CHEMICAL EQUILIBRIUM

1. In a chemical reaction, $A + 2B \underset{}{\overset{K}{\rightleftharpoons}} 2C + D$, the initial concentration of B was 1.5 times of the concentration of A, but the equilibrium concentrations of A and B were found to be equal. The equilibrium constant(K) for the aforesaid chemical reaction is :

(1) 16 (2) 4

(3) 1 (4) $\frac{1}{4}$

2. Two solids dissociate as follows

$A(s) \rightleftharpoons B(g) + C(g)$; $K_{p_1} = x \text{ atm}^2$

$D(s) \rightleftharpoons C(g) + E(g)$; $K_{p_2} = y \text{ atm}^2$

The total pressure when both the solids dissociate simultaneously is :-

(1) (x + y) atm (2) $x^2 + y^2$ atm

(3) $2\left(\sqrt{x+y}\right)$atm (4) $\sqrt{x+y}$ atm

3. Consider the reaction,

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

The equilibrium constant of the above reaction is K_P. If pure ammonia is left to dissociate, the partial pressure of ammonia at equilibrium is given by (Assume that $P_{NH_3} << P_{total}$ at equilibrium)

(1) $\frac{3^{\frac{3}{2}} K_P^{\frac{1}{2}} P^2}{4}$ (2) $\frac{3^{\frac{3}{2}} K_P^{\frac{1}{2}} P^2}{16}$

(3) $\frac{K_P^{\frac{1}{2}} P^2}{16}$ (4) $\frac{K_P^{\frac{1}{2}} P^2}{4}$

4. Consider the following reversible chemical reactions :

$A_2(g) + Br_2(g) \overset{K_1}{\rightleftharpoons} 2AB(g)$ .....(1)

$6AB(g) \overset{K_2}{\rightleftharpoons} 3A_2(g) + 3B_2(g)$ .....(2)

The relation between K_1 and K_2 is :

(1) $K_2 = K_1^3$ (2) $K_2 = K_1^{-3}$

(3) $K_1K_2 = 3$ (4) $K_1K_2 = \frac{1}{3}$

5. 5.1g NH_4SH is introduced in 3.0 L evacuated flask at 327°C. 30% of the solid NH_4SH decomposed to NH_3 and H_2S as gases. The K_p of the reaction at 327°C is

(R = 0.082 L atm $mol^{-1}K^{-1}$, Molar mass of S = 32 g $mol^{/01}$, molar mass of N = 14g mol^{-1})

(1) 1×10^{-4} atm^2

(2) 4.9×10^{-3} atm^2

(3) 0.242 atm^2

(4) 0.242×10^{-4} atm^2

6. The value of K_p/K_C for the following reactions at 300K are, respectively :

(At 300K, RT = 24.62 dm^{3}atm mol^{-1})

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

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

(1) 1, 24.62 dm^{3}atm mol^{-1}, 606.0 dm^{6}atm^{2}mol^{-2}

(2) 1, 4.1×10^{-2} dm^{-3}atm^{-1} mol^{-1}, 606.0 dm^6 atm^2 mol^{-2}

(3) 606.0 dm^{6}atm^{2}mol^{-2}, 1.65×10^{-3} dm^{3}atm^{-2} mol^{-1}

(4) 1, 24.62 dm^{3}atm mol^{-1}, 1.65×10^{-3} dm^{-6}atm^{-2} mol^2

7. For the following reactions, equilibrium constants are given :

$S(s) + O_2(g) \rightleftharpoons SO_2(g); K_1 = 10^{52}$

$2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g); K_2 = 10^{129}$

The equilibrium constant for the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ is :

(1) 10^{181} (2) 10^{154}

(3) 10^{25} (4) 10^{77}

8. For the reaction,

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$,

$\Delta H = -57.2 kJ\ mol^{-1}$ and

$K_c = 1.7 \times 10^{16}$.

Which of the following statement is INCORRECT?

(1) The equilibrium constant is large suggestive of reaction going to completion and so no catalyst is required.

(2) The equilibrium will shift in forward direction as the pressure increase.

(3) The equilibrium constant decreases as the temperature increases.

(4) The addition of inert gas at constant volume will not affect the equilibrium constant.

