Chapter 4 - Atoms and the Periodic Table

4.1 - Atomic Structure

What happens if you take matter and keep breaking it in half?

4th Century - Democritus

Suggested everything made of atoms

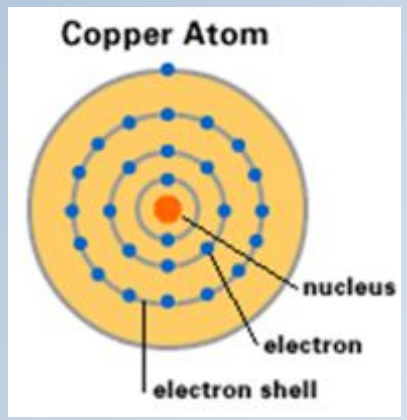
1808 - Dalton

Atoms cannot be divided

Atoms of an element are all the same

They join to form compounds

Atoms - smallest part of element with same properties of element



Copper coin - all one element

Water - H_2O

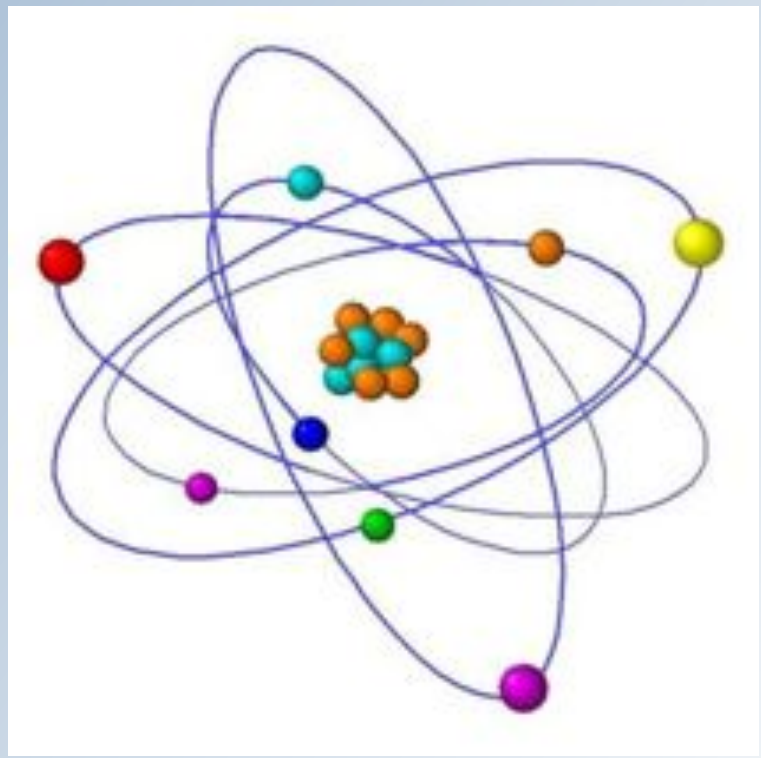
Diameter of atom - 50 to 500 billionths of a millimeter

