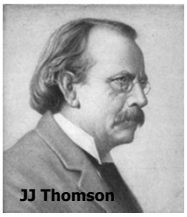
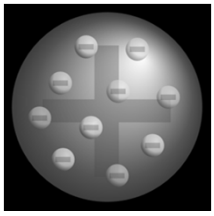
Physical Science

Chapter 18
Atoms and Bonding

Atomic Models in History

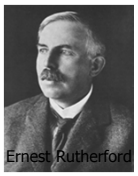
- Democritus, Greek philosopher, around 400 BC used the term "atomos" which means "indivisible-unbreakable" to describe (where we get the word "atom")
- John Dalton, 1808 – very similar to Democritus said atoms were like solid balls
- JJ Thomson, 1897 – described the atom as a positively charged sphere with negatively charged electrons embedded inside to create a neutrally charged particle. Often described as a muffin w/ berries scattered throughout.

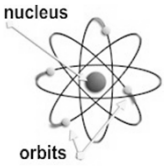


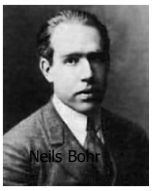


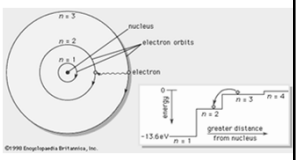
Atomic Models in History

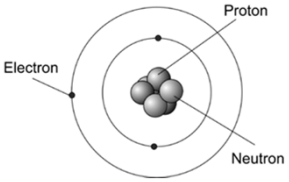
- Rutherford, 1911 – refined Dalton's theory & stated atom is mostly empty space and the negatively charged electrons randomly orbit the positively charged nucleus.
- Bohr, 1913 – Said electron NOT random but in specific layers or energy levels. Increasing in energy the farther from the nucleus
- Chadwick, 1932 – realized the mass of the atoms didn't correspond to the mass suggested by Bohr's model. He discovered the neutron and determined they were in the nucleus with the protons
- Modern Theory, present – shows electrons not in orbits but specific clouds, each having their own level of energy


Ernest Rutherford



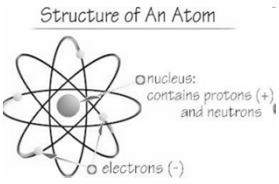

Neils Bohr

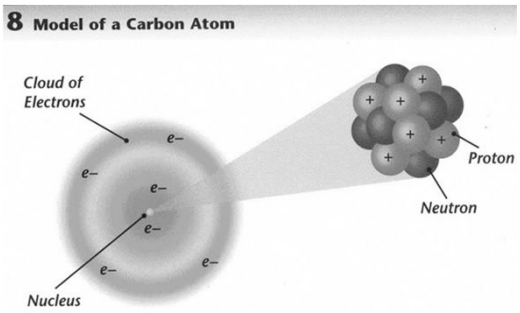




Parts of an Atom

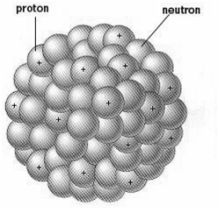
- An atom consists of a nucleus surrounded by one or more electrons
- Atoms are **electrically neutral** w/ the ***same number of protons as electrons***.
- Majority of the atom is **empty space**. If nucleus were the size of a pencil eraser, the closest electron would be 100 yards away!
- Subatomic Particles
  - Protons
  - Neutrons
  - Electrons
- Nucleus: Tightly packed Protons & Neutrons
- Electrons Orbiting nucleus @ 1% speed of light!!





