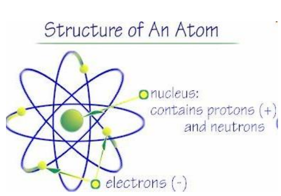
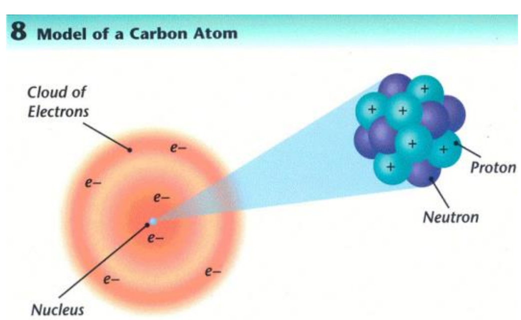
Physical Science

Chapter 16
The Periodic Table

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 Number

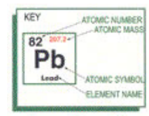
- By definition:

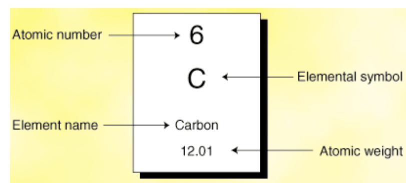
  The Atomic Number = the number of Protons present in the nucleus of an atom
- Each Element in the Periodic Table has a different number of Protons, therefore each element has a different, unique, atomic number.

"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

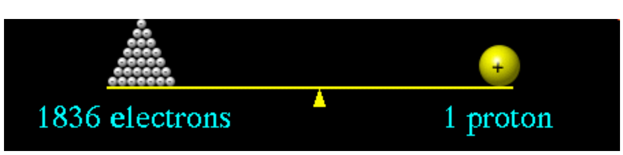
When reading the Periodic table notice each element has a unique 1 or 2 letter symbol and "big" & "small" number listed

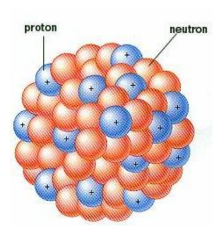




Atomic Mass

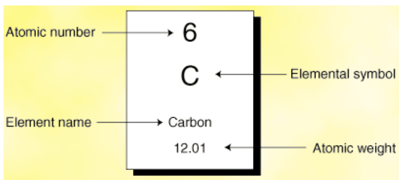
- How much does an atom "weigh"?
- What is the mass of an atom?
- SI Unit for mass is the Gram…. Way toooo big to accurately "mass" an atom
- Came up w/ new unit, an AMU (atomic mass unit)
- 1 AMU = mass of 1 Proton
- mass of subatomic particles
  - Proton = 1 AMU
  - Neutron = 1 AMU
  - Electron = .0005 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)





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!!



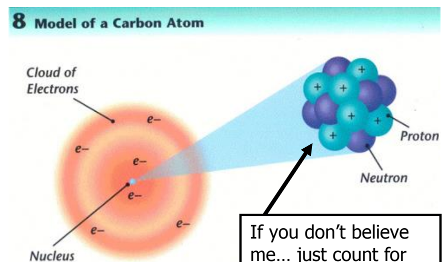
For Example w/ Carbon:

Atomic Mass-Atomic # = # Neutrons

Atomic Mass = 12, Atomic # 6

12 – 6 = 6

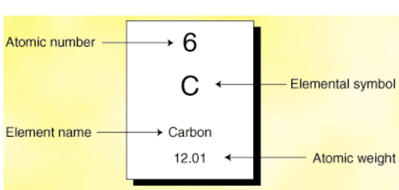
Therefore there are 6 neutrons present in the Carbon nucleus



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

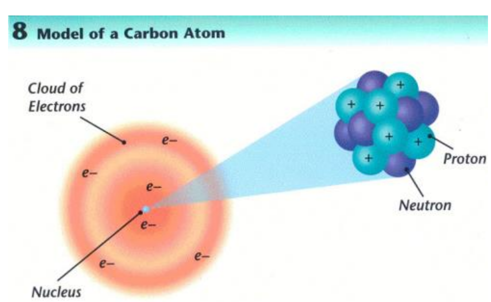
Electrical Atomic Charge

- Electrical charge – all atoms have a neutral charge
  - (a zero net electrical charge)
- **P**rotons have a **p**ositive (+) electrical charge
- **Neut**rons have a **neut**ral (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**!!



