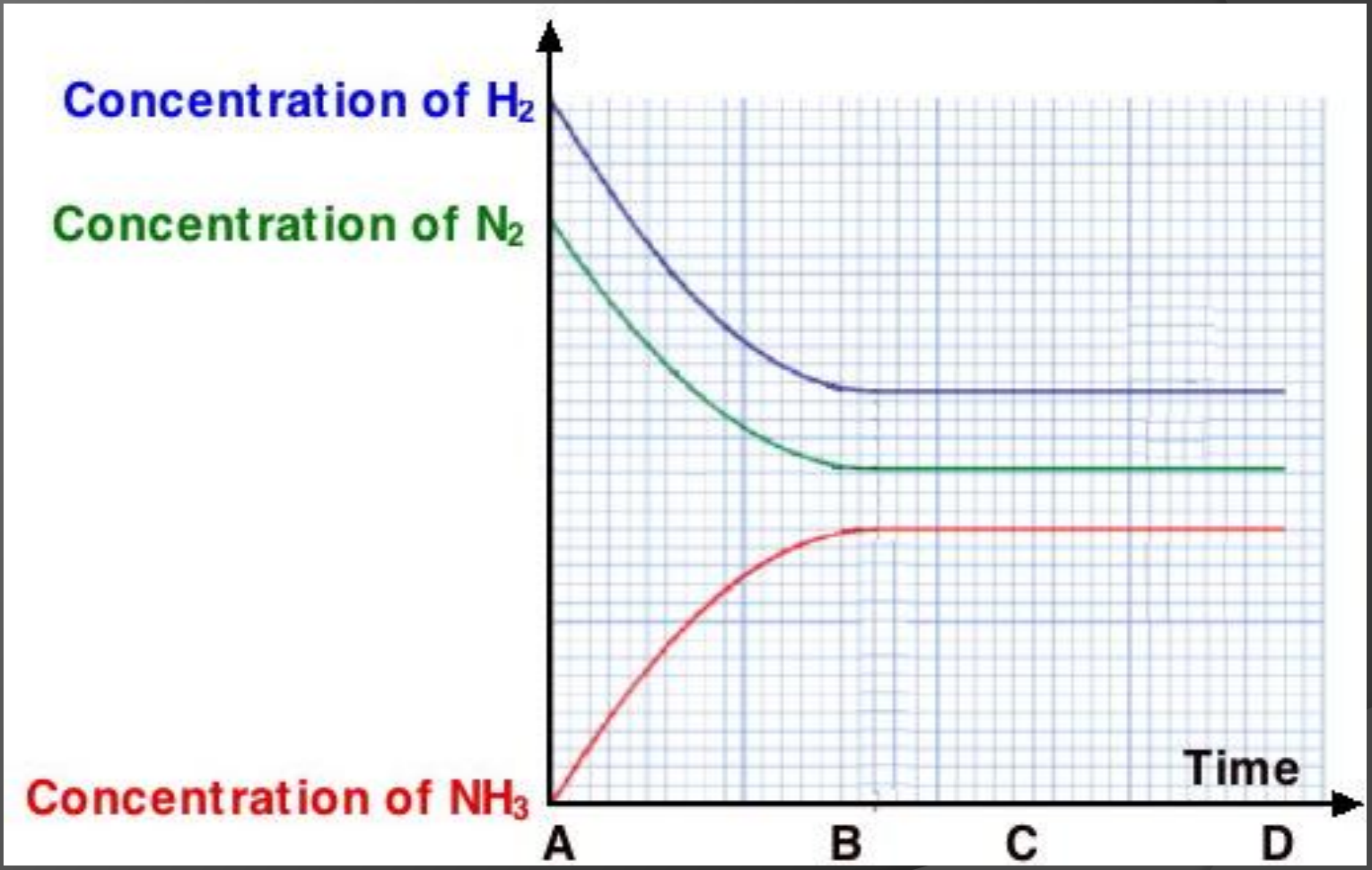
GENERAL CHEMISTRY STANDARD 11.1

11.1: Calculate the equilibrium constant for a reversible chemical reaction

DEFINITIONS

- **Forward Reaction:** The chemical reaction read from left to right
- **Reverse Reaction:** The chemical reaction read from right to left
- **Chemical Equilibrium:** The time when the rate of the forward reaction is equal to the rate of the reverse reaction
    - Amount of reactants and products are constant at equilibrium, but dynamically changing
- **Product-Favored Reaction:** Reactions in which reactants are completely or largely converted to products when equilibrium is reached
- **Reactant-Favored Reaction:** Reactions in which products are completely or largely converted to products when equilibrium is reached
- **Equilibrium Constant Expression:** The ratio of products to reactants with each raised to the power of their stoichiometric coefficient
    - Also known as a **Mass Action Expression**
- **Equilibrium Constant:** The constant, unitless numerical value that is equal to an equilibrium constant expression for a given chemical reaction and temperature

CHEMICAL EQUILIBRIUM



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EQUILIBRIUM CONSTANT EXPRESSION

- Also known as a **Mass Action Expression**

$$aA + bB \leftrightarrow cC + dD$$

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

K_{eq} = Equilibrium Constant [ ] Brackets Mean Concentration/Pressure

Constant for a given chemical reaction and given temperature

Only include chemicals in the aqueous or gaseous phase

Chemicals that are pure liquids or solids do not affect equilibrium

