

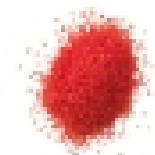
Chapter 4: Types of Chemical Reactions and Solution Stoichiometry

- 4.1 Water, the Common Solvent
- 4.2 The Nature of Aqueous Solutions: Strong and Weak Electrolytes
- 4.3 The Composition of Solutions (MOLARITY)
- 4.4 Types of Chemical Reactions
- 4.5 Precipitation Reactions
- 4.6 Describing Reactions in Solution
- 4.7 Selective Precipitation (limited coverage)
- 4.8 Stoichiometry of Precipitation Reactions
- 4.9 Acid-Base Reactions
- 4.10 Oxidation-Reduction Reactions
- 4.11 Balancing Oxidation-Reduction Equations
- 4.12 Single Oxidation-Reduction Titrations

Definitions – Solute, Solvents and Solutions

> Solute

- Substance being dissolved, mixed, diluted.
- Example: sugar



> Solvent

- Substance doing the dissolving, mixing, diluting.
- Example: water



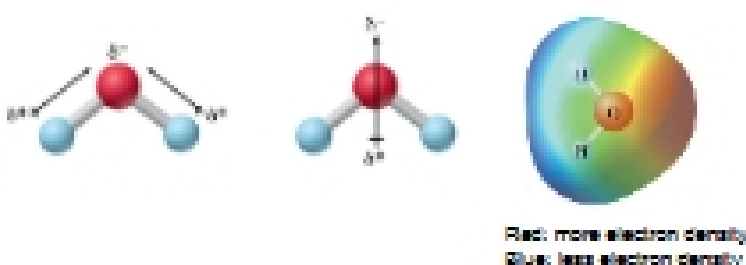
> Solution

- Final combination of dissolution, mixing, and dilution.
- Example: Kool-Aid



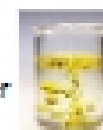
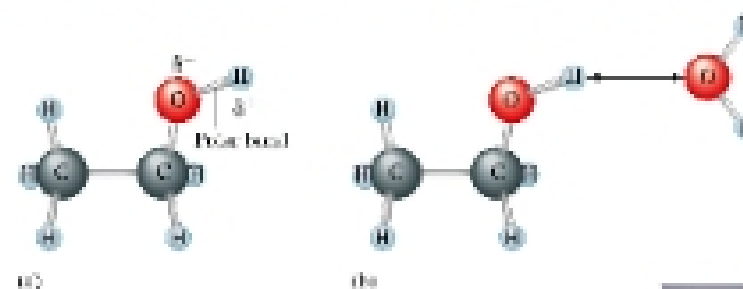
Water as a Solvent

- Water is an important solvent – dissolves many substances
- "Aqueous" means a solution in which water is the solvent
- Water is a POLAR molecule



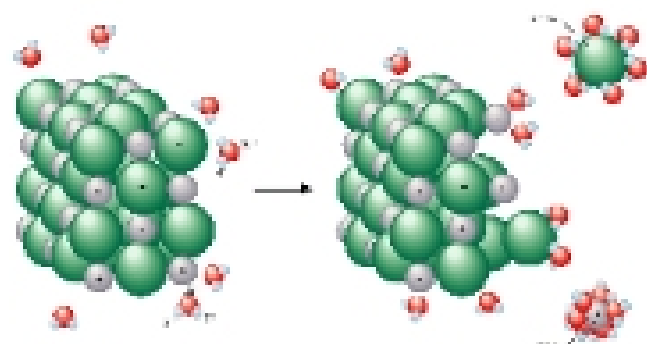
Polar and Nonpolar Solutes

- Water dissolves some non-ionic substances if they are polar (ethanol-water)
- Ethanol molecules are polar (contain directional O-H bond)



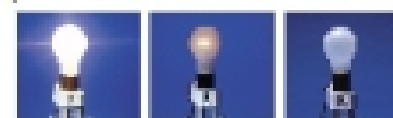
Ionic Solutes

- Polar water molecules dissolve ionic compounds (salts)
- "Hydration" breaks ionic compounds into anions and cations
- Water dissolves different ionic compounds to different degrees (more in Ch. 8)



The Role of Water as a Solvent: Dissolution of Ionic Compounds

Electrical conductivity: the flow of electricity in a solution indicates the presence of ions in solution.



Electrolyte: a substance that conducts a current when dissolved in water.

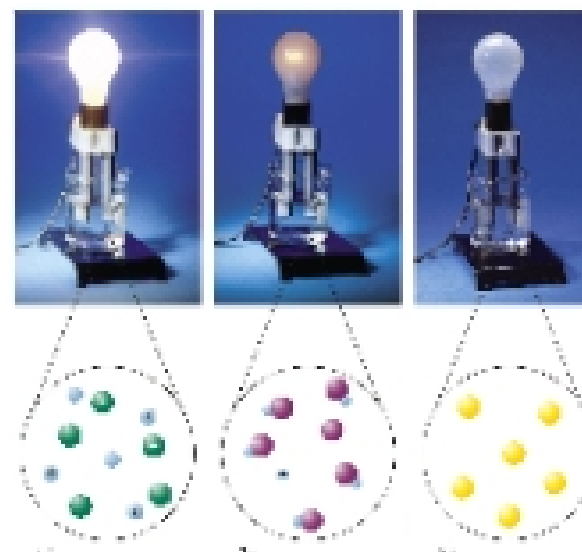


- Ions become solvated/hydrated – they are surrounded by water molecules.
- These ions are labeled "aqueous" – they are free to move throughout the solution and conduct electricity.

