"You are not separate from the whole. You are one with the sun, the earth, the air. You don't have a life. You are life."
- Eckhart Tolle

Fundamental Building Blocks: Chemistry, Water and pH

Chapter 2

From dust were ye made!

"Everything is made from dirt" – Uncle Barry

Concrete: limestone
calcium sulfate ($CaSO_4$)
aggregate or rock (granite)
ash

Glass: silica (quartz) SiO_2
sodium carbonate(Na_2CO_3)
lime (calcium oxide CaO)
calcium magnesium carbonate $CaMg(CO_3)_2$
aluminum oxide (Al_2O_3)

Metal (steel): iron (Fe)
carbon (C)
manganese (Mg)
phosphorus (P)
sulfur (S)

Matter, Mass, and the Atom

Matter: anything that takes up space and has mass

Mass: measure of the quantity of matter in a given object
- Volume and density

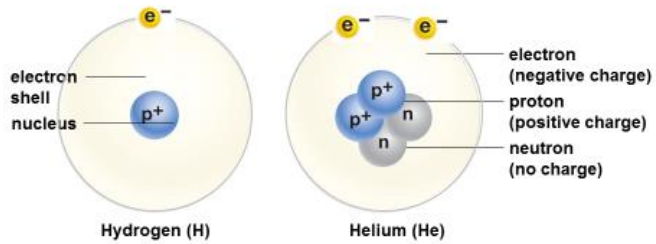
Democritus (400 BCE): atoms are indivisible
- Indivisible: cannot be _____ further

Atoms are the fundamental unit of matter

The Atom

Atoms are made up of three subatomic particles:
- _____: component of the atom's nucleus with a positive electrical charge.
  - Elements are defined by number of protons.
- **Neutrons**: component of the atom's nucleus with _____.
  - Isotopes are defined by number of neutrons.
- **Electrons**: located some distance from atom nucleus and has a negative electrical charge.

Structure of the Atom



Elements

Element: a substance that can not be reduced to a more simple set of components through chemical processes.

- Elements are *pure* forms of chemicals consisting of a single type of atom

Currently 118 elements have been discovered/created

*Carbon, Oxygen, Nitrogen and Hydrogen make up 96% of human body mass

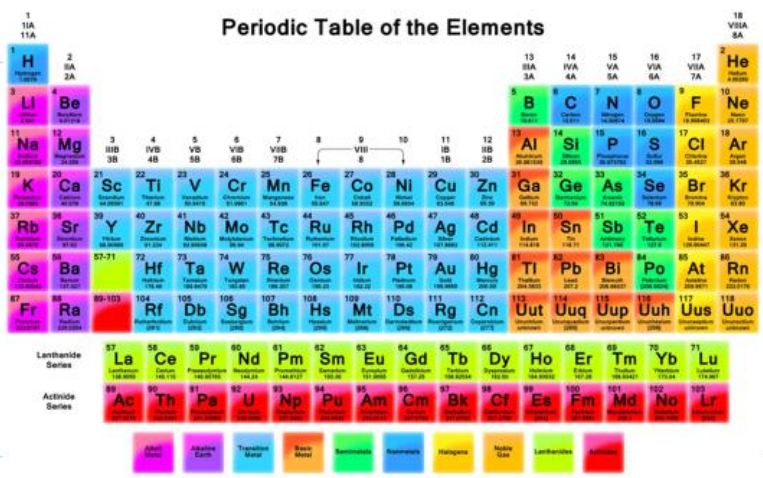
_____: two or more atoms together

- Ex. O_2

Compound: two or more elements together

- Ex. H_2O

Periodic Table of the Elements



Understanding the Elements

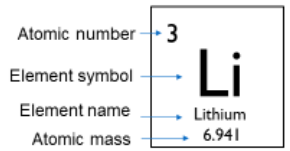
Atomic number: number of protons in the atom's nucleus

- Elements differ in the _____ in their nucleus

Element symbol: abbreviation of element's name

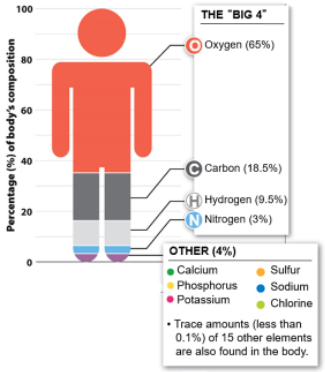
Atomic mass: combined mass of atom's protons and neutrons

- Neutron = 1
- Proton = 0.99862349, 99.86% mass of neutrons
- Electron = 0.00054386734, 0.054% mass of neut



Elements in the Human Body

- Only ___ elements make up 99% of the human body. Four of these ten elements (oxygen, _____, hydrogen and nitrogen) making up around 96% of your body



Check Your Understanding

1. What is the elemental symbol for potassium?
2. How many protons are found in the nucleus of calcium?
3. What is the average combined mass of the protons and neutrons in Beryllium?

