Equilibrium Constants (K_{Eq})

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

Molar Concentration

Where...

$$aA + bB \rightleftharpoons cC + dD$$

$$K_p = \frac{(P_C)^c (P_D)^d}{(P_A)^a (P_B)^b}$$

Partial Pressure

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

Acid Dissociation

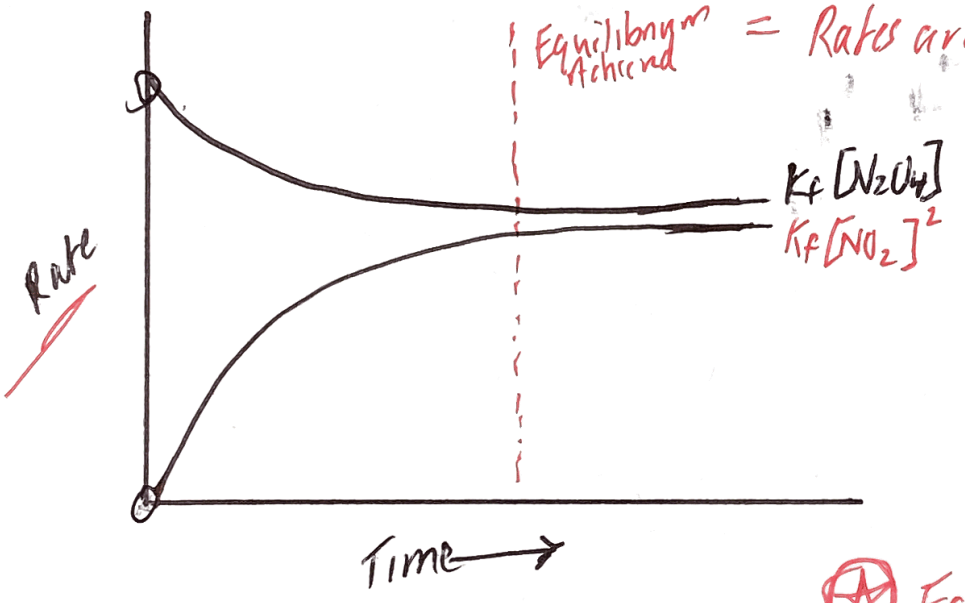
$$K_b = \frac{[OH^-][HB^+]}{[B]}$$

Base Dissociation

① Expressing Equilibrium

★ Any bond or IMF that can be formed, can be broken
Both processes are in competition that is sensitive to initial concentration & external disturbances.

$$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$$



Equilibrium = Rates are ~~equal~~/constant
= Amts of rxt & product remain constant.

★ Equilibrium does NOT mean the reaction stops.

The Equilibrium Constant (K_{eq})

Forward Rxn: $N_2O_4 \longrightarrow 2NO_2$

Rate Law: ★ Rate = $k_f[N_2O_4]$

Reverse Rxn: $2NO_2 \longrightarrow N_2O_4$

Rate Law: Rate = $k_r[NO_2]^2$

∴ at equilibrium $Rate_f = Rate_r$

↓

$$K_f[N_2O_4] = K_r[NO_2]^2$$

$$\frac{K_f}{K_r} = \frac{[NO_2]^2}{[N_2O_4]} \leftarrow \frac{[Product]}{[Reactant]} = K_{eq}$$

$$aA + bB \rightleftharpoons cC + dD$$

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

Concentration (in M)

Ex 1 Write equilibrium expression for K_c

a) $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$

$$\frac{[O_2]^3}{[O_3]^2} = K_c$$

b) $2NO_{(g)} + Cl_{2(g)} \rightleftharpoons 2NOCl_{(g)}$

$$K_c = \frac{[NOCl]^2}{[NO]^2[Cl_2]}$$

K_{eq} can be expressed in other ways...

$$\rightarrow K_p = \frac{(P_C)^c(P_D)^d}{(P_A)^a(P_B)^b}$$

↑ pressure

Relationship between K_c & K_p

We can use $PV = nRT$ to relate the 2.

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

* Δn = mole of prod − mole of rxt

Ex2 In synthesis of NH_3 from N_2 & H_2
Calculate the K_p for the rxn @ this temp

$$N_{2(g)} + 3\,H_{2(g)} \rightleftharpoons 2\,NH_{3(g)}$$

$K_c = 9.60$ at $300^\circ C$

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

$$9.60\left[\left(0.0821 \frac{L \cdot atm}{mol \cdot K}\right)(573\ K)\right]^{-2}$$

Δn = 2 − 4

Δn = −2

$K_p = 0.0043$

So what the heck does K_{eq} mean?

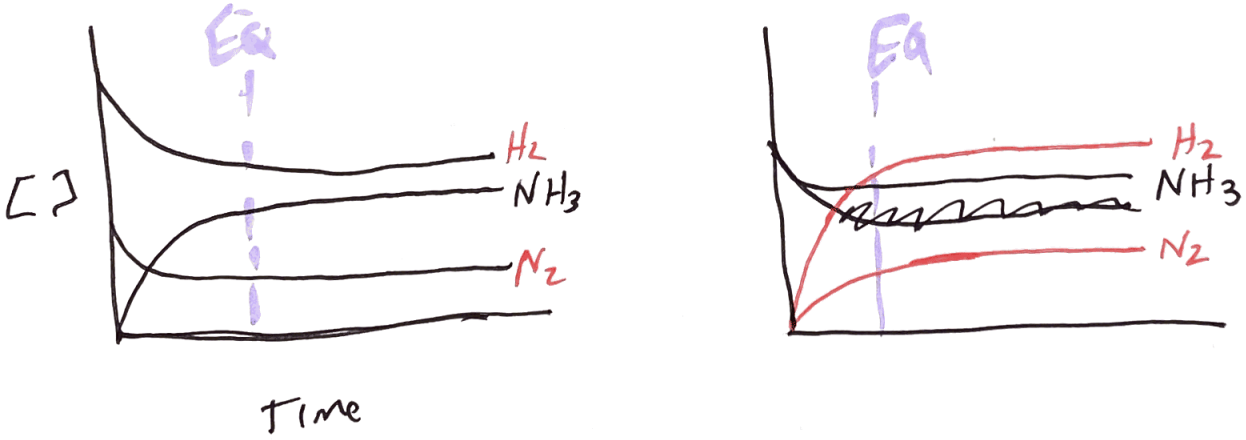
$K = \frac{Pro}{RxT}$ * If K is ↑ ($K >>> 1$), rxn is Product Favored (Mor product @ EQ

RXT ⇌ Pro

If K is ↓ ($K <<< 1$), rxn is Reactant favored (LOTS of RXT @ EQ →

RxT ⇌ PRO

ie If K is small = $\frac{Product\downarrow}{RxT\uparrow}$



Equilibrium can be reached from either direction.

The K_{eq} will remain constant at this temp regardless of initial concentrations.

= @ equilibrium, proportions of all 3 is same = K_{eq} is same

Ex 3 $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI$

K_c vary w/ Temp $K_c = 794$ @ 298k

$K_c = 54$ @ 700k

Is the formation of HI favored more at low / high temps

$K_c = \frac{P}{R}$

↑ K = Product favored
= Low temp

≡ SO; if you want to produce HI, run the rxn at a lower Temp

Keq is useful!