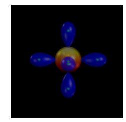
For example:

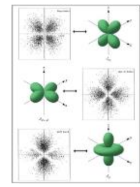
Carbon has an atomic # of 6, it therefore has 6 Protons which has an electrical charge of +6, to make the atom neutral we need 6 negative charges found in the 6 electrons orbiting the nucleus.

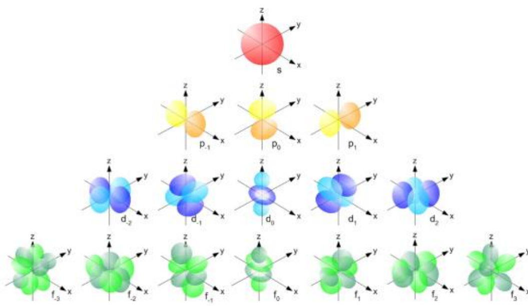


Electron Orbits – Energy Levels

- 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

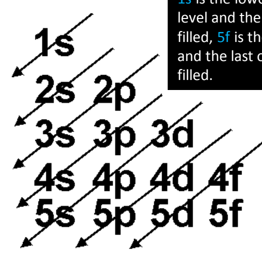






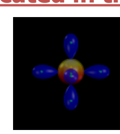
Here's the order used to fill the different energy levels

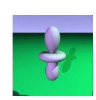
1s is the lowest energy level and the first filled, 5f is the highest and the last one to be filled.



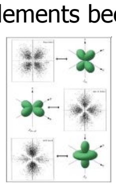
Valence Electrons

- Electrons are found in specific orbits/clouds spinning around the nucleus
- **Valence electrons are the electrons located in the outermost orbit**
- ONLY Valence electrons are used in chemical bonds!

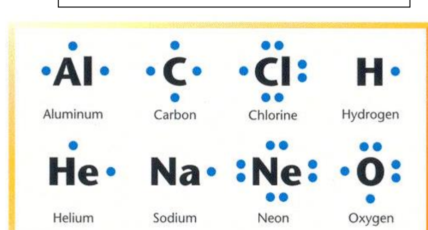




Elements become stable when: their outer orbit contains 8 electrons or their outer orbit becomes empty

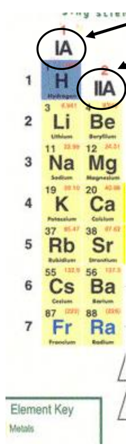


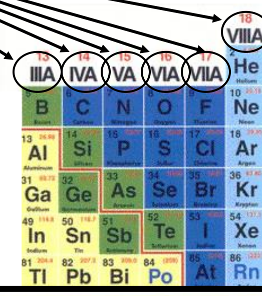
Lewis Dot Diagrams show the # of Valence Electrons



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!





Soooo…

The Alkali Metals have 1 valence electron

The Alkaline Earth Metals have 2 valence electrons

The Boron Family has 3 valence electrons

The Carbon Family has 4 valence electrons

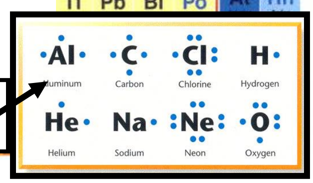
The Nitrogen Family has 5 valence electrons

The Chalogens have 6 valence electrons

The Halogens have 7 valence electrons and the

Noble Gases have 8 valence elctrons

Lewis Dot Diagrams show the # of Valence Electrons



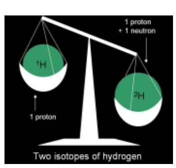
Isotopes

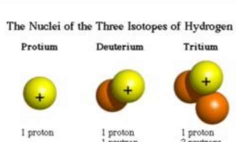
Atoms of the same element can have different numbers of neutrons

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.





