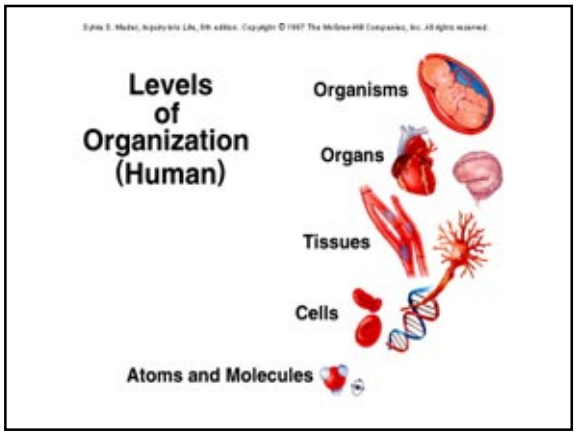
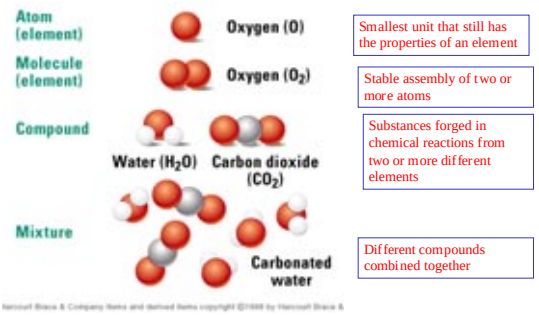
Chemical Foundations of Life



Atom, element, compound, and Mixture



Atomic Structure

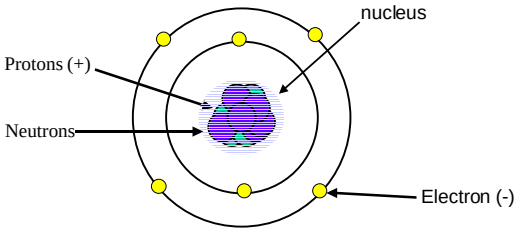
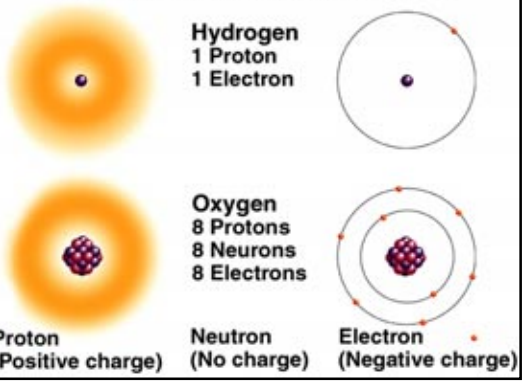
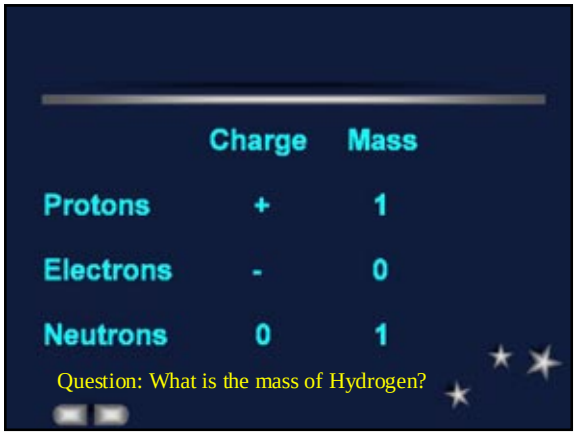
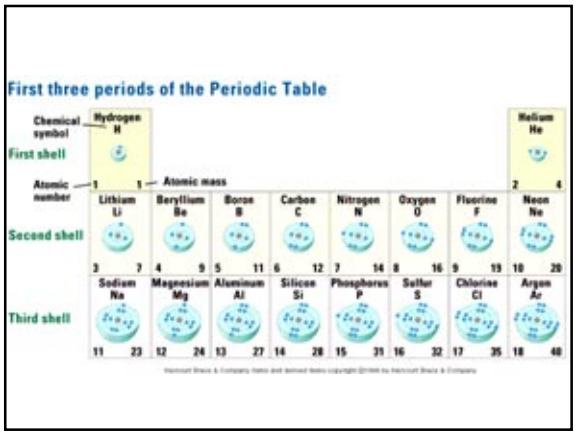


