The Mass Action Expression and Equilibrium

Recall: Lab $Fe^{3+} + SCN^- \rightleftharpoons FeSCN^{2+}$

this expression gives a constant

ratio → $\dfrac{[FeSCN^{2+}]}{[Fe^{3+}][SCN^-]}$ ← product

reactant, reactant

multiply

Mass Action Expression - General

$aA + bB \rightleftharpoons cC + dD$

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

Examples-

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

$$K_{eq} = \frac{[NO_2]^2}{[N_2O_4]}$$

2. $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2 [O_2]}$$

Heterogeneous Equilibrium - different states

- Substances in (s) or (ℓ) states are not part of Mass Action Exp.

s, ℓ, g, aq

Questions 1-5, p. 497

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Calculations Using Mass Action Expression

1. Calculate Keq given moles (conc.) + balanced equation.

$$N_{2(g)} + 3Cl_{2(g)} \rightleftharpoons 2NCl_{3(g)}$$

At equil. 0.0070 mol N_2 V = 5.0 L
0.0022 mol Cl_2
0.95 mol NCl_3

Calculate Keq

a. Find all concentrations

$$[N_2] = \frac{0.0070\ mol}{5.0\ L} = 0.0014\ mol/L$$

$$[Cl_2] = \frac{0.0022\ mol}{5.0\ L} = 0.00044\ mol/L$$

$$[NCl_3] = \frac{0.95\ mol}{5.0\ L} = 0.19\ mol/L$$

b. $$K_{eq} = \frac{[NCl_3]^2}{[N_2][Cl_2]^3} = \frac{(0.19)^2}{(0.0014)(0.0004}$$

$$= 3.0 \times 10^{11}$$

2. Calculate equilibrium concentrations
given: equation, K_{eq}, all other [ ]'s

For $N_2 + 3Cl_2 \rightleftharpoons 2NCl_3$

$K_{eq} = 3.0 \times 10^{11}$

$[N_2] = 0.17\ mol/L \quad [Cl_2] = 0.51\ mol/L$

Calculate $[NCl_3]$ (at equil.)

a. $K_{eq} = \dfrac{[NCl_3]^2}{[N_2][Cl_2]^3}$ 2.

$3.0 \times 10^{11} = \dfrac{[NCl_3]^2}{[0.17][0.51]^3}$

$(3.0 \times 10^{11})(0.17)(0.51)^3 = [NCl_3]^2$

$\sqrt{6.8 \times 10^8} = \sqrt{[NCl_3]^2}$

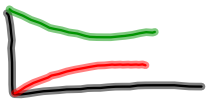
$= 8.2 \times 10^4\ mol/L$

Questions 6–10, p. 499, p. 508
14, 15

The Meaning of Keq

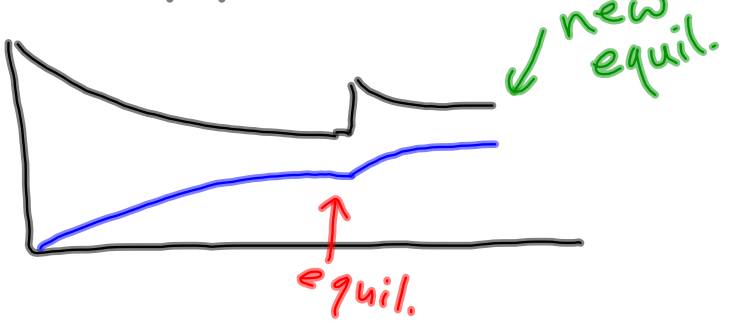
* When K is large (K>1) more products than reactants.

* When K is small (K<1) more reactants....



* When K=1 about the same amounts of product and reactant

Equilibrium Analogy Part B



Le Chatelier's Principle

When a system at equilibrium is stressed, it will shift to accomodate the stress.

Lab - Le Chatelier

Change	Stress	Colour change	Shift r or p
1. Add H_2O			
2. Add HCl			
3. Add $CaCl_2$			
4. Add $AgNO_3$			
5. Heat			
6. Cool			

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