Atomic Mass

- How much does an atom "weigh"?
- What is the mass of an atom?
- SI Unit for mass is the Gram…. Way toooo big to accurately "mass" an atom
- Came up w/ new unit, an AMU (atomic mass unit)
- 1 AMU = mass of 1 Proton
- mass of subatomic particles
  - Proton = 1 AMU
  - Neutron = 1 AMU
  - Electron = .0005 AMU
- Atomic Mass = the total # of both Protons & Neutrons in the atom
  - (we don't worry about the mass of the electrons since they have almost no mass)



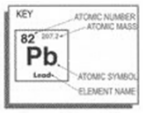
Atomic Number

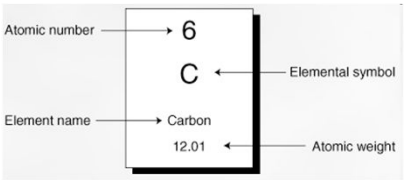
- By definition:
  - The Atomic Number = the number of Protons present in the nucleus of an atom
- Each Element in the Periodic Table has a different number of Protons, therefore each element has a different, unique, atomic number.

"Small" number is always the atomic #, therefore the number of protons present

"Large" number is always the Atomic Mass which tells us the total # of both Protons & Neutrons present

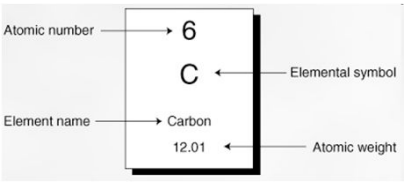
When reading the Periodic table notice each element has a unique 1 or 2 letter symbol and "big" & "small" number listed

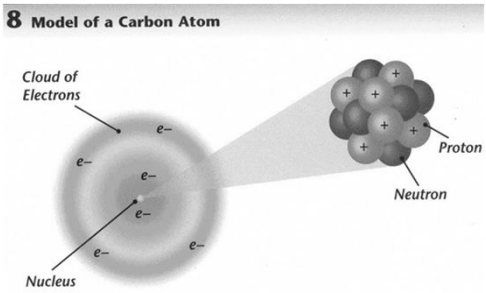




Electrical Atomic Charge

- Electrical charge – all atoms have a neutral charge
  - (a zero net electrical charge)
- Protons have a positive (+) electrical charge
- Neutrons have a neutral (0) electrical charge
- Electrons have a negative (-) electrical charge
- Since the net electrical charge is 0 (neutral), if you have 10 Protons (10 "+" charges) then there must be 10 "-" charges (10 electrons) present to balance out the atom.
- Therefore, as long as you know the Atomic #, you know the # of Protons and also the # of Electrons!!





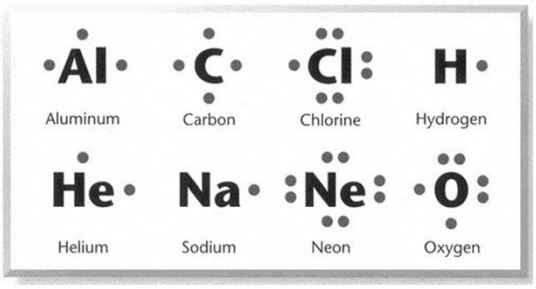
For example:

Carbon has an atomic # of 6, it therefore has 6 Protons which has an electrical charge of +6, to make the atom neutral we need 6 negative charges found in the 6 electrons orbiting the nucleus.

Valence Electrons

- Electrons are found in specific orbits/clouds spinning around the nucleus
- Valence electrons are the electrons located in the outermost orbit/cloud

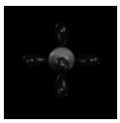
Elements become stable when: their outer orbit contains 8 electrons or their outer orbit becomes empty

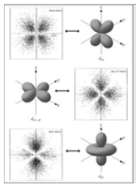


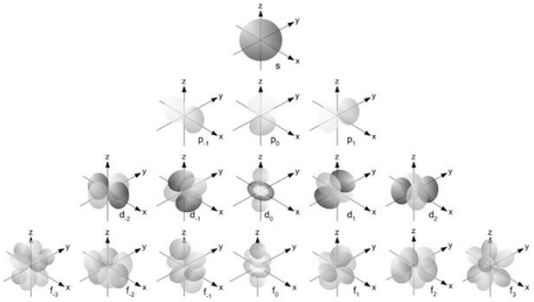
Lewis Dot Diagrams show the # of Valence Electrons