Atoms - made of subatomic particles

Protons

Neutrons

Found in the **Nucleus**



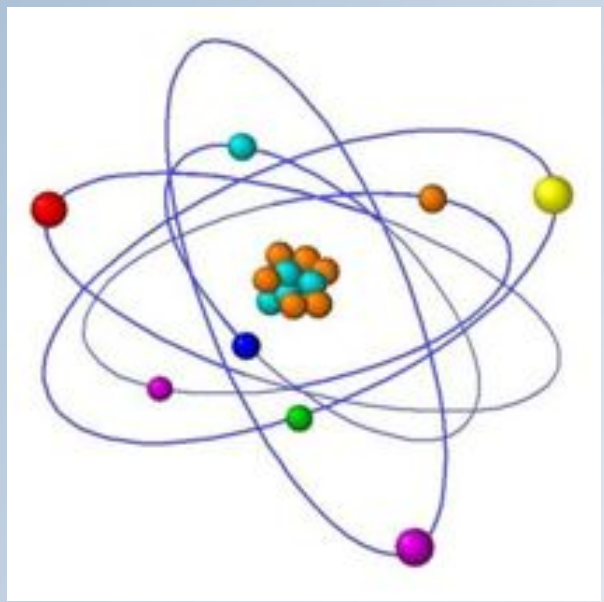
Protons

Neutrons

Same size, mass

Positive charge

No charge

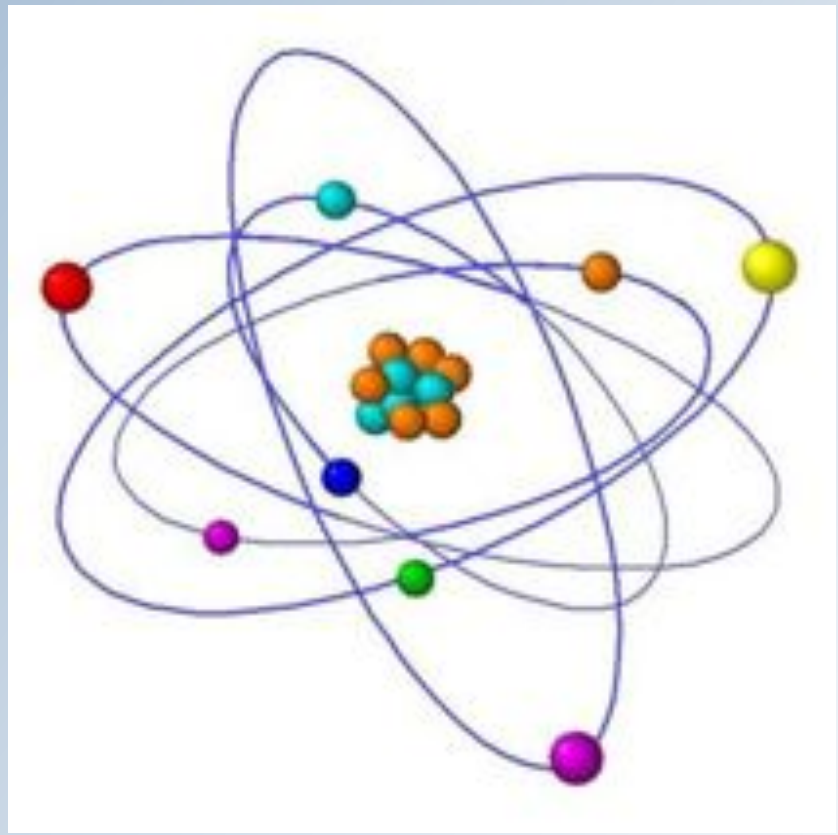


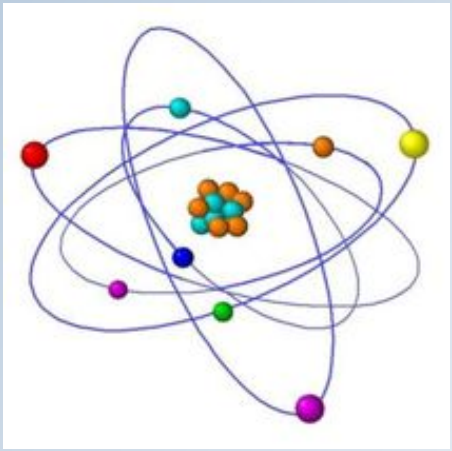
Electrons

Tiny, almost mass-less particles

Orbit around nucleus

Negative charge





If nucleus = size of marble

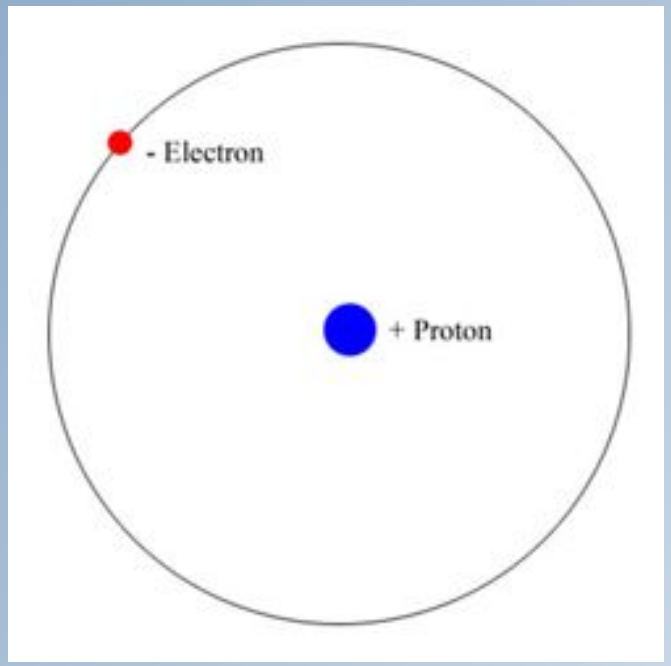
Whole atom would be size of a football stadium

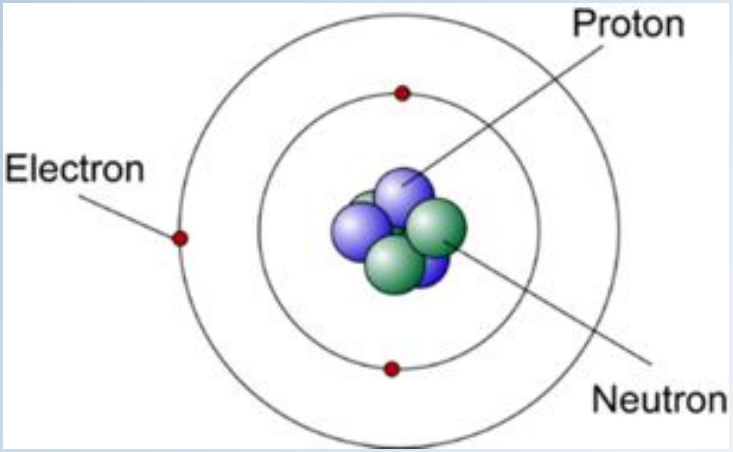
Lots of empty space!