Allotropes of Oxygen

Elemental Oxygen - O_1

Molecular Oxygen - O_2

Ozone - O_3

Allotropes

Some Elements can exist in different forms

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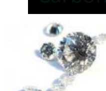

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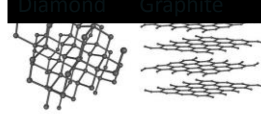
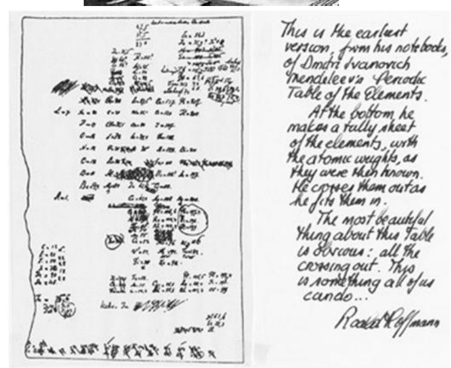


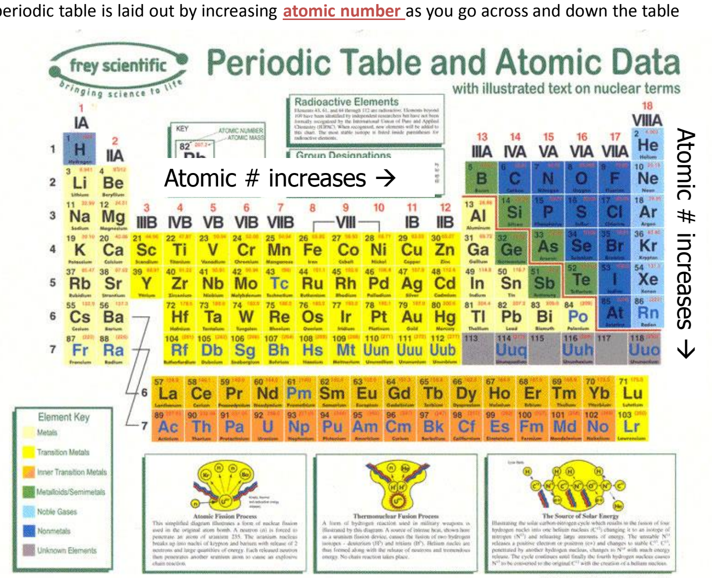
Dmitri Mendeleev - 1869

- 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

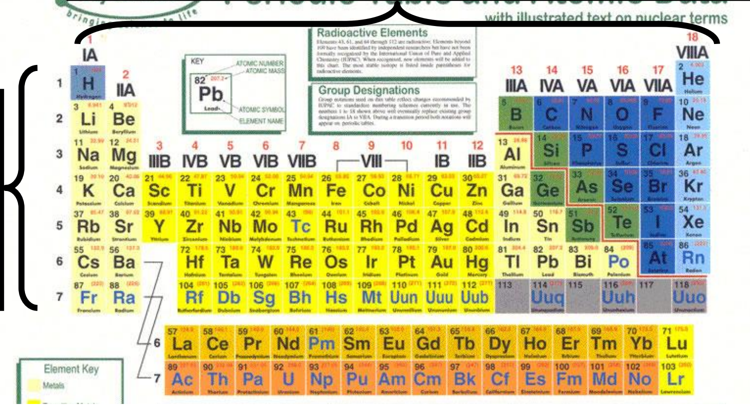
- The periodic table is laid out by increasing **atomic number** as you go across and down the table

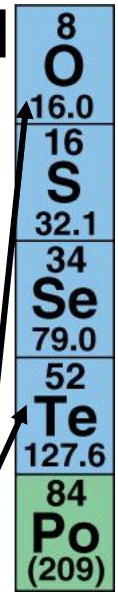


Periods, Groups & Families

Groups & Families are in vertical columns, there are 18 Groups

Periods are Rows





There are 7 numbered Periods and 18 numbered Groups

Families are named in 2 ways, 1st after the top element in the column, The Oxygen Family contains O, S, Se, Te & Po.