Electron Orbits – Energy Levels

- Orbits are named: 1s,2s,2p,3s,3p,3d,4s,4p,4d,4f,5s,5p,5d,5f,6s,6p,6d,6f,7s
- How many in electrons each sub orbit?
  - S sub orbits hold 2 electrons
  - P sub orbits hold 6 electrons
  - D sub orbits hold 10 electrons
  - F sub orbits hold 14 electrons

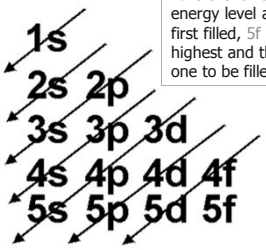






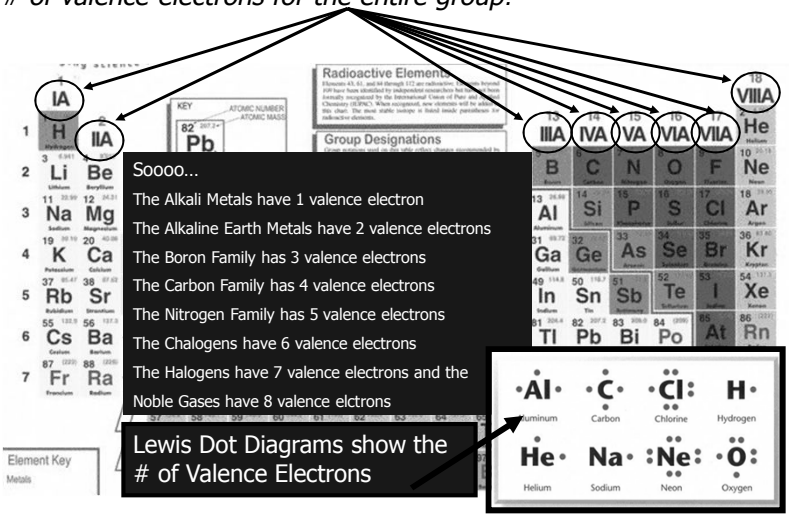
Here's the order used to fill the different energy levels

1s is the lowest energy level and the first filled, 5f is the highest and the last one to be filled.



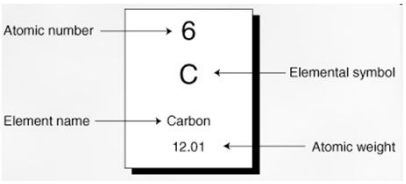
Valence Electrons

- Our Periodic Table also is arranged to easily determine the number of valence electrons an atom has:
- *By looking at the "A" group #'s, the Roman numeral identifies the # of valence electrons for the entire group!*



How many Neutrons are there?

- Remember:
  - The Atomic # = the # of Protons
  - The Atomic mass = The # of both Protons & Neutrons.
  - Therefore, if you subtract the Atomic # (the number of Protons) from the Atomic mass (the number of both Protons & Neutrons) what is left over must be the number of Neutrons!!



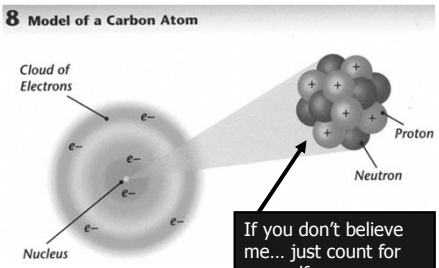
For Example w/ Carbon:

Atomic Mass-Atomic # = # Neutrons

Atomic Mass = 12, Atomic # 6

12 – 6 = 6

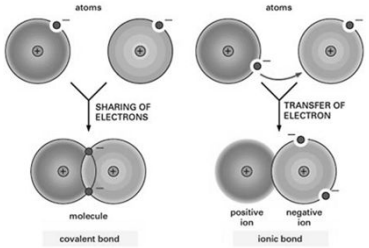
Therefore there are 6 neutrons present in the Carbon nucleus



If you don't believe me… just count for yourself.