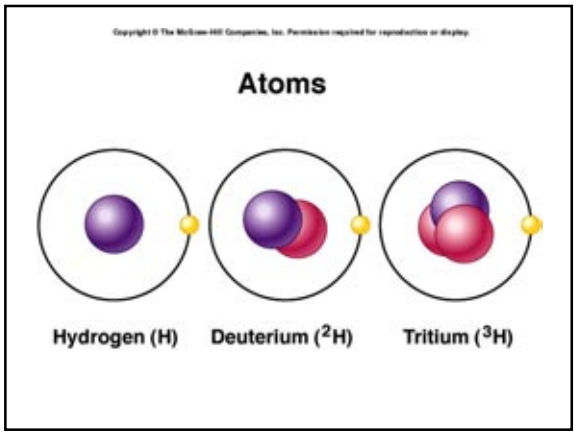
Fig. 2.2

Basic Structure of Atoms









Properties of an atom

Number of proton +neutrons

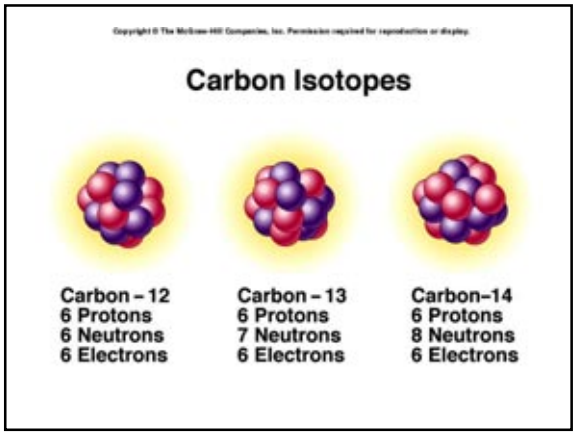
mass number
atomic number **Element**

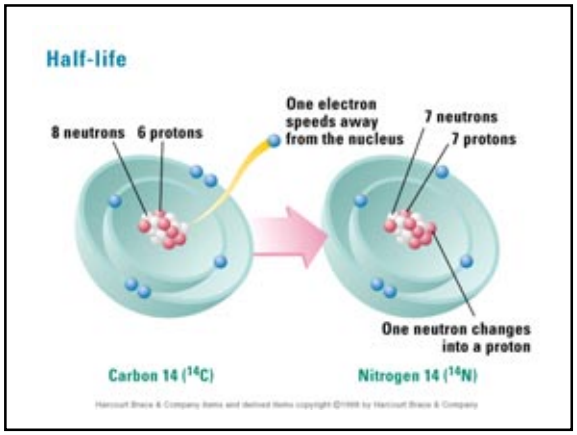
Number of protons

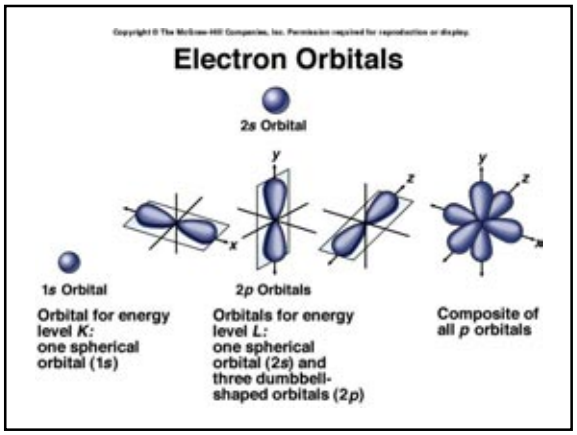
$^{12}_{6}C$ Carbon

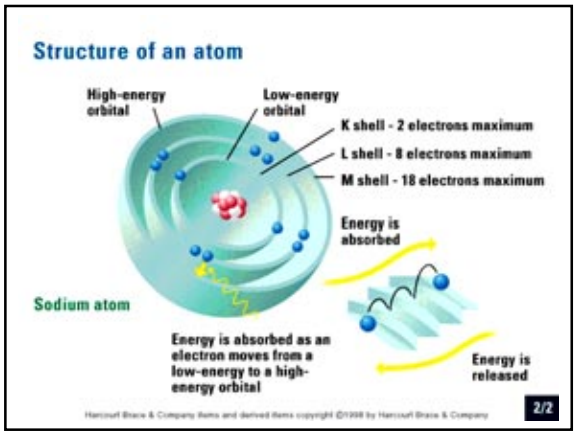
Isotopes

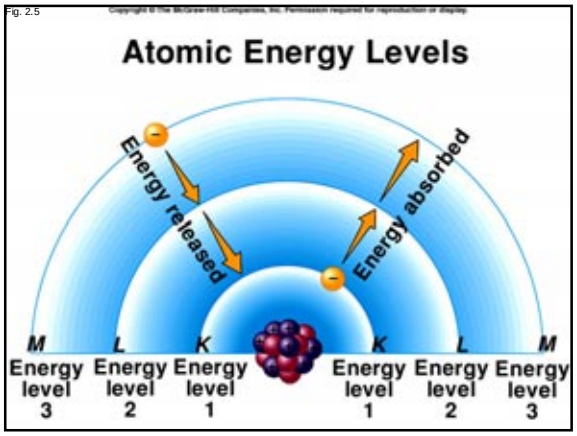
- Atoms that have the same number of protons but a different number of neutrons.
