PHYSICAL CHEMISTRY

DPP

DAILY PRACTICE PROBLEMS

DPP No. 38

Total Marks : 31

Max. Time : 35 min.

Topic : Chemical Equilibrium

Type of Questions		M.M., Min.
Single choice Objective ('–1' negative marking) Q.1 to Q.5	(3 marks, 3 min.)	[15, 15]
Subjective Questions ('–1' negative marking) Q.6 to Q.9	(4 marks, 5 min.)	[16, 20]

1. For the equilibrium $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$ in a closed vessel, K_p is found to be double of K_c. This is attained when :

(A) T = 2 K (B) T = 12.18 K (C) T = 24.36 K (D) T = 27.3 K

2. K_p / K_c for the reaction $CO(g) + \frac{1}{2} O_2(g) \rightleftharpoons CO_2(g)$ will be :

(A) 1 (B) $\sqrt{RT}$ (C) $\frac{1}{\sqrt{RT}}$ (D) R T

3. For the reaction : $N_2O_4(g) \rightleftharpoons 2NO_2(g)$ at 360 K, the value of K_c = 0.4 mole lit^{-1}. The value of K_p for the reaction at the same temperature would be :

(A) 12 atm (B) 1.2 atm (C) 1.2×10^2 atm (D) 1.2×10^{-3} atm

4. Starting with one mole of nitrogen and 3 moles of hydrogen, at equilibrium 50% of each had reacted according to the reaction : $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

If the equilibrium pressure is P, the partial pressure of hydrogen at equilibrium would be :

(A) P/2 (B) P/3 (C) P/4 (D) P/6

5. For which of the following equilibria, is $K_p = K_c$:

(A) $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ (B) $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

(C) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ (D) $COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$

6. For the following chemical equation, write expression for equilibrium constants K_c and K_p

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

Also write their proper units.

7. PCl_5 dissociates into PCl_3 and Cl_2 in a 2 L flask at about 600ºC. At equilibrium, mixture is found to contain 1 mole PCl_5 and 2 moles each of PCl_3 and Cl_2. Calculate :

(i) equilibrium molar concentrations.

(ii) equilibrium mole fractions.

(iii) equilibrium constant K_c for the chemical equilibrium : $PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

8. For an equilibrium $A(g) + 2B(g) \rightleftharpoons 2C(g) + D(g)$, A and B are mixed in a reaction vesel at 300 K. The initial concentration of B was 1.5 times the initial concentration of A. After the equilibrium, the equilibrium concentrations of A and D are same. Calculate K_C for the given reaction .

9. n mole of PCl_3 and n mole of Cl_2 are allowed to react at constant temperature T to have a total equilibrium pressure P, as : $PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$

If y mole of PCl_5 are formed at equilibrium, find K_P for the given reaction.

Answer Key

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1. (C) 2. (C) 3. (A) 4. (A) 5. (C)

6. $K_c = \frac{[N_2O_4]}{[NO_2]^2} = \left(= \frac{mol\ L^{-1}}{(mol\ L^{-1})^2}, K_c \text{ has unit of } L\ mol^{-1}\right)$ $K_p = \frac{p_{N_2O_4}}{p^2_{NO_2}} \left(= \frac{atm}{atm^2}, K_p \text{ has unit of } atm^{-1}\right)$

7. (i) $[PCl_5] = 0.5$ mol L^{-1} ; $[PCl_3] = 1.0$ mol L^{-1} ; $[Cl_2] = 1.0$ mol L^{-1} (ii) $X_{PCl_5} = 0.2$; $X_{PCl_3} = 0.4$; $X_{Cl_2} = 0.4$

(iii) $K_c = 2$ L mol^{-1} 8. $K_C = 4.0$. 9. $\frac{(2n-y)y}{(n-y)^2.P}$

Hints & Solutions

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1. $K_p = K_c (RT)^{\Delta n}$
$2K_c = K_c (RT)^{\Delta n}$
$2 = (RT)^1$
$$T = \frac{2}{0.0821} = 24.36 \text{ K}$$

4.

N_2	+	$3H_2$	$\rightleftharpoons$	$2NH_3$
1		3		0
0.5		1.5		1

$$P_{H_2} = \frac{1.5}{3}P = P/2$$

6. $2NO_2 \rightleftharpoons N_2O_4$

$$K_c = \frac{[N_2O_4]}{[NO_2]^2} = \left(= \frac{mol\ L^{-1}}{(molL^{-1})^2}, K_c \text{ has unit of } L\ mol^{-1}\right)$$

$$K_p = \frac{p_{N_2O_4}}{p^2_{NO_2}} \left(= \frac{atm}{atm^2}, K_p \text{ has unit of } atm^{-1}\right)$$

(Since mole fraction is itself unitless hence, K_x is also unitless)

7. (i) Molar concentrations :

$$[PCl_5] = \frac{mol}{L} = \frac{1}{2} = 0.5 \text{ mol L}^{-1}$$

$$[PCl_3] = \frac{2}{2} = 1.0 \text{ mol L}^{-1}$$

$$[Cl_2] = \frac{2}{2} = 1.0 \text{ mol L}^{-1}$$

(ii) Mole fractions :

Total moles at equilibrium = 1 + 2 + 2 = 5

$$\therefore \quad X_{PCl_5} = \frac{n_{PCl_5}}{n_{total}} = \frac{1}{5} = 0.2$$

$$X_{PCl_3} = \frac{n_{PCl_3}}{n_{total}} = \frac{2}{5} = 0.4$$

$$X_{Cl_2} = \frac{n_{Cl_2}}{n_{total}} = \frac{2}{5} = 0.4$$

(iii) Equilibrium constants :

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{1 \times 1}{0.5} = 2 \text{ (mol L}^{-1})^{-1} = 2 \text{ L mol}^{-1}$$

8. $K_C = 4.0.$

9. $PCl_3 + Cl_2 \rightleftharpoons PCl_5$

	PCl_3	Cl_2	PCl_5
t = 0	n	n	0
t = teq.	n-y	n-y	y

$$K_p = \frac{y}{(n-y)\,(n-y)}\left[\frac{P}{2n-y}\right]^{-1}$$

$$K_p = \frac{(2n-y)y}{(n-y)^2 P}$$