Atoms have no over all charge

Example - Hydrogen = 1 proton and 1 electron

+1 & -1 = 0 charge

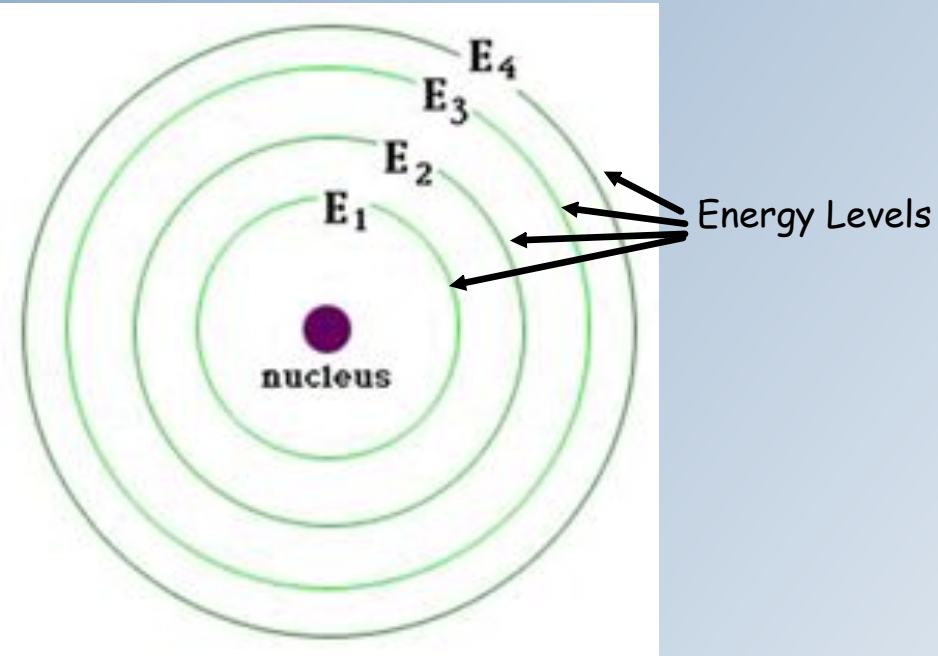


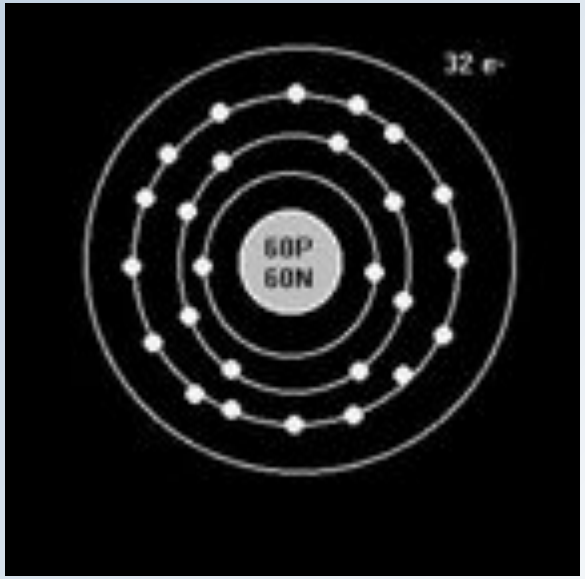


1913 - Bohr suggested electrons follow set paths around nucleus like planets orbiting sun

