

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

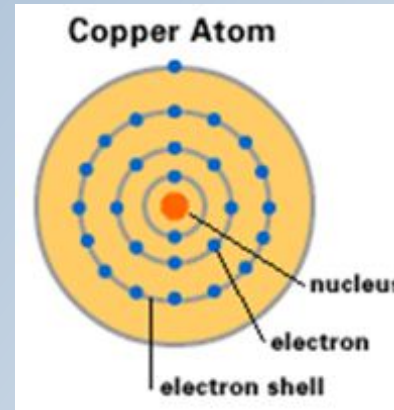
1808 - Dalton

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 - H₂O



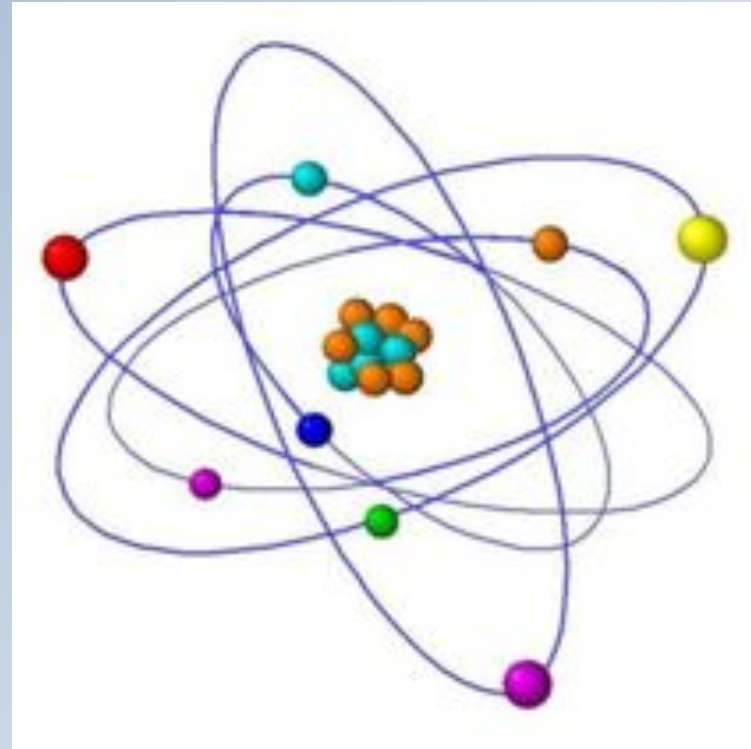
Diameter of atom - 50 to 500
billionths of a millimeter

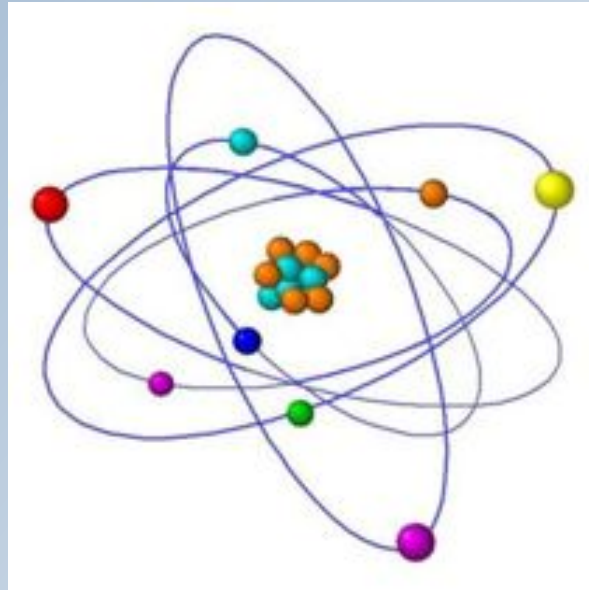
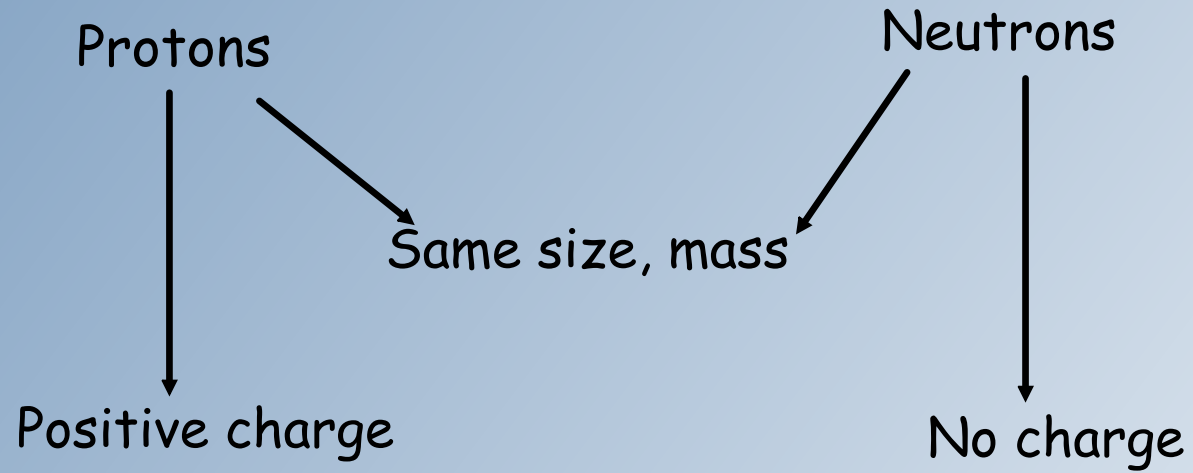
Atoms - made of subatomic particles