2nd way to name them is w/ their "old fashion" names. (see next slide)

"Need-to-Know Families

"Old Fashion Names" of certain Families

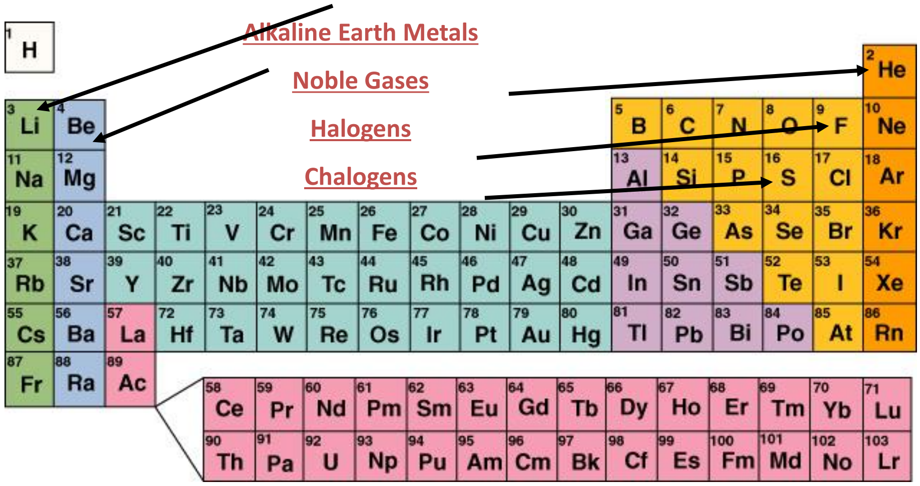
Alkali Metals

Alkaline Earth Metals

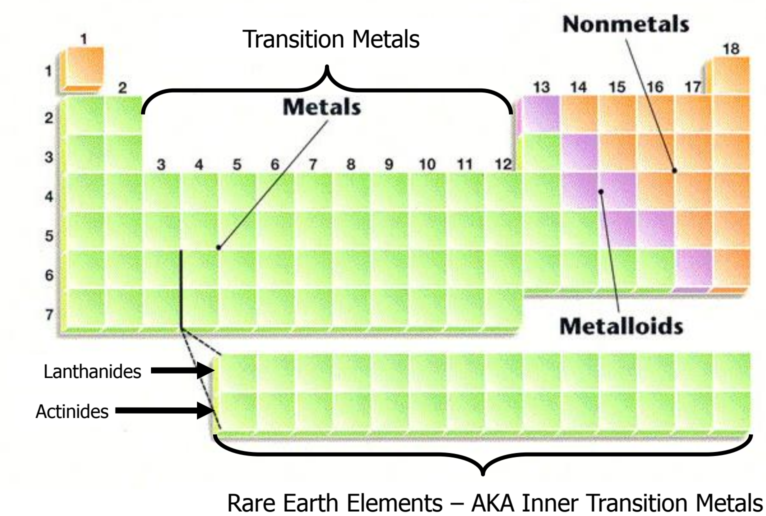
Noble Gases

Halogens

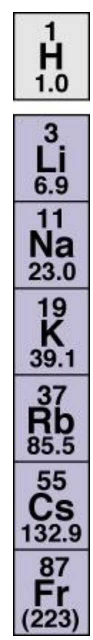
Chalogens



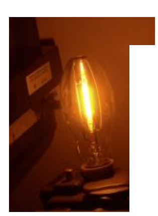
More Need-to-Knows



The **Alkali Metals** – **Group 1**



- Very reactive metals that have only one valence electron in the outer orbit and will freely give it away to become stable. Very soft metal (you could cut it w/ a plastic knife!). They form ionic bonds w/ Halogens and Chalogens. Examples include **Sodium** and **Potassium**.