Each electron carries energy

Electrons in farther out orbits have more energy

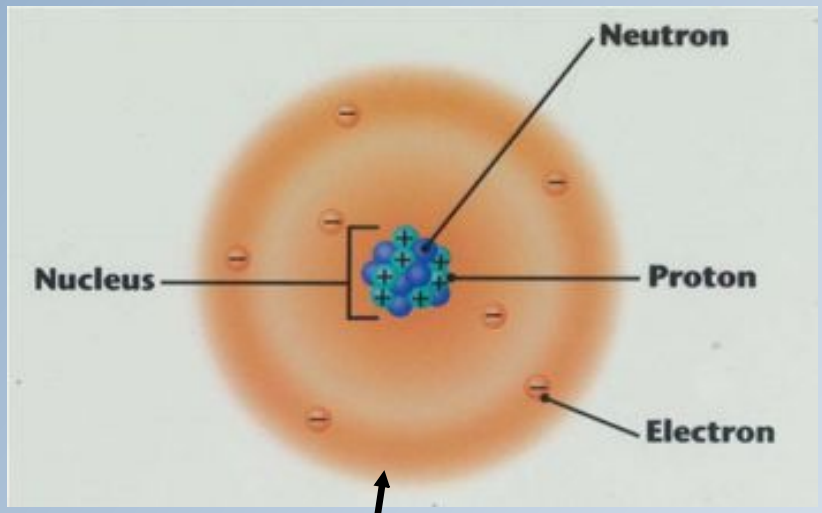


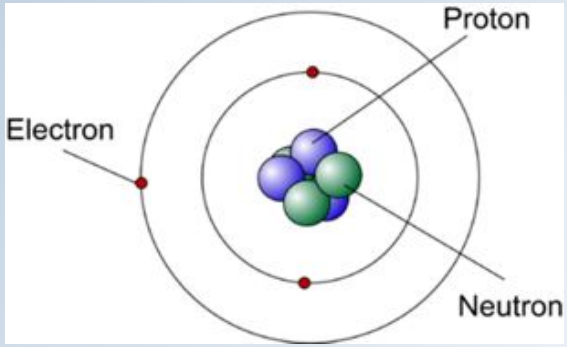


It's impossible to know the exact location of an electron

Like blades on a fan

Electron Cloud - general area electrons occupy





More accurate depiction

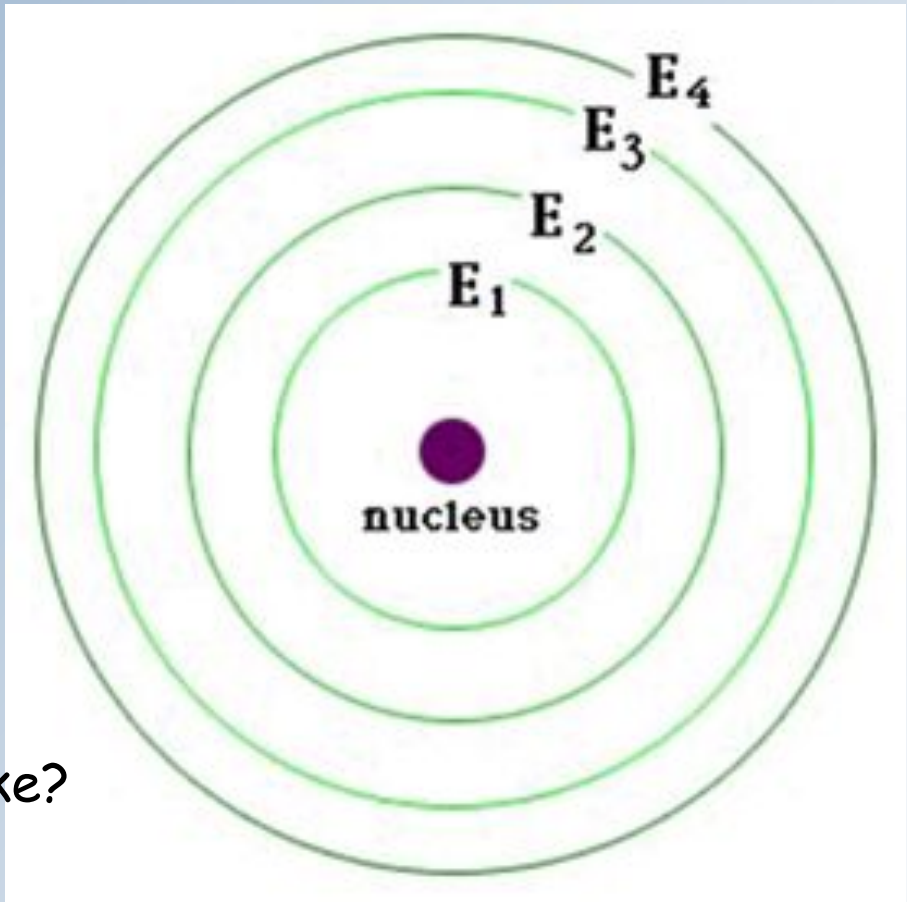
Energy Levels

The first energy level holds 2 electrons

2^{nd} = 8 electrons

3^{rd} = 18 electrons

4^{th} = 32 electrons



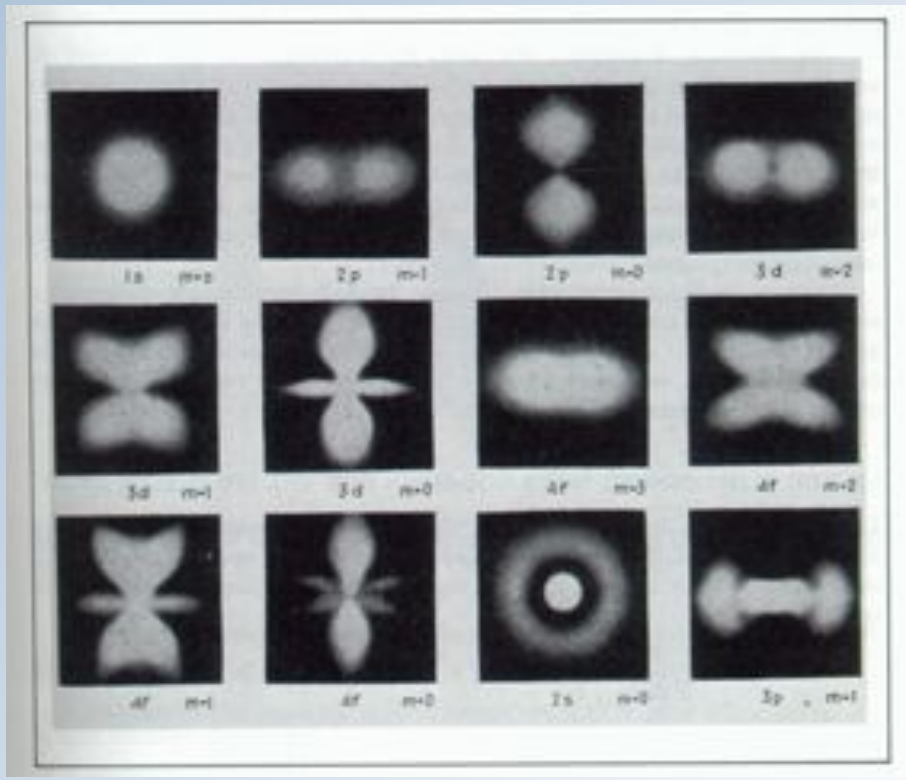
What would oxygen look like?

Within each energy level there are various **orbitals**

s, p, d, and f

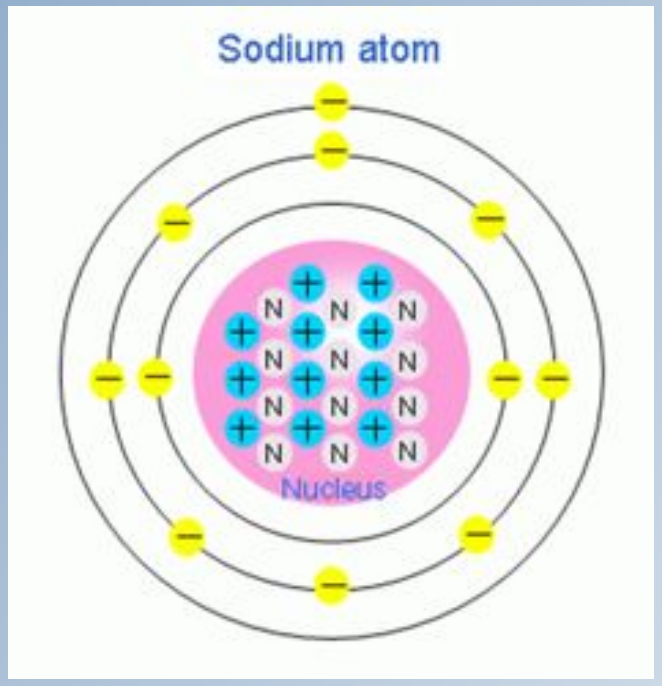
low energy ⟶ high

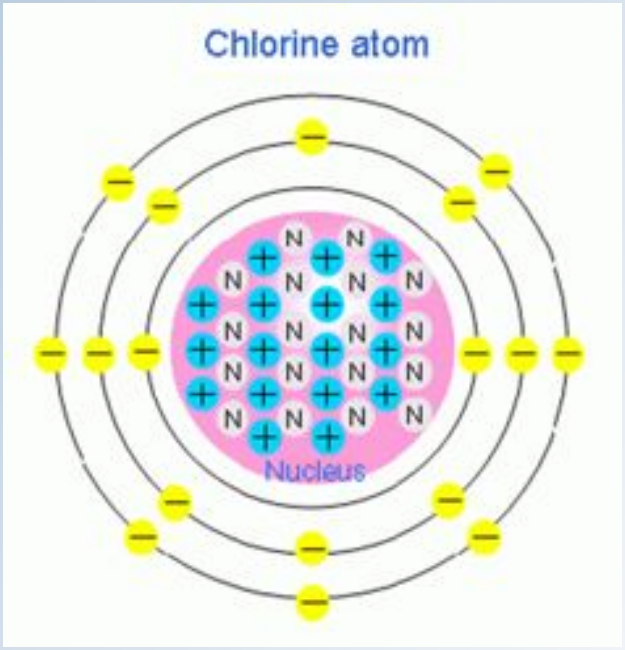
each orbital holds 2 electrons



Electrons in outermost energy level
are called **valence electrons**

These electrons determine chemical properties of atoms
and how they form bonds with other atoms





Octet Rule

Atoms tend to gain, lose or share one or more of their valence electrons to achieve a filled outer electron shell