Protons

Neutrons

Found in the Nucleus



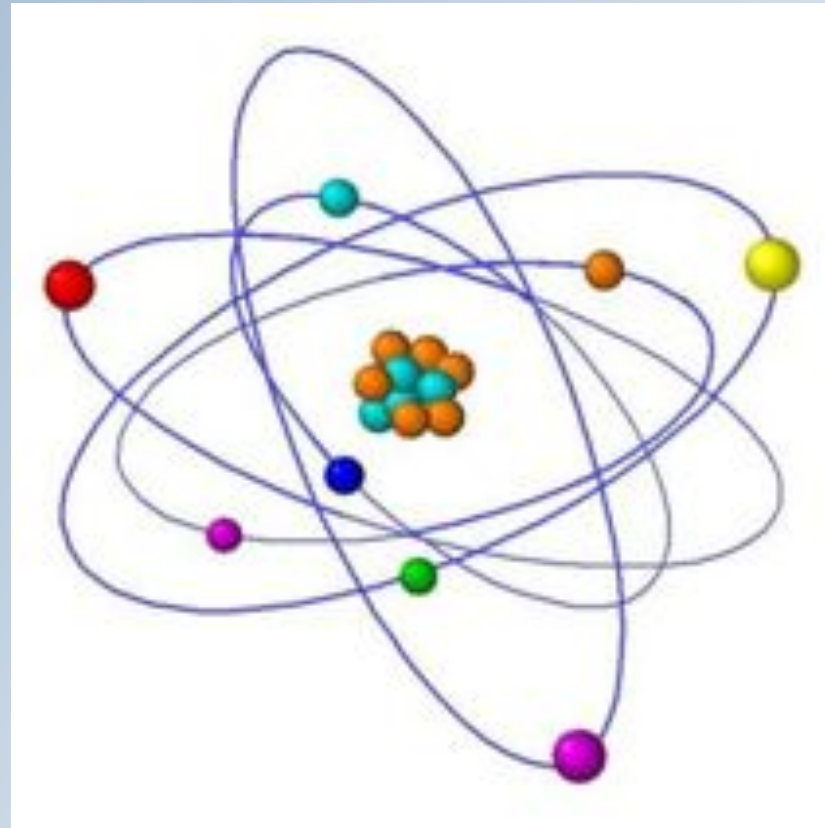


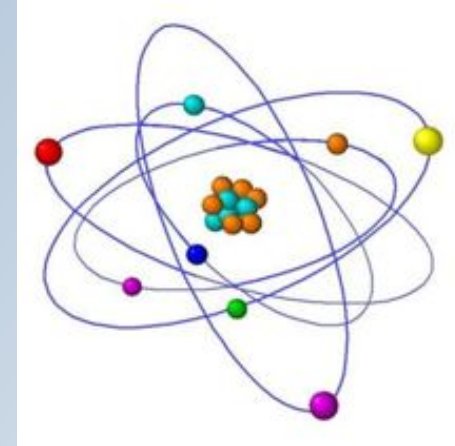
Electrons

Tiny, almost mass-less particles

Orbit around nucleus

Negative charge





If nucleus = size of marble

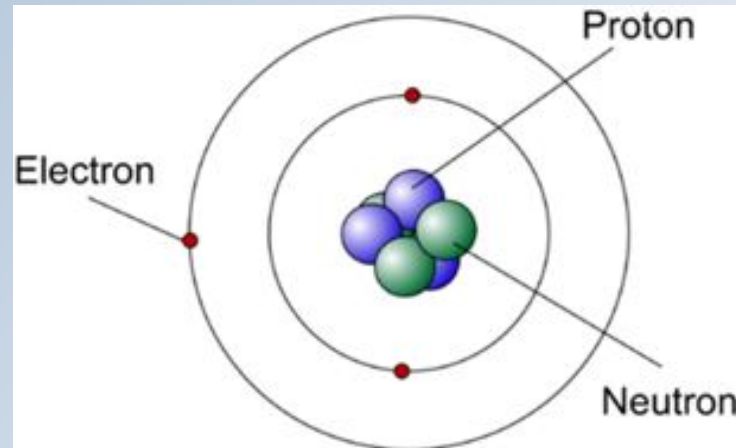
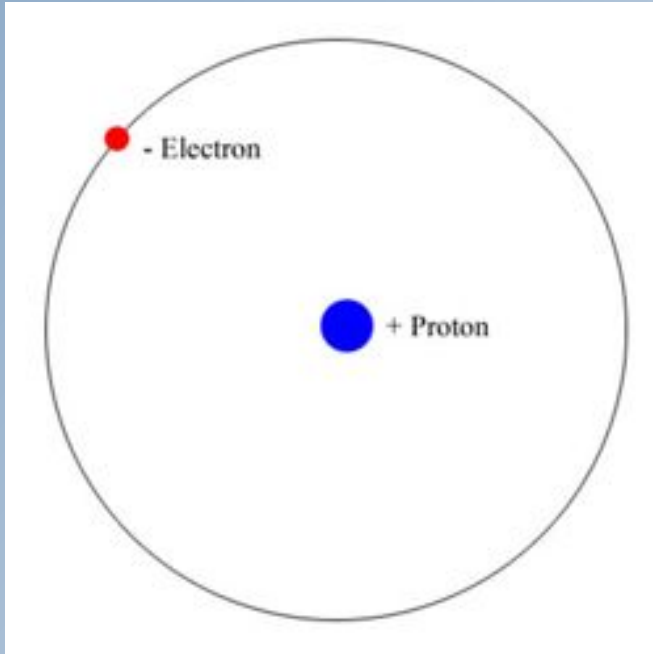
Whole atom would be size of a football stadium