- All of these are isotopes of the element carbon. $^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

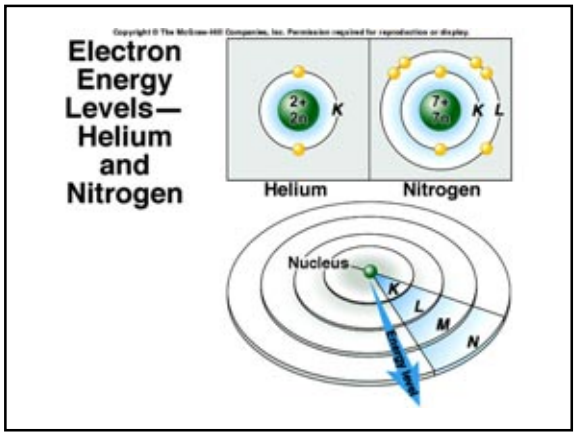










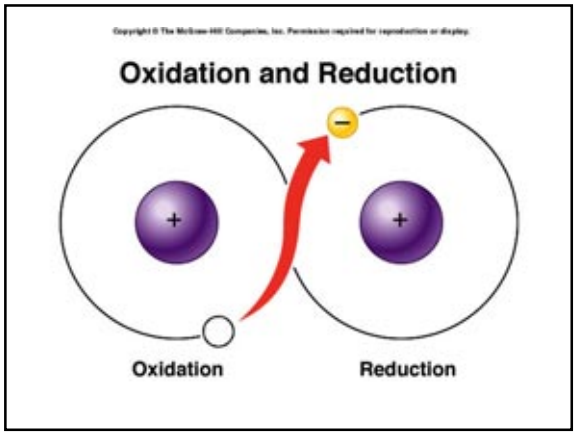


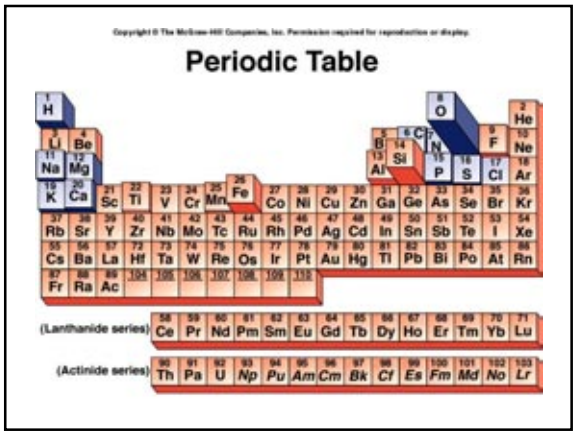
Molecular weight

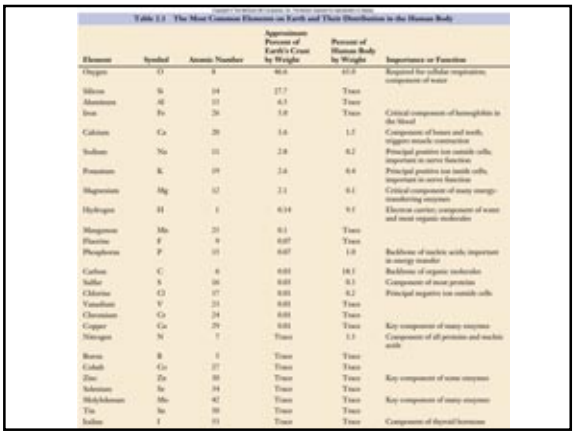
- The molecular weight of a substance the sum of the atomic mass units of atoms in the molecule.
- *Water (H_2O) has two molecules of hydrogen (amu = 1) and one atom of oxygen (amu = 16).*