The **Alkaline Earth Metals – Group 2**

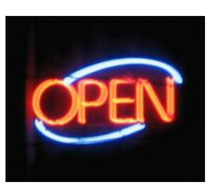
- not as reactive as Alkali Metals, but still very reactive. They have two valence electrons and generally give them up to nonmetals to form ionic bonds. Examples include **Calcium** and **Magnesium**

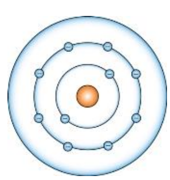
4	Be	9.0
12	Mg	24.3
20	Ca	40.1
38	Sr	87.6
56	Ba	137.3
88	Ra	226.0


Noble Gases - Group 18

- Non reactive, have a full compliment of valence electrons, 8 and are called the "**Inert Gases**" because they do not react w/ other elements. Examples include **Helium** (very low mass and is used in filling children's balloons and **even airships** and the "Goodyear Blimp) and **Neon** used in lighted bulbs to make a red glowing light (a neon light).

2	He	4.0
10	Ne	20.2
18	Ar	40.0
36	Kr	83.8
54	Xe	131.3
86	Rn	(222)




Halogens – Group 17

- Very reactive nonmetals w/ 7 valence electrons. Need only one more electron to fill their outer shell. Will steal an electron from a reactive metal to form ionic bonds. Examples include **Fluorine** (the most reactive nonmetal), **Chlorine** (the most abundant halogen), **Iodine** and **Bromine** (found in Seawater).

9 F 19.0
17 Cl 35.5
35 Br 80.0
53 I 126.9
85 At (210)

- **Physical Properties**

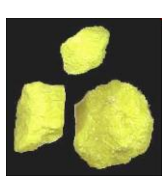
Fluorine	yellow gas
Chlorine	green gas
Bromine	volatile brown liquid
Iodine	volatile purple solid

revisionworld

Chalogens AKA:
Oxygen Family – Group 16

- nonmetals w/ 6 valence electrons, need 2 electrons to fill the outer shell. **Oxygen's m**ost common oxidation state is -2. Examples are **Oxygen** (**ozone** is one of its allotropes), **Sulfur** (responsible for that **rotten egg smell** when it combines w/ oxygen to form sulfur dioxide) **and Selenium** (one of the few non metals that are also a good **conductor of electricity**).

8 O 16.0
16 S 32.1
34 Se 79.0
52 Te 127.6
84 Po (209)



The **Nitrogen Family**– Old Group **VA** ,new Group **15**

- These elements have 5 valence electrons
- Include **Nitrogen** – most abundant gas in the atmosphere
- **Phosphorus** – has allotropes that are Red and White
- **Bismuth** – the metal used in automatic sprinklers because of its low melting point
- **Arsenic** – a poisonous element used in medicine and even rat poison.

7 N 14.0
15 P 31.0
33 As 75.0
51 Sb 121.8
83 Bi 209.0

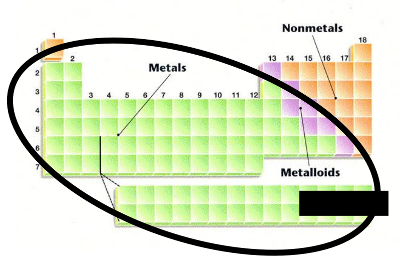
Transition Metals – Groups 3 thru 12

- These all vary dramatically in reactivity, Their oxidation states (# of valence electrons) vary. They are a bridge between the very reactive Alkali and Alkaline Earth Metals and the nonmetals.

21 Sc 45.0	22 Ti 47.9	23 V 51.0	24 Cr 52.0	25 Mn 55.0	26 Fe 55.8	27 Co 59.0	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4
39 Y 88.9	40 Zr 91.2	41 Nb 92.9	42 Mo 95.9	43 Tc (97)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4
71 Lu 175.0	72 Hf 178.5	73 Ta 181.0	74 W 183.9	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 201.0
103 Lr (260)	104 (261)	105 (262)	106 (263)	107 (264)		109 (266)			

