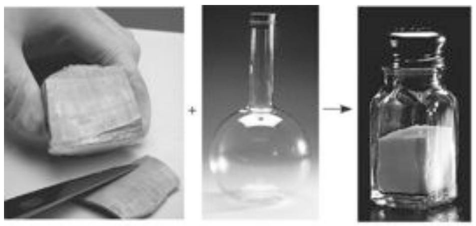
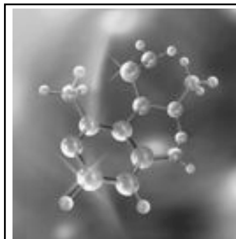
- **Matter** is a substance that has mass and (usually) volume and takes up space
- **Matter** is made up of **elements**, substances that cannot be broken down to other substances.
- **Atom** - The *smallest* unit of matter that retains all the properties of an element.

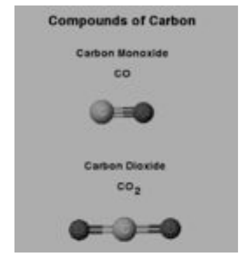


Sodium + Chlorine → Sodium chloride



Molecule: smallest particle of a substance that retains all the properties of the substance and is composed of two or more atoms

Compound: pure substance consisting of two or more different chemical elements that can be separated into simpler substances by chemical reactions.



All compounds are composed of molecules, but not vice-versa

Atoms and Elements

Element - Matter that cannot be broken down to other substances

Water

Water = H_20

H_20: **two** atoms of Hydrogen (H) to **one** atom Oxygen (O)

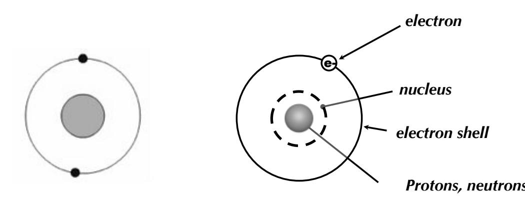
So, water itself is not an element because it is composed of other components. Water is a **compound.**

Atoms and Elements

Element – contains only one kind of atom…

Atom - The *smallest* unit of matter that retains all the properties of an element.

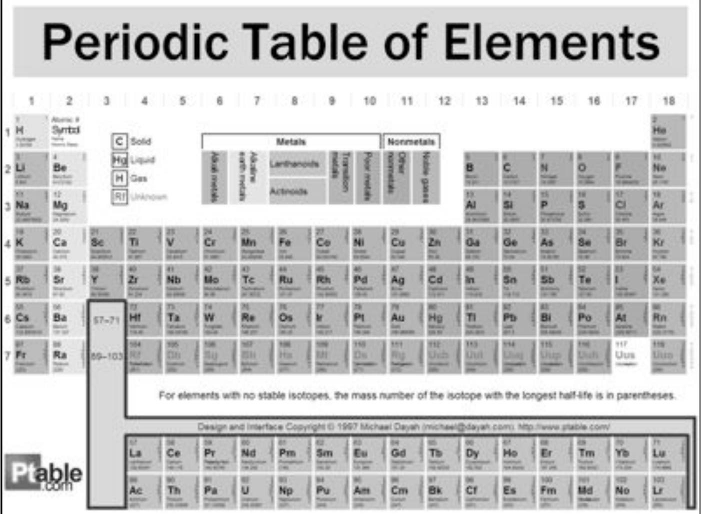
Atoms themselves are composed of **sub**atomic particles



Proton - positively charged, in the nucleus

Neutron – no charge, in nucleus

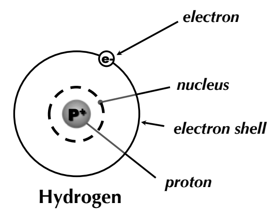
Electron - negatively charged, orbits the nucleus

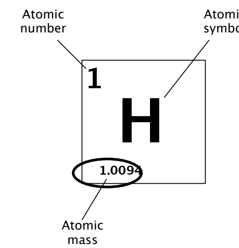


Atoms and Elements

Element - A substance that cannot be broken down to other substances

Atom - The smallest unit of matter that retains the properties of an element.