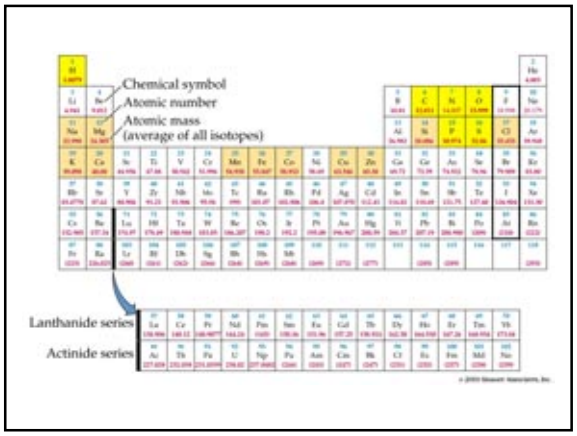
2(1) + 1(16) = 18;

So, 18 is the molecular weight of water









Octet Rule

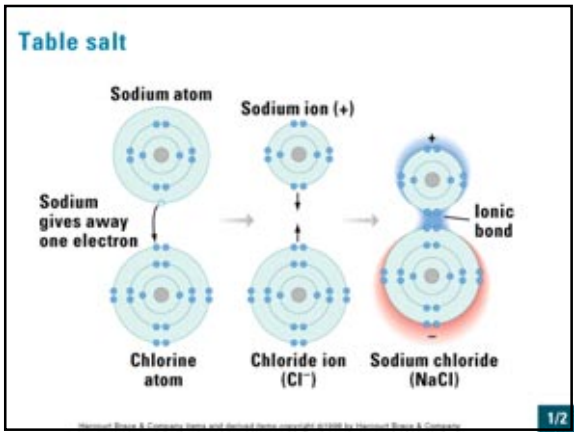
- Atoms need to fill the outer shell with a maximum of 8 electrons to attain and maintain stability.

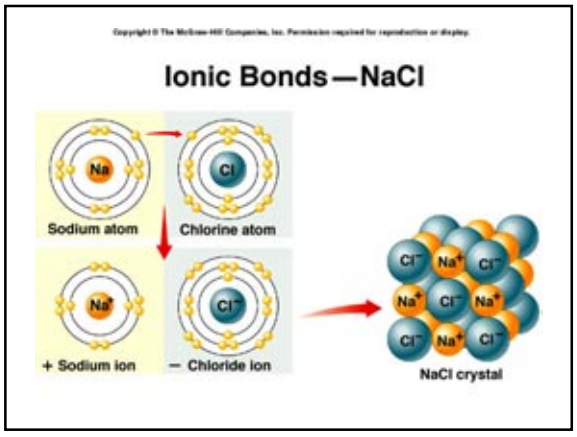
How are molecules held together (Chemical Bonds)?

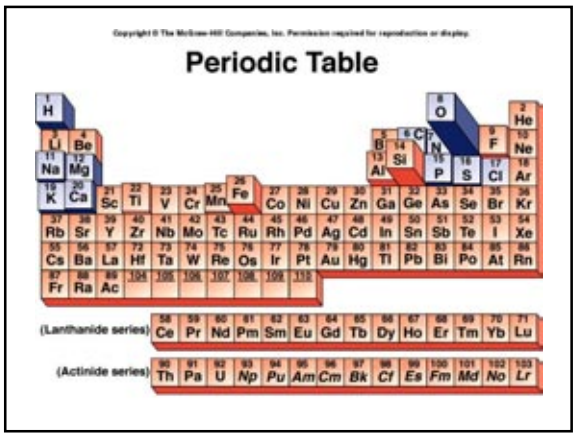
- Atoms try to have full octet of electrons in the outer shell.
  - Strong bonds
    - Covalent bonds
      - Sharing of electrons.
    - Ionic bonds
      - Donating/accepting of electrons between two atoms
  - Weak bonds
    1. Hydrogen bonds - an attraction between molecules due to partial charges
    2. van der Waals - attraction between close molecules - very weak

Ionic Bond

- Formed by the donating and accepting of electrons by two atoms.
- Strong bond.
- Atoms that have nearly full or nearly empty shells tend to form ions.
  - Positively-charged ions are called cations.
  - Negatively-charged ions are called anions.

