

Equilibrium Constants

Read from **Lesson 2: Equilibrium** in the **Chemistry Tutorial Section, Chapter 14** of **The Physics Classroom**.

Part b: [Equilibrium Constant Expressions](#)

Part c: [Calculations of K and Concentration](#)

Law of Chemical Equilibrium

1. Law Overview

- For a reversible reaction at a given temperature:

$$aA + bB \rightleftharpoons cC + dD$$
- The ratio remains constant at equilibrium. Concentrations are raised to the power of their stoichiometric coefficients.

2. The Equilibrium Constant, K

- K or K_{eq} is known as the **equilibrium constant**
- The K value is unique to every reaction and dependent only upon the temperature.
- The K value does not depend on the equilibrium concentrations, but the equilibrium concentrations depend on the K value and the initial concentrations.

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

3. Writing Equilibrium Expressions (K)

- Place product concentrations in the numerator, reactants in the denominator.
- Use exponents matching coefficients from the balanced equation.
- Multiply concentrations when there are multiple species.
- Include only gases and aqueous solutions; exclude solids and liquids.

4. Types of Equilibrium Constants

- K_c uses molar concentrations (mol/L).
- K_p uses partial pressures for gaseous species:

$$aA(g) + bB(g) \rightleftharpoons cC(g) + dD(g)$$

$$K_p = \frac{P_C^c \cdot P_D^d}{P_A^a \cdot P_B^b}$$

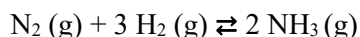
5. Interpreting K Values

- $K = 1 \rightarrow$ Products \approx Reactants
- $K \gg 1 \rightarrow$ Products favored
- $K \ll 1 \rightarrow$ Reactants favored

6. Equilibrium Language

- "Equilibrium lies to the right" \rightarrow favors formation of products
- "Equilibrium lies to the left" \rightarrow favors formation of reactants

Example:



At equilibrium: $[N_2] = 2.67\text{ M}$, $[H_2] = 3.55\text{ M}$, and $[NH_3] = 10.0\text{ M}$

$$K_c = \frac{[NH_3]^2}{[N_2] \cdot [H_2]^3}$$

$$K_c = \frac{[NH_3]^2}{[N_2] \cdot [H_2]^3} = \frac{(10.0\text{ M})^2}{(2.67\text{ M}) \cdot (3.55\text{ M})^3} = 0.837 \quad \text{Reactants are favored}$$

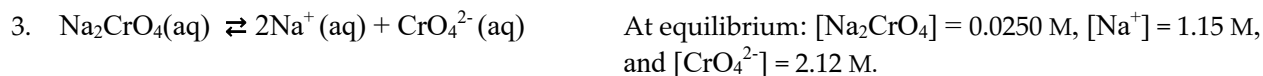
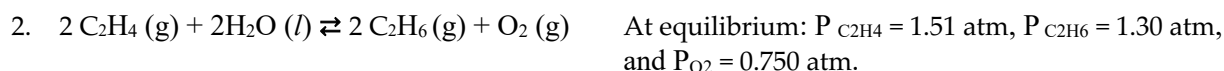
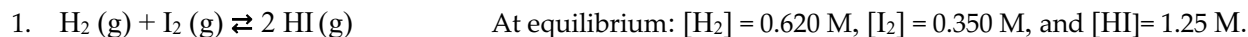
$$K_c \text{ for the reverse reaction is } 1/K_c = 1/0.837 = 1.19$$

Kinetics and Equilibrium

Questions

For each of the following reactions:

- Write the equilibrium constant expression K_{eq} as either K_c for concentration or K_p for pressure.
- Calculate the value of K_{eq} as K_c or K_p for the forward reaction, given the equilibrium concentrations or pressures.
- Based on the given equilibrium concentrations or pressures, determine whether the reaction is product-favored, reactant-favored, or approximately balanced (i.e., $[products] \approx [reactants]$).
- Calculate the value of K_c or K_p for the reverse reaction.



Kinetics and Equilibrium

