General concepts

Balanced chemical reactions are the math of chemistry

- They show the relationship between the reactants and the products

How will chemical reactions proceed?

- Thermodynamics allows us to calculate the feasibility of reactions and to understand when/how equilibrium is established

Equilibrium

- Allows us to understand chemical processes such as ionic speciation, oxidation state distributions gas solubility, the carbonate system

Net ionic equations

An example:

If a solution of lead nitrate is added to a solution of sodium chloride, lead chloride precipitates:

- $Pb(NO_3)_2(aq) + 2\ NaCl(aq) \rightarrow PbCl_2(s) + 2\ NaNO_3(aq)$

(This is a conventional equation)

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To better describe the reaction, the formulas of the dissolved substances are replaced with the actual species in solution:

- $Pb^{2+}(aq) + 2\ NO_3^-(aq) + 2\ Na^+(aq) + 2\ Cl^-(aq) \rightarrow$
- $PbCl_2(s) + 2\ Na^+(aq) + 2\ NO_3^-(aq)$

(This is an *ionic equation*)

We can then eliminate the "spectators".

Net ionic equations

The result is a *net ionic equation*, which tells exactly what chemical change took place, and nothing else:

- $Pb^{2+}(aq) + 2\ Cl^{-}(aq) \rightarrow PbCl_2(s)$

Conventional equation for reference:

- $Pb(NO_3)_2(aq) + 2\ NaCl(aq) \rightarrow PbCl_2(s) + 2\ NaNO_3(aq)$

Net ionic equations

Steps in writing a net ionic equation:

- Write the conventional equation, including designations of state [(g), (l), (s), (aq)]. Balance the equation.
- Write the ionic equation by replacing each *dissolved substance* (aq) with the species in solution. Never change states in this step. Be sure the equation is balanced for both atoms and charge.
- Write the net ionic equation by removing the spectators. Reduce coefficients to lowest terms. Be sure the equation is balanced for both atoms and charge.

How do we know if a reaction will proceed?

Chemical equilibrium:

- Is a geochemical system at chemical equilibrium?
- If not, what reactions are most likely to occur?

- Solubility -
- Redox -
- Complexation -
- Carbonate system -

How do we know if a reaction will proceed?

Chemical equilibrium:

- Is a geochemical system at chemical equilibrium?
- If not, what reactions are most likely to occur?

- Solubility - diatoms in surface seawater
- Redox - organic matter oxidation
- Complexation - iron speciation & plankton growth
- Carbonate system - $CaCO_3$ stability in marine sediments

Chemical Equilibrium

Consider a reversible reaction taking place at constant temperature:

$$aA + bB \rightleftharpoons cC + dD$$

The *reactants* A and B combine to form *products* C and D.

Chemical Equilibrium

Consider a reversible reaction taking place at constant temperature:

$$aA + bB \rightleftarrows$$

The *reactants* A and B combine to form

The concentrations of A and B decrease
change with time:

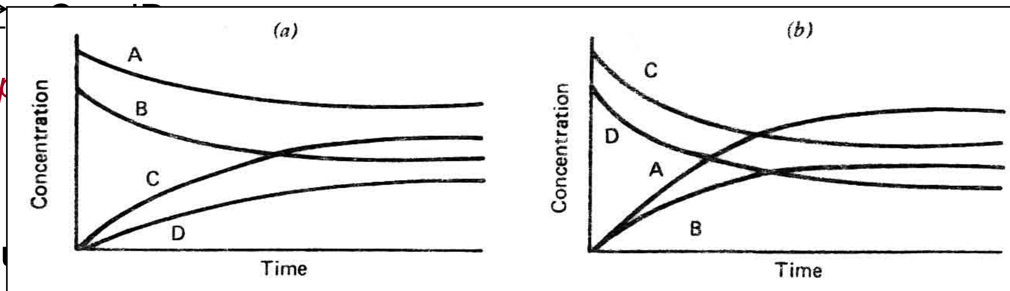
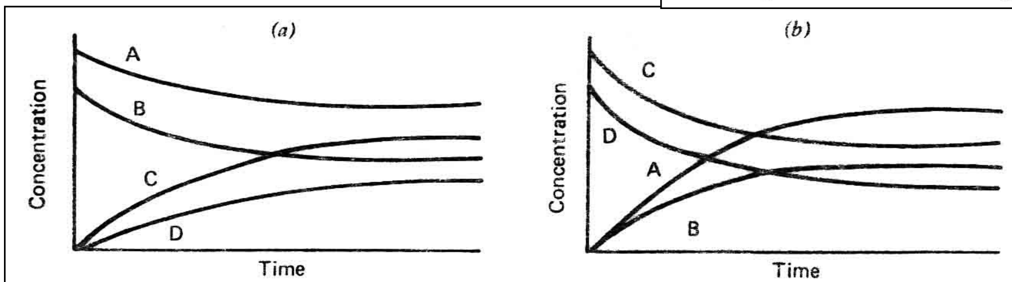


Fig. 3-1. Course of reaction between A, B, C, and D. (a) Initially only A and B are present; (b) initially only C and D are present.



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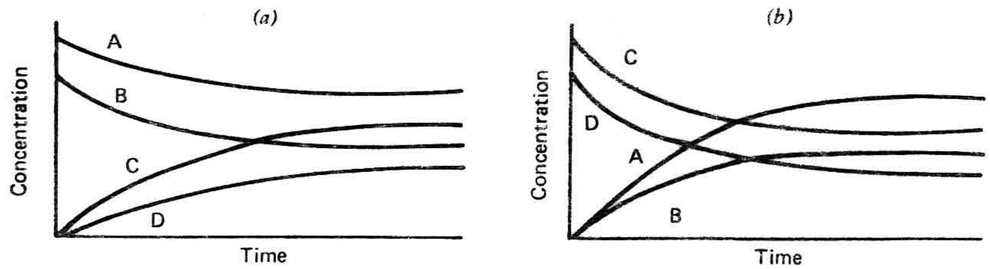
Chemical Equilibrium



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$$K \equiv \frac{\{C\}^c \{D\}^d}{\{A\}^a \{B\}^b}$$

- The time-invariant concentrations of reactants and products are called *equilibrium concentrations*.
- The ratio of these concentrations (or *activities* – active concentrations) is characteristic for each reaction, and is called the *equilibrium constant, K*:
  - Note that at equilibrium, the forward and reverse reactions proceed at the same, stable rate.

- Other than adding reactants and waiting until concentrations no longer change, how do we know what the equilibrium is?