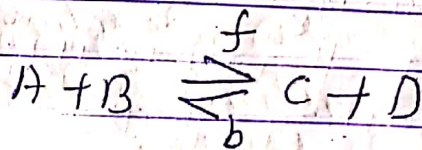


Law of mass action — Rate of formation of reaction is directly proportional to product of power of reactant active masses. Here active mass means the molar concentration of reactant.

Let us consider ~~the reaction~~ a reversible reaction



$[A], [B], [C], [D]$ are the active mass of A, B, C, D.

According to law of mass action

Rate of forward reaction $\propto [A][B]$

or $r_f = k_f [A][B]$ — (i)

Where r_f = rate of forward reaction
 k_f = rate constant of forward reaction

Similarly

$$r_b \propto [C][D]$$

or $r_b = k_b [C][D]$ — (ii)

r_b = rate of backward reaction
 k_b = Rate constant for backward reaction

At chemical equilibrium $r_f = r_b$

or $k_f [A][B] = k_b [C][D]$

or,

$$\frac{k_f}{k_b} = \frac{[C][D]}{[A][B]}$$

or,
$$K = \frac{[C][D]}{[A][B]}$$
 (iii)

Where $K = \frac{k_f}{k_b}$ = ~~Rate~~ equilibrium constant of reaction.

As only concentration term is considered, this equilibrium constant is equilibrium constant for concentration.

If pressure is considered in stead of concentration for gas, the equilibrium constant is called equilibrium constant for pressure and will be given by the following equation

$$K_p = \frac{[P_c][P_D]}{[P_A][P_B]} \quad \text{(iv)}$$

Where, P_c, P_D, P_A and P_B are the partial pressure of A, B, C, D.

When mole fraction is considered for C, D, A and B as C_x, D_x, A_x and B_x

Then
$$K_x = \frac{[C_x][D_x]}{[A_x][B_x]} \quad \text{(v)}$$

Relation between K_p and K_c

for ideal gas:

$$PV = nRT$$

$$\text{or, } P = \frac{n}{V} RT$$

$$\text{or, } P = C RT$$

= concentration $\times R \times T$

We know

$$K_p = \frac{P_c \cdot P_D^d}{P_A^a \cdot P_B^b} \text{ for } aA + bB \rightleftharpoons cC + dD$$

$$= (C_c RT)^c \cdot (C_D RT)^d$$

$$\frac{(C_A RT)^a (C_B RT)^b}{(C_C RT)^c (C_D RT)^d}$$

$$= \frac{[C_c]^c [C_D]^d \cdot (RT)^{c+d}}{[C_A]^a [C_B]^b \cdot (RT)^{a+b}}$$

$$= K_c \cdot R T^{(c+d) - (a+b)}$$

$$= K_c \cdot R T^{\Delta n}$$

$$\boxed{K_p = K_c \cdot (RT)^{\Delta n}}$$

$$\Delta n = (c+d) - (a+b)$$

Relation between K_p and K_x

We know partial pressure = mole fraction \times Total Pressure.

$$\therefore P_A = X_A P, \quad P_B = X_B P$$

$$P_C = X_C P \quad \text{and} \quad P_D = X_D P$$

Where P_A, P_B, P_C, P_D are partial pressure of A, B, C and D and X_A, X_B, X_C, X_D are mole fraction of A, B, C, D and P is the Total pressure.

From Definition of Law of mass action.

$$K_p = \frac{P_C^c \cdot P_D^d}{P_A^a \cdot P_B^b} \quad \text{for } aA + bB \rightleftharpoons cC + dD$$

$$\text{or } K_p = \frac{[X_C P]^c [X_D P]^d}{[X_A]^a [X_B]^b}$$

$$= \frac{[X_C]^c [X_D]^d \cdot P^{c+d}}{[X_A]^a [X_B]^b \cdot P^{a+b}}$$

$$= K_x \cdot P^{(c+d) - (a+b)}$$

$$\boxed{K_p = K_x \cdot P^{\Delta n}}$$