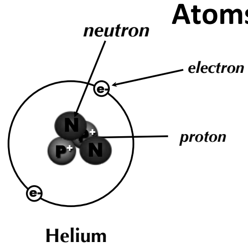


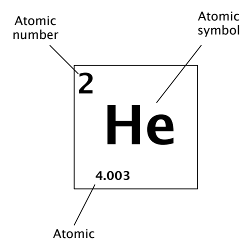


Proton - positively charged, in the nucleus

Electron - negatively charged, orbits the nucleus

Atoms and Elements





Proton - positively charged, in the nucleus

Electron - negatively charged, orbits the nucleus

Neutron - neutral, in the nucleus

An element always has the same number of protons and electrons, but neutrons can vary

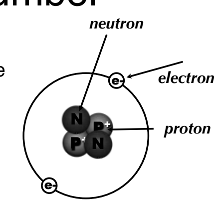
Atomic Mass/ Number

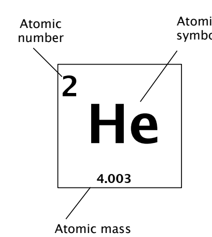
Protons and neutrons are similar in mass, and have been given an arbitrary mass of **1 "dalton"**.

Electrons are SO small, have almost no mass (~ 1/2,000th of a proton or neutron)

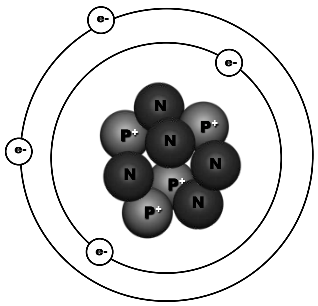
The **atomic number** of an *element* is the # of protons in the nuclei, and is unique to each element

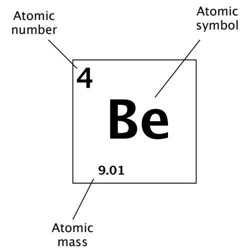
The **atomic mass** of an *element* (or the **atomic weight**) is the# of protons and neutrons in the nuclei (avg atomic mass of all the element's **isotopes**)





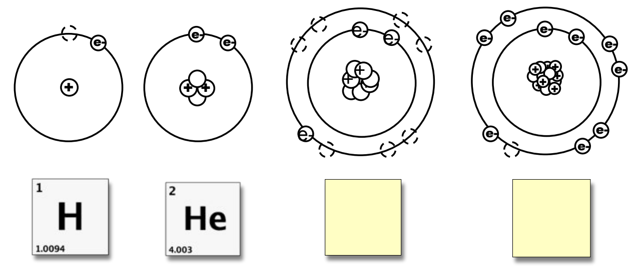
Beryllium



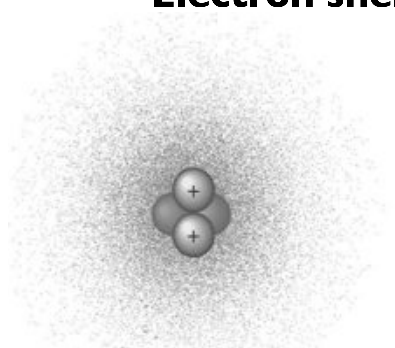


Energy Levels

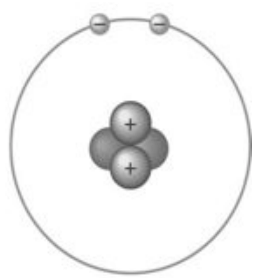
- The first energy level (aka electron shell) can hold two electrons
- All atoms want their energy levels full!
- The second energy level can hold eight electrons
- ***Chemistry is the giving, taking and sharing of electrons.***