Lots of empty space!

Atoms have no overall charge

Example - Hydrogen = 1 proton and 1 electron

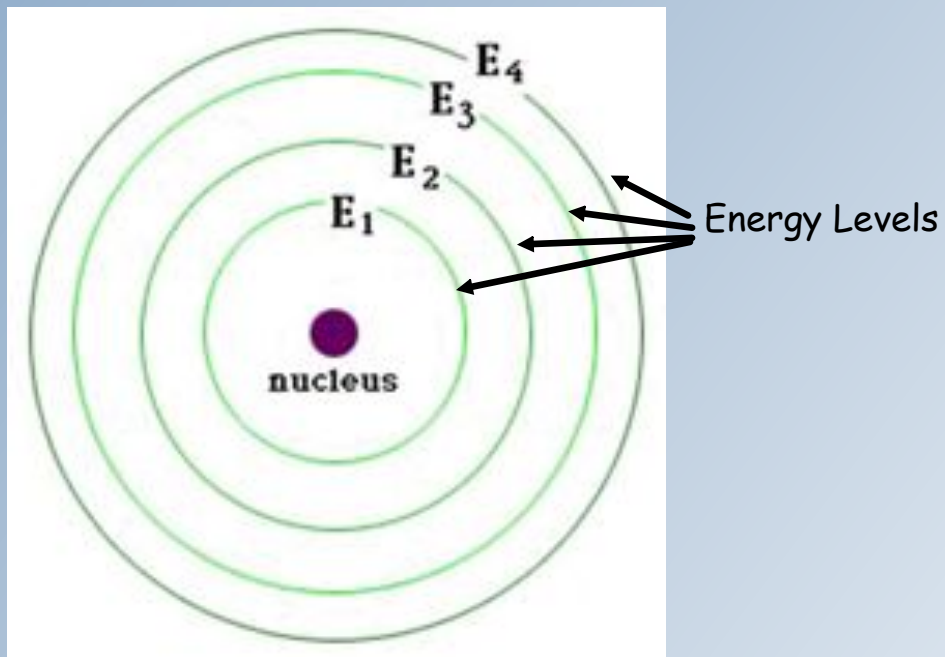
$+1$ & $-1 = 0$ charge



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

Each electron carries energy

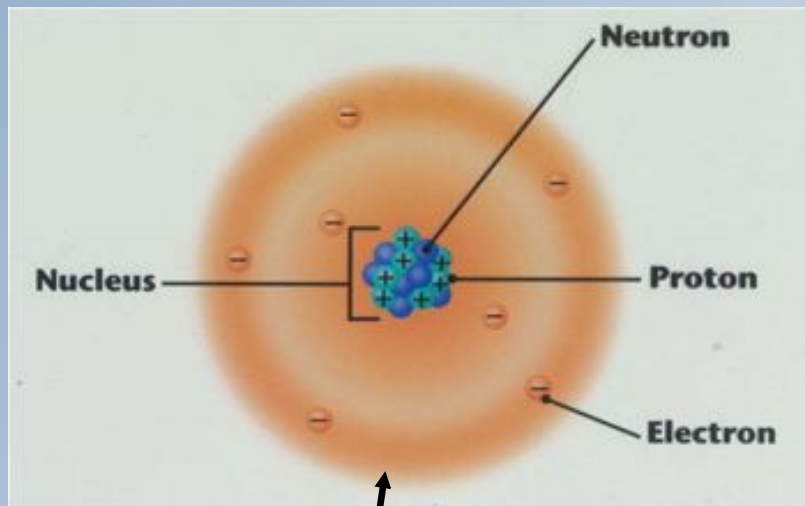
Electrons in farther out orbits have more energy