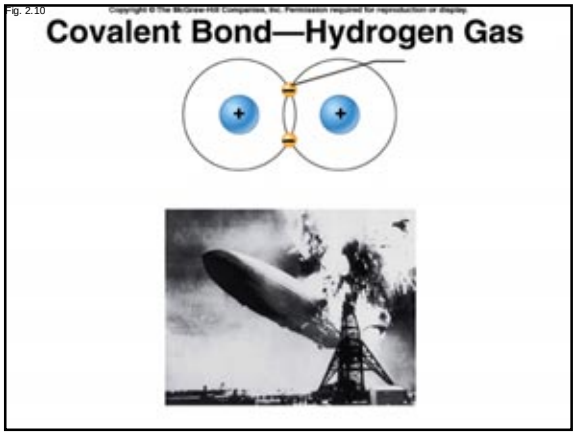


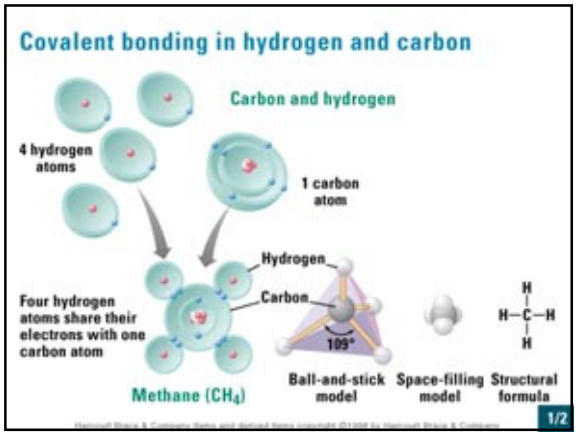


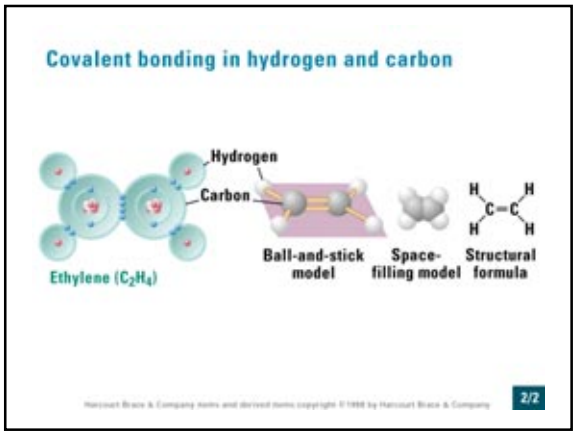


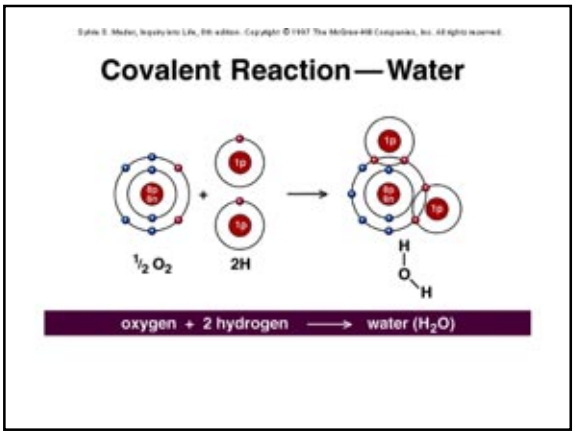
Covalent bonds

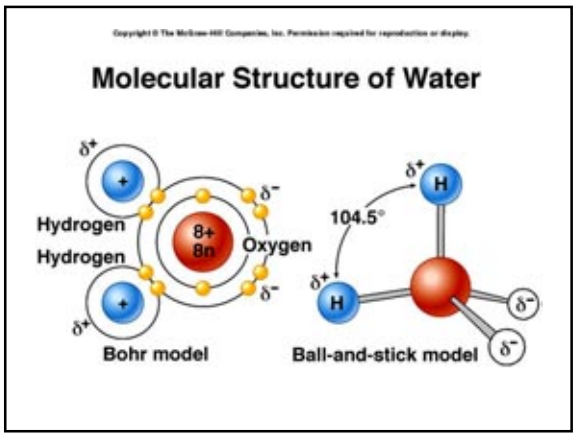
- Formed by the sharing of electrons.
- Two electrons are shared per covalent bond.
- Strong bond..
- SPONCH (sulfur, phosphorus, oxygen, nitrogen, carbon, hydrogen)