Isotopes

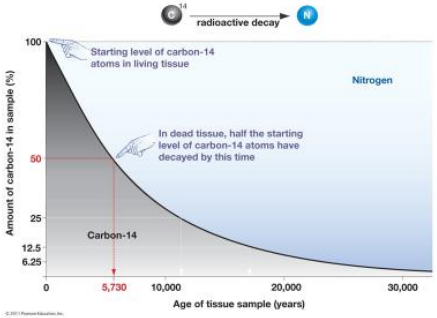
Isotopes: a form of an element as defined by the number of _____ contained in the nucleus

	CARBON-12	CARBON-13	CARBON-14
Protons	6	6	6
Neutrons	6	7	8
Electrons	6	6	6
Atomic mass	12	13	14

Radiometric Dating

Isotopes such as Carbon-14 are unstable and decay over time

- Rate of _____ can be measured
- **Half-life:** time is takes for 50% of isotope to decay
- Half-life of Carbon-14 = 5730 years

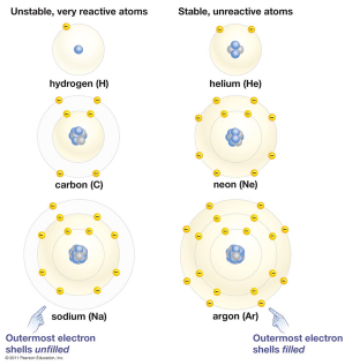


Electron Energy Levels

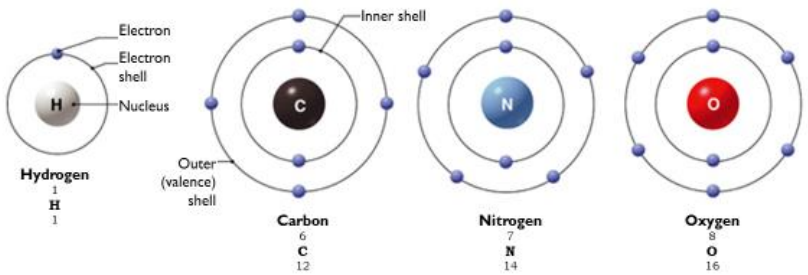
Electrons (e^-) orbit atom nucleus at different energy levels (shells)

1st shell = 2 e^-
2nd shell = 8 e^-
3rd shell = 8 e^-
And so on…

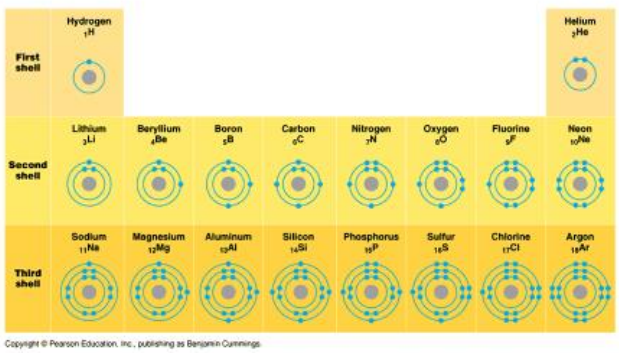
- Atoms with vacancies in their outermost electron shell are _____, whereas atoms with full shells are _____



Electron Energy Levels



Another look at the Periodic Table



Check Your Understanding

1. Draw the structures for a calcium and chloride atom. Be sure to include the correct number of electrons in the outer most shell.
   - Calcium has an atomic number of 20 and chloride has an atomic number of 17

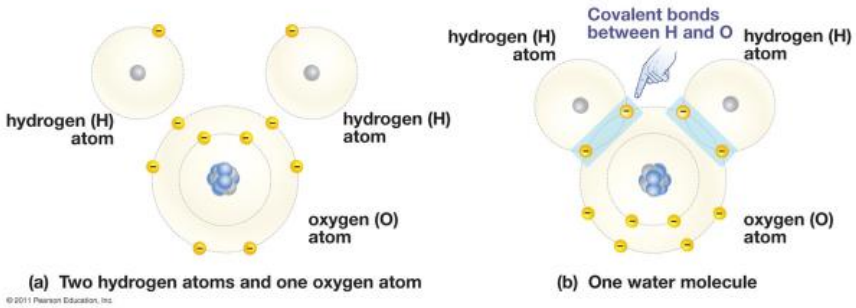
Check your Understanding

2. How many electrons are found in a sodium atom? Hint: The atomic number for sodium is 11.

3. How many neutrons are found in the nucleus of the isotope Oxygen-18? Hint: The atomic number for oxygen is 8.

Making Stable Compounds

Atoms bond together to _____ outer shell electrons

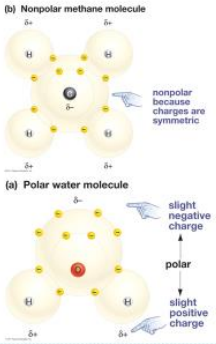


Types of Chemical Bonding

Covalent bonding: when two atoms _____ pairs of electrons

- **Non-polar covalent bond**: when a covalent bond results in a _____ molecule
  - Ex: Carbon dioxide = CO_2
- **Polar covalent bond**: when a covalent bond results in a polar molecule
  - Ex: Water molecule = H_2O