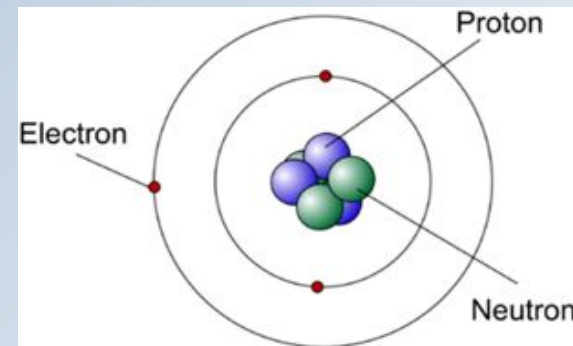
It's impossible to know the exact location of an electron

Like blades on a fan

Electron Cloud - general area electrons occupy



More accurate depiction



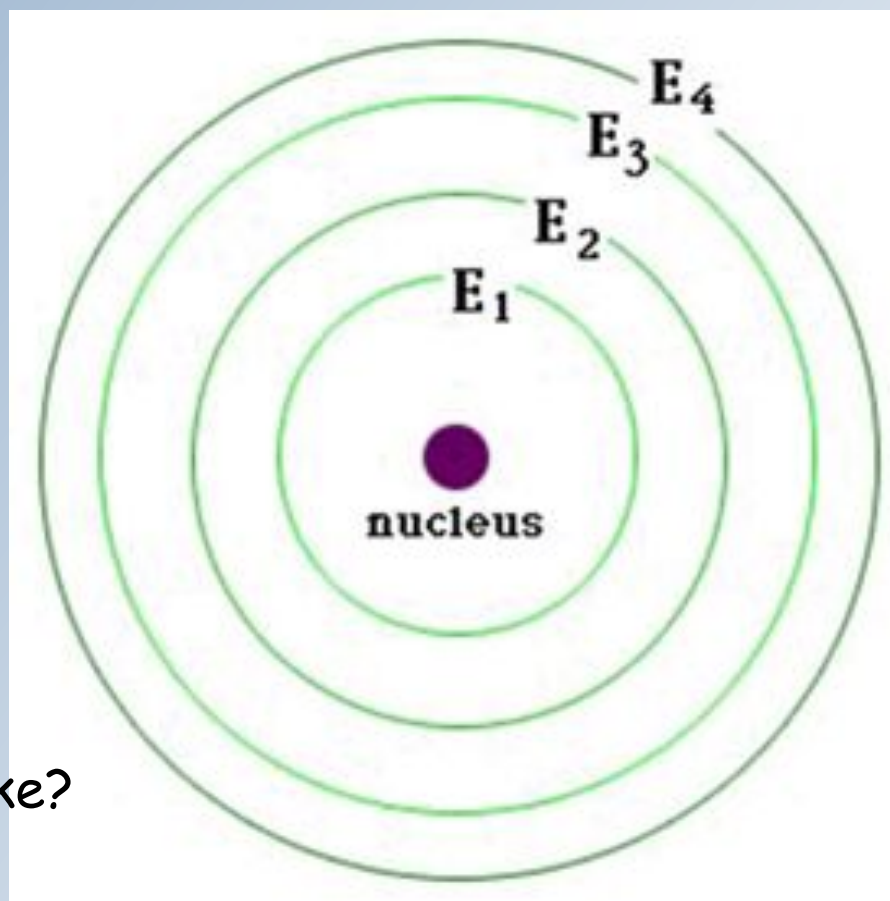
Energy Levels

The first energy level holds 2 electrons

2nd = 8 electrons

3rd = 18 electrons

4th = 32 electrons



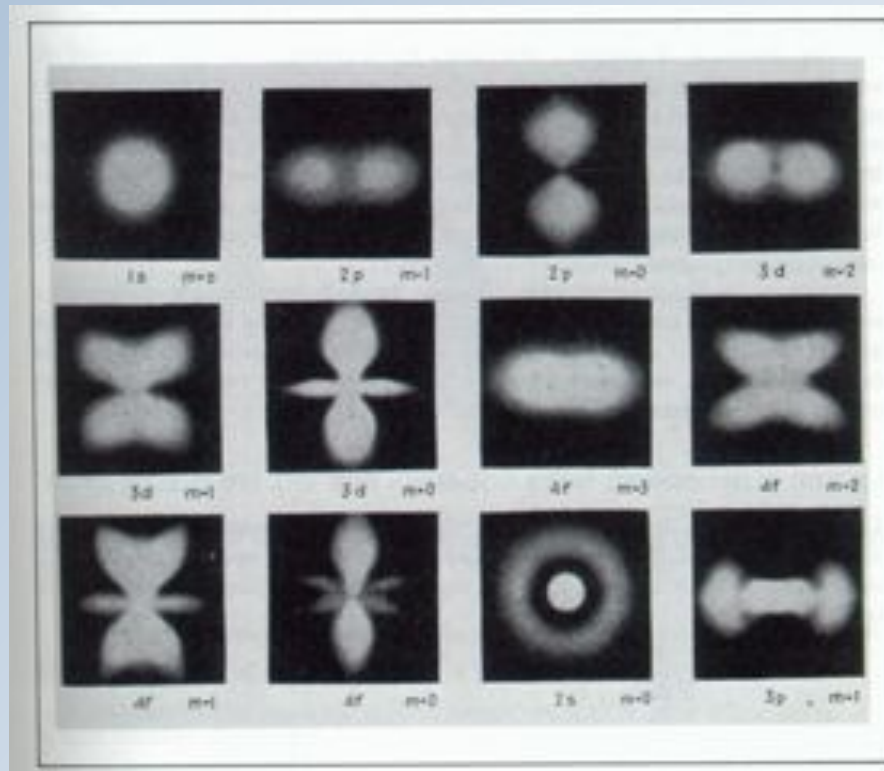
What would oxygen look like?