Electrolytes and Non-Electrolytes

Electrolytes and electrical conductivity

- If a solution conducts electricity, it contains ions
- A solution that contains many ions is a **strong electrolyte**.
- A solution that contains only a few ions is a **weak electrolyte**.
- A solution that contains no ions is a **nonelectrolyte**.



Strong Electrolytes

strong electrolytes: substances that are good conductors of electricity

- These substances break up to produce many ions in water
 - many ions present to move electrons/conduct electricity → **strong electrolyte**

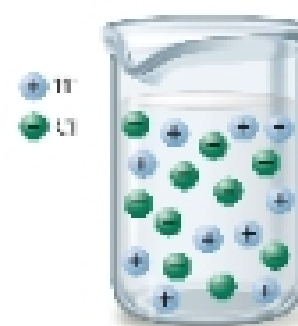
For example,



Examples: strong acids, strong bases, all soluble ionic compounds

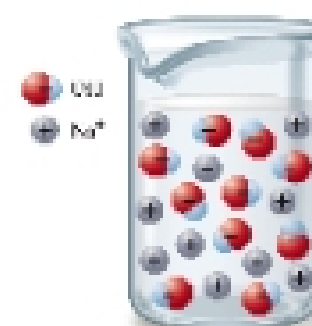
HCl (aq) is completely ionized.

Strong acids fully dissociate, forming the anion and a hydrated proton.



NaOH (aq) is completely ionized.

Strong bases fully dissociate, forming a cation and the hydroxide anion.



Weak Electrolytes

weak electrolytes: substances that are weak/good conductors of electricity

- These substances mostly remain intact as compounds, producing very few ions in water
 - only a few ions present to move electrons/conduct electricity → **weak electrolyte**

For example,

acetic acid is a typical weak acid:



ammonia is a common weak base:

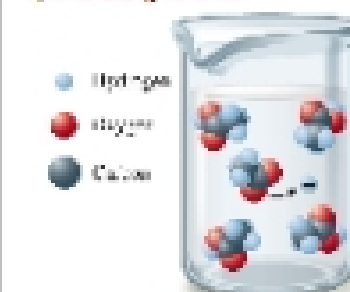


Both of these species are ionized only ~1%

Examples: weak acids, weak bases, insoluble ionic compounds

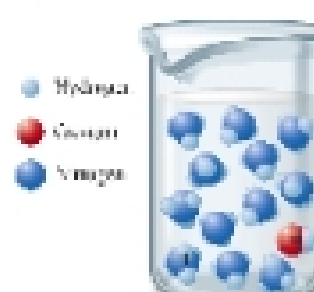
Acetic acid (HC₂H₃O₂) exists in water mostly as undissociated molecules.

Weak acids partially dissociate, forming only a small number of anions and hydrated protons.



The reaction of NH₃ in water.

Weak bases partially dissociate (or react with water to a limited extent), forming only a small number of cations and hydroxide anions.



Non-electrolytes

nonelectrolytes: substances that cannot conduct electricity

- These molecules never break down into ions.
- They always remain intact as neutral molecules that have no charge → no ions to move electrons/conduct electricity

For example,



Examples: sugar (e.g. sucrose), ethanol (C_2H_5OH), and all other molecules that are not acids

Dissolving compounds in water

- When an ionic compound is dissolved in water:
 - Ions are "hydrated"
 - Separated from their solid crystal
 - Become individual ions in solution



Determining Moles of Ions in Aqueous Solutions of Ionic Compounds

How many moles of each ion are formed when the following compounds are dissolved in water:

- 4.0 moles of sodium carbonate
- 46.5 g of rubidium fluoride
- 9.32×10^{21} formula units of iron(III) chloride

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$$\begin{aligned} \text{moles of } Na^+ &= 4.0 \text{ moles } Na_2CO_3 \times \frac{2 \text{ mol } Na^+}{1 \text{ mol } Na_2CO_3} \\ &= 8.0 \text{ moles } Na^+ \text{ AND } 4.0 \text{ moles of } CO_3^{2-} \end{aligned}$$

Determining Moles of Ions in Aqueous Solutions of Ionic Compounds



$$\text{moles of } RbF = 46.5 \text{ g } RbF \times \frac{1 \text{ mol } RbF}{104.47 \text{ g } RbF} = 0.445 \text{ moles } RbF$$

thus, 0.445 mol Rb^+ and 0.445 mol F^-

Determining Moles of Ions in Aqueous Solutions of Ionic Compounds



$$\begin{aligned} \text{moles of } FeCl_3 &= \\ 9.32 \times 10^{21} \text{ formula units} &\times \frac{1 \text{ mol } FeCl_3}{6.022 \times 10^{23} \text{ formula units } FeCl_3} \\ &= 0.0155 \text{ mol } FeCl_3 \\ &= 0.0155 \text{ mol } Fe^{3+} \end{aligned}$$

$$\text{moles of } Cl^- = 0.0155 \text{ mol } FeCl_3 \times \frac{3 \text{ mol } Cl^-}{1 \text{ mol } FeCl_3} = 0.0465 \text{ mol } Cl^-$$