

Questions

- 1 Consider the following equilibrium reaction.

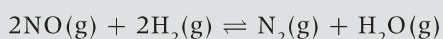


In a 1.00 dm³ closed container, at 375 °C, 8.60 × 10⁻³ mol of SO₂ and 8.60 × 10⁻³ mol of Cl₂ were introduced. At equilibrium, 7.65 × 10⁻⁴ mol of SO₂Cl₂ was formed.

- Deduce the equilibrium constant expression K_c for the reaction. [1]
- Determine the value of the equilibrium constant K_c . [3]
- If the temperature of the reaction is changed to 300 °C, predict, stating a reason in each case, whether the equilibrium concentration of SO₂Cl₂ and the value of K_c will increase or decrease. [3]
- If the volume of the container is changed to 1.50 dm³, predict, stating a reason in each case, how this will affect the equilibrium concentration of SO₂Cl₂ and the value of K_c . [3]
- Suggest, stating a reason, how the addition of a catalyst at constant pressure and temperature will affect the equilibrium concentration of SO₂Cl₂. [2]

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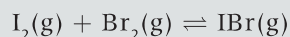
- 2 When a mixture of 0.100 mol NO, 0.051 mol H₂ and 0.100 mol H₂O were placed in a 1.0 dm³ flask at 300 K, the following equilibrium was established.



At equilibrium, the concentration of NO was found to be 0.062 mol dm⁻³. Determine the equilibrium constant, K_c , of the reaction at this temperature.

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3. 0.50 mol of I₂(g) and 0.50 mol of Br₂(g) are placed in a closed flask. The following equilibrium is established.



The equilibrium mixture contains 0.80 mol of IBr(g). What is the value of K_c ?

A. 0.64

B. 1.3

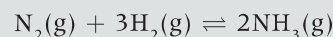
C. 2.6

D. 64

[1]

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4. a) The production of ammonia is an important industrial process.



- Using the average bond enthalpy values in Table 10 of the *Data Booklet*, determine the standard enthalpy change for this reaction. [3]
 - The standard entropy values, S , at 298 K for N₂(g), H₂(g) and NH₃(g) are 193, 131 and 192 JK⁻¹ mol⁻¹ respectively. Calculate ΔS° for the reaction and with reference to the equation above, explain the sign of ΔS° . [4]
 - Calculate ΔG° for the reaction at 298 K. [1]
 - Describe and explain the effect of increasing temperature on the spontaneity of the reaction. [2]
- b) The reaction used in the production of ammonia is an equilibrium reaction. Outline the characteristics of a system at equilibrium. [2]
- c) Deduce the equilibrium constant expression, K_c , for the production of ammonia. [1]
- d) i) 0.20 mol of N₂(g) and 0.20 mol of H₂(g) were allowed to reach equilibrium in a 1 dm³ closed container. At equilibrium the concentration of NH₃(g) was 0.060 mol dm⁻³. Determine the equilibrium concentrations of N₂(g) and H₂(g) and calculate the value of K_c . [3]
- ii) Predict and explain how increasing the temperature will affect the value of K_c . [2]

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Topic 17 – Equilibrium (AHL)

End of topic questions (page 394)

1. a) $K_c = \frac{[\text{SO}_2\text{Cl}_2]}{[\text{Cl}_2][\text{SO}_2]}$
 b) 12.5;
 c) value of K_c increases; $[\text{SO}_2\text{Cl}_2]$ increases; decrease in temperature favours (forward) reaction which is exothermic;
 d) no effect on the value of K_c , as it depends only on temperature; $[\text{SO}_2\text{Cl}_2]$ decreases; increase in volume favours the reverse reaction which has more gaseous moles;
 e) no effect; catalyst increases the rate of forward and reverse reactions (equally)/catalyst decreases activation energies (equally);
2. $2\text{NO}(\text{g}) + 2\text{H}_2(\text{g}) \leftrightarrow \text{N}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$

	NO (g)	H ₂ (g)	N ₂ (g)	H ₂ O (g)
Initial (mol dm ⁻³)	0.100	0.051	0.000	0.100
Change (mol dm ⁻³)	-0.038	-0.038	+0.019	+0.038
Equilibrium (mol dm ⁻³)	0.062	0.013	0.019	0.138

[H₂] at equilibrium = 0.013 mol dm⁻³

[N₂] at equilibrium = 0.019 mol dm⁻³

[H₂O] at equilibrium = 0.138 mol dm⁻³

$$K_c = \frac{[\text{N}_2][\text{H}_2\text{O}]^2}{[\text{NO}]^2 [\text{H}_2]^2} = \frac{(0.019)(0.138)^2}{(0.062)^2(0.013)^2} = 5.6 \times 10^2$$