Within each energy level there are various orbitals

s, p, d, and f

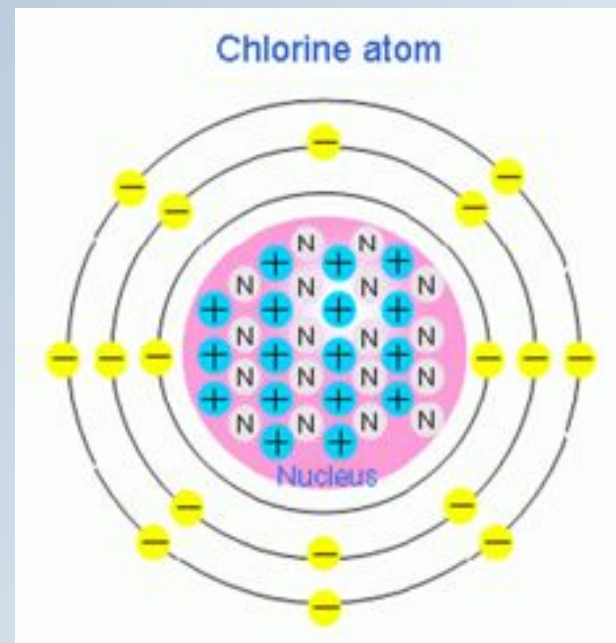
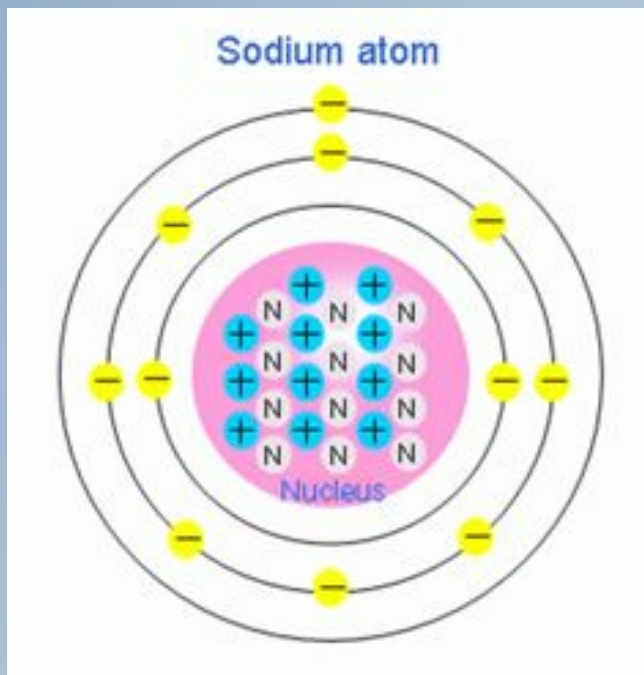
low energy → high

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

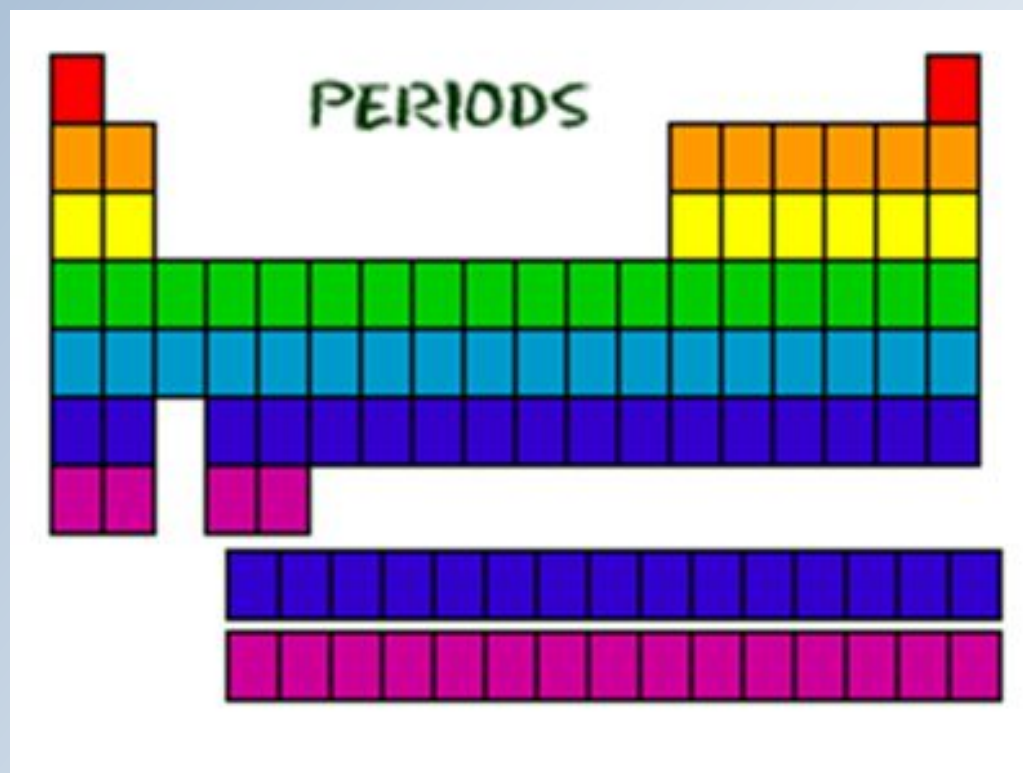
Each period has same number of energy levels