Electron shell models

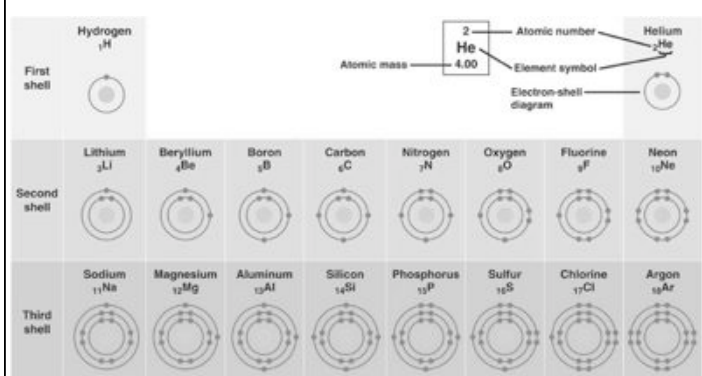


Electron cloud



Bohr

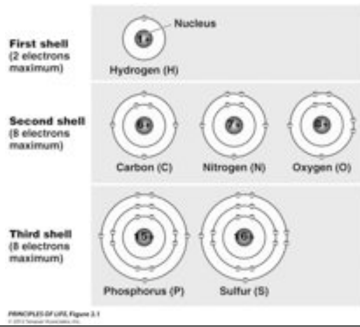
Electron Shells



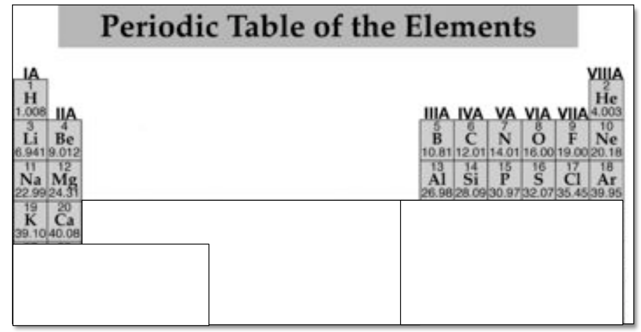
Valency and the Octet Rule

- The first energy level (aka electron shell) can hold two electrons
- The second, third, etc. can hold **eight** electrons (hence the "octet" rule)
- The outside energy level is called the **valence** level, and its state is referred to as the **valency** of the atom

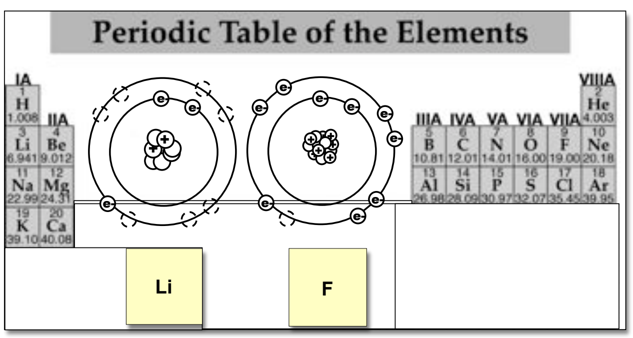
- All atoms want their outside energy levels full!



- The outermost electron shell determines the reactivity of an element
- Sodium (Na) and lithium (Li) both have ONE electron in their outermost electron shell. They have very similar chemistry.



The Periodic Table

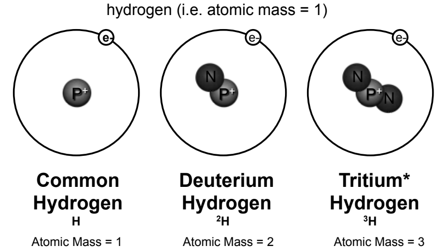


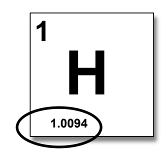
Isotopes

Isotopes of an element have the same number of protons but different number of neutrons.

Neutrons and Protons have the same mass.

