Chemical Equilibrium

- only depends on Temp
- Dynamic process
- All measurable quantity become constant ($\Delta v = 0$)
- $\Delta G = 0$
- $K_p = K_c$ only if $\Delta n_g = 0$ or $T = 1/R$

$$K_{eq} = \frac{K_f}{K_b} \overset{K_c}{=} \frac{[C]^c[D]^d}{[A]^a[B]^b} = \overset{K_p}{\frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}}$$

$$= \frac{(x_C)^c(x_D)^d}{(x_A)^a(x_B)^b}$$

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

Δn_g ← no. of gaseous mole (prod − react)

- $(K_{eq})_{forward} \times (K_{eq})_{backward} = 1$
- $A \longrightarrow B$ K

$nA \longrightarrow nB$ $K' = (K)^n$

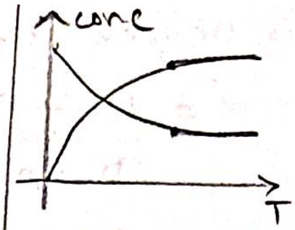
$\frac{A}{n} \longrightarrow \frac{B}{n}$ $K' = (K)^{1/n}$

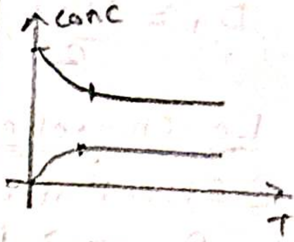
- Unit of $K_c = (mol/L)^{\Delta n}$
- Unit of $K_p = (atm/bar)^{\Delta n_g}$
- Unit of K_x = unitless

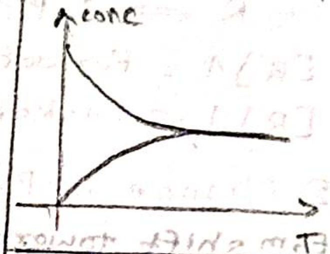
- $A \longrightarrow B$ K_1

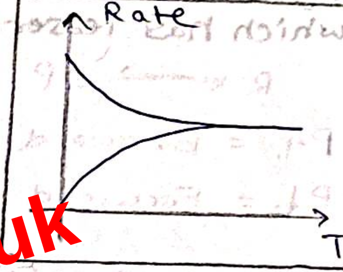
$+\ B \longrightarrow C$ K_2

$A \longrightarrow C$ $K' = K_1 \times K_2$









case (i) if c is given $R \rightleftharpoons 2P$ $10 \quad -$ $10-x \quad 2x$ $K_c = \frac{(2x)^2}{10-x}$	case (ii) if P is given $R \rightleftharpoons 2P$ $P_0 \quad -$ $P_0-x \quad 2x$ $K_p = \frac{(2x)^2}{(P_0-x)}$	case (iii) if mole is given $R \rightleftharpoons 2P$ $n \quad -$ $n-x \quad 2x$ $c = \frac{n-x}{V} \quad \frac{2x}{V}$ $K_c = \frac{\left(\frac{2x}{V}\right)^2}{\left(\frac{n-x}{V}\right)}$	case (iv) α is given $R \rightleftharpoons 2P$ $c \quad -$ $c-c\alpha \quad 2c\alpha$ $K_c = \frac{\left(\frac{2c\alpha}{V}\right)^2}{\left(\frac{c-c\alpha}{V}\right)}$	case (v) $R \rightleftharpoons 2P$ mole $1-\alpha \quad 2\alpha$ at eqm $n_{total} = 1+\alpha$ $P_R = x_R(P_{total})$ $P_P = x_P(P_{total})$ $K_p = \frac{(P_P)^2}{(P_R)^1}$ $= \frac{\left(\frac{2\alpha}{1+\alpha} \times P_T\right)^2}{\left(\frac{1-\alpha}{1+\alpha} \times P_T\right)^2}$

$$K_c = \left[\begin{matrix}K_{eq} \text{ in mole} \\ \text{form}\end{matrix}\right]\left(\frac{1}{V}\right)^{\Delta n_g}$$

$$K_p = \left[\begin{matrix}K_{eq} \text{ in mole} \\ \text{form}\end{matrix}\right]\left(\frac{P_T}{n_{Total}}\right)^{\Delta n_g}$$

Application of Eqm constant

① Direction of reaction

Reaction quotient (Q)

$Q < K_{eq} \longrightarrow$ Forward

$Q = K_{eq} \longrightarrow$ No

$Q > K_{eq} \longrightarrow$ Back

$K_c > 10^3 \longrightarrow [P] > [R]$

$10^{-3} < K_c < 10^3 \longrightarrow$

$K_c < 10^{-3} \longrightarrow [P] < [R]$

② Keq only depend on Temp

$$\Delta^\circ G = -2.303RT \log(K_{eq})$$

$$\log(K_{eq}) = \frac{-\Delta H}{2.303RT} + \frac{\Delta^\circ S}{2.303R}$$

$$\ln(K_{eq}) = \frac{\Delta^\circ S}{R} - \frac{\Delta H}{RT}$$

$$\ln\frac{K_2}{K_1} = \frac{\Delta H^\circ}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$