Chemical Bonds

- A *chemical bond* forms between two atoms when valence electrons move between them
- Two main types of chemical bonds
  - Covalent Bonds: occur between atoms when valence electrons are shared.
  - Ionic Bonds: occur when valence electrons are transferred (stolen) between atoms
  - A third type of bond between atoms are hydrogen bonds



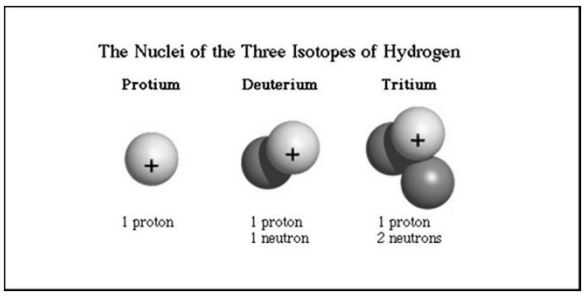
Isotopes & Allotropes

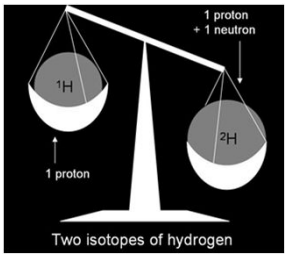
Atoms of the same element can have different numbers of neutrons

The number of Neutrons in an atom will sometimes vary, that's why the atomic mass of the elements is not an even number. For Hydrogen, the mass is 1.008. Most atoms of Hydrogen have 0 neutrons, but some have 1 neutron and a very very few will have 2 neutrons.

When you "weigh" trillions of Hydrogen atoms you find that almost all of them will not have any Neutrons, & several of the atoms will have 1 neutron and maybe 1 or 2 will have 2 Neutrons.

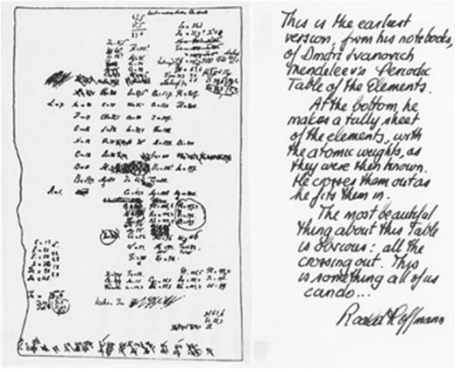
If you were to take an average of all of the Hydrogen atoms in your sample, the atomic mass would reflect the different Isotopes present and be 1.008 AMU's.





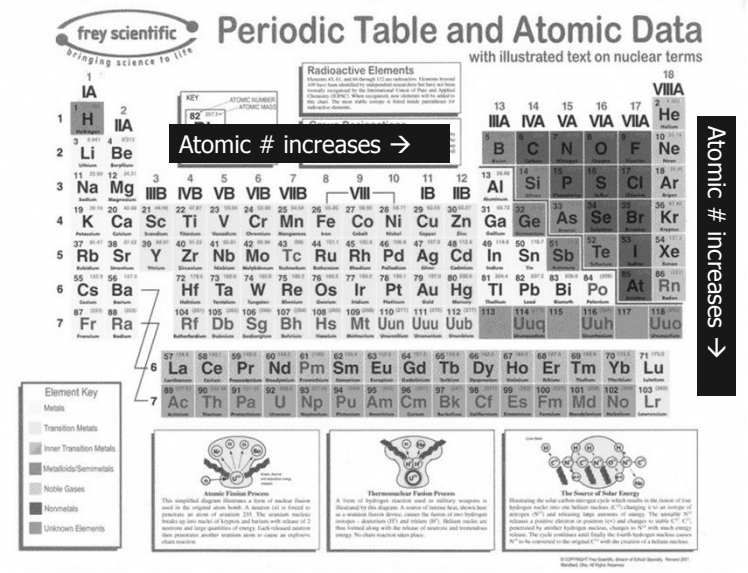
Dmitri Mendeleev - 1869

- Mendeleev was born in Siberia, Russia in the year 1834. He died in 1907
- He was a professor of Chemistry at the St. Petersburg University.
  - Trying to explain to his students how elements had similar properties, he started organizing the elements into rows and columns
- He observed that some elements have similar chemical & physical properties
- The first periodic table was organized by atomic mass
  - The masses were compared to Hydrogen, the lightest known element at the time.
- The modern Periodic Table is organized by Atomic number