- 99.99% of the Earth's hydrogen is "standard" hydrogen (i.e. atomic mass = 1)



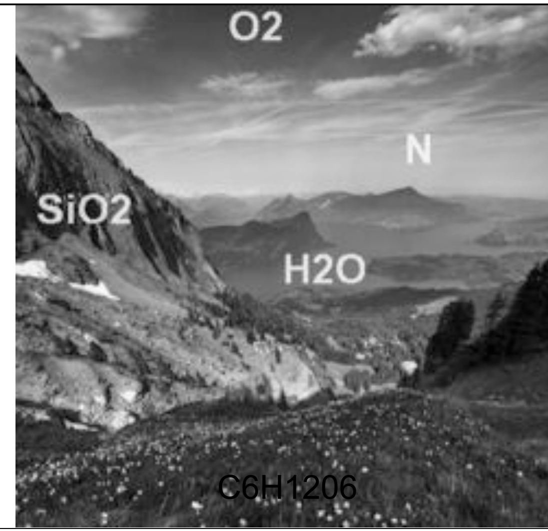


Only Four Elements Comprise 96% of the Human Body

NATURALLY OCCURRING ELEMENTS IN THE HUMAN BODY

Symbol	Element	Wet Weight Percentage*	
O	Oxygen	65.0	96.3
C	Carbon	18.5	
H	Hydrogen	9.5	
N	Nitrogen	3.3	
Ca	Calcium	1.5	
P	Phosphorus	1.0	
K	Potassium	0.4	
S	Sulfur	0.3	
Na	Sodium	0.2	
Cl	Chlorine	0.2	
Mg	Magnesium	0.1	

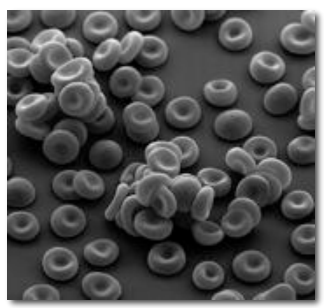
Trace elements (less than 0.01%): boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), and zinc (Zn).



Trace Elements

Dietary minerals needed by the human body in very small quantities (generally less than 100mg/day)

They include **iron**, cobalt, chromium, copper, iodine, manganese, selenium, zinc, and molybdenum.



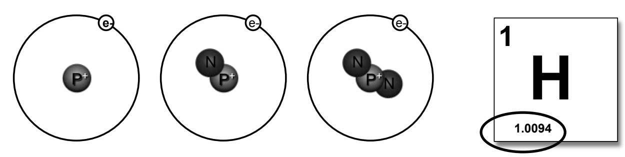
*Hemoglobin in red blood cells requires **iron (Fe)***

Isotopes

Isotopes of an element have the same # of protons but different # of neutrons.

Neutrons and Protons have the same mass.

- 99.99% of the Earth's hydrogen is "standard" hydrogen (i.e. atomic mass = 1)



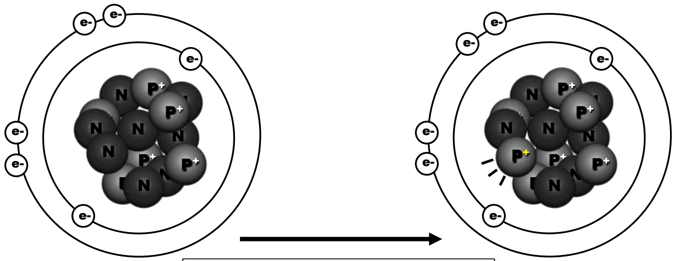
Common Hydrogen H Atomic Mass = 1

Deuterium Hydrogen ^2H Atomic Mass = 2

Tritium* Hydrogen ^3H Atomic Mass = 3

*radioactive

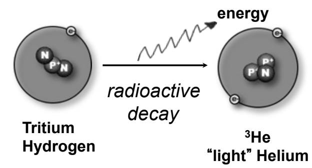
Carbon 14 (^{14}C) Nitrogen 14 (^{14}N)