8 = happy atoms 

Section 2 - A Guided Tour of the Periodic Table

Each row is called a **period**

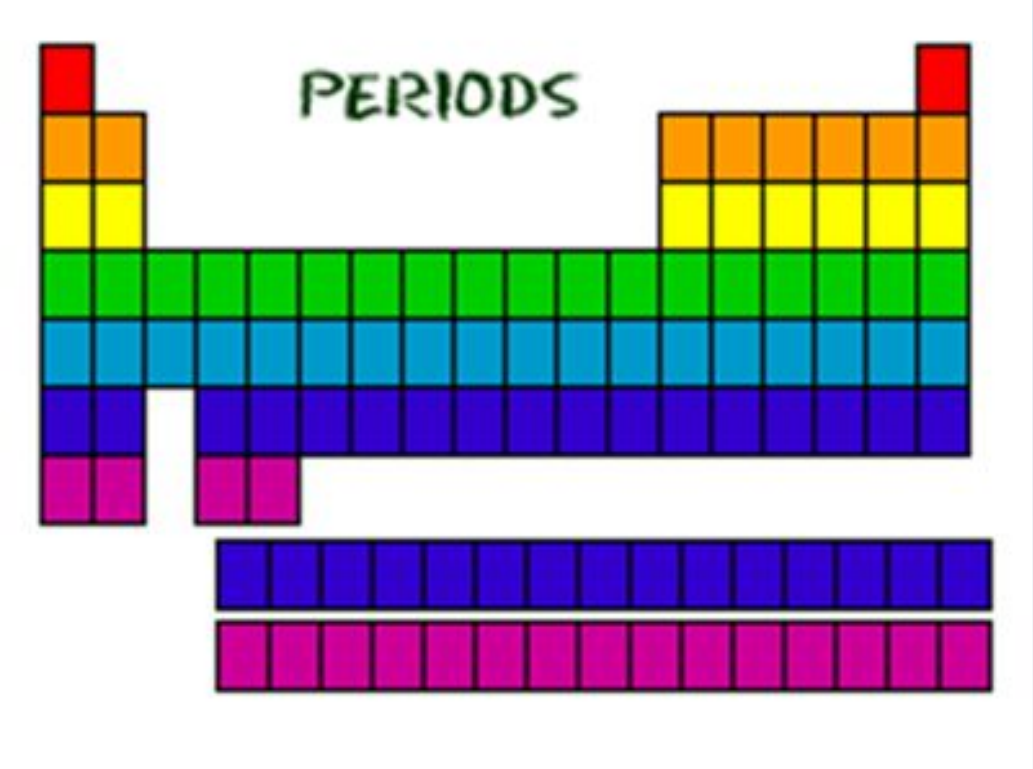
Each period has same number of energy levels

