**CONCEPT:** EQUILIBRIUM CONSTANT (K)

- Equilibrium constant (K) specifies the favored _____ of a reaction while rate constant (k) deals with _____.
  - □ **K:** concentration units; **k:** concentration and time units ($M \cdot time^{-1}$)

**Equilibrium Constant Expressions**

- **Equilibrium Constant (K** or **Keq)** is a _____ of product to reactant concentrations at equilibrium.
  - □ Equilibrium Constant is temperature _____: change in temperature changes the _____ of K.

**Equilibrium Constant Expression (Formula)**

$aA + bB \rightleftharpoons cC + dD$

□ a, b, c, d = coefficients

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

□ **K= Kp or Kc**
- Kp used when [ ]s are in ____
- Kc used when [ ]s are in ____

- □ Solids and pure liquids are _____ from K expressions
  - adding a solid (s) or pure liquid (l) does _____ change their concentrations

$$Mg(OH)_2\,(s) + 2\,HCl\,(aq) \rightleftharpoons 2\,H_2O\,(l) + MgCl_2\,(aq)$$

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

**EXAMPLE:** What is the equilibrium constant expression for the following reaction:

$$2\,HgO\,(s) + H_2O\,(l) + 2\,Cl_2\,(g) \rightleftharpoons 2\,HOCl\,(aq) + HgO\,(s) + HgCl_2\,(s)$$

**CONCEPT:** EQUILIBRIUM CONSTANT (K)

**PRACTICE:** Provide K expression for the reverse of the following reaction:

$$Fe_2O_3(s) + 3\ H_2\ (g) \rightleftharpoons 2\ Fe\ (s) + 3\ H_2O\ (g)$$

a) $\mathbf{K} = \dfrac{[Fe]^2\,[H_2O]^3}{[Fe_2O_3]\,[H_2]^3}$

c) $\mathbf{K} = \dfrac{[Fe_2O_3]\,[H_2]^3}{[Fe]^2\,[H_2O]^3}$

b) $\mathbf{K} = \dfrac{[H_2O]^3}{[H_2]^3}$

d) $\mathbf{K} = \dfrac{[H_2]^3}{[H_2O]^3}$

**CONCEPT:** EQUILIBRIUM CONSTANT (K)

**Magnitude of Equilibrium Constant**

● Magnitude of **K** indicates how far _____ or _____ a reaction lies at equilibrium, at a given temperature.

| Magnitude of Equilibrium Constant | |
|---|---|
| K > 1: _____ and _____ reaction are favored. | $K = \frac{10}{2} = 5$ |
| K < 1: _____ and _____ reaction are favored. | $K = \frac{2}{10} = 0.2$ |
| K = 1: _____ direction is favored. | $K = \frac{10}{10} = 1$ |

□ Magnitude of K can also be determined from rate constants of forward and reverse reactions.

$$K = \frac{k_{forward}}{k_{reverse}}$$

□ K = Equilibrium Constant

□ k = Rate Constant

**EXAMPLE:** When this reaction comes to an equilibrium, which will be higher in pressure, reactants or products?

$$2\ CH_4\ (g) + 2\ H_2S\ (g) \rightleftharpoons CS_2\ (g) + 4\ H_2\ (g) \qquad Kp = 1.3 \times 10^3$$

a) reactants b) products c) neither d) impossible to estimate

**CONCEPT:** EQUILIBRIUM CONSTANT (K)

**PRACTICE:** Which of the reactions is likely to produce more $O_2$ at equilibrium at 25ºC?

a) $2\ NO\ (g) \rightleftharpoons N_2\ (g) + O_2\ (g)$ $K_{eq} = 2.4 \times 10^{30}$

b) $2\ NO_2\ (g) \rightleftharpoons 2\ NO + O_2\ (g)$ $K_{eq} = 5.8 \times 10^{-5}$

c) $2\ CO_2\ (g) \rightleftharpoons O_2\ (g) + 2\ CO\ (g)$ $K_{eq} = 3.1 \times 10^{-5}$

d) $2\ H_2O\ (g) \rightleftharpoons 2\ H_2\ (g) + O_2\ (g)$ $K_{eq} = 5.1 \times 10^{-82}$

**PRACTICE:** Consider the reaction $A\ (g) \rightleftharpoons B\ (g) + C\ (g)$, with $k_{forward}$ of $5.7 \times 10^{-2}$ and $k_{reverse}$ of $3.8 \times 10^{-4}$. Which would be greater at equilibrium, partial pressure of A or partial pressures of B and C?

a) partial pressure of A b) partial pressure of B & C c) partial pressures will be equal