1st Period = 1 Shell

2nd Period = 2 Shells

3rd Period = 3 Shells

4th Period = 4 Shells



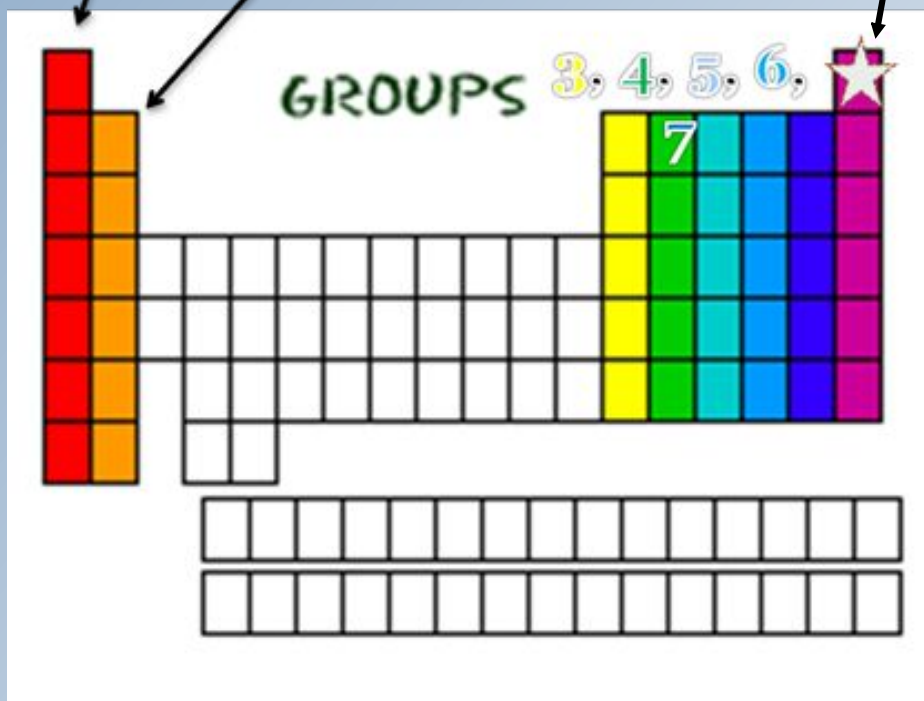
Columns are called groups

Have same number of valance electrons

Group 8 = 8 electrons

Group 1 = 1 electron

Group 2 = 2 electrons

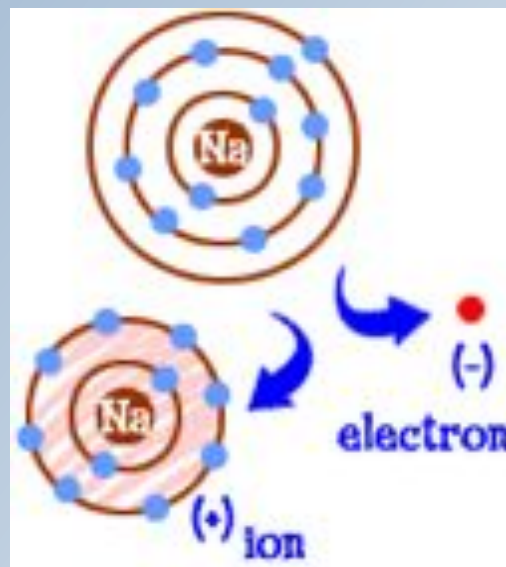


Except He,
which has 2

Atoms have no overall 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 occurring

Over 100 total

The image shows a standard periodic table of elements. It includes the following series:

- Main Body:** Elements from Hydrogen (1) to Oganesson (118).
- Lanthanide series:** Elements 57 (Lanthanum) to 70 (Ytterbium).
- Actinide series:** Elements 89 (Actinium) to 102 (Nobelium).