1st Period = 1 Shell

2nd Period = 2 Shells

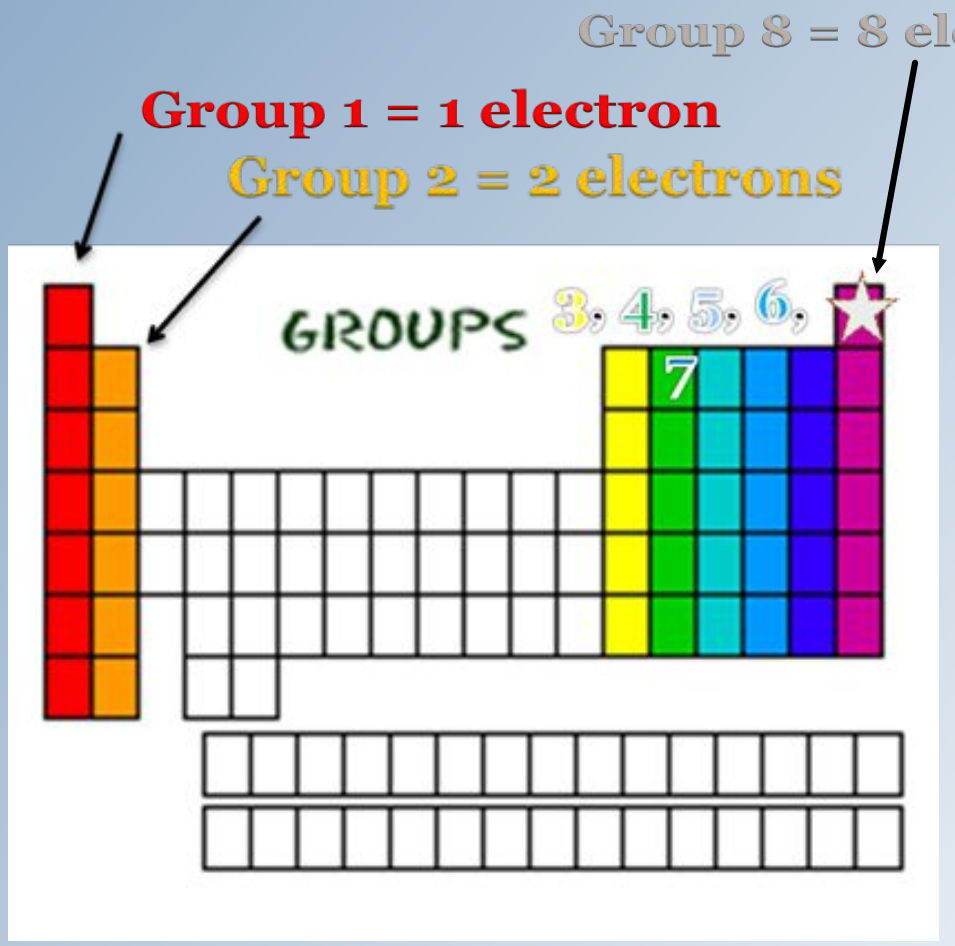
3rd Period = 3 Shells

4th Period = 4 Shells



Columns are called **groups**

Have same number of valance electrons

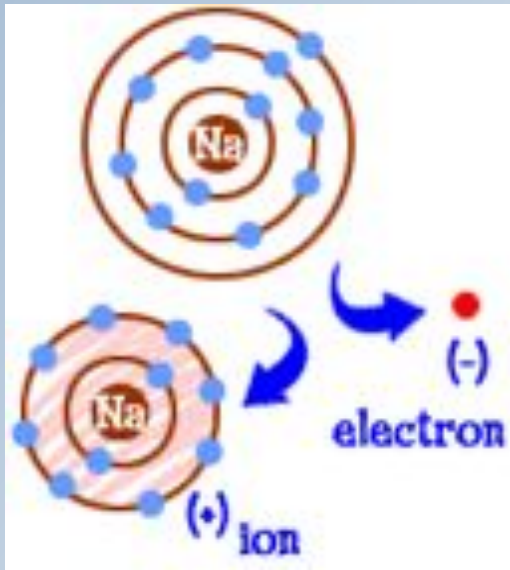


Except He, which has 2

Atoms have no over all charge

# of protons = # of electrons

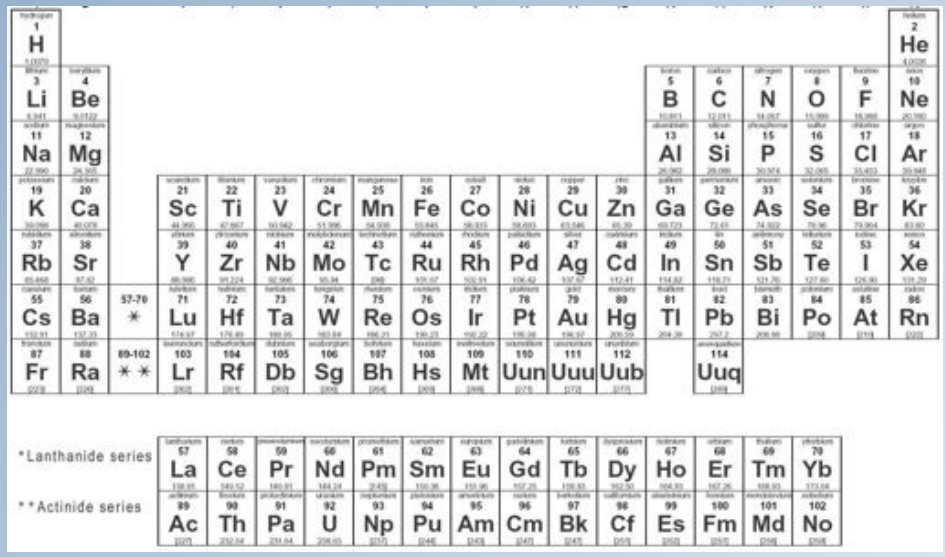
Ions are atoms that have lost or gained electrons, giving them a charge



Elements - substances cannot be broken down

92 naturally occuring

Over 100 total



# of protons determine the identity of element

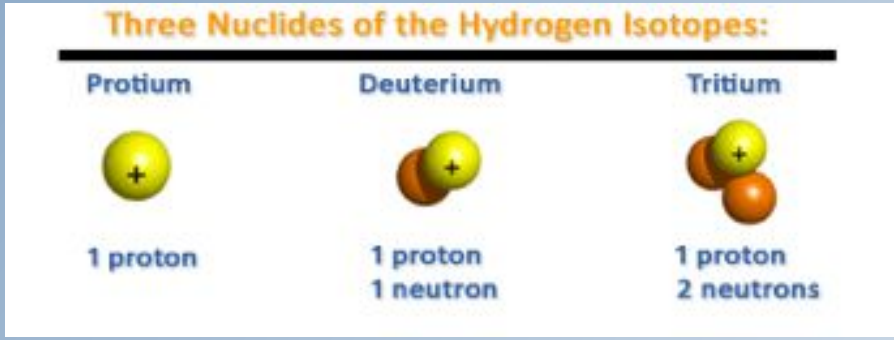
8 protons = Oxygen

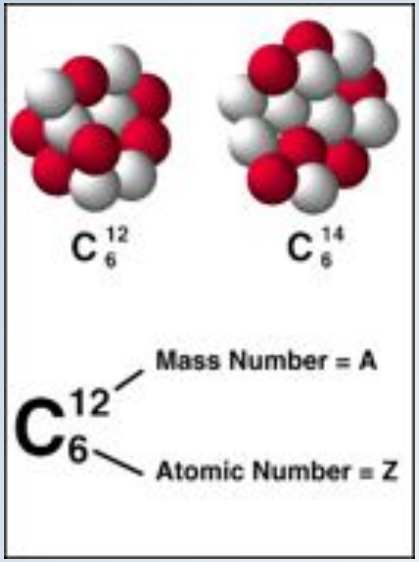
1 proton = Hydrogen

# of protons is called **atomic number**

Mass number - protons + neutrons

Oxygen - 8 protons + 8 neutrons = 16 amu's





Neutron numbers can vary!

