Chemistry and Matter

"By faith we understand that the worlds were framed by the word of God, so that the things which are seen were not made of things which are visible." Hebrews 11:3

- Chemistry: organized study of composition and interactions of matter
- John Dalton (1803)
  -atomic theory of matter: all matter consists of tiny particles called "atoms" (not cuttable)
  -atoms combine in various ways to form different substances
- Dalton's Atomic Theory:
  1. Every element consists of tiny particles called atoms.
  2. All atoms of a particular element have the same properties.
  3. Different elements have different properties because their atoms are different.
  4. Atoms of different elements can combine in specific ways to form compounds.
  5. Chemical processes are the result of rearrangement, combination, or separation of atoms.
- (2018) 118 elements; 88 occur naturally and 30 produced in laboratory
  -Pure elements uncommon in earth; elements usually found combined into compounds or mixtures (physical combinations of elements or compounds)
  -pure elements also uncommon in everyday life; elements combined to make various materials including alloys (metal mixtures) and plastics
- Elements given a chemical symbol, usually based on its common or Latin name [Periodic Table handout]
  *Memorize: aluminum, boron, calcium, carbon, chlorine, copper, gold, helium, hydrogen, iodine, iron, lead, magnesium, mercury, neon, nickel, nitrogen, oxygen, phosphorus, potassium, silicon, silver, sodium, sulfur, tin, zinc

Inside the Atom

- Atoms composed of still smaller particles called subatomic particles
- Nucleus: dense central core
- Protons: (+) electrical charge; located in nucleus; determine the identity of an atom, giving it particular properties
- Atomic number: number of protons in nucleus; only one element has a particular atomic #
- Neutron: (0) electrical charge; located in nucleus
  Different numbers of neutrons can exist in atoms of the same element; isotopes: atoms of the same element that have different #neutrons
- Quarks: components of protons and neutrons; three quarks needed to make a proton or neutron

- Electron: (-) electrical charge
  -total electron charge is equal to total positive charge of the proton in a neutral (uncharged) atoms
- Electrons arranged in concentric layers that surround the nucleus called electron shells/energy levels/clouds/orbitals:

Letter designation	Numerical designation	Maximum #electrons
K	1	2
L	2	8
M	3	18
N	4	32
O	5	50

- Atoms may gain or lose outermost electrons due to heat, electricity radiation, chemical interactions; losing electrons will cause an atom's charge to be unbalanced:
  -ion: atom that has an electrical charge because of losing or gaining electrons
  -anions are (-) ions
  -cations are (+) ions
- Mass number: total number of protons + neutrons in the nucleus; atoms with higher mass numbers have more mass than atoms with lower mass numbers
- Different isotopes of same element will have different mass numbers since the number of neutrons will vary
  Ex: carbon's atomic mass = 12 from 6 protons + 6 neutrons
  carbon 14 isotope (^{14}C) = 14 from 6 neutrons + 8 neutrons
- Heaviest atom _ is uranium-238 with a mass of only 3.95×10^{-23}g
  -Because atoms are so small, masses of atoms usually measured in atomic mass units (u); one atomic mass unit = 1/12 mass of a carbon-12 atom
  -mass of an atom in atomic mass units is approximately equal to the mass number
- Average atomic mass is the average mass of all the naturally occurring isotopes of the element; when more than one isotope of an element occurs naturally, any random sample will contain all of those isotopes, not just one
- Atomic models illustrate structure of atoms
- Quantum theory (Planck): tiny particles such as electrons do not absorb or release energy in a smooth flow; energy is always absorbed or released in a packet called a quantum
  Electrons change shells when they gain or lose energy; electron gains energy → moves to higher energy level, electron loses energy → electron moves to lower energy level
- Bohr model [p.121]

- Wave-mechanical model / quantum mechanical model [p.121]; mathematical equations represent probability of finding an electron at a given point
  Electrons have characteristics of particles (when they interact with other matter) and waves (when they travel)
- Heisenberg uncertainty principle: electrons essentially unpredictable, so principle declares probability that an electron will be at a certain place at a certain time
- Electron clouds (Born): electrons move unpredictably inside regions called orbitals; like a cloud in which dots indicate probability of finding electron [p.122]; translated into probability contour
- Quantum numbers: mathematical representation of overall motion of each electron:
  1. Number of electron shell
  2. Shape of electron orbital (sphere, dumbbell, cloverleaf, double cloverleaf)
  3. Orbital's orientation in space (horizontal, vertical, diagonal)
  4. Spin of an electron (clockwise, counterclockwise)
- Pauli exclusion principle: no two electrons in an atom can have the same four quantum numbers