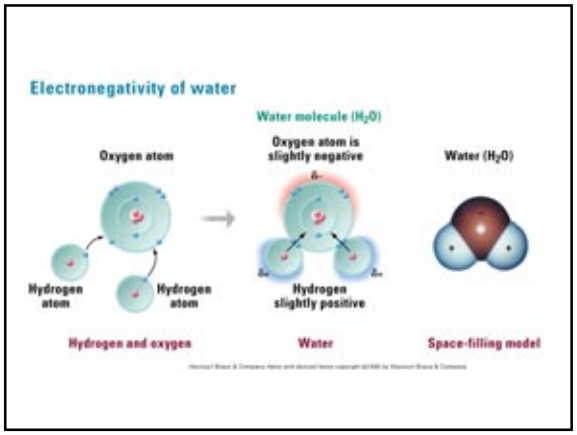






Electronegativity

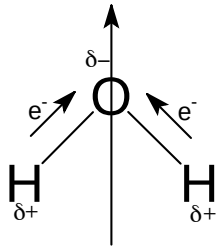
- Tendency to gain electrons
  - Most electronegative
    - Oxygen
    - Chlorine
- Tendency to loose electrons
  - Least electronegative
    - Sodium
    - Potasium
    - lithium



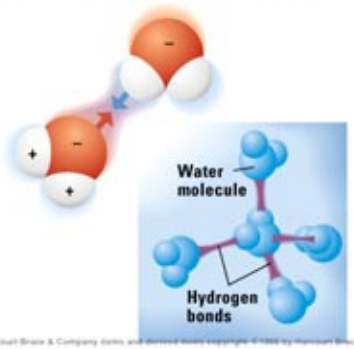
Hydrogen Bond

- Formed by partial positive (δ+) and partial negative (δ-) charges formed by electronegative atoms in two molecules
- Weak bond.