of protons determine the identity of element

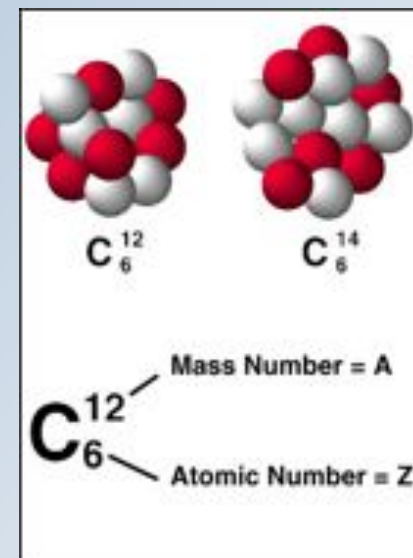
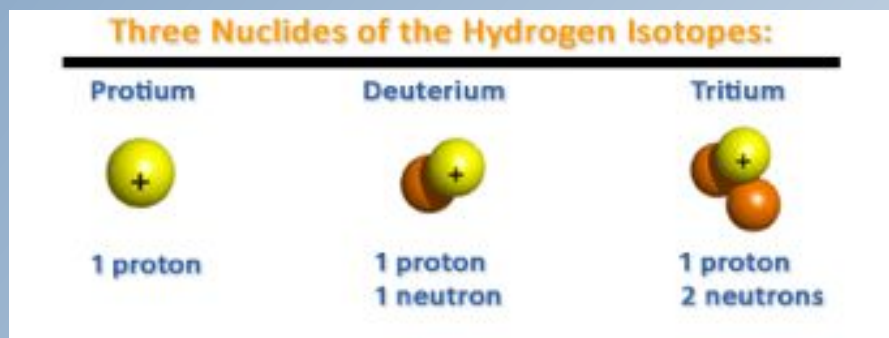
8 protons = Oxygen

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

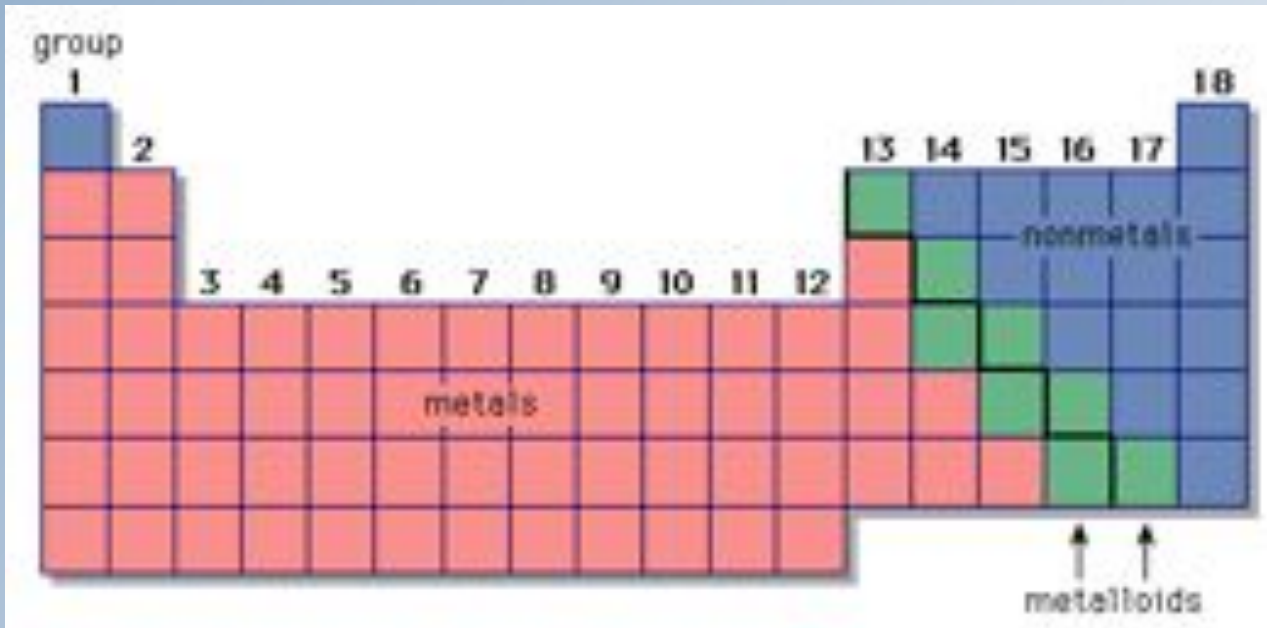
141 - 146 neutrons

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"

