

Dynamic Equilibrium

Systems in Equilibrium:

- * In constant motion (Dynamic)
- * Reversible
- * Constant (Forward and reverse reactions occur at equal rates)
- * ALWAYS in a closed system, which means that matter cannot enter or leave the system

Types of Equilibria

- * There are several types of equilibria:
 - * Solubility Equilibria
 - * Phase Equilibria
 - * Chemical Reaction Equilibria

Solubility Equilibrium

- * Reached when the concentration of the dissolved solute is constant
- * must contain both dissolved and undissolved solute at the same time
- * rate of dissolving = rate of crystallization
- * $\text{CaSO}_4(\text{s}) \rightleftharpoons \text{Ca}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq})$

Phase Equilibrium

- * Evaporation/condensation equilibrium
 - * at equilibrium, the pressure of gas remains constant
- * Solid/liquid equilibrium
 - * established at the melting/freezing point
 - * $\text{H}_2\text{O}_{(s)} \rightleftharpoons \text{H}_2\text{O}_{(l)}$

Chemical Reaction Equilibrium

- * **Quantitative reactions: when a chemical reaction proceeds to completion (in an open system)**
- * **an equilibrium can be reach in a closed system**



Example



Reversible Reactions

- * an equilibrium will have the same composition whether approached from reactants or pure products

Law of Chemical Equilibrium

- * **Law of Chemical Equilibrium:** In a chemical system, there is a constant ratio between concentrations of products and reactants.

Equilibrium Constant

- * Equilibrium Constant (K_{eq}): is the ratio of equilibrium concentrations for a particular chemical system at a particular temperature

For the reaction $aA + bB \rightleftharpoons cC + dD$

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

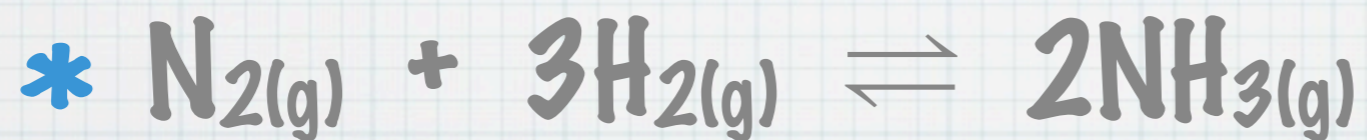
Where $[A]$, $[B]$, $[C]$, and $[D]$ represent the relative concentrations of products and reactants and the exponents a , b , c , d represent the stoichiometric coefficients

K_{eq}

- * The numerical value of K_{eq} tells you the relative concentrations of products and reactants, and what is being favored.
- * If $K_{eq} > 1$, products are favored
- * If $K_{eq} < 1$, reactants are favored
- * If $K_{eq} = 1$, products and reactants equally favored

Example

* Write the equilibrium law expression for the following reaction.



Example



$$K_{\text{eq}} = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3}$$

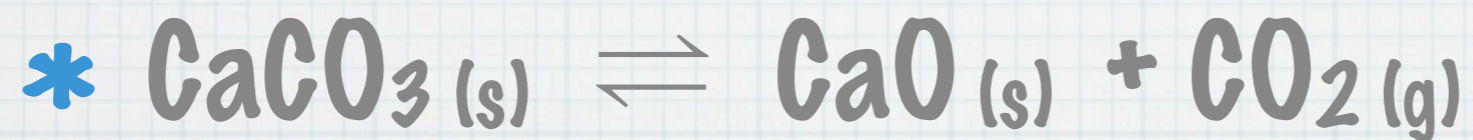
- * Homogeneous equilibria: all the reactants and products are in the same phase.**
- * Heterogeneous equilibria: more than one phase exists in a reaction mixture**

Rules for Writing K_{eq}

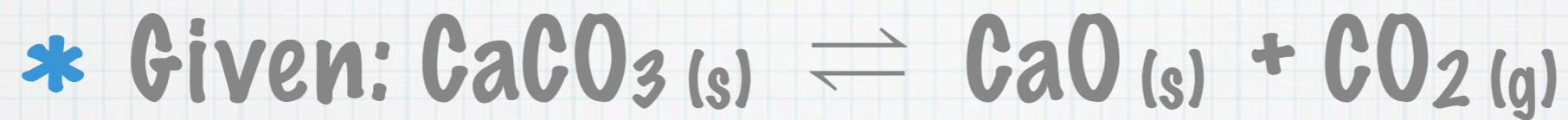
- * Solids **NEVER** appear in equilibrium expressions.
- * Liquids and solvents **NEVER** appear in equilibrium expressions.
- * The concentration of a pure liquid or solid is unchangeable. Therefore they are **CONSTANT**.

Example

* Write the equilibrium law expression for the following reaction.

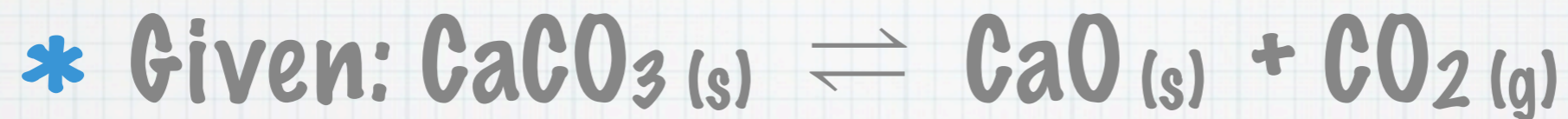


Example



$$K = \frac{[\text{CaO}][\text{CO}_2]}{[\text{CaCO}_3]}$$

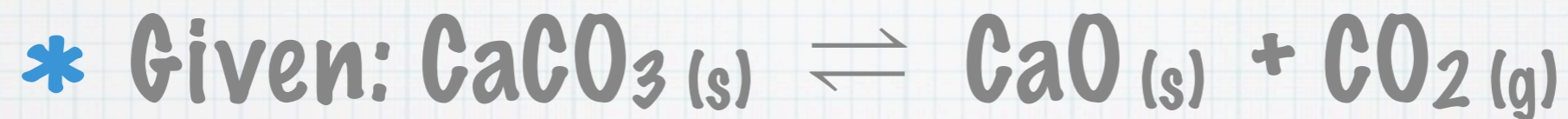
Example



$$K = \frac{[\text{CaO}][\text{CO}_2]}{[\text{CaCO}_3]}$$

$$K_{eq} = \frac{\cancel{[\text{CaO}][\text{CO}_2]}}{\cancel{[\text{CaCO}_3]}}$$

Example



$$K = \frac{[\text{CaO}][\text{CO}_2]}{[\text{CaCO}_3]}$$

$$K_{eq} = \frac{\cancel{[\text{CaO}][\text{CO}_2]}}{\cancel{[\text{CaCO}_3]}}$$

$$K_{eq} = [\text{CO}_2]$$

Homework

* pg 430 #1 1-16