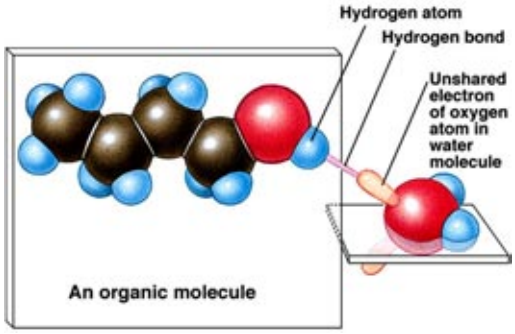
Polarity



Hydrogen bonds between water molecules



Hydrogen Bond Structure



Hydrogen Bonding in Water Molecules

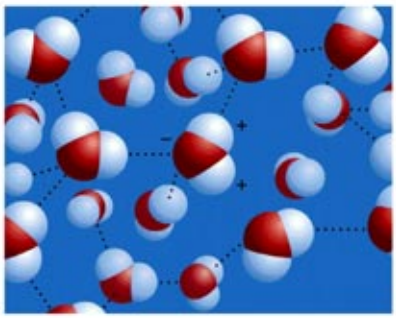


Fig. 2.11

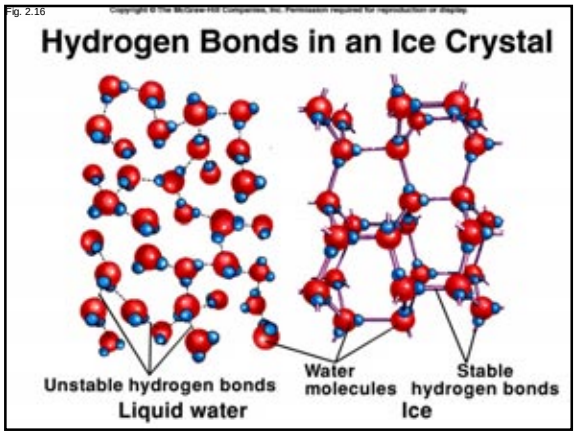
Forms of Water

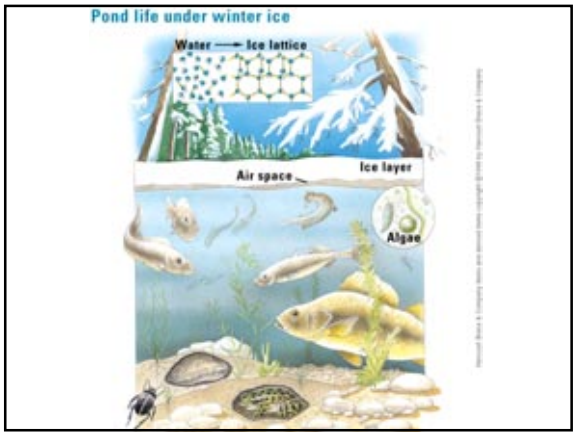
Table 2.2 The Properties of Water

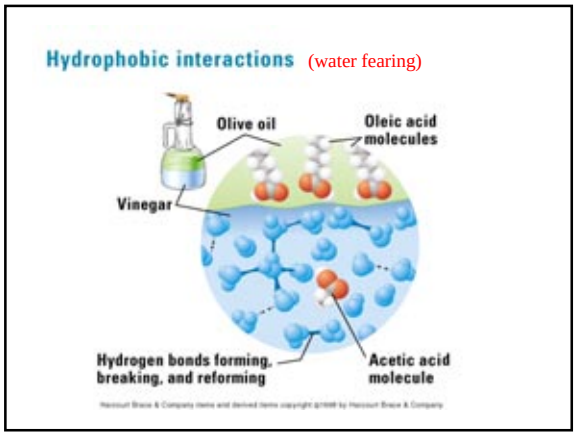
Property	Explanation	Example of Benefit to Life
Cohesion	Hydrogen bonds hold water molecules together	Leaves pull water upward from the roots; seeds swell and germinate
High specific heat	Hydrogen bonds absorb heat when they break, and release heat when they form, minimizing temperature changes	Water stabilizes the temperature of organisms and the environment
High heat of vaporization	Many hydrogen bonds must be broken for water to evaporate	Evaporation of water cools body surfaces
Lower density of ice	Water molecules in an ice crystal are spaced relatively far apart because of hydrogen bonding	Because ice is less dense than water, lakes do not freeze solid
High polarity	Polar water molecules are attracted to ions and polar compounds, making them soluble	Many kinds of molecules can move freely in cells, permitting a diverse array of chemical reactions

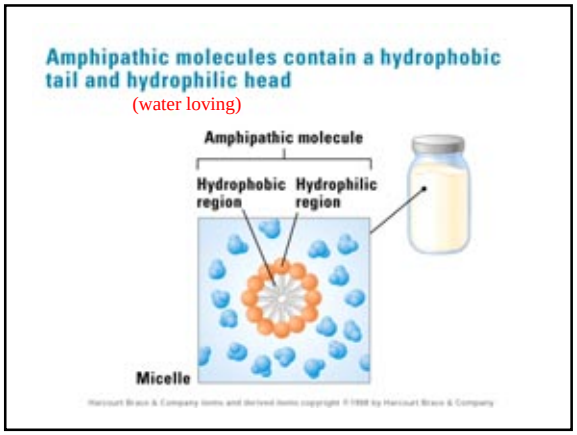
Properties of Water

- Denser as liquid than a solid (ice formation)
- High heat capacity
  - High boiling point
  - Good evaporative coolant
- Surface tension and cohesion
- Adhesion--sticks to everything
  - Capillary action
- Good solvent (polar medium)
  - Solutes (NaCl, sugars, etc.)









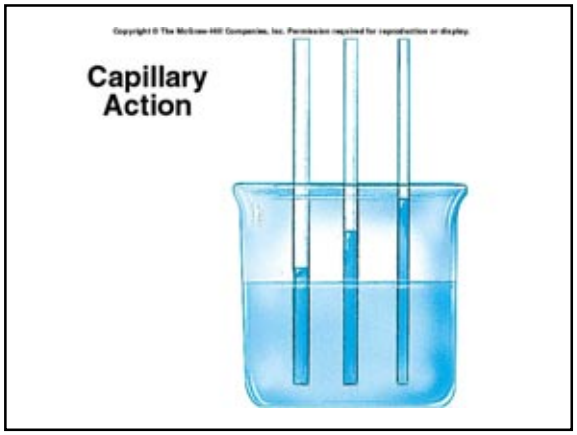


Fig. 2.14

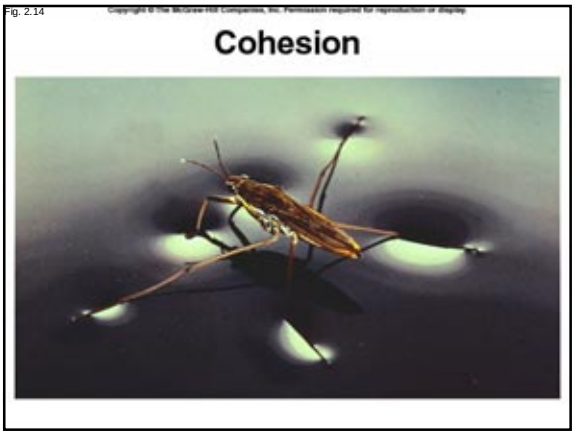
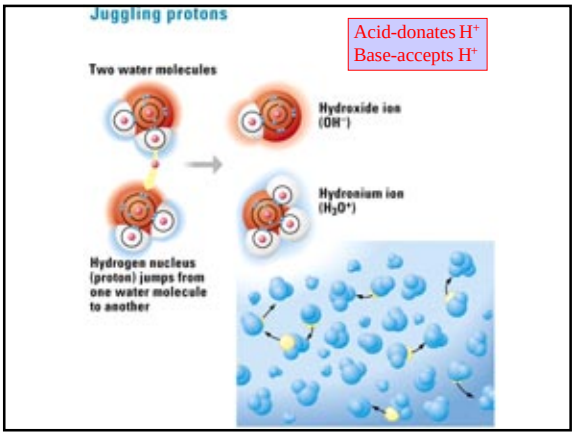


