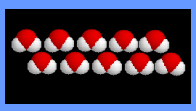
The Extraordinary Properties of Water

Water

- A water molecule (H_2O), is made up of three atoms --- one oxygen and two hydrogen.

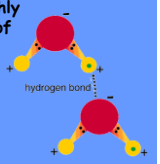


Water is Polar

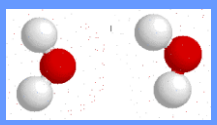
- In each water molecule, the oxygen atom attracts more than its "fair share" of electrons
- The oxygen end "acts" negative
- The hydrogen end "acts" positive
- Causes the water to be POLAR
- However, Water is neutral (equal number of e- and p+) --- Zero Net Charge

Hydrogen Bonds Exist Between Water Molecules

- Formed between a highly Electronegative atom of a polar molecule and a Hydrogen
- One hydrogen bond is weak , but many hydrogen bonds are strong

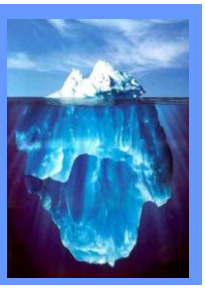


Interaction Between Water Molecules



Negative Oxygen end of one water molecule is attracted to the Positive Hydrogen end of another water molecule to form a HYDROGEN BOND

What are the Properties of Water?



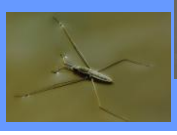
Properties of Water

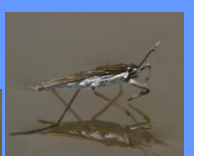
- At sea level, pure water boils at 100 °C and freezes at 0 °C.
- The boiling temperature of water decreases at higher elevations (lower atmospheric pressure).
- For this reason, an egg will take longer to boil at higher altitudes

Cohesion

- Attraction between particles of the same substance (why water is attracted to itself)
- Results in Surface tension (a measure of the strength of water's surface)
- Produces a surface film on water that allows insects to walk on the surface of water

Cohesion …





Helps insects walk across water

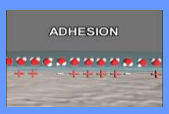
Adhesion

- Attraction between two different substances.
- Water will make hydrogen bonds with other surfaces such as glass, soil, plant tissues, and cotton.
- Capillary action-water molecules will "tow" each other along when in a thin glass tube.
- Example: transpiration process which plants and trees remove water from the soil, and paper towels soak up water.

Adhesion Causes Capillary Action

Which gives water the ability to "climb" structures

Adhesion Also Causes Water to …



Form spheres & hold onto plant leaves

Attach to a silken spider web

High Specific Heat

- Amount of heat needed to raise or lower 1g of a substance 1° C.
- Water resists temperature change, both for heating and cooling.
- Water can absorb or release large amounts of heat energy with little change in actual temperature.

High Heat of Vaporization

- Amount of energy to convert 1g of a substance from a liquid to a gas
- In order for water to evaporate, hydrogen bonds must be broken.
- As water evaporates, it removes a lot of heat with it.

High Heat of Vaporization

- Water's heat of vaporization is 540 cal/g.
- In order for water to evaporate, each gram must GAIN 540 calories (temperature doesn't change --- 100°C).
- As water evaporates, it removes a lot of heat with it (cooling effect).

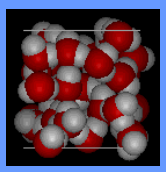
- Water vapor forms a kind of global "blanket" which helps to keep the Earth warm.
- Heat radiated from the sun warmed surface of the earth is absorbed and held by the vapor.

Water is Less Dense as a Solid

- Ice is less dense as a solid than as a liquid (ice floats)
- Liquid water has hydrogen bonds that are constantly being broken and reformed.
- Frozen water forms a crystal-like lattice whereby molecules are set at fixed distances.

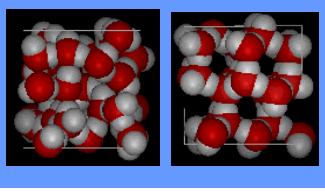
Water is Less Dense as a Solid

·Which is ice and which is water?



Water is Less Dense as a Solid

Water Ice



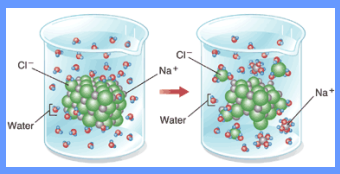
Homeostasis

- Ability to maintain a steady state despite changing conditions
- Water is important to this process because:
  a. Makes a good insulator
  b. Resists temperature change
  c. Universal solvent
  d. Coolant
  e. Ice protects against temperature extremes (insulates frozen lakes)

Solution

- Ionic compounds disperse as ions in water
- Evenly distributed
- SOLUTE
  - Substance that is being dissolved
- SOLVENT
  - Substance into which the solute dissolves

Solution



Acids, Bases and pH

One water molecule in 550 million naturally dissociates into a Hydrogen Ion (H+) and a Hydroxide Ion (OH-)

$$H_2O \leftrightarrows H^+ + OH^-$$

Hydrogen Ion
Acid

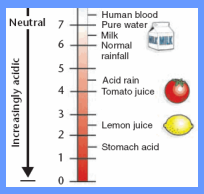
Hydroxide Ion
Base

The pH Scale

- Indicates the concentration of H^+ ions
- Ranges from 0 – 14
- pH of 7 is neutral
- pH 0 up to 7 is acid … H^+
- pH above 7 – 14 is basic… OH^-
- Each pH unit represents a factor of 10X change in concentration
- pH 3 is 10 x 10 x 10 (1000) stronger than a pH of 6

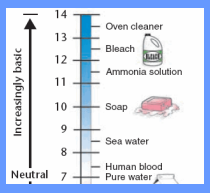
Acids

- Strong Acids have a pH of 1-3
- Produce lots of H^+ ions



Bases

- Strong Bases have a pH of 11 to 14
- Contain lots of OH^- ions and fewer H+ ions



Buffers

- Weak acids or bases that react with strong acids or bases to prevent sharp, sudden changes in pH (neutralization).
- Produced naturally by the body to maintain homeostasis

Weak Acid

Weak Base