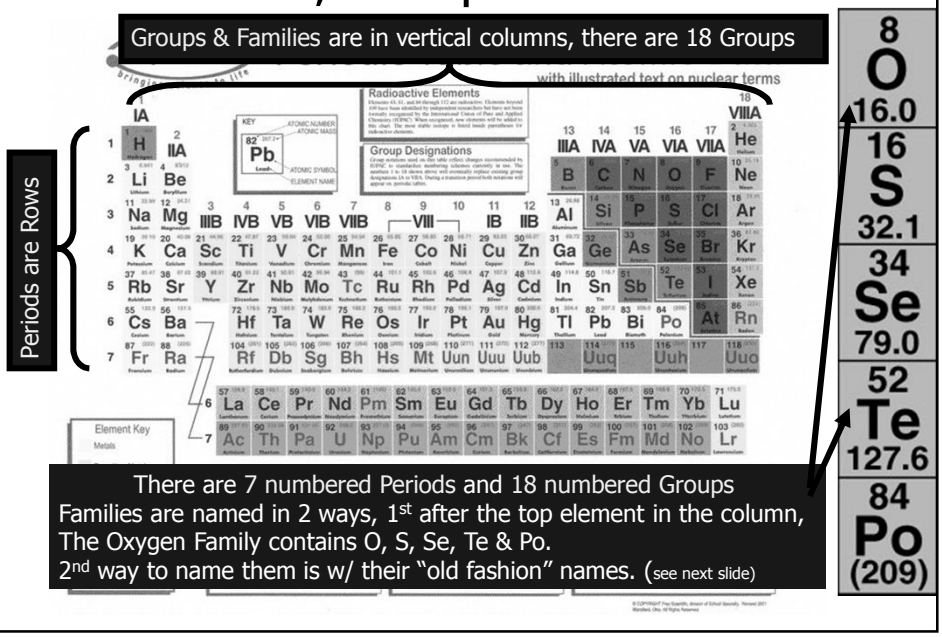


Organizing the Elements

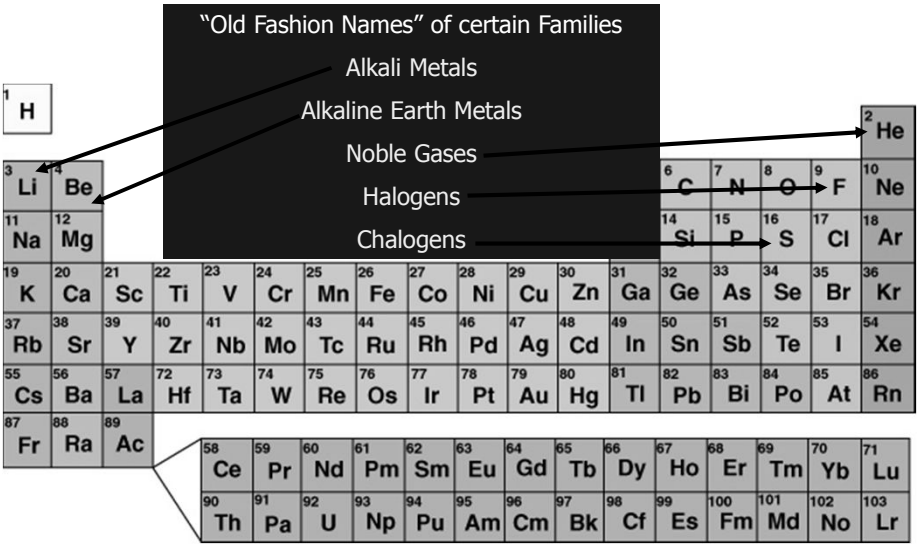
- The periodic table is laid out by increasing **atomic number** as you go across and down the table