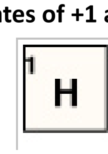
Most of the elements are Metals

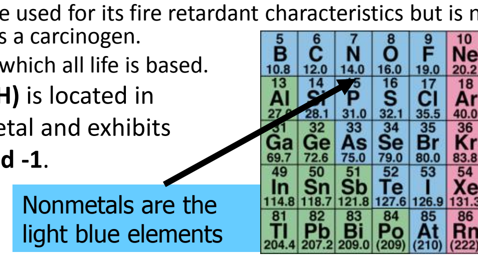
- Examples include: **Iron, Bismuth, Tin, Sodium, Calcium, Gallium, etc.**
- **Bismuth – used in automatic sprinklers**
- **Gallium - has an oxidation number +3**
- **Cobalt – A metal w/ more than one oxidation state**
- Metals tend to form **positive** (+) ions.
- Most Metals form Ionic bonds w/ nonmetals.
- Physical Properties
  - Such as hardness, shiny, **malleability** (pounded into shapes),
  - **ductility** (stretched or pulled into a wire) electrical conductivity and magnetic.
- Chemical Properties
  - Metals show a wide range of chemical properties.



17 Nonmetals

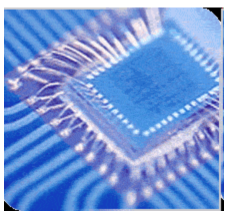
- a. There are **17 nonmetals**, each are located to the right of the zigzag line in the periodic table.
- b. **Phosphorus** – has Common allotropes of Red & white
- c. **Selenium** – nonmetal that is a "good conductor"
- Non metals tend to steal electrons when they form negative (-) ions.
- c. **Physical Properties** – in general, the physical properties of nonmetals are opposite those of metals. Powdery, gaseous, crumbly, non conductive, dull, not ductile or malleable.
- d. **Chemical properties** – usually form ionic bonds when combined w/ metals ($NaCl$, FeO_2, and $CaCl_2$) and usually form covalent bonds when combined w/ other nonmetals (CO_2, O_2, $C_6H_{12}O_6$)
  - **Asbestos** – substance once used for its fire retardant characteristics but is no longer used because of it's a carcinogen.
  - **Carbon** – the element on which all life is based.
- e. Even though **Hydrogen (H)** is located in Group 1, it is still a nonmetal and exhibits **oxidation states of +1 and -1**.

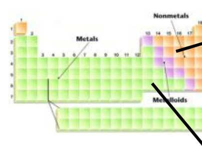


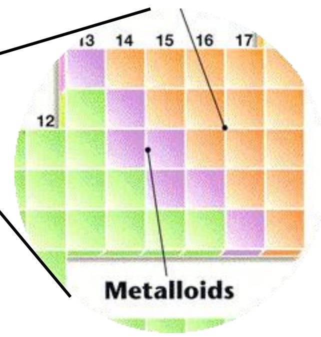


Metalloids

- AKA "**semi metals**"
- **7** elements on the zigzag border between metals and the non metals.
- Their properties will sometimes make them act like a metal and then sometimes act like a nonmetal.
- Most important characteristic is their varying ability to conduct electricity. **Silicon** is used to make **Semiconductors** which are used in making **computer chips**.







"Need-to-Know" Elements

Remember: Atomic Mass – # of Protons = # of Neutrons

Element	Symbol	Atomic Number	Atomic Mass	- # Protons	= # Neutrons	# Electrons	Solid Liquid Gas	Metal Metaloid Nonmetal
Hydrogen	H	1	1	1	0	1	G	NM
Oxygen	O	8	16	8	8	8	G	NM
Carbon	C	6	12	6	6	6	S	NM
Nitrogen	N	7	14	7	7	7	G	NM
Calcium	Ca	20	40	20	20	20	S	M
Phosphorus	P	15	31	15	16	15	S	NM
Sulfur	S	16	32	16	16	16	S	NM
Helium	He	2	4	2	2	2	G	NM
Sodium	Na	11	23	11	12	11	S	M
Chlorine	Cl	17	35	17	18	17	G	NM
Aluminum	Al	13	27	13	14	13	S	M
Potassium	K	19	39	19	20	19	S	M

Remember: Atomic # = # of Protons & also # of Electrons