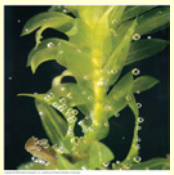
The Chemistry of Life

The biochemistry of all living things is similar.

Elements

Lead


Gold

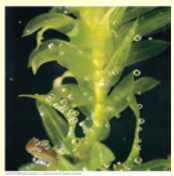

Oxygen

- All matter is made up of a limited number of elements (92)
- You can't change one element into another.

Elements

Pb


Au


O

- Elements have 1 or 2-letter abbreviations.

Elements in Biology

- Living things require about 25 elements, six major:
  - Oxygen: O
  - Hydrogen: H
  - Carbon: C
  - Nitrogen: N
  - Calcium: Ca
  - Phosphorus: P
  - Remember "CHON"

- Others are called "trace" and make up less than 1% of living things:
  - Potassium, Sulphur, Sodium, Chlorine, Magnesium, Iron, etc…

- From your text:

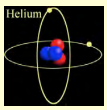
Table 2.1 Naturally Occurring Elements in the Human Body

Symbol	Element	Atomic Number (see p. 33)	Percentage of Human Body Weight
Elements making up about 96% of human body weight			
O	Oxygen	8	65.0
C	Carbon	6	18.5
H	Hydrogen	1	9.5
N	Nitrogen	7	3.3
Elements making up about 4% of human body weight			
Ca	Calcium	20	1.5
P	Phosphorus	15	1.0
K	Potassium	19	0.4
S	Sulfur	16	0.3
Na	Sodium	11	0.2
Cl	Chlorine	17	0.2
Mg	Magnesium	12	0.1
Elements making up less than 0.01% of human body weight (trace elements)			
Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)			

Atoms

- Each element is made up of atoms
- The world is made of atoms

Let's Get Small: subatomic particles



Helium

Lead

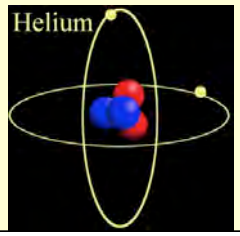
- Atoms are made of protons, electrons, and neutrons

Properties of Subatomic Particles

	Atomic Mass (a.m.u.)	Charge
Proton	1	+
Electron	1/1800	-
Neutron	1	none

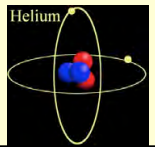
Atomic structure

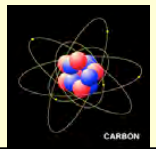
- Protons and Neutrons are found in the nucleus of an atom; electrons orbit around the nucleus



Atomic Number

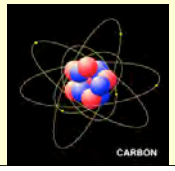
- The number of protons in the nucleus (the "atomic number") determines what element the atom is.
- Every helium atom has two protons, every carbon atom has exactly six.





Atomic Mass (or weight)

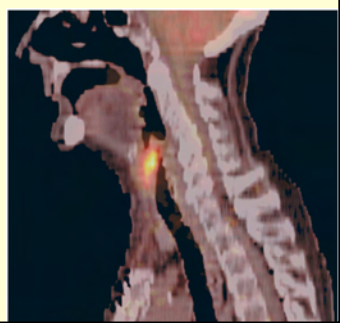
- The number of protons and neutrons together in the nucleus determine the atomic mass.
- Every carbon atom has exactly six protons, but some carbon atoms have six neutrons, some have eight.
  - 6+6…"Carbon 12"
  - 6+8…"Carbon 14"



Isotopes

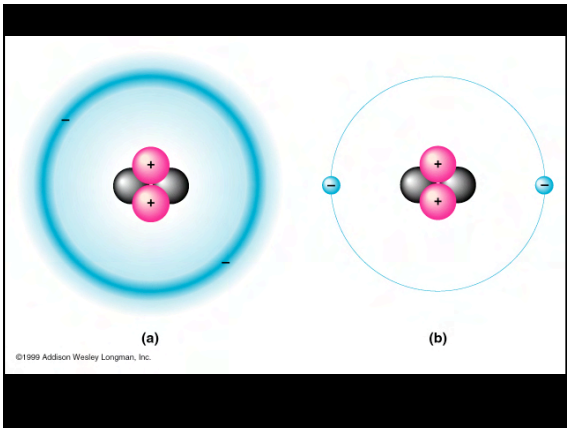
- Atoms that have the same atomic number, but different atomic weights are called isotopes.
- Chemically, isotopes behave identically.
- Some isotopes, *radioisotopes*, occasionally self-destruct and give off a lot of energy

