]$ is varied.

Initial concentrations			
$\text{CH}_3\text{COCH}_3(\text{aq}) / \text{mol dm}^{-3}$	$\text{Br}_2(\text{aq}) / \text{mol dm}^{-3}$	$\text{H}^+(\text{aq}) / \text{mol dm}^{-3}$	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
1.50×10^{-3}	2.00×10^{-1}	2.50×10^{-1}	1.70×10^{-7}
4.50×10^{-3}	2.00×10^{-1}	2.50×10^{-1}	5.10×10^{-7}

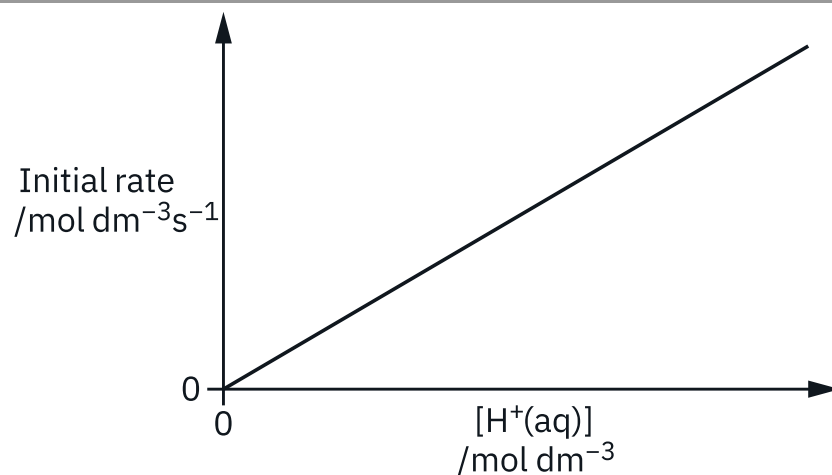
Experiment 2

Only $[\text{Br}_2(\text{aq})]$ is varied.



Experiment 3

Only $[\text{H}^+(\text{aq})]$ varied.



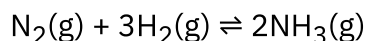
Use the student's results to determine the order with respect to each of the three chemicals, the rate equation and rate constant for Reaction 3.1. Explain your reasoning.

Explain how the student's results can be used to show that the mechanism of Reaction 3.1 has more than one step.

[6 marks]

Q5 · November 2020 · Paper 1 (Periodic table, elements and physical chemistry) · Q9 · [1 mark]

The reversible reaction of nitrogen and hydrogen to form ammonia is shown below.



In the equilibrium mixture, the partial pressure of N_2 is 18.75 MPa and the partial pressure of H_2 is 2.50 MPa.

The total pressure is 25 MPa.

What is the value of K_p , in MPa^{-2} ?

Tick (✓) one box.

☐ **A** 1.2×10^{-4}

☐ **B** 0.048

☐ **C** 0.075

☐ **D** 21

Q6 · November 2020 · Paper 3 (Unified chemistry) · Q5 · [9 marks]

This question also needs Enthalpy changes, Lattice enthalpy, entropy and free energy and Rate equations.

The equilibrium constant K_p and temperature T (in K) are linked by the mathematical relationship shown in equation 5.1 (R = Gas constant in $\text{J mol}^{-1} \text{K}^{-1}$ and ΔH is enthalpy change in J mol^{-1}).

$$\ln K_p = -\Delta H / R \times 1 / T + \Delta S / R \text{ Equation 5.1}$$

5(a) The table shows the values of K_p at different temperatures for an equilibrium.

Complete the table by adding the missing values of $1/T$ and $\ln K_p$.

Temperature, T / K	400	500	600	700	800
K_p	3.00×10^{58}	5.86×10^{45}	1.83×10^{37}	1.46×10^{31}	1.14×10^{26}
$1/T / K^{-1}$	2.50×10^{-3}				
$\ln K_p$	135				

[2 marks]