EXAMPLES

- Write the mass action expression for the following chemical reactions at equilibrium:

$$Mg\ (s) + 2\ Ag^{+}\ (aq) \leftrightarrow Mg^{2+}\ (aq) + 2\ Ag\ (s)$$

$$K_{eq} = \frac{[Mg^{2+}]}{[Ag^{+}]^2}$$

$$O_2\ (g) + NO_2\ (g) \leftrightarrow O_3\ (g) + NO\ (g)$$

$$K_{eq} = \frac{[O_3]\ [NO]}{[NO_2]\ [O_2]}$$

TRY IT YOURSELF

- Write the mass action expression for the following chemical reactions at equilibrium:

$$4\ HCl\ (g) + O_2\ (g) \leftrightarrow 2\ H_2O\ (l) + 2\ Cl_2\ (g)$$

$$Sb_2S_3\ (s) + 3\ H_2\ (g) \leftrightarrow 2\ Sb\ (s) + 3\ H_2S\ (g)$$

TRY IT YOURSELF SOLUTIONS

- Write the mass action expression for the following chemical reactions at equilibrium:

$$4\ HCl\ (g) + O_2\ (g) \leftrightarrow 2\ H_2O\ (l) + 2\ Cl_2\ (g)$$

$$K_{eq} = \frac{[Cl_2]^2}{[HCl]^4\,[O_2]}$$

$$Sb_2S_3\ (s) + 3\ H_2\ (g) \leftrightarrow 2\ Sb\ (s) + 3\ H_2S\ (g)$$

$$K_{eq} = \frac{[H_2S]^2}{[H_2]^2}$$

MORE TRY IT YOURSELF

- Calculate the equilibrium constant at 25°C when given the following equilibrium concentrations:

H_2 (g) + Cl_2 (g) ←→ 2 HCl (g)
At equilibrium, [H_2] = 0.42 M, [Cl_2] = 0.075 M, [HCl] = 0.95 M

2 NO (g) + Br_2 (g) ←→ 2 NOBr (g)
At equilibrium, [NO] = 0.50 M, [Br_2] = 0.25 M, and [NOBr] = 3.5 M

MORE TRY IT YOURSELF SOLUTIONS

- Calculate the equilibrium constant at 25°C when given the following equilibrium concentrations:

H_2 (g) + Cl_2 (g) ←→ 2 HCl (g)
At equilibrium, [H_2] = 0.42 M, [Cl_2] = 0.075 M, [HCl] = 0.95 M

K_{eq} = 29

2 NO (g) + Br_2 (g) ←→ 2 NOBr (g)
At equilibrium, [NO] = 0.50 M, [Br_2] = 0.25 M, and [NOBr] = 3.5 M

K_{eq} = 200