Isotopes are atoms with varying numbers of neutrons

Uranium = 92 protons

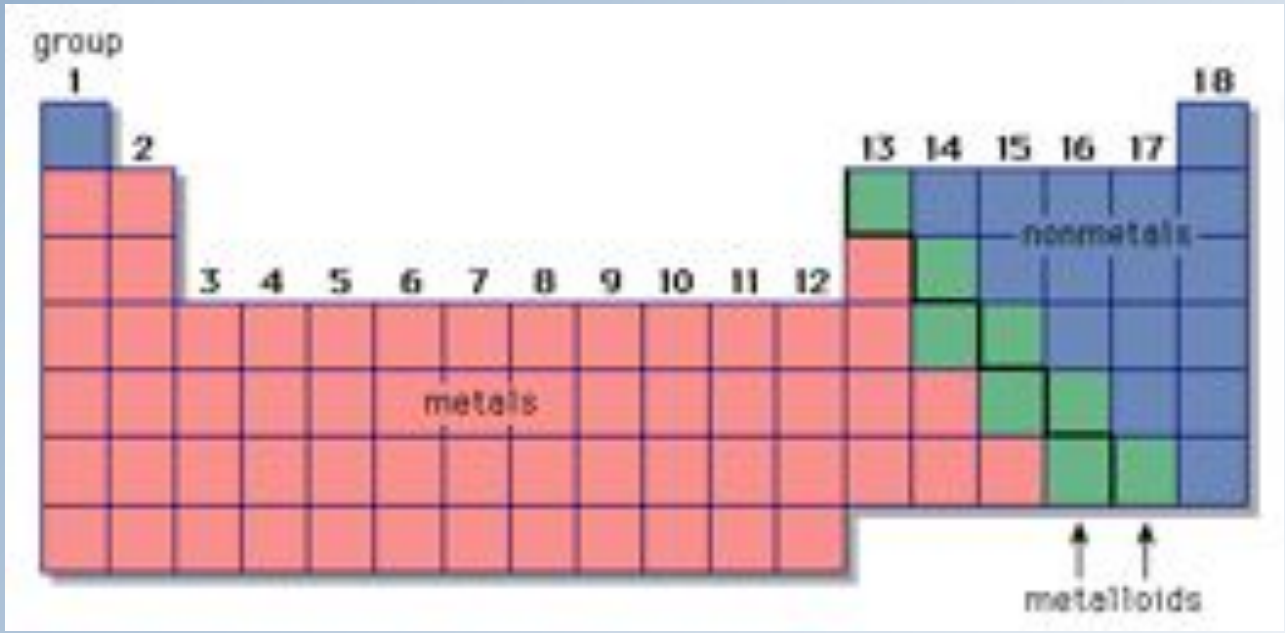
141 - 146 neutrons

Section 3 - Families of Elements

Metals - Shiny, conduct electricity and heat well

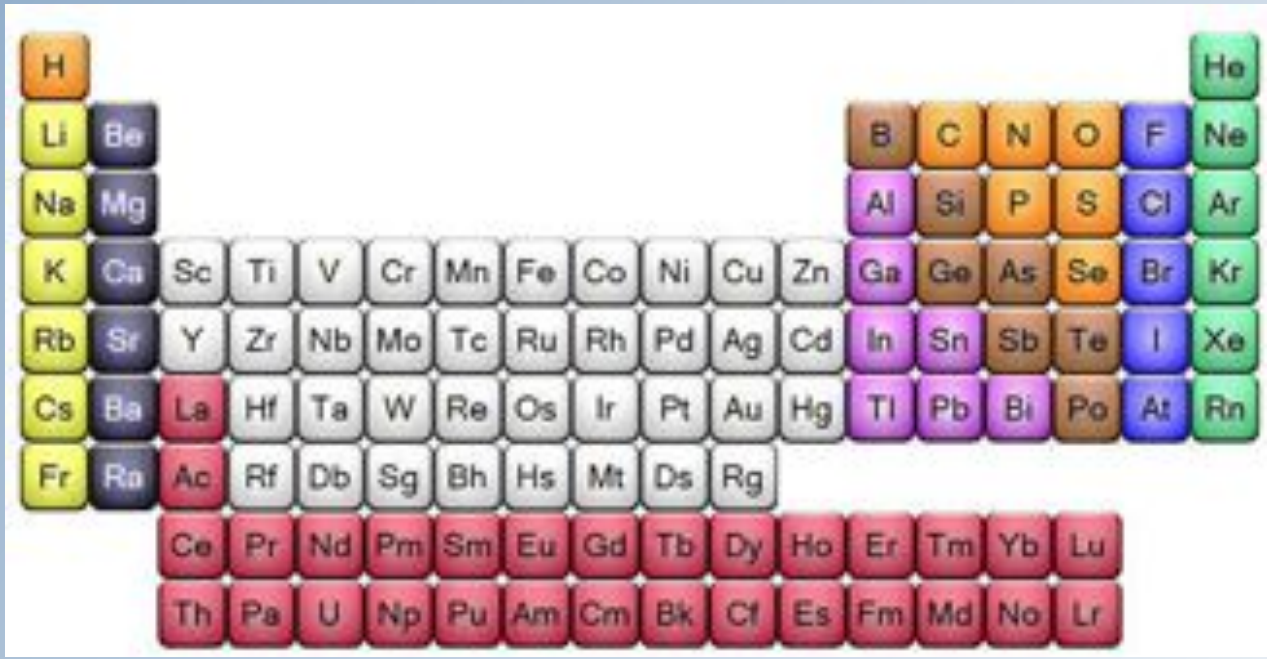
Nonmetals - Do not conduct electricity and heat well (insulator)

Semimetals (metalloids) - Conduct, but not as well as metals



Periodic table set up so elements with similar properties are grouped together

Some groups are referred to as "families"



Metal Families

Alkali Metals – Group 1. React violently with water!

- Lithium
- Sodium (must be stored in oil to prevent it from reacting with moisture in the air!)
- Potassium
- Rubidium
- Cesium
- Francium

Have 1 valence electron

Because so reactive, not found in nature alone

Instead they form compounds

Metal Families

Alkaline-Earth Metals – Group 2. Less reactive than alkali metals.

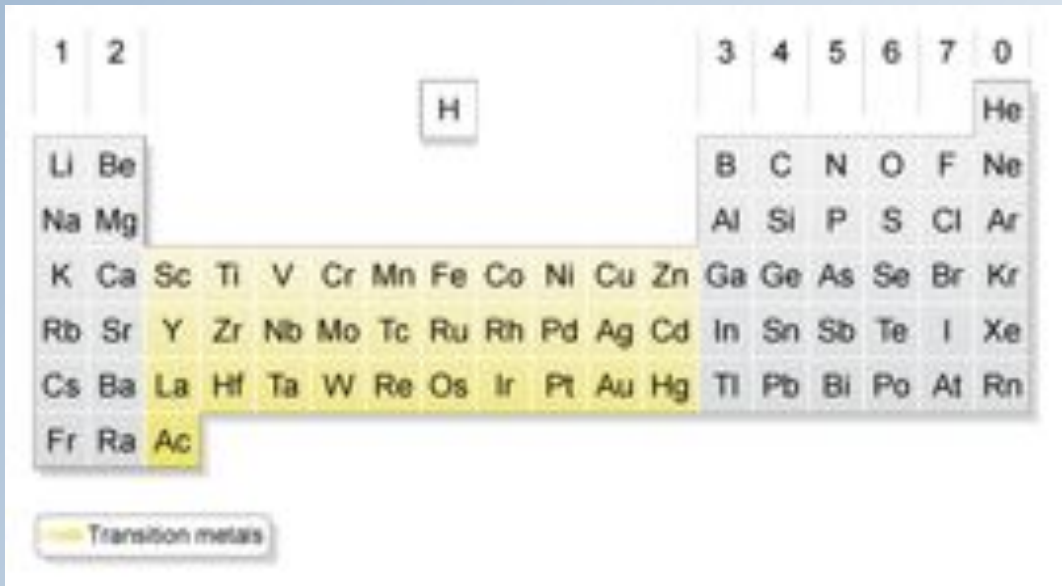
- Beryllium
- Magnesium
- Calcium (Calcium compounds form hard shells of many sea animals and egg shells)
- Strontium
- Barium
- Radium