A periodic table of elements where each element is represented by a colored square containing its chemical symbol. The colors are used to group elements into families. The colors are: Hydrogen (orange), Helium (green), Lithium (yellow), Beryllium (dark blue), Boron (brown), Carbon (orange), Nitrogen (orange), Oxygen (orange), Fluorine (blue), Neon (green), Sodium (yellow), Magnesium (dark blue), Aluminum (purple), Silicon (brown), Phosphorus (orange), Sulfur (orange), Chlorine (blue), Argon (green), Potassium (yellow), Calcium (dark blue), Scandium (grey), Titanium (grey), Vanadium (grey), Chromium (grey), Manganese (grey), Iron (grey), Cobalt (grey), Nickel (grey), Copper (grey), Zinc (grey), Gallium (purple), Germanium (brown), Arsenic (orange), Selenium (orange), Bromine (blue), Krypton (green), Rubidium (yellow), Strontium (dark blue), Yttrium (grey), Zirconium (grey), Niobium (grey), Molybdenum (grey), Technetium (grey), Ruthenium (grey), Rhodium (grey), Palladium (grey), Silver (grey), Cadmium (grey), Indium (purple), Tin (brown), Antimony (orange), Tellurium (orange), Iodine (blue), Xenon (green), Cesium (yellow), Barium (dark blue), Lanthanum (red), Hafnium (grey), Tantalum (grey), Tungsten (grey), Rhenium (grey), Osmium (grey), Iridium (grey), Platinum (grey), Gold (grey), Mercury (grey), Thallium (purple), Lead (purple), Bismuth (purple), Polonium (brown), Astatine (blue), Radon (green), Francium (yellow), Radium (dark blue), Actinium (red), Rutherfordium (grey), Dubnium (grey), Seaborgium (grey), Bohrium (grey), Hassium (grey), Meitnerium (grey), Darmstadtium (grey), Roentgenium (grey), Copernicium (grey), Tennessine (grey), Oganesson (grey), Cerium (red), Praseodymium (red), Neodymium (red), Promethium (red), Samarium (red), Europium (red), Gadolinium (red), Terbium (red), Dysprosium (red), Holmium (red), Erbium (red), Thulium (red), Ytterbium (red), Lutetium (red), Thorium (red), Protactinium (red), Uranium (red), Neptunium (red), Plutonium (red), Americium (red), Curium (red), Berkelium (red), Californium (red), Einsteinium (red), Fermium (red), Mendelevium (red), Nobelium (red), Lawrencium (red).

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

Periodic table highlighting transition metals (groups 3-10 and the lanthanide/actinide series).

1	2												3	4	5	6	7	0
																		He
Li	Be												B	C	N	O	F	Ne
Na	Mg												Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn		Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd		In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg		Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac																

Transition metals

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

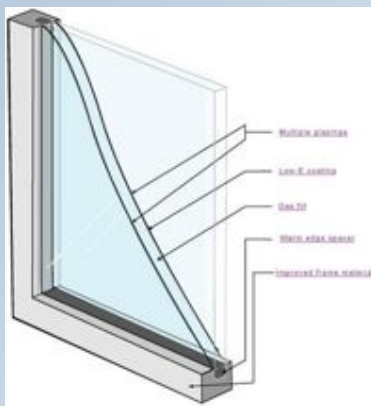


Nonmetal Families

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

$$6.022 \times 10^{23} \text{ particles / mol}$$

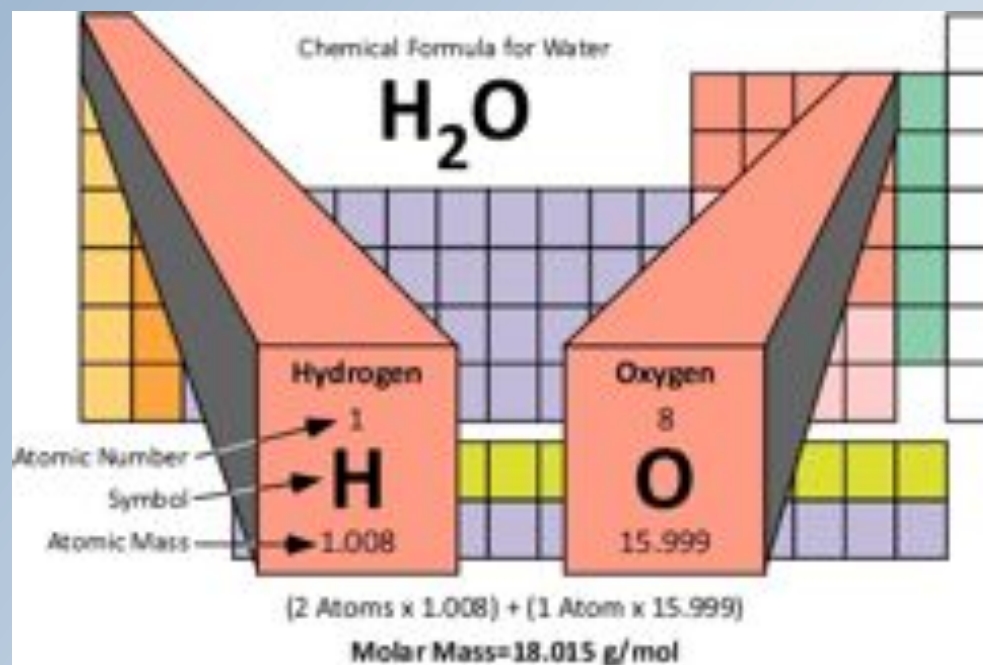
- This number is referred to as Avogadro's Constant



$$1 \text{ mole} = 6.022 \times 10^{23}$$

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 from 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?