Chemical Equilibrium

- Some chemical reactions are **Reversible**

reactants → products — forward reaction

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

reactants ← products — reverse reaction

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

You can show a reversible reaction by using a **DOUBLE ARROW**

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

- **Equilibrium** occurs when...

the rate of the forward reaction **equals** the rate of the reverse reaction.

@ equilibrium

- The concentration of reactants & products **does NOT change**
- The concentration of reactants & products **do NOT have to be equal.**
- concentration of reactant can be written as [reactant] - same w/ products

- Writing an equilibrium expression

$aA + bB \rightleftharpoons cC + dD$

Only substances in **aqueous** or **gas** states are written in the expression

equilibrium constant

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

Examples

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

$$K_{eq} = \frac{[NH_3]^2}{[N_2][H_2]^3}$$

(2) $2\,SO_2(g) + O_2(g) \rightleftharpoons 2\,SO_3(g)$

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

(3) $H_2O(g) + C(s) \rightleftharpoons H_2(g) + CO(g)$

$$K_{eq} = \frac{[H_2][CO]}{[H_2O]}$$

(4) $H_2O(l) \rightleftharpoons H^{1+}(aq) + OH^{1-}(aq)$

$$K_{eq} = [H^{1+}][OH^{1-}]$$

(5) $2HCl(aq) + Ca(OH)_2(aq) \rightleftharpoons H_2O(l) + CaCl_2(aq)$

$$K_{eq} = \frac{[CaCl_2]}{[HCl]^2[Ca(OH)_2]}$$

If K_{eq} is...	⟶ reaction is favored.
$= 1$	neither
< 1	reverse
> 1	forward

Ex

(6) $2NO(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$

Calculate K_{eq} if $[NO] = .0200M$, $[Cl_2] = .0250M$, and $[NOCl] = .500M$. Is the forward or reverse reaction favored?

$$K_{eq} = \frac{[NOCl]^2}{[NO]^2[Cl_2]} = \frac{[.500M]^2}{[.0200M]^2[.0250M]} \cdot \frac{M^2}{1} = 25000$$

$$M^2 \cdot M$$

$$= 2.50 \times 10^4 \frac{1}{M}$$

(7) $2O_3(g) \rightleftharpoons 3O_2(g)$

$K_{eq} = .031$ and $[O_3] = 1.6 \times 10^{-2} M$. Calculate $[O_2]$. Which reaction is favored? reverse

$$K_{eq} = \frac{[O_2]^3}{[O_3]^2} \qquad .031 = \frac{[x]^3}{[1.6 \times 10^{-2}]^2}$$

$$\sqrt[3]{7.936 \times 10^{-6}} = \sqrt[3]{x^3}$$

$$.000256 \cdot .031 = \frac{x^3}{.000256} \cdot .000256$$

$$.0199 = x$$

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

$K_{eq} = .212$ and there is .04375 mol NO_2 dissolved in .50L. Calculate $[N_2O_4]$. which reaction is favored?