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
* $CaSO_{4(s)} \rightleftharpoons Ca^{2+}_{(aq)} + SO_4^{2-}{}_{(aq)}$

Phase Equilibrium

* Evaporation/condensation equilibrium
  * at equilibrium, the pressure of gas remains constant
* Solid/liquid equilibrium
  * established at the melting/freezing point
  * $H_2O_{(s)} \rightleftharpoons H_2O_{(l)}$

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

$$N_2O_{4(g)} + \text{heat} \rightleftharpoons 2NO_{2(g)}$$

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.
  * $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

Example

* Given: $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$

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

* 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.
  * $CaCO_{3\,(s)} \rightleftharpoons CaO_{(s)} + CO_{2\,(g)}$

Example

* Given: $CaCO_{3\,(s)} \rightleftharpoons CaO_{(s)} + CO_{2\,(g)}$

$$K = \frac{[CaO][CO_2]}{[CaCO_3]}$$

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$$K_{eq} = \frac{[CaO][CO_2]}{[CaCO_3]}$$

Example

* Given: $CaCO_{3\,(s)} \rightleftharpoons CaO_{(s)} + CO_{2\,(g)}$

$$K = \frac{[CaO][CO_2]}{[CaCO_3]}$$

$$K_{eq} = \frac{[CaO][CO_2]}{[CaCO_3]}$$

$$K_{eq} = [CO_2]$$

Homework

* pg 430 #11-16