HINTS & SOLUTIONS WORKBOOK - 2

Chemical Equilibrium

Daily Tutorial Sheet	Level-0

Very Short Answer Type (1 Mark)

1. $K_c = \dfrac{[SO_3]^2}{[SO_2]^2[O_2]} = \dfrac{(1.90M)^2}{(0.60M)^2(0.82M)} = 12.229M^{-1}$ or $12.229\,L\,mol^{-1}$

2. $4\,NO(g) + 6\,H_2O(g) \rightleftharpoons 4NH_3(g) + 5\,O_2(g)$

3. **(i)** Equilibrium is possible only in a close system at a given temperature

(ii) Both the opposing processes occur at the same rate and there is a dynamic but stable condition

4. Refer NCERT Part-I Class-XI page number-189

5. Refer NCERT Part-I Class-XI page number-194

6. If we make any change (in terms of pressure, volume, concentration of reactant or product) at equilibrium then system try to avoid this change and move in the direction where it can diminished the change occured at equilibrium.

Short Answer Type-I (2 Marks)

7. Partial pressure of I atoms $(P_I) = \dfrac{40}{100} \times 10^5\,Pa = 0.4 \times 10^5\,Pa$

Partial pressure of $I_2\,(P_{I_2}) = \dfrac{60}{100} \times 10^5\,Pa = 0.60 \times 10^5\,Pa$

$$K_p = \frac{P_I^2}{P_{I_2}} = \frac{(0.4 \times 10^5)^2}{0.60 \times 10^5} = 2.67 \times 10^4\,Pa$$

8. **(a)** $\Delta n_g = 3 - 2 = 1,\ K_p = K_c(RT)$ or $K_c = \dfrac{K_p}{RT} = \dfrac{1.8 \times 10^{-2}}{0.0831 \times 500}$

$(R = 0.0831\ \text{bar litre mol}^{-1})$

$= 4.33 \times 10^{-4}$

(b) $\Delta n_g = 1 - 0 = 1,\ K_c = \dfrac{K_p}{RT} = \dfrac{167}{0.0831 \times 1073} = 1.87$

9. [Pure liquid] or [Pure solid]

$$= \frac{\text{No. of moles}}{\text{Volume in L}} = \frac{\text{Mass/mol. mass}}{\text{Volume}} = \frac{\text{Mass}}{\text{Volume}} \times \frac{1}{\text{Mol. mass}} = \frac{\text{Density}}{\text{Mol. mass}}$$

As density of a pure liquid and pure solid is constant at constant temperature and molecular mass is also constant, therefore, their molar concentrations are constant and included into the equilibrium constant.

10.

	$2\,HI(g)$	$\rightleftharpoons$	$H_2(g)$	+	$I_2(g)$
Initial pressure	0.2 atm		0		0
At eqm.	0.04 atm		$\dfrac{0.16}{2}$ atm = 0.08 atm		$\dfrac{0.16}{2}$ atm = 0.08 atm

(Decrease in the pressure of HI = 0.2 – 0.04 = 0.16 atm.)

$$K_p = \frac{P_{H_2} \times P_{I_2}}{P^2_{HI}} = \frac{0.08 \text{ atm} \times 0.08 \text{ atm}}{(0.04 \text{ atm})^2} = 4.0.$$

11. $K_f = \frac{1}{K_b}$ **12.** Activity $= \frac{P}{RT}$

13. $K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} \Rightarrow 1.79 = \frac{1.59 \times 1.59}{[PCl_5]} \Rightarrow [PCl_5] = \frac{1.59 \times 1.59}{1.79} = 1.41 M$

Short Answer Type-II (3 Marks)

14.