_____: a difference in electrical charge on opposing ends of molecule



Types of Chemical Bonding

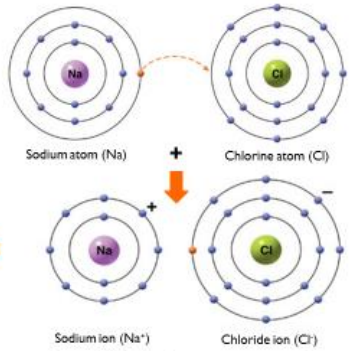
Ionic bonding: when one atom _____ an electron to another atom, with resulting ions become linked by attraction of opposing charges

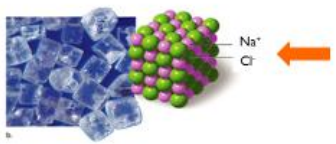
- After gaining or losing an electron, atoms become charged
  - **Cation**: a positively charged ion
    - Ex: Na^+
  - **Anion**: a negatively charged ion
    - Ex: Cl^-

Ion: a charged atom; number of _____ does not equal number of _____

Ionic Bond

- Sodium (Na) and Chlorine (Cl)
  - NaCl



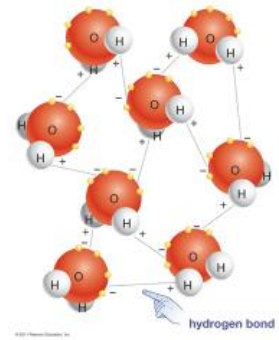


Outer shells of both atoms are now complete

Types of Chemical Bonding

Hydrogen bonding: covalent bond between hydrogen atoms and an electronegative atom

- Bound by attraction of electrical charge
- Relatively _____ bonds



Summary of Molecule Bonding

Covalent bonding: a bond formed between two atoms that share electrons

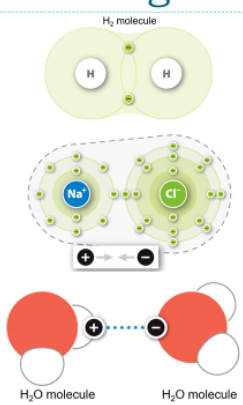
- Bond strength : _____

Ionic bonding: a compound that is formed by the attraction of two oppositely charged ions

- Bond strength: _____

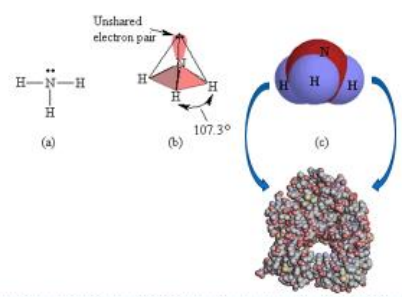
Hydrogen bonding: a bond formed between the slightly positively charged hydrogen atom and the slightly negatively charged region of another atom

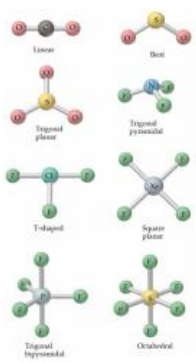
- Bond strength: _____



The Importance of Molecule Shape

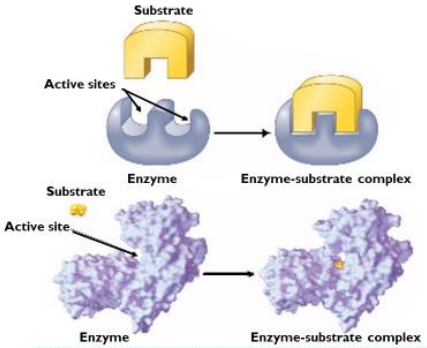
When atoms bind together the resulting molecule takes on a specific shape

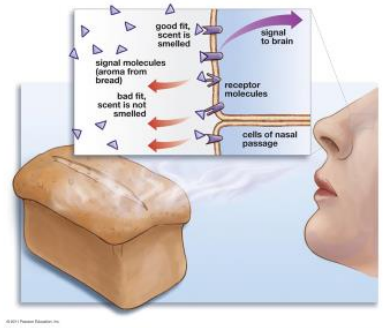




The Importance of Molecule Shape

Molecular shape works like a *lock and key* with enzymes





The Amazing H_2O

Water is essential to life

- Life started in water
- Terrestrial life depends of water
  - Cells immersed in water
  - 66% of our body weight