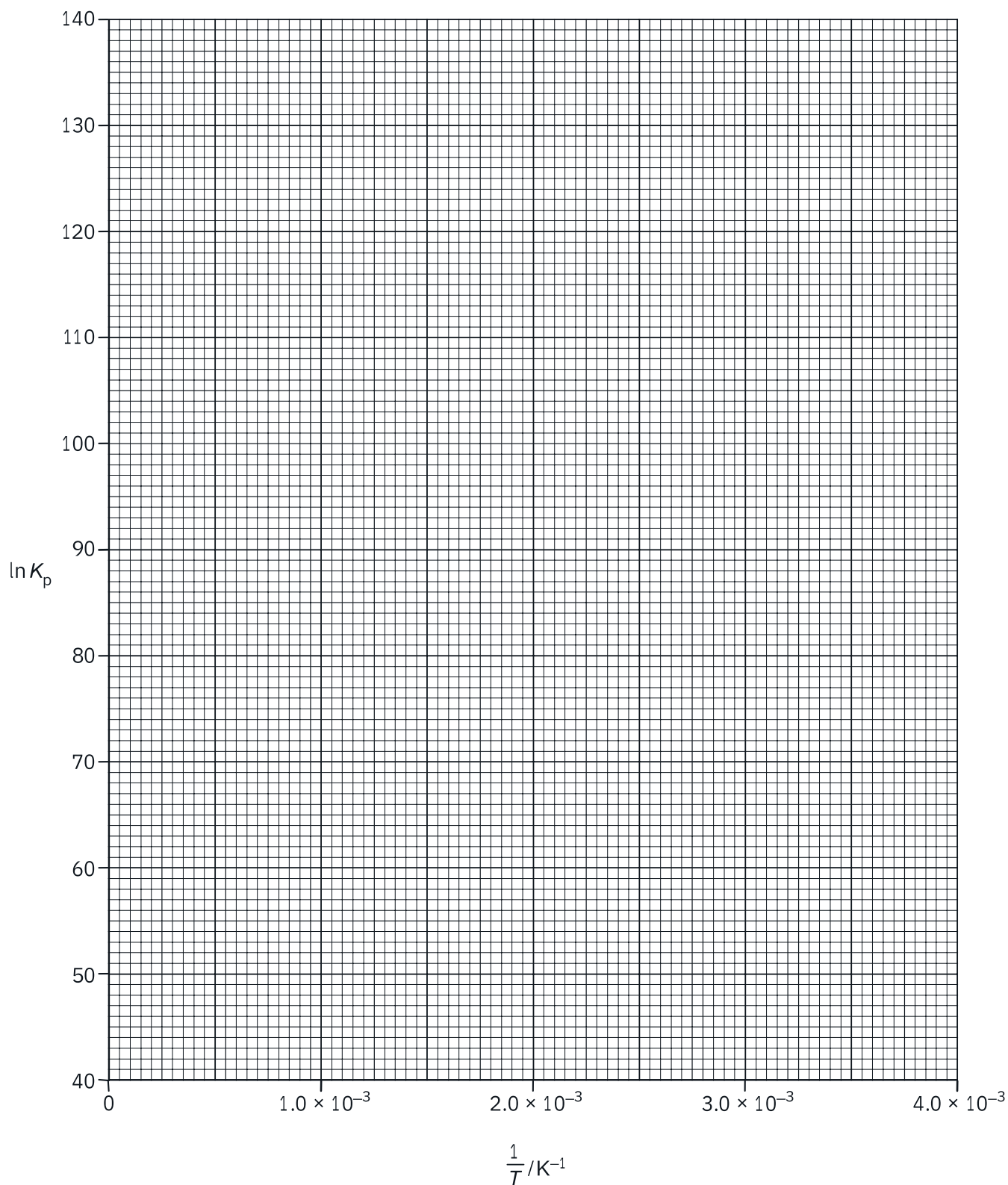
5(b) State and explain how increasing the temperature affects the position of this equilibrium and whether the forward reaction is exothermic or endothermic.

[1 mark]

5(c) Plot a graph of $\ln K_p$ against $1/T$ using the axes provided on the opposite page.

Use your graph and equation 5.1 to determine ΔH , in kJ mol^{-1} , for this equilibrium.

Give your answer to 3 significant figures.



$$\Delta H = \text{kJ mol}^{-1}$$

[4 marks]

Draw your answer on the figure above.

5(d) Explain how ΔS could be calculated from a graph of $\ln K_p$ against $1/T$.

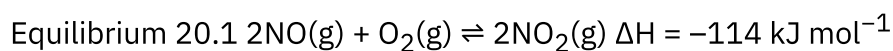
[2 marks]

Q7 • November 2021 • Paper 1 (Periodic table, elements and physical chemistry) • Q20 • [11 marks]

This question also needs Amount of substance, Lattice enthalpy, entropy and free energy and Reaction rates and equilibrium.

This question is about chemical equilibrium.

Nitrogen monoxide, NO, and oxygen, O₂, react to form nitrogen dioxide, NO₂, in the reversible reaction shown in Equilibrium 20.1.



$$\Delta S = -147 \text{ J mol}^{-1} \text{ K}^{-1}$$

20(a) A dynamic equilibrium exists in a closed system.

State one other feature of a dynamic equilibrium.

[1 mark]

20(b)(i) Show that the formation of NO_2 in Equilibrium 20.1 is feasible at 25 °C.

[2 marks]

20(b)(ii) Determine the maximum temperature, in K, for feasibility.

Give your answer to an appropriate number of significant figures.

maximum temperature = K

[1 mark]

A chemist investigates the equilibrium shown in Equilibrium 20.1.

The chemist mixes together 1.60 mol of NO(g) and 1.50 mol of O₂(g) in a container and the mixture is allowed to reach equilibrium.

At equilibrium:

- 75% of the NO(g) has been converted to NO₂(g)
- the total pressure is 1.21 MPa.

20(c)(i) Calculate K_p, in MPa⁻¹, for Equilibrium 20.1.

Give your answer to 3 significant figures.

K_p = MPa⁻¹

[4 marks]

20(c)(ii) The chemist then repeats the experiment three times. In each experiment, the chemist makes one change but uses the same initial amounts of NO and O₂.

Complete the table to show the predicted effect of each change compared with the original experiment.

Only use the words greater, smaller or same.

Change	K _p	Equilibrium amount of NO ₂ (g)	Initial rate
Temperature increase			
Pressure increase			
Catalyst added			

[3 marks]

Source: OCR A-Level Chemistry A past papers. Reproduced for revision at whiteboardchemistry.com.

Mark scheme:

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