Questions

1 Consider the following equilibrium reaction.

$Cl_2(g) + SO_2(g) \rightleftharpoons SO_2Cl_2(g) \quad \Delta H^\ominus = -84.5$ kJ

In a 1.00 dm^3 closed container, at 375 °C, 8.60×10^{-3} mol of SO_2 and 8.60×10^{-3} mol of Cl_2 were introduced. At equilibrium, 7.65×10^{-4} mol of SO_2Cl_2 was formed.

a) Deduce the equilibrium constant expression K_c for the reaction. [1]

b) Determine the value of the equilibrium constant K_c. [3]

c) If the temperature of the reaction is changed to 300 °C, predict, stating a reason in each case, whether the equilibrium concentration of SO_2Cl_2 and the value of K_c will increase or decrease. [3]

d) If the volume of the container is changed to 1.50 dm^3, predict, stating a reason in each case, how this will affect the equilibrium concentration of SO_2Cl_2 and the value of K_c. [3]

e) Suggest, stating a reason, how the addition of a catalyst at constant pressure and temperature will affect the equilibrium concentration of SO_2Cl_2. [2]

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2 When a mixture of 0.100 mol NO, 0.051 mol H_2 and 0.100 mol H_2O were placed in a 1.0 dm^3 flask at 300 K, the following equilibrium was established.

$2NO(g) + 2H_2(g) \rightleftharpoons N_2(g) + H_2O(g)$

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.

IB, May 2009

3. 0.50 mol of $I_2(g)$ and 0.50 mol of $Br_2(g)$ are placed in a closed flask. The following equilibrium is established.

$$I_2(g) + Br_2(g) \rightleftharpoons IBr(g)$$

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.

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

i) Using the average bond enthalpy values in Table 10 of the *Data Booklet*, determine the standard enthalpy change for this reaction. [3]

ii) The standard entropy values, *S*, at 298 K for $N_2(g)$, $H_2(g)$ and $NH_3(g)$ are 193, 131 and 192 JK^{-1} mol^{-1} respectively. Calculate $\Delta S^\ominus$ for the reaction and with reference to the equation above, explain the sign of $\Delta S^\ominus$. [4]

iii) Calculate $\Delta G^\ominus$ for the reaction at 298 K. [1]

iv) 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 $N_2(g)$ and 0.20 mol of $H_2(g)$ were allowed to reach equilibrium in a 1 dm^3 closed container. At equilibrium the concentration of $NH_3(g)$ was 0.060 mol dm^{-3}. Determine the equilibrium concentrations of $N_2(g)$ and $H_2(g)$ 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)** $K_c = \dfrac{[SO_2\ Cl_2]}{[Cl2][SO2]}$

b) 12.5;

c) value of K_c increases; $[SO_2Cl_2]$ 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; $[SO_2Cl_2]$ 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. $2NO\ (g) + 2H_2\ (g) \leftrightarrow N_2\ (g) + 2H_2\ O(g)$

	NO (g)	H_2 (g)	N_2 (g)	H_2O (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

$[H_2]$ at equilibrium = 0.013 mol dm^{-3}

$[N_2]$ at equilibrium = 0.019 mol dm^{-3}

$[H_2O]$ at equilibrium = 0.138 mol dm^{-3}

$$K_C = \frac{[N_2][H_2O]^2}{[NO]^2\ [H_2]^2} = \frac{(0.019)(0.138)^2}{(0.062)^2(0.013)^2} = 5.6 \times 10^2$$