

[[class notes]] 2/8



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

- to predict whether reaction is reactant or product favored, look at K

THE EQUILIBRIUM CONSTANT



- 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

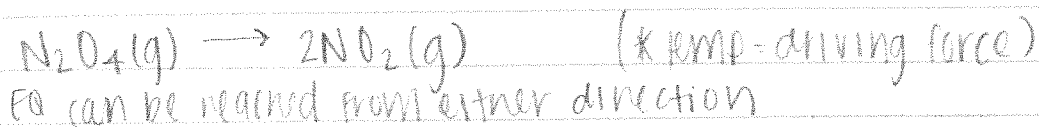
- driving force pushes reaction to right

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

- case 3: more students on right

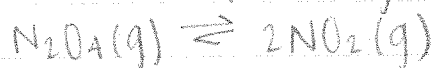
$$K = \frac{[\text{products}]}{[\text{reactants}]} < 1 \quad \text{reactant favored}$$

- driving force pushes reaction to left



EXPRESSION FOR K

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



$$\text{rate}_{\text{forward}} = k_f [\text{N}_2\text{O}_4] \quad \text{rate}_{\text{reverse}} = k_r [\text{NO}_2]^2$$

where k_f and k_r are rate constants

at equilibrium

$$\text{rate}_{\text{forward}} = \text{rate}_{\text{reverse}}$$

$$k_f [\text{N}_2\text{O}_4] = k_r [\text{NO}_2]^2$$

$$\frac{[\text{NO}_2]^2}{[\text{N}_2\text{O}_4]} = \frac{\overset{\text{a constant}}{k_f}}{k_r} = K$$

For general reaction



EQ expression

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

* K is unitless

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



$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

* concentrations at equilibrium

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

EQUILIBRIUM CONSTANT K_p (pressure constant)

K_p { for gases 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

$$K_p = \frac{(P_D)^d (P_F)^e}{(P_A)^a (P_B)^b} = \frac{P(\text{NH}_3)^2}{P(\text{N}_2)P(\text{H}_2)^3} = K_p$$

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 $\Delta n = (\text{moles of gaseous product}) - (\text{moles gaseous reactants})$

K_p and K_c may or may not be the same

THE MEANING OF K

reactants $\rightleftharpoons$ PRODUCTS $K \gg 1$, E° lies to the right"
product favored

REACTANTS $\rightleftharpoons$ products $K \ll 1$, E° 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

$$K_2 = K_1^2 \quad \text{when you multiply rxn 1 by 2}$$

add reactions, multiply K 's

$$K_3 = K_1 \times K_2 \quad \text{when you add rxn 1 + rxn 2}$$