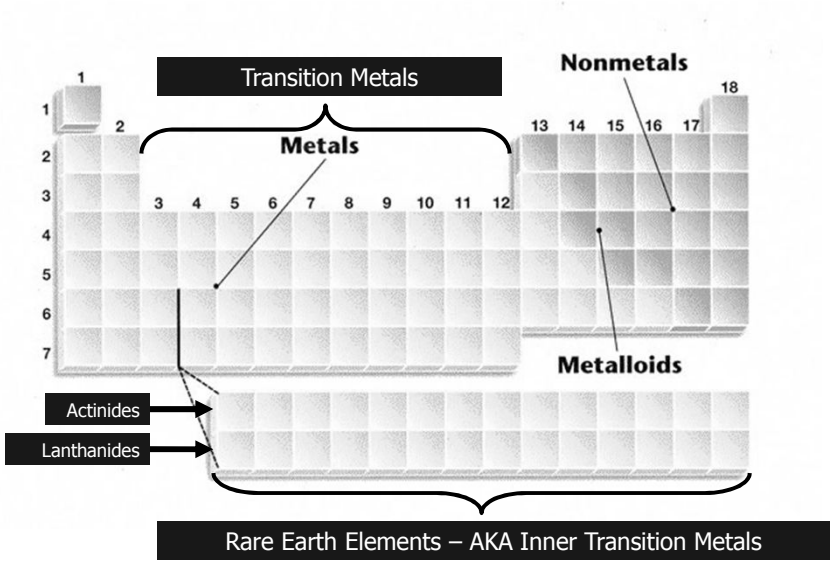
Periods, Groups & Families



"Need-to-Know Families

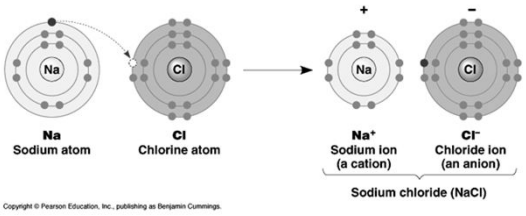


More Need-to-Knows



Ionic Bonding

- When an atom gains or loses and electron or two they no longer have a neutral charge. A charged atom is called an "Ion"
- An Ion w/ extra electrons makes it negatively charged, this an Anion
- An Ion w/ more protons than electrons makes it positively charged & is called a Cation.
- A "+" ion (cation) is attracted to a (-) ion (anion) just like two magnets are attracted to each other
- When ions get close enough together they form an chemical bond – an Ionic Bond!



Ding-a-Ling! Ding-a-Ling! A metal and a nonmetal will form Ionic Bonds when chemically bonded together!!

Naming Ionic compounds

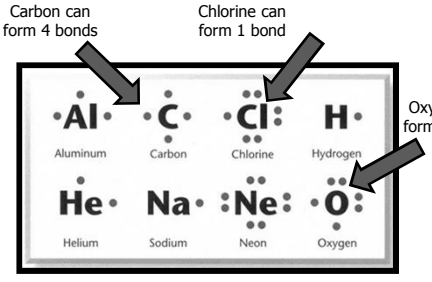
1. The metal is named first
2. If the anion is an element, the end of its name is changed ti "ide"
3. Polyatomic ions usually keep their names

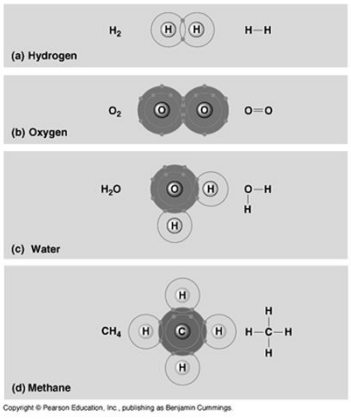
NTK - "Polyatomic" ions

HCO_3^{-1} Bicarbonate
NO_3-1 Nitrate
O^{-2} Oxide
SO_4^{-2} Sulfate
CO_3^{-2} Carbonate

Covalent Bonding

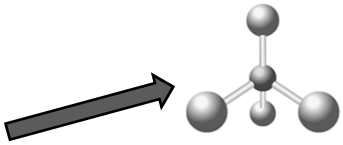
- When valence electrons are "shared", covalent bonds are formed
- They are generally weaker than Ionic bonds
- The number of bonds an atom can form is equal to the number of electrons needed to reach the required 8 valence electrons
- Hydrogen needs only 1 to be like Helium that has 2 and fills its "S" orbit.