	$2N_2(g)$	+ $O_2(g)$	$\rightleftharpoons$ $2N_2O(g)$
Initial	0.482 mol	0.933 mol	
At eqm.	0.482 – x	0.933 –x/2	x
Molar conc.	$\frac{0.482 - x}{10}$	$\frac{0.933 - x/2}{10}$	$\frac{x}{10}$

As $K = 2.0 \times 10^{-37}$ is very small, this means that the amount of N_2 and O_2 reacted (x) is very small,

Hence, at equilibrium, we have $[N_2] = 0.0482 \text{ mol L}^{-1}$, $[O_2] = 0.0933 \text{ mol L}^{-1}$, $[N_2O] = 0.1x$

$$K_c = \frac{(0.1x)^2}{(0.0482)^2(0.0933)} = 2.0 \times 10^{-37} \qquad \text{(Given)}$$

On solving, this gives $x = 6.6 \times 10^{-20}$, $[N_2O] = 0.1x = 6.6 \times 10^{-21} \text{ mol L}^{-1}$

15. The reaction is: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$$Q_c = \frac{[NH_3]^2}{[N_2]\,[H_2]^3} = \frac{\left(\frac{8.13}{20}\text{molL}^{-1}\right)^2}{\left(\frac{1.57}{20}\text{molL}^{-1}\right)\left(\frac{1.92}{20}\text{molL}^{-1}\right)^3} = 2.38 \times 10^3$$

As $Q_c \neq K_c$, the reaction mixture is not in equilibrium.

As $Q_c > K_c$, the net reaction will be in the backward direction.

16. For reaction (c), as Kc is neither high nor very low, reactants and products will be present in comparable amounts.

17. $K_p = \frac{(P_{CO})^2}{P_{CO_2}} = \frac{0.66 \times 0.66}{0.15} = 2.904 \approx 3.0$

18.

	N_2	+ $3H_2$	$\rightleftharpoons$ $2NH_3$
at equili.	1.57	1.92	8.17

$[N_2] = \frac{1.57}{20}$, $[H_2] = \frac{1.92}{20}$, $[NH_3] = \frac{8.17}{20}$

$$\Rightarrow \quad K_c = \frac{[NH_3]}{[N_2][H_2]^3}$$

19. $Q_c = \frac{[B][C]}{[A]^2} = \frac{(3 \times 10^{-3})(3 \times 10^{-3})}{(3 \times 10^{-3})^2} = 1$

$K_c = 2 \times 10^{-2}$

Since $Q_c > K_c$ backward reaction will be faster.

Long Answer Type (5 Marks)

20. Reactions affected will be those in which $(n_p \neq n_r)_{gaseous}$. Hence, reactions (i) and (iii) will be affected. By applying Le Chatelier's principle, we can predict the direction. Increase of pressure will shift the equilibrium to the side in which the number of moles is less.

(i) $n_p = 2, n_r = 1$, i.e., $n_p > n_r$, reaction will go in the backward direction

(ii) $n_p = 3, n_r = 3$, i.e., $n_p = n_r$, reaction will not be affected by pressure

(iii) $n_p = 1, n_r = 3$, i.e., $n_p < n_r$, reaction will go in the forward direction

21. **(a)** Equilibrium will shift in the forward direction (b) Equilibrium will shift in the backward direction

(c) Equilibrium will shift in the backward direction (d) Equilibrium will shift in the forward direction Explain on the basis of Le Chatelier's principle in each case.

22. **(a)** $K_c = \frac{[PCl_3(g)][Cl_2(g)]}{[PCl_5(g)]}$ **(b)** $K' = \frac{1}{K_c} = \frac{1}{8.3 \times 10^{-3}} = 120.48$

(c) **(i)** No effect as K_c is constant at constant temperature

(ii) No effect

(iii) As given reaction is endothermic, on increasing the temperature, K_f will increase. As $K_c = \frac{k_f}{k_b}$, K_c will increases with increases of temperature.

23. **(ii)** When value of K_c is very high, equilibrium has almost shifted in forward direction.

24. **(i)** On adding a catalyst in reversible reaction, equilibrium attained in lesser time but value of K_c does not change.

(ii) If we add inert gas at constant volume, value of K_c does not change. But if we add inert gas at constant pressure equilibrium shift in the direction towards greater number of moles of gaseous substance.

25. **(ii)** When concentration of reactant increases at equilibrium then rate of forward reaction increases.