1

To review before we begin

-Chemical equations and stoichiometry (Chapter 4-5)

- Reactions in aqueous solutions

Electrolites → ions

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2

Chemical Equations

Depict the kind of reactants and products and their relative amounts in a reaction.

physical state

$4\,Al(s) + 3\,O_2(g) \longrightarrow 2\,Al_2O_3(s)$

The numbers in the front are called stoichiometric coefficients

The letters (s), (g), and (l) are the physical states of compounds.

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3

Chemical Equations

- Because the same atoms are present in a reaction at the beginning and at the end, the amount of matter in a system does not change.
- The Law of the Conservation of Matter

$2\,HgO(s) \longrightarrow 2\,Hg(liq) + O_2(g)$

2 2 2 2

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4

Chemical Equations

Because of the principle of the conservation of matter,

an equation must be balanced.

It must have the same number of atoms of the same kind on both sides.

Lavoisier, 1788

Book (just for fun)
Lavoisier in The Year One
by Madison Smart Bell

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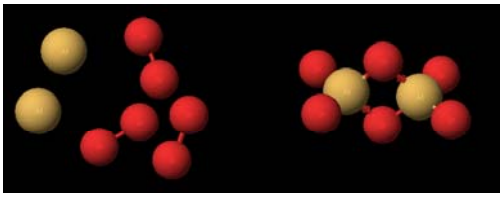
Balancing Equations

$2\,Al(s) + 3\,Br_2(liq) \longrightarrow 1\,Al_2Br_6(s)$



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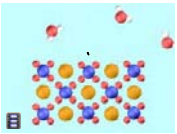
6

Reactions in Aqueous Solution

Many reactions involve ionic compounds, especially reactions in water — aqueous solutions.

$KMnO_4$ in water → $K^+(aq) + MnO_4^-(aq)$



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Aqueous Solutions

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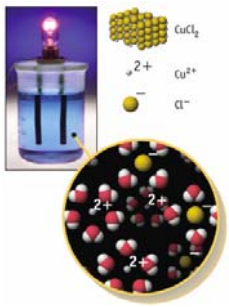
How do we know ions are present in aqueous solutions?

The solutions **conduct electricity!**

They are called **ELECTROLYTES**

HCl, $CuCl_2$, and NaCl are strong electrolytes. They dissociate completely (or nearly so) into ions.



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Aqueous Solutions

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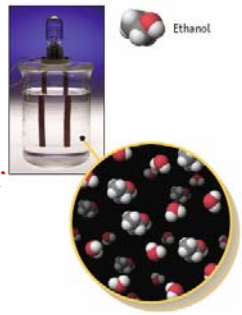
Some compounds dissolve in water but do not conduct electricity. They are called **nonelectrolytes.**

Examples include:
- sugar
- ethanol
- ethylene glycol



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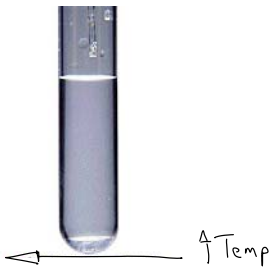
Overview of Chapter 16

Chemical Equilibria

- Chemical reactions are reversible
- Equilibrium is achieved eventually in a closed system
- Outside forces can affect equilibrium
  - Temperature effects
  - Pressure effects

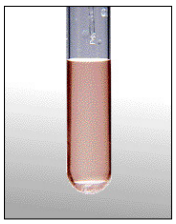
CHEMICAL EQUILIBRIUM
Chapter 16



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

Properties of an Equilibrium

Equilibrium systems are
- DYNAMIC (in constant motion)
- REVERSIBLE
- can be approached from either direction



↑Temp Pink to blue
$Co(H_2O)_6Cl_2$ ---> $Co(H_2O)_4Cl_2 + 2\ H_2O$

↓Temp Blue to pink
$Co(H_2O)_4Cl_2 + 2\ H_2O$ ---> $Co(H_2O)_6Cl_2$

Chemical Equilibrium
$Fe^{3+} + SCN^- \leftrightharpoons FeSCN^{2+}$

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Not all Fe^{3+} and SCN^- react. At the equilibrium, there are still some free Fe^{3+} and SCN^-

- After a period of time, the concentrations of reactants and products are constant.
- The forward and reverse reactions continue after equilibrium is attained.

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Equilibrium

When a reaction is at equilibrium, the rate of the forward reaction equals the rate of the reverse reaction. There is no net observed change in the system

THE EQUILIBRIUM CONSTANT

For any type of chemical equilibrium of the type

$$a\,A + b\,B \leftrightarrows c\,C + d\,D$$

the following is a CONSTANT (at a given T)

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

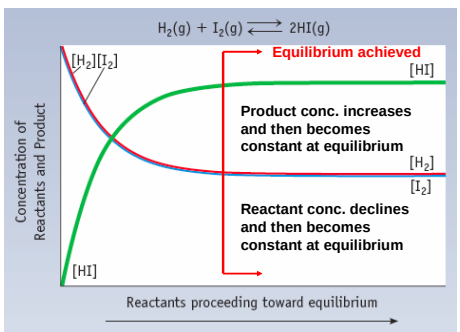
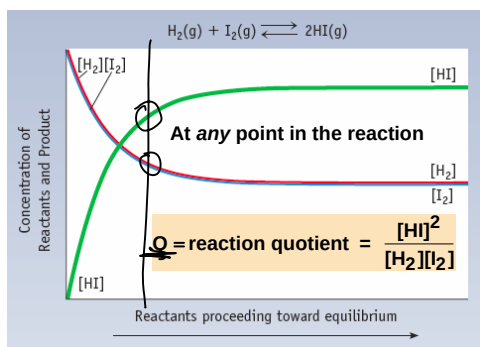
conc. of products

conc. of reactants

equilibrium constant

If K is known, then we can predict concs. of products or reactants.

Reaction Quotient & Equilibrium Constant



Reaction Quotient & Equilibrium Constant