Have 2 valence electrons

Transition Metals – Groups 3-12

Much less reactive than groups 1-2

- Gold, silver, platinum, copper, nickel, iron
- Copper – electrical wiring and plumbing
- Tungsten – Light bulb filaments
- Mercury – Only metal liquid at room temperature



Nonmetal Families

- Except for hydrogen, nonmetals are found on the right side of the periodic table

- Carbon is a unique nonmetal

Exists as graphite (pencil "lead")
Diamonds
Fullerenes
Also, important element in all living things, all fossil fuels

Nonmetal Families

Halogens – Group 7 elements

- Fluorine (Additive in toothpaste and water supply to prevent tooth decay)
- Chlorine (Used to kill bacteria in pools, and drinking water)
- Bromine
- Iodine
- Astatine

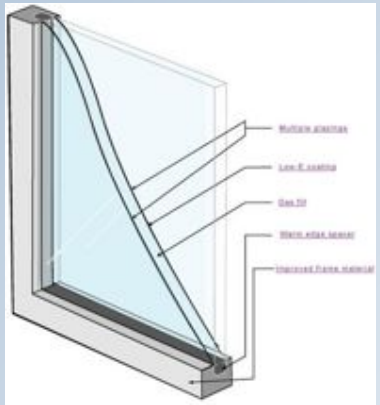
Have 7 valence electrons, like to form compounds with group 1 elements

Nonmetal Families

Noble Gases – Group 8 elements

- Helium (Lighter than air, balloons)
- Neon (Signs – Mixing neon with elements such as mercury changes the color)
- Argon (Used to fill light bulbs and insulated windows)
- Krypton
- Xenon
- Radon

Very stable, their outermost energy level is full!



Semiconductors

Semiconductors – Technically "nonmetals", but under right circumstances can conduct heat and electricity

- Boron
- Silicon
- Germanium
- Arsenic
- Antimony
- Tellurium

Section 4 - Using Moles to Count Atoms

We use many different units to count things

- Dozen Eggs, 500 sheets/ream, small, medium, large

Often we “count” things by measuring mass

- Candy shopkeeper knows that 10 gumballs have a mass of 21.4 grams
- You could then assume that 50 gumballs weight how much?

Chemists measure small particles with a unit called the **mole** (mol)

- 1 mol = 602, 213, 670,000,000,000,000,000 particles

6.022×10^{23} particles / mol

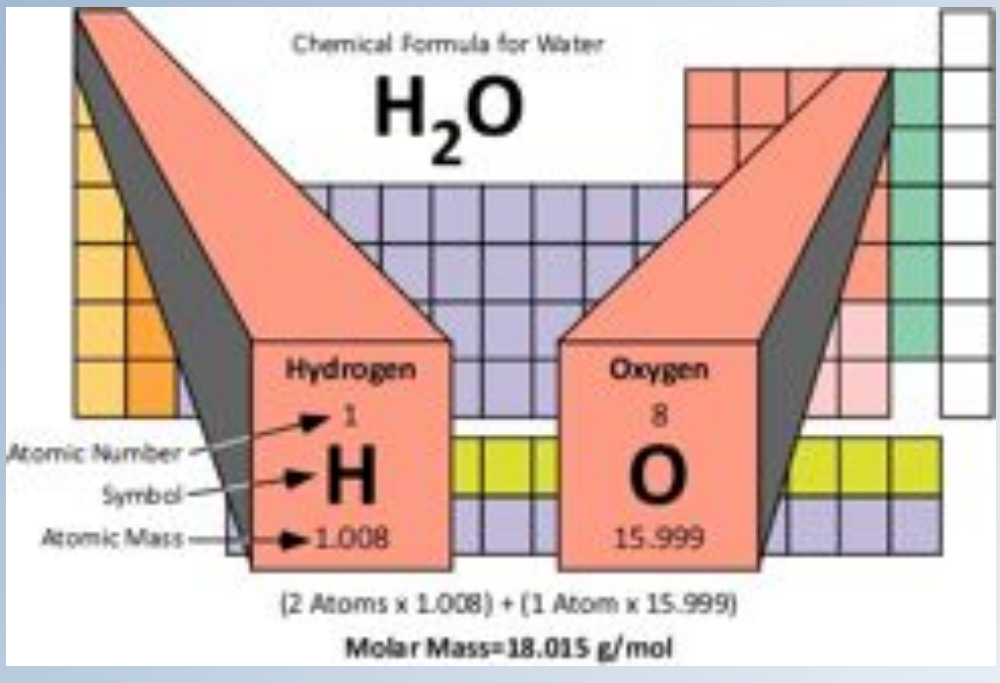
- This number is referred to as **Avogadro's Constant**

1 mole =

6.022×10^{23}

The mass in grams of 1 mol of a substance is called its **molar mass**

- 1 mol of carbon-12 atoms has a molar mass of 12 g/mol
- Molar mass (g/mol) = average atomic mass (amu)/mol



Conversion factor is a ratio that is derived from the equality of two different units and that can be used to convert form one unit to another

- How can we use conversion factors to figure out the mass of 50 gumballs, if we know that 10 gumballs = 21.4 grams?