Fig. 2.17



Acid-donates H^+
Base-accepts H^+

pH is a measure of the hydrogen ion concentration

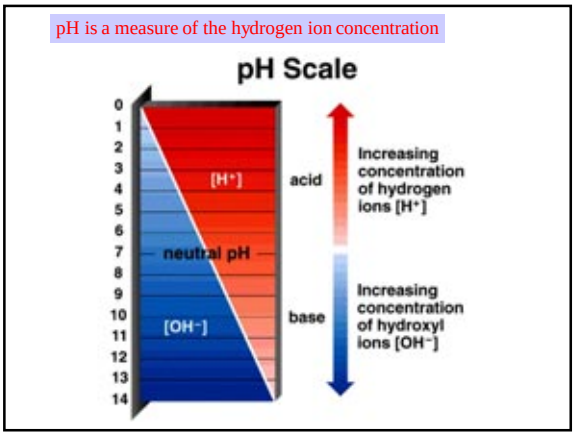
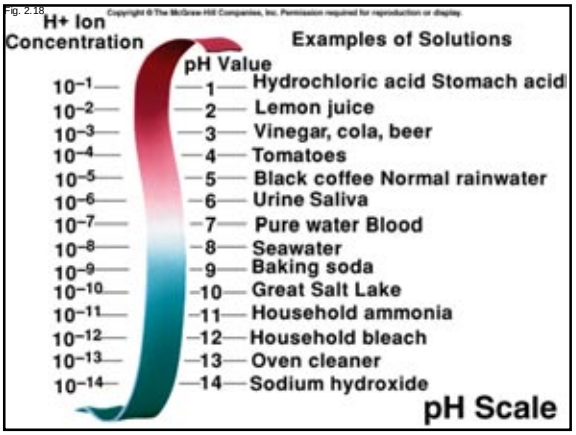
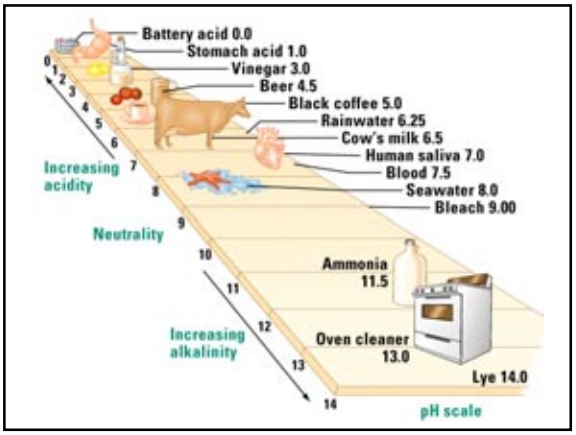
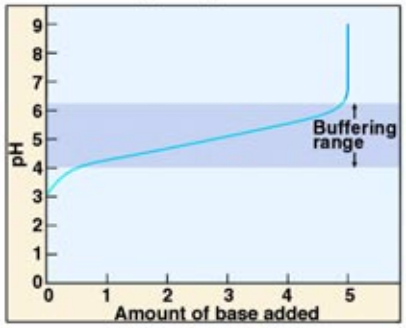


Fig. 2.18

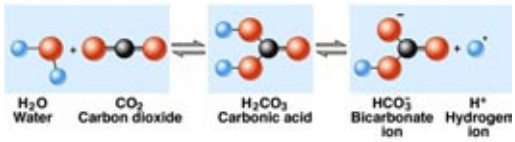




Relationship of pH and Buffers



Buffer Formation



Buffers

- ✓ Molecules that easily converts between acid and base forms
- ✓ Ex. Carbonic acid and bicarbonate in the blood

Blood ⇨ $CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-$

Lungs ⇨ $H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow CO_2 + H_2O$

Formation of Acid Precipitation