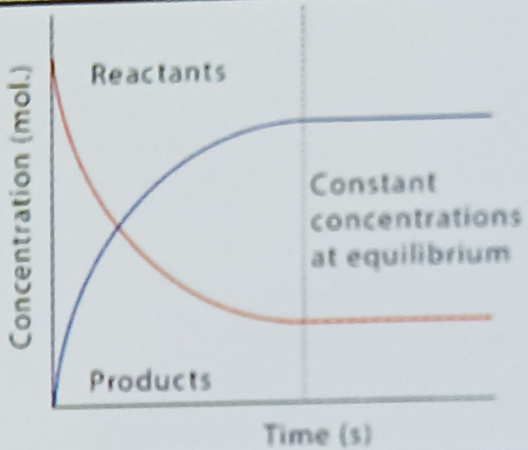
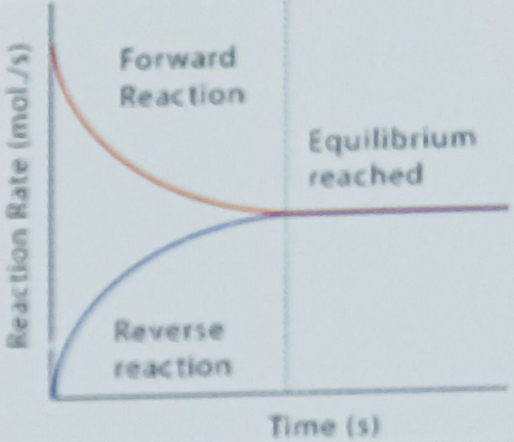
CHEMICAL EQUILIBRIUM

Graphical Analysis

Concentration vs time	Rate vs Time
	

For a reaction, $mA + nB \leftrightharpoons pC + qD$

$k_f = [C]^p[D]^q$ and $k_b = [A]^m[B]^n$

k_f= rate constant of forward reaction

k_b= rate of backward reaction

At Equilibrium, $k_f = k_b$ and $k_f / k_b = K_{eq}$

$K_c = \dfrac{[C]^p[D]^q}{[A]^m[B]^n}$	[ ] = represents concentration
$K_p = \dfrac{(p_C)^p(p_D)^q}{(p_A)^m(p_B)^n}$	p = partial Pressure also, $p = x \times P_T$

Relation between K_C, K_p, K_x

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

Case I : $n_p > n_r$; $\Delta n_g > 0$; $K_p > K_c$
Case II : $n_p < n_r$; $\Delta n_g < 0$; $K_p < K_c$
Case III : $n_p = n_r$; $\Delta n_g = 0$; $K_p = K_c$

K also confirms the stability of Reactants and Products

K↑ = Products Stable

K↓ = Reactants Stable

Factors Affecting K

- **Temperature (According to Van't Hoff equation)**

$$\log\left(\frac{K_2}{K_1}\right) = \frac{\Delta H^\circ}{2.303R}\left[\frac{1}{T_1} - \frac{1}{T_2}\right] \quad (\text{Here } T_2 > T_1)$$

$\Delta H = +ve$ (Endothermic); $K_2 > K_1$
$\Delta H = -ve$ (Exothermic) ; $K_1 > K_2$

- **Stoichiometry of a reaction and representation**

For a reaction $aA + bB \rightleftarrows cC + dD$, Eq. Constant= **K**

1. Multiply reaction by 2 : $\mathbf{K^2}$
2. Divide Reaction by 2 : $\mathbf{K^{1/2}}$
3. Reverse the reaction : **1/K**
4. Add Equation with Eq. constant K_2 = $\mathbf{K.K_2}$
5. Subtract Equation with Eq. constant K_2 = $\mathbf{K/K_2}$

Reaction Quotient

For a reaction $aA + bB \rightleftarrows cC + dD$, Eqm Constant : K

At a stage other than eqm.

$$Q_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$

Q > K : Form Reactants
Q < K : Form Products
Q = K : Equilibrium

Degree of Dissociation ($0<\alpha<1$)

Fraction of initial molecules that are converted at eqm.

Case I : $aA \rightleftharpoons bB$
n (Eq.) $2-ax$ bx

If Initial moles = 2
Degree of diss. $\alpha = ax/2$

Case II : $aA + bB \rightleftharpoons cC + dD$
n (Eq.) $3-ax$ $2-bx$ cx dx

If Initial A=3 ; B=2
DOD (α_A) = ax/3

Relation between Standard Gibbs Free Energy and K

$$\Delta G^o = -2.303RT \log K = -RT \ln K$$

$\Delta G^o < 0$	$K>1$	Spontaneous Reaction
$\Delta G^o > 0$	$K<1$	Non-Spontaneous Reaction
$\Delta G^o = 0$	$K=0$	Equilibrium

Le-Chatlier's Priniciple

When a simple system in equilibrium is subjected to a change in Conc., T, V, or P.

(1) the system changes to a new equilibrium

(2) this change partly counteracts the applied change.

Concentration	↑ Reactants - **Forward** Reaction ↑Products - **Backward** Reaction
Temperature	Endothermic : ↑Temp - **Forward** Exothermic : ↑Temp - **Backward**
Catalyst	BORRINGGG....**NO EFFECT**
Pressure	↑ Pressure : **Towards Lower moles** ↓ Pressure : **Towards Higher moles**
Inert Gas	At Constant P, **Towards Higher Moles** At Constant V, **NO Effect**