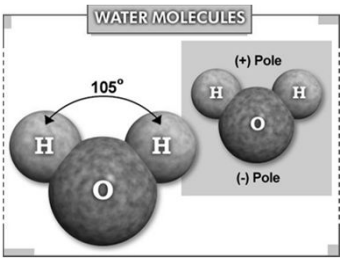
Ding-a-Ling! Ding-a-Ling! Two or more nonmetals will form Covalent Bonds when chemically bonded together!!

Polar or Nonpolar Covalent Bonding



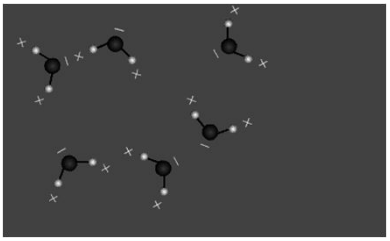
Carbon Tetrachloride

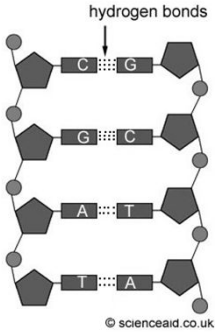
- Nonpolar Covalent Bonds - Equal sharing of electrons
- Polar Covalent Bonds – an unequal sharing of electrons
- Some atoms pull stronger on the shared electrons than other atoms
  - These electrons move closer to these atoms and they become more negatively charged
  - The atom that the shared electrons move away from become slightly positively charged

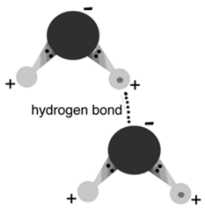


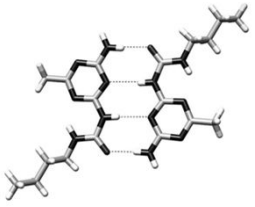
Hydrogen Bonds

- The weak attractive force of a hydrogen atom and a negatively charged part of another molecule/atom.





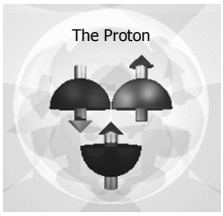


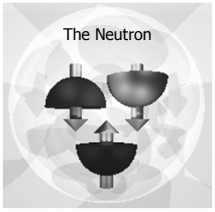


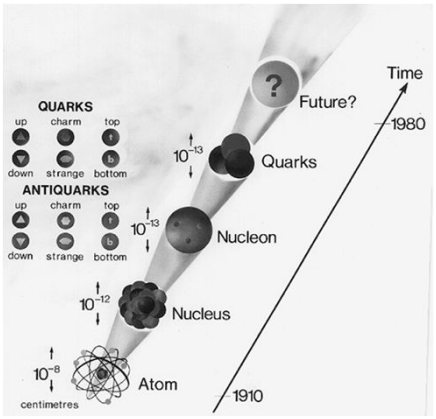
Here's a little secret….Quarks!

- Protons and Neutrons can be broken into smaller elemental particles called quarks!
- Quarks – the building blocks of subatomic particles. These "FLAVORS" come in 3 pairs, so there are 6 different quarks: Up, Down, Top, Bottom, Charmed and Strange
- A quark has a mass of 1/3 AMU
- An Up quark has a 2/3 positive charge and a Down quark has a 1/3 negative charge
- A proton is made up of 2 "up" quarks and 1 "down" quark
- A neutron is made of 2 "Down" quarks and 1 "Up" quark.

The electron is also an elementary particle known as a "Lepton" & has a mass 1/612 that of a quark







No Mas!!
No Mas!!
We be done!!