[CLASS NOTES] 2/8

$O_2(g) + O(g) \rightleftharpoons O_3(g)$

At equilibrium, the rate of ozone formation = rate of ozone destruction

(rate of formation = rate of destruction)

- to predict whether reaction is reaction or product favored.

look at K

THE EQUILIBRIUM CONSTANT

candy(right) $\rightleftharpoons$ candy(left)

- case 1: equal # of students
- driving force equal on both sides (K=1)

$K = \frac{[\text{products}]}{[\text{reactants}]} = 1$

- case 2: more students on left
- driving force pushes reaction to right

$K = \frac{[\text{products}]}{[\text{reactants}]} > 1$ product favored

- case 3: more students on right

$K = \frac{[\text{products}]}{[\text{reactants}]} < 1$ reactant favored

- driving force pushes reaction to left

$N_2O_4(g) \longrightarrow 2NO_2(g)$ (* temp - driving force)

EQ can be reached from either direction

EXPRESSION FOR K

- in a system at equilibrium, both the forward and reverse reactions are proceeding:

$$N_2O_4(g) \rightleftharpoons 2NO_2(g)$$

$rate_{forward} = k_f[N_2O_4]$ $rate_{reverse} = k_r[NO_2]^2$

where k_f and k_r are rate constants

at equilibrium

$$rate_{forward} = rate_{reverse}$$

$$k_f[N_2O_4] = k_r[NO_2]^2$$

$$\frac{[NO_2]^2}{[N_2O_4]} = \overbrace{\frac{k_f}{k_r}}^{\text{a constant}} = K$$

For general reaction

$$aA + bB \rightleftharpoons dD + eE$$

EQ expression

$$K = \frac{[D]^d[E]^e}{[A]^a[B]^b} \begin{matrix} \leftarrow \text{products} \\ \leftarrow \text{reactants} \end{matrix}$$

* K is unitless

concentrations are in molar $\left(\frac{mol}{L}\right) = M$

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

$$K_c = \frac{[NH_3]^2}{[N_2][H_2]^3}$$ *concentrations at equilibrium

(*Note: K depends on temp. which might be a driving force)

EQUILIBRIUM CONSTANT Kp (pressure constant)

K_p $\Big\{$ for gasses in a particular volume, pressure is proportional to the concentration, so we could write K_p, the EQ constant in terms of pressures, rather than concentrations

- replace concentration terms w/ pressure

$$K_p = \frac{(P_D)^d (P_E)^e}{(P_A)^a (P_B)^b} = \frac{P(NH_3)^2}{P(N_2)P(H_2)^3} = K_p$$

How do K_p and K_c relate

$PV = nRT$ (the ideal gas law)

$P = \left(\frac{n}{V}\right) RT$ (where n/V is concentration)

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

where Δn = (moles of gaseous product) - (moles gaseous reactants)

K_p and K_c may or may not be the same

THE MEANING OF K

reactants $\rightleftharpoons$ PRODUCTS — $K >> 1$, EQ "lies to the right" product favored

REACTANTS $\rightleftharpoons$ products — $K << 1$, EQ "lies to the left" reactant favored

reverse a reaction, take the inverse of K

$K_2 = 1/K_1$

multiply by a constant, raise K to that power

$K_2 = K_1^2$ when you multiply rxn 1 by 2

add reactions, multiply K's

$K_3 = K_1 \times K_2$ when you add rxn 1 & rxn 2