9. In which one of the following equilibria, $K_p \neq K_c$?

(1) $NO_2(g) + SO_2(g) \rightleftharpoons NO(g) + SO_3(g)$

(2) $2\ HI(g) \rightleftharpoons H_2(g) + I_2(g)$

(3) $2NO(g) \rightleftharpoons N_2(g) + O_2(g)$

(4) $2C(s) + O_2(g) \rightleftharpoons 2CO(g)$

SOLUTION

1. Ans.(2)

$$A + 2B \rightleftharpoons 2C + D$$

	A	2B	2C	D
t=0	a_0	$1.5a_0$	0	0
$t = t_{eq}$	$a_0 - x$	$1.5a_0 - 2x$	2x	x

At equilibrium [A] = [B]

$a_0 - x = 1.5a_0 - 2x \Rightarrow x = 0.5a_0$

$t = t_{eq}$ $0.5a_0$ $0.5a_0$ a_0 $0.5a_0$

$$K_C = \frac{[C]^2[D]}{[A][B]^2} = \frac{(a_0)^2(0.5a_0)}{(0.5a_0)(0.5a_0)^2} = 4$$

2. Ans. (3)

$A(s) \rightleftharpoons B(g) + C(g)$ $K_{P_1} = x = P_B \cdot P_C$

P_1 P_1 $x = P_1(P_1 + P_2)$ ...(1)

$D(s) \rightleftharpoons C(g) + E(g)$ $K_{P_2} = y = P_C \cdot P_E$

P_2 P_2 $y = (P_1+P_2)(P_2)$ ...(2)

Adding (1) and (2)

$x + y = (P_1 + P_2)^2$

Now total pressure

$P_T = P_C + P_B + P_E$

$= (P_1 + P_2) + P_1 + P_2 = 2(P_1 + P_2)$

$P_T = 2\left(\sqrt{x+y}\right)$

3. Ans. (2)

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\frac{1}{K_P}$

t = 0 P_1 – –

t = t $P_1 - 2P_2$ P_2 $3P_2$

$(P1 - 2P^2) + P_2 + 3P_2 = P$

As $(P_1 - 2P_2) <<< P$

$P_2 = \frac{P}{4}$

$$\frac{1}{K_P} = \frac{(P/4)(3P/4)^3}{P^2_{NH_3}}$$

4. Ans. (2)

$A_2(g) + B_2(g) \xrightarrow{k_1} 2AB$ ...(1)

$\Rightarrow$ eq. (1) × 3

$6\,AB(g) \rightleftharpoons 3A_2(g) + 3B_2(g)$

$\Rightarrow \left(\frac{1}{k_1}\right)^3 = k_2 \Rightarrow k_2 = (k_1)^{-3}$

5. Ans. (3)

$NH_4SH(s) \rightleftharpoons NH_3(g) + H_2S(g)$

$n = \frac{5.1}{51} = 0.1\,mole$ 0 0

$0.1(1-\alpha)$ 0.1α 0.1α

$\alpha = 30\% = .3$

so number of moles at equilibrium

.1 (1 – .3) .1 × .3 .1 × .3

= .07 =.03 =.03

Now use PV = nRT at equilibrium

$P_{total} \times 3$ lit = (.03 + .03) × .082 × 600

P_{total} = .984 atm

At equilibrium

$P_{NH_3} = P_{H_2S} = \frac{P_{total}}{2} = .492$

So $k_p = P_{NH_3} \cdot P_{H_2S} = (.492)(.492)$

$k_p = 0.242\ atm^2$

6. Ans. (4)

$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

$$\frac{k_p}{k_c} = (RT)^{\Delta n_g} = (RT)^0 = 1$$

$N_2O_4(g) \rightleftharpoons 2NO_2(g)$

$$\frac{k_p}{k_c} = (RT)^1 = 24.62$$

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

$$\frac{k_p}{k_c} = (RT)^{-2} = \frac{1}{(RT)^2} = 1.65 \times 10^{-3}$$

7. Ans. (3)

Sol. $S(s) + O_2(g) \rightleftharpoons SO_2(g) \quad K_1 = 10^{52} \quad ...(1)$

$2S(s) + 3O_2(g) \rightleftharpoons 2SO_3(g) \; K_2 = 10^{129} \; ...(2)$

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \; K_3 = x$

multiplying equation (1) by 2;

$2SO(s) + 2O_2(g) \rightleftharpoons 2SO_2(g) \quad K_1' = 10^{104} \; ...(3)$

$\Rightarrow$ Substracting (3) from (2); we get

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g);$

8. Ans. (1)

Sol. In option (2)- Δn_g is –ve therfore increase in pressure will bring reaction in forward direction.

In option (3)- as the reaction is exothermic therefore increase in temperature will decrease the equilibrium constant.

In option (4)- Equillibrium constant changes only with temperature.

Hence, option (2), (3) and (4) are correct therefore option (1) is incorrect choice.

9. Ans. (4)

Sol. if $\Delta n_g \neq 0$

$Kp \neq Kc$