Radioactive decay of ^{14}C

Isotopes

Many **isotopes** are stable, but some are **radioactive**

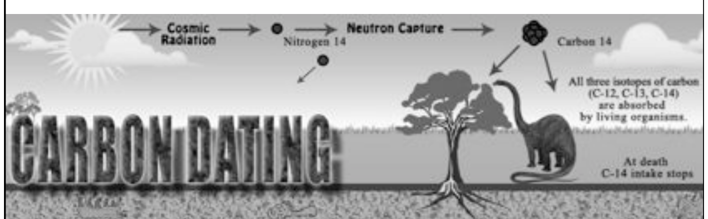


Uses in biology/ medicine

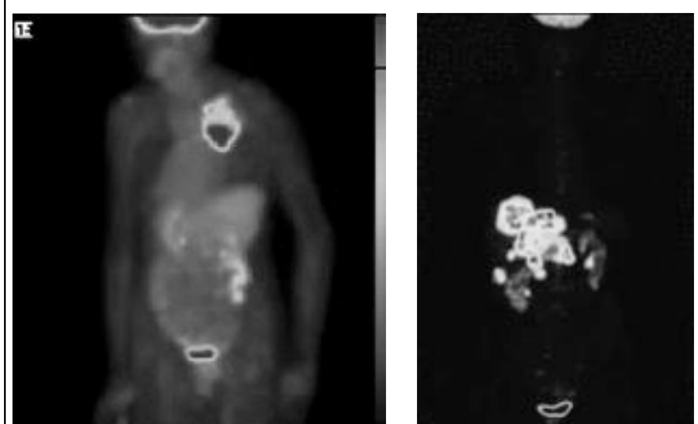
- Imaging

Dating using C-14

C14/C12 ratio is fixed in the atmosphere



PET Scanning Using Radioactive Isotopes



Isotopes

Most isotopes are stable, but some are **radioactive**

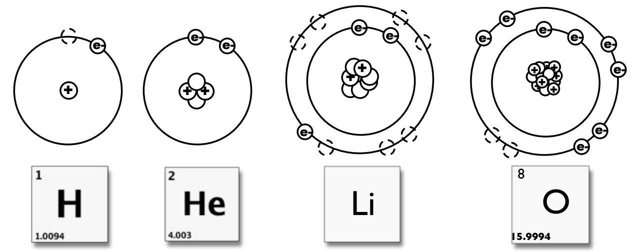
Uses in biology/ medicine

- Treatment

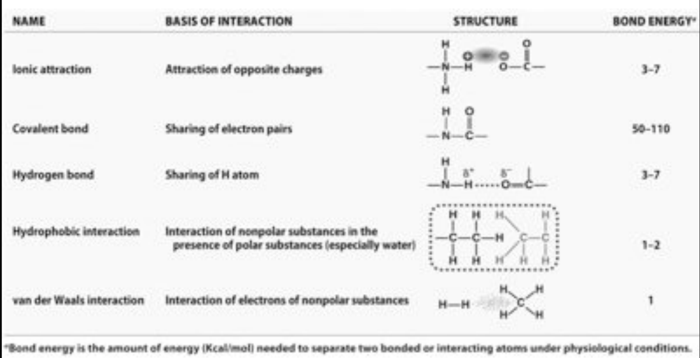
Energy Levels

- For an electron to move away from the nucleus, energy is needed. Why?
- Element's reactivity depends on how many electrons are in outer shell
- All atoms want their energy levels full

• ***Chemistry is the giving, taking and sharing of electrons.***



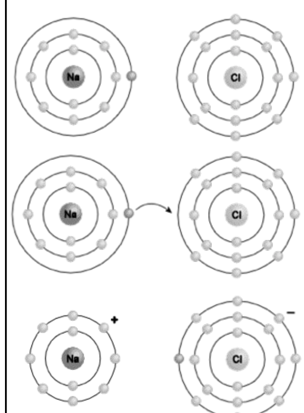
Chemical Bonds



NAME	BASIS OF INTERACTION	STRUCTURE	BOND ENERGY*
Ionic attraction	Attraction of opposite charges		3–7
Covalent bond	Sharing of electron pairs		50–110
Hydrogen bond	Sharing of H atom		3–7
Hydrophobic interaction	Interaction of nonpolar substances in the presence of polar substances (especially water)		1–2
van der Waals interaction	Interaction of electrons of nonpolar substances		1

*Bond energy is the amount of energy (Kcal/mol) needed to separate two bonded or interacting atoms under physiological conditions.