Water has unique properties that allow life to exist on earth

Properties of Water

The Universal Solvent

- Water can dissolve more substances than any other liquid

Solute: substance being _____ to form a solution

Solvent: substance that a solute is dissolved in to form a solution

- Aqueous solution = water is the solvent

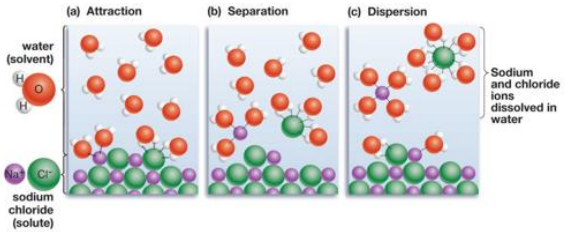
Solution: a _____ mixture of two or more substances

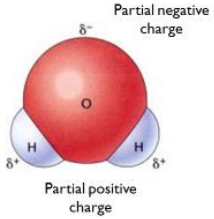
<u>Hydrogen bonds of water molecule pull other compounds apart</u>

Properties of Water

Water is a polar molecule

- _____ works to pull apart ions

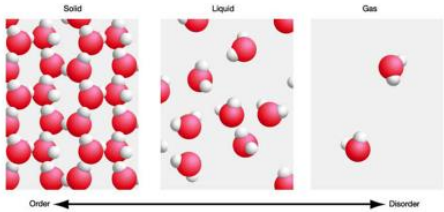




Properties of Water

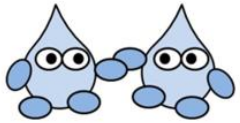
Liquid form is _____ than solid form

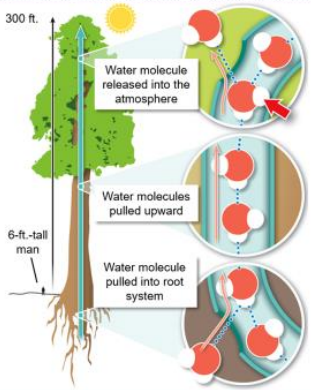
- Ice floats on water!



Properties of Water

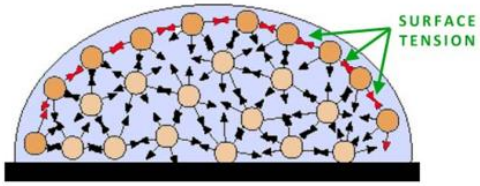
_____: the tendency for like molecules to cling together due to attractive forces





Properties of Water

Surface tension: water molecules are _____ to air and pack more tightly at interface



Properties of Water

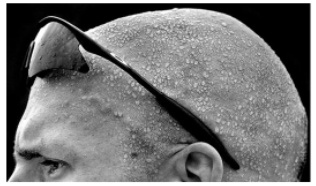
Specific heat: amount of energy required to raise temp 1°C

- Water has a high specific heat compared to other molecules
  - Water acts as _____ to temperature changes

Properties of Water

High heat of vaporization

- Vaporization: transformation from _____



Fastest moving water molecules transform to a gaseous state.

- Sweat helps release internal body heat
  - **Evaporative cooling**: cooling of surface when liquid evaporates

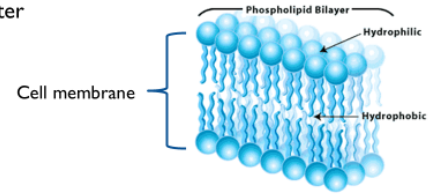
Molecular Attraction to Water

Hydrophilic ("water loving"): compounds that will interact with water

- Ex. Sodium Chloride (NaCl)

_____ ("water fearing"): compounds that do not interact with water

- Ex: Hydrocarbons (petroleum, oil) and lipids (fats)
- Hydrophobic molecules help contain water



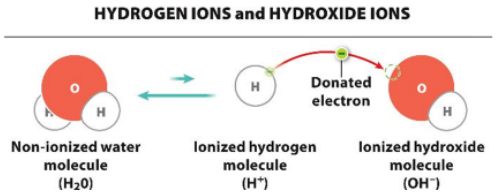
Acids and Bases

Acid: substance that _____ hydrogen ions in an aqueous (water-based) solution

- Hydrogen ion = lone proton H^+

Base: substance that _____ hydrogen ions in an aqueous solution

- Hydroxide ion = Oxygen and Hydrogen OH^-
- Alkaline = basic solution



Acids and Bases

pH Scale : measures (p)ower of (H)ydrogen

↓ pH = more acidic (6-0) pH of 7 = neutral ↑ pH = more basic (8-14)