- Radioisotopes are useful tools



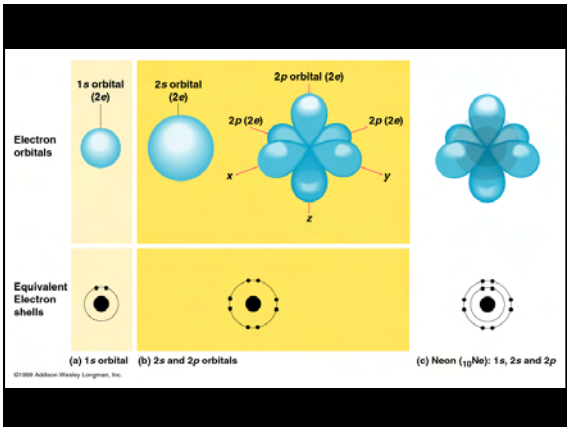
Atomic number, mass, and charge

- # protons = atomic number
- # protons + # neutrons = atomic mass (in "atomic mass units" or "AMU" or "Daltons")
- # electrons = # protons (if there is no net charge)

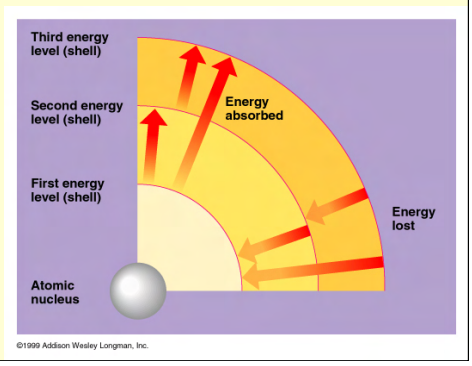


Electrons Determine How an Atom Forms Bonds with Other Atoms

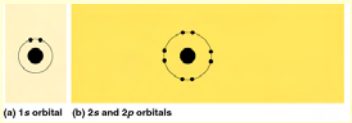
- Electrons move in "orbitals"
- One or more orbitals with similar energy = an electron "shell"



Electrons can move between shells



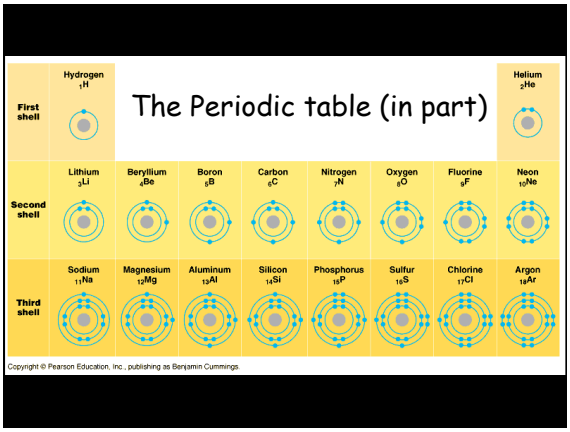
Valence Electrons



- The valence electrons are the electrons in the outermost shell
- The valence electrons are the electrons that react (form bonds) with other atoms
- The innermost shell holds 2 electrons (Hydrogen).
- Other shells hold 8 (N,C,O).

Valence Electrons

- Atoms with filled outer shells are stable.
- Hydrogen's valence shell holds 2 electrons; all other atoms you will encounter need 8
- How do atoms fill their valence shell?



Common Elements and Their Electron Configurations

Atom	# Valence e$^-$	# needed
Hydrogen	1	1
Carbon	4	4
Nitrogen	5	3
Oxygen	6	2
Chlorine	7	1
Na, K	1	?

How do atoms fill their outer shells?

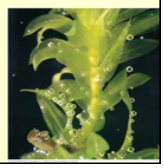
They form chemical bonds.

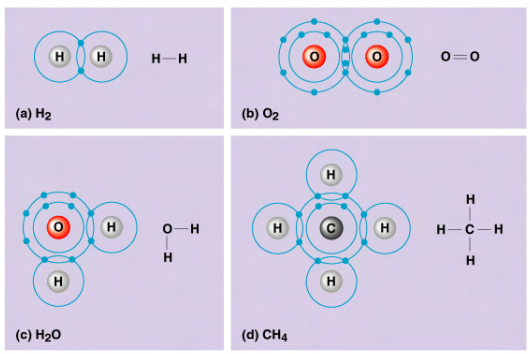
Types of Chemical Bonds

- We will consider four types of chemical bonds
  - Covalent bonds
  - Polar covalent bonds
  - Ionic bonds
  - Hydrogen bonds