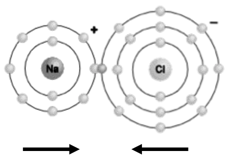
Chemical Bonds- Ionic



Ionic bonds form when one atom completely, and permanently, loses an electron to another atom.

1. An electron from a sodium atom (Na) is transferred to a chlorine atom (Cl). Results in filled outer shells for both atoms.
2. Both now have an unequal number of protons and electrons and, therefore, carry a charge. They are now called **ions**.

Table Salt Demonstrates Ionic Bonding

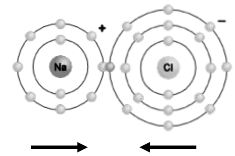


3. The two oppositely charged ions are attracted to each other. Their opposite charge holds the ions together.

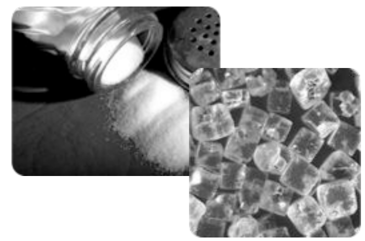
Sodium cation (Na^+)   Chloride anion (Cl^-)

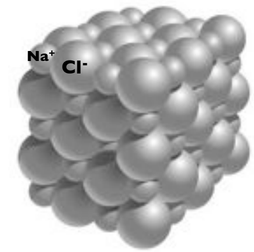
Positively charged ions are referred to as **cations**
Negatively charged ions are referred to as **anions**

Table Salt Demonstrates Ionic Bonding

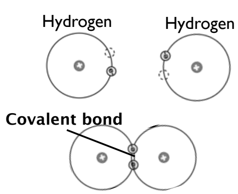


3. The two oppositely charged ions are attracted to each other. Their opposite charge holds the ions together.

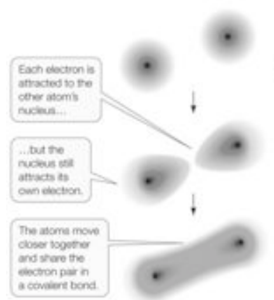




Chemical Bonds- Covalent

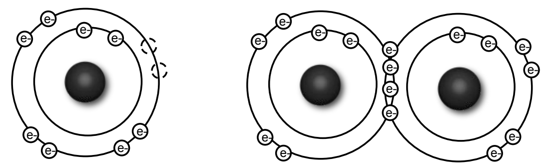


Instead of donating (or stealing) of electrons, they are "shared".



