1. For a concentrated solution of a weak electrolyte (K_{eq} =equilibrium constant) A_2B_3 of concentration 'C', the degree of dissociation 'α' is
[2023 (06 Apr Shift 1)]

(1) $\left(\frac{K_{eq}}{5c^4}\right)^{\frac{1}{5}}$

(2) $\left(\frac{K_{eq}}{108c^4}\right)^{\frac{1}{5}}$

(3) $\left(\frac{K_{eq}}{25c^2}\right)^{\frac{1}{5}}$

(4) $\left(\frac{K_{eq}}{6c^5}\right)^{\frac{1}{5}}$

2. The equilibrium composition for the reaction
$PCl_3 + Cl_2 \rightleftharpoons PCl_5$ at 298 K is given below:

$[PCl_3]_{eq} = 0.2\ \text{mol L}^{-1}$, $[Cl_2]_{eq} = 0.1\ \text{mol L}^{-1}$, $[PCl_5]_{eq} = 0.40\ \text{mol L}^{-1}$

If 0.2 mol of Cl_2 is added at the same temperature, the equilibrium concentrations of PCl_5 is _____ $\times 10^{-2}$ mol L^{-1}

Given: K_c for the reaction at 298 K is 20
[2023 (06 Apr Shift 2)]

3. The number of correct statement/s involving equilibria in physical processes from the following is _____

(A) Equilibrium is possible only in a closed system at a given temperature.

(B) Both the opposing processes occur at the same rate.

(C) When equilibrium is attained at a given temperature, the value of all its parameters became equal

(D) For dissolution of solids in liquids, the solubility is constant at a given temperature.
[2023 (10 Apr Shift 1)]

4. A mixture of one mole of H_2O and 1 mole of CO is taken in a 10 litre container and heated to 725 K. At equilibrium 40% of water by mass reacts with carbon monoxide according to the equation: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$. The equilibrium constant $K_C \times 10^2$ for the reaction is _____ (Nearest integer)
[2023 (11 Apr Shift 1)]

5. 4.5 moles each of hydrogen and iodine is heated in a sealed ten litre vessel.At equilibrium, 3 moles of HI were found. The equilibrium constant for $H_2(g)+I_2(g) \rightleftharpoons 2\,HI_{(g)}$ is .....
[2023 (11 Apr Shift 2)]

ANSWER KEYS

1. (2) **2.** (49) **3.** (3) **4.** (44) **5.** (1)

1. (2)

Given that concentration of A_2B_3 is C and degree of dissociation is α

The equilibrium reaction of weak electrolyte A_2B_3 is

$$\begin{array}{lccc} A_2B_3 & \rightleftharpoons 2A^{3+} & +3B^{2-} \\ C & - & - \\ \downarrow & \downarrow & \downarrow \\ C(1-\alpha) & 2C\alpha & 3C\alpha \end{array}$$

Now, The equilibrium constant is the ratio of the concentrations of reactants and products raised to the stoichiometric coefficients.

$K_{eq} = \frac{(2C\alpha)^2(3C\alpha)^3}{C(1-\alpha)} = 108C^4\alpha^5$

$\frac{K_{eq}}{108C^4} = \alpha^5 \Rightarrow \alpha = \left(\frac{K_{eq}}{108C^4}\right)^{\frac{1}{5}}$

2. (49)

$\underset{0.2}{PCl_3(g)} + \underset{0.1}{Cl_2(g)} \rightleftharpoons \underset{0.4}{PCl_5(g)}$

$K_c = \frac{0.4}{0.2\times0.1} = 20$

If 0.2 moles of Cl_2 is added. When reactant is added the reaction takes place in forward direction.

$20 = K_c = \frac{0.4+X}{(0.3-X)(0.2-X)}$

$\Rightarrow (0.4+X) = 20(0.3-X)(0.2-X)$

$\therefore\ 0.4+X = 20(0.06+X^2-0.5X)$

$0.4+X = 1.2+20X^2-10X$

$20X^2-11X+0.8=0$

$X = \frac{11\pm\sqrt{121-64}}{40}$

$= \frac{11-7.55}{40} \simeq 0.08625$

$\therefore\ (PCl_5) = 0.48625 \simeq 48.625\times10^{-2}$ or 49×10^{-2}

3. (3)

The equilibrium is possible when there is no exchange of matter between system and surroundings.

At equilibrium state the forward and backward processes occur with same rate (speed)

When a system reaches equilibrium at a given temperature, the forward and reverse reactions are occurring at the same rate, and the concentrations (or partial pressures) of the reactants and products no longer change with time. At this point, the system has achieved a steady state, where the rate of the forward reaction is equal to the rate of the reverse reaction. So when equilibrium is attained, the value of all its parameters became constant.

The solubility is function of solubility product, the value of which is constant at a given temperature.

4. (44)

$$CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$$

initial moles	1	1		
moles at equilibrium	$1-0.4$	$1-0.4$	0.4	0.4
Molarity	$0.6/10$	$0.6/10$	$0.4/10$	$0.4/10$

Now, the equilibrium constant $K_C = \frac{[CO_2][H_2]}{[CO][H_2O]}$

$\Rightarrow K_C = \frac{0.04\times0.04}{0.06\times0.06} = 0.44$

$\therefore K_c\times10^2 = 44$

5. (1)

The equilibrium moles of each reactant and product can be calculated as follows,

$$H_2(g) + I_2(g) \rightleftharpoons 2HI_{(g)}$$

initial	4.5	4.5	0
At equilibrium	$4.5-1.5$	$4.5-1.5$	3

Now, using equilibrium moles, equilibrium constant calculated as shown below.

$K_{eq} = \frac{[HI]^2}{[H_2][I_2]} = \frac{(3)^2}{3\times3} = 1$