Covalent Bonds

- Involve shared pairs of electrons
- The strongest type of bond
- Can be single, double or triple





a. O=C—H

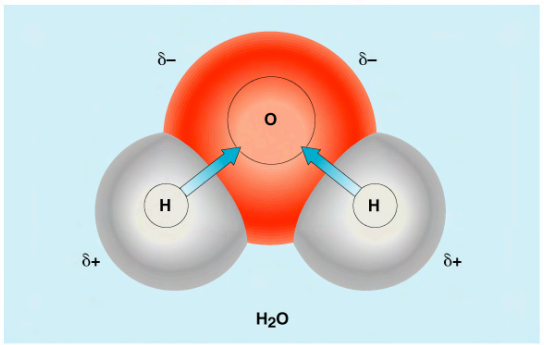
b. H—O—C(H)—C=O (H)

c. H—C(H)—H—C(H)=O (H)

d. H—N=O (H)

Polar Covalent Bonds

- Covalent bonds between two atoms that differ in electronegativity (Look for Oxygen!)
- Electrons are shared unequally
- One end of the bond is more negatively charged, one more positively charged
- Entire molecules can be polar



Ionic Bonds

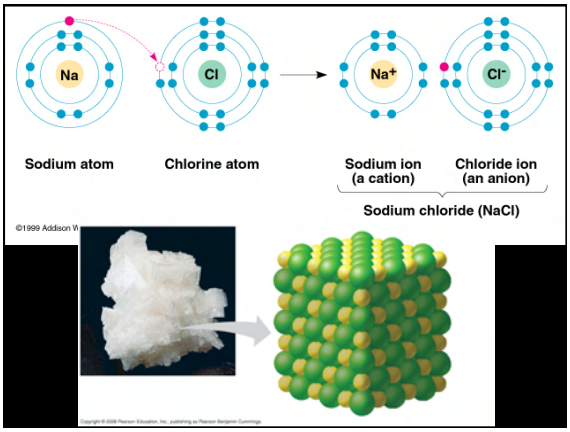
- Atoms gain or lose electrons to become ions
- Ions with opposite charges attract, forming a bond
- Weaker than covalent
- Very soluble in water

Ions

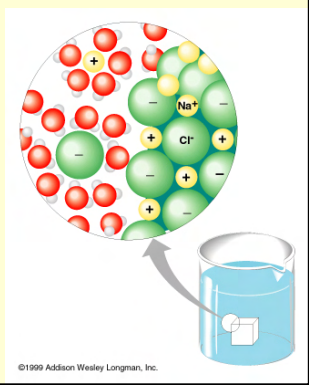
- Formed by loss or gain of an electron
- Cations: positive charge
- Anions: negative charge

Common Elements and Their Electron Configurations

Atom	# Valence e^-	# needed
Hydrogen	1	1
Carbon	4	4
Nitrogen	5	3
Oxygen	6	2
Chlorine	7	1
Na, K	1	?



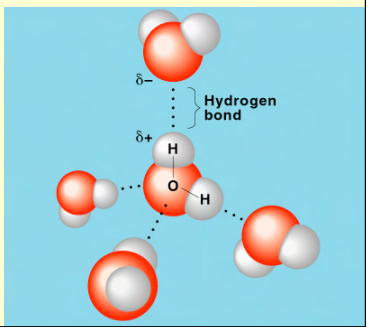
Ionic bonds are easily dissolved in water



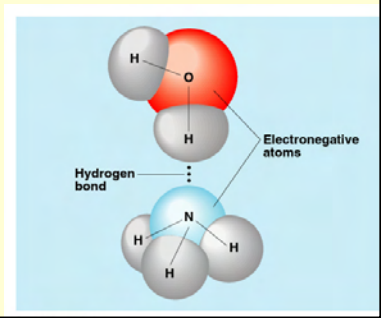
Hydrogen Bonds

- Occur between <u>polar molecules</u> - attraction between *partial* negative and partial positive charges
- Weak bonds, but very important in biology

Hydrogen bonds attract one water molecule to another



Oxygen *and* Nitrogen are "electron hungry" and make polar bonds



Hydrophilic, Hydrophobic

- Polar molecules and ions are hydrophilic ("water-loving")
  - Examples: salts, alcohols, ammonia
- Nonpolar molecules are often hydrophobic ("afraid of water")
  - examples
- Given its formula, you should be able to predict whether a molecule is hydrophobic or hydrophilic

Molecules

- A Molecule is 2 or more atoms, bound in a regular arrangement
  - Examples and counterexamples

- The specific *shape* of a biological molecule often determines its function