Alternative way of expressing covalent bonds   H – H
Atmospheric Hydrogen H_2

Oxygen Forms Covalent Bonds with Two Electrons



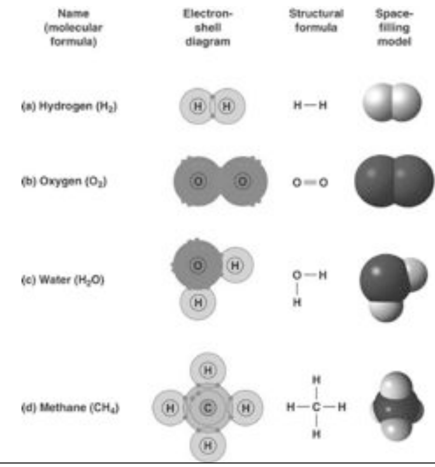
Oxygen $O = O$

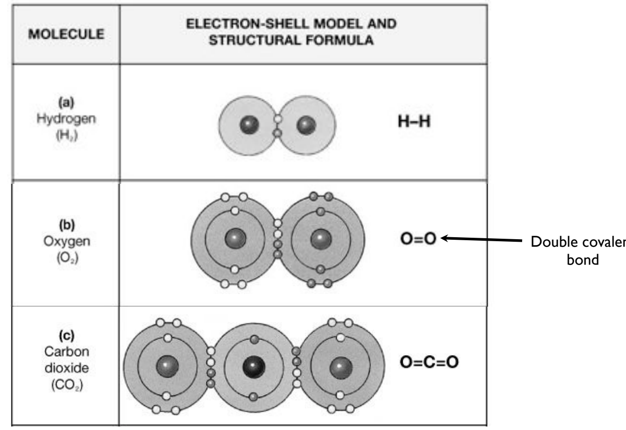
O_2

* Atoms that participate in covalent bonds usually only share as many electrons as they need.

Nonpolar covalent bond: electrons are shared equally

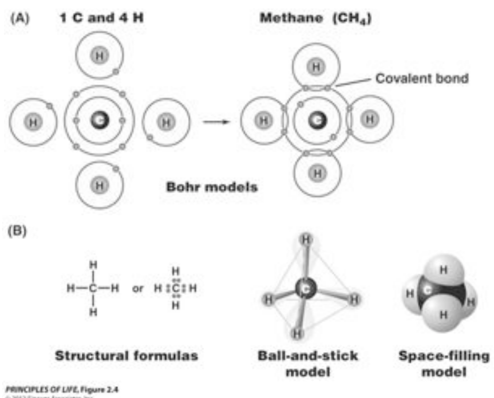
Covalent bonding in four different molecules





Covalent bond- Carbon

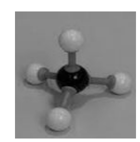
If carbon has 6 electrons, how many covalent bonds can it form?



Covalent bond

4 important aspects of covalent bonds

1. Orientation
2. Strength/stability
3. Multiple covalent bonds
4. Degree of electron sharing



1. Bonds between the same elements always have the same length and angle.

3. Covalent bonds can involve a single pair C-H
   2 pairs (double bond) C=C
   or 3 pairs (triple bond) of electrons

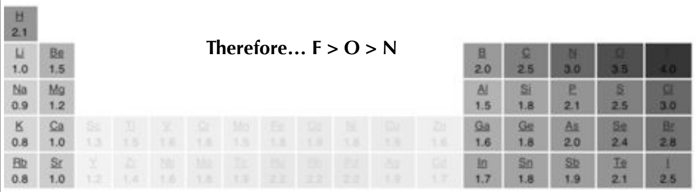
4. One nucleus may exert a greater attractive force on the electron pair, so it tends to be closer to its nucleus

Electronegativity

An elements ability to **GAIN** (steal) electrons is a measure of its "**electronegativity**"

The further to the *right and the top* of the table are elements that are **most electronegative**

Therefore… F > O > N



Electronegativity

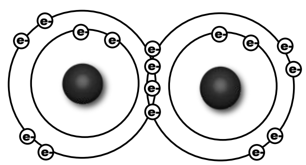
- An elements ability to **GAIN** (steal) an electron is a measure of its "**electronegativity**"

TABLE 2.2 Some Electronegativities

ELEMENT	ELECTRONEGATIVITY
Oxygen (O)	3.4
Chlorine (Cl)	3.2
Nitrogen (N)	3.0
Carbon (C)	2.6
Phosphorus (P)	2.2
Hydrogen (H)	2.2
Sodium (Na)	0.9
Potassium (K)	0.8

PRINCIPLES OF LIFE, Table 2.2

Review: Covalent vs. Ionic bonds



- Two or more atoms joined in a bond are now referred to as a **molecule**
- Covalent bonds are typically stronger than ionic bonds
- Ionic bonds: steal e- Covalent bonds: share e-
- Atoms will typically share the same number of electrons they need to fill their outer orbital