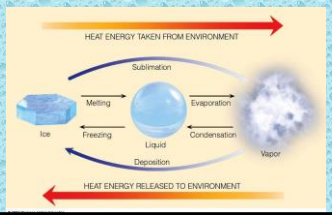
WATER

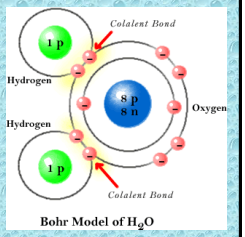
- life on earth evolved in water (3/4 of the earth is covered in water)
- most abundant molecule in living organisms
- 2/3 of human body is water
- 80% of cytoplasm is water
- 95% of jellyfish

- water is the only substance that naturally occurs in all three physical states of matter- solid, liquid and gas.
- water's unusual properties are emergent from the structure and molecular interactions of water.



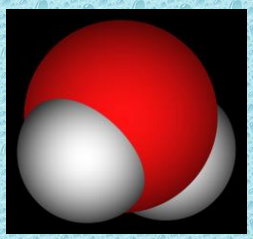
POLARITY

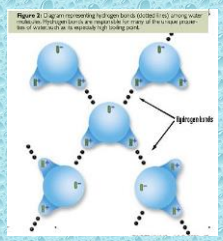
- Water is a <u>polar molecule</u>.
- Oxygen has a higher electronegativity than hydrogen and attracts the electrons more than hydrogen.
- Oxygen's side of the molecule then has a negative charge. Hydrogen's side is positive. (Covalent bonds are holding these together.)



Bohr Model of H_2O

- Triangular shaped like a Mickey Mouse hat (each water molecule can form a maximum of four hydrogen bonds with neighboring water molecules).





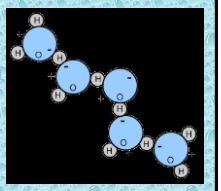
Polarity contributes to its properties

- <u>Cohesion</u>: attraction of water molecules to each other.
- <u>Adhesion</u>: attraction to water to other charged molecules.
- <u>Surface tension</u>: related to cohesion the surface of water has more tension than most other liquids.

- Because of cohesion, adhesion and osmotic pressure together form capillary action in which water can travel from the roots of plants to the top of the plant.
- Because of surface tension (causes beading), some animals can walk on water.

Water has a high specific heat

- (amount of heat that must be absorbed or lost for 1 g of that substance to change by 1 ºC)
- water is 1 calorie per gram per degree Celsius
- because of hydrogen bonding (initial heat absorbed goes into breaking hydrogen bonds) water changes its temperature less as it absorbs or releases heat.

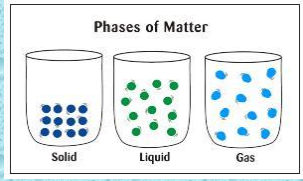


Water has a high specific heat

- water can be used as insulator against frost because as the water freezes it releases heat which prevents the fruit from becoming frozen.
- water can be used as a heat sink (think of nuclear power plants).
- water in ocean stays stable allowing life (same in land organisms).

Water allows for evaporative cooling

- if molecules of water have enough kinetic energy to overcome the hydrogen bonds then they can transform from a liquid to a gas (vaporization).



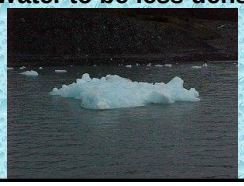
Water allows for evaporative cooling

- evaporative cooling occurs because as the water molecules leave the liquid they take their "heat" (highest kinetic energy) with them causing the remaining liquid to be "cooler (lower kinetic energy)."
- Ex. sweating allows organisms to maintain homeostasis through evaporative cooling.

- Water has a high heat of vaporization (the amount of heat a liquid must absorb for 1 g to be converted to a gas).

Ice Floats

- water is one of the few substances that are less dense as a solid then a liquid.
- hydrogen bonds (causes regular spacing among water molecules) causes water to be less dense as a solid.



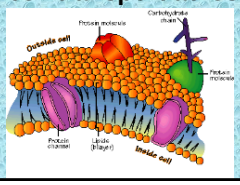
- Ex. Prevents bodies of water from freezing solid from bottom to top.
- Ex. Transitions between seasons are less abrupt because in the winter the water freezing releases heat and in the spring the water melting absorbs the heat.

Water as a solvent

- water is polar causing it to dissolve or break apart certain substances.
- closest to universal solvent

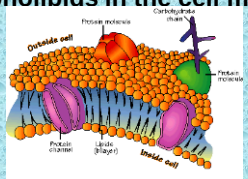
Hydrophilic

- means water loving.
- charged regions of water will be attracted to other polar or ionic compounds. Therefore in general polar compounds are water-soluble.
- Ex. Important in cell transport across the cell membrane.



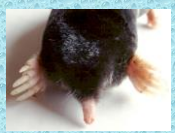
Hydrophobic

- means water fearing.
- non-polar compounds or non-electronegative substances are NOT water-soluble.
- Ex. Also important in cell transport due to phospholipids in the cell membrane.



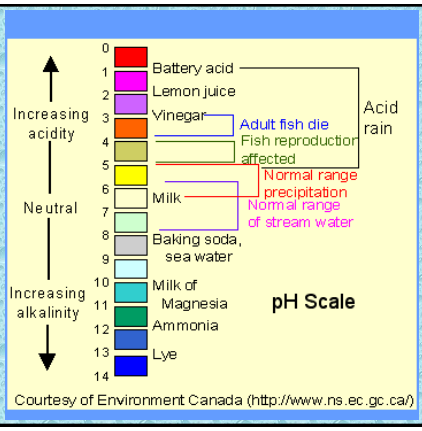
Solution Concentration

- solute concentration is determined by calculating how many moles are dissolved in the aqueous solution.
- moles are determined by calculating the molecular weight of a substance.
- molarity is equal to the number of moles of solute per liter of solution.



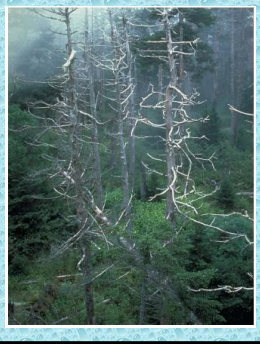
pH

- Water dissociates partially into hydrogen ion (H+) and hydroxide ions (OH-)
- $H_2O \leftrightarrow H^+ + OH^-$
- at equilibrium most of the H2O is not ionized.
- The concentration of H+ and OH- in pure water is equal.
- pH of pure water is M= 10-7



Acids

- solutions become acidic when a substance is added that increases the H+ concentration.
- Ex. HCl
- also removes OH- because it tends to combine with H+ to form H2O.
- strong acids completely disassociate in water, weak do not.



Bases

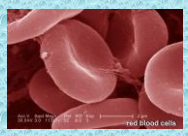
- solutions become basic when a substance is added that decreases the concentration of H+.
- Ex. NH_3 (directly because it absorbs H+ from solution to form ammonia).
- strong bases completely disassociate in water, weak do not.

Calculating pH

- $[H^+][OH^-] = 1.0 \times 10^{-14}$
- in a neutral solution $[H^+] = 10^{-7}$ and $[OH^-] = 10^{-7}$
- if you know the concentration of H+ then you know the concentration of OH-.
- use logarithms to calculate pH. The pH =- log [H+].
- Ex. pH 5 = 10^{-5} moles H+/L
- pH 5 is 10x more acidic than pH 6 (so difference between a pH of 3 and 6 is thousand).

Buffers

- substance that keeps the pH constant by releasing H+ or OH- as they enter or leave the fluid.
- main buffer in living organisms is the bicarbonate ion (HCO_3^-).
- it takes up excess H+ or OH-
- Ex. $H^+ + HCO_3^- \leftrightarrow H_2CO_3$
  Bicarbonate Ion — Carbonic acid



- Drop in pH will cause formation of carbonic acid.
- Rise in pH will cause formation of bicarbonate ion, which is weak base.