Basics and Atomic Structure	Nuclear Chemistry	Electrons	Periodic Table	Bonding and Structure	Reactions	Stoich.	

Crash Course:
N1 - Honors Chem Review

Advanced Chemical Ratios	Gas Laws	Thermo.	Solutions	Kinetics	Equilibrium	Acids and Bases	Redox

*Note about remote learning impacts on topics covered

- In March 2020 school transitioned to "Remote Learning"
- Due to the school closing in March 2020 some topics were not covered in as much detail as a normal year, or not covered at all.
- Therefore two years of Honors Chem students did not cover the topics needed to start AP Chem like normal.
- The missing topics were added to the Summer Assignments so you should be caught up.
- Items marked with a (*) were not covered in class during the 2019-2020 school year due to school closing in March 2020.
- Items marked with a (**) were not covered in the 2020-2021 school year due to "remote teaching" limiting what we could cover because of reduced instructional minutes.

Unit #1
Chemistry Basics and Atomic Structure

- Scientific notation
- Metric system
- Dimensional analysis
- Significant figures
- Chemical/Physical properties/changes
- Types of matter
- Atomic numbers and Isotopes
- Models of the atom
- Average Atomic Mass Calculations

Scientific Notation

Tired of really big or really small numbers???

- Use scientific notation!
- Move your decimal and rewrite it in "scientific notation format"

$3 \cdot 54 \times 10^{2}$

"x 10^{EXPONENT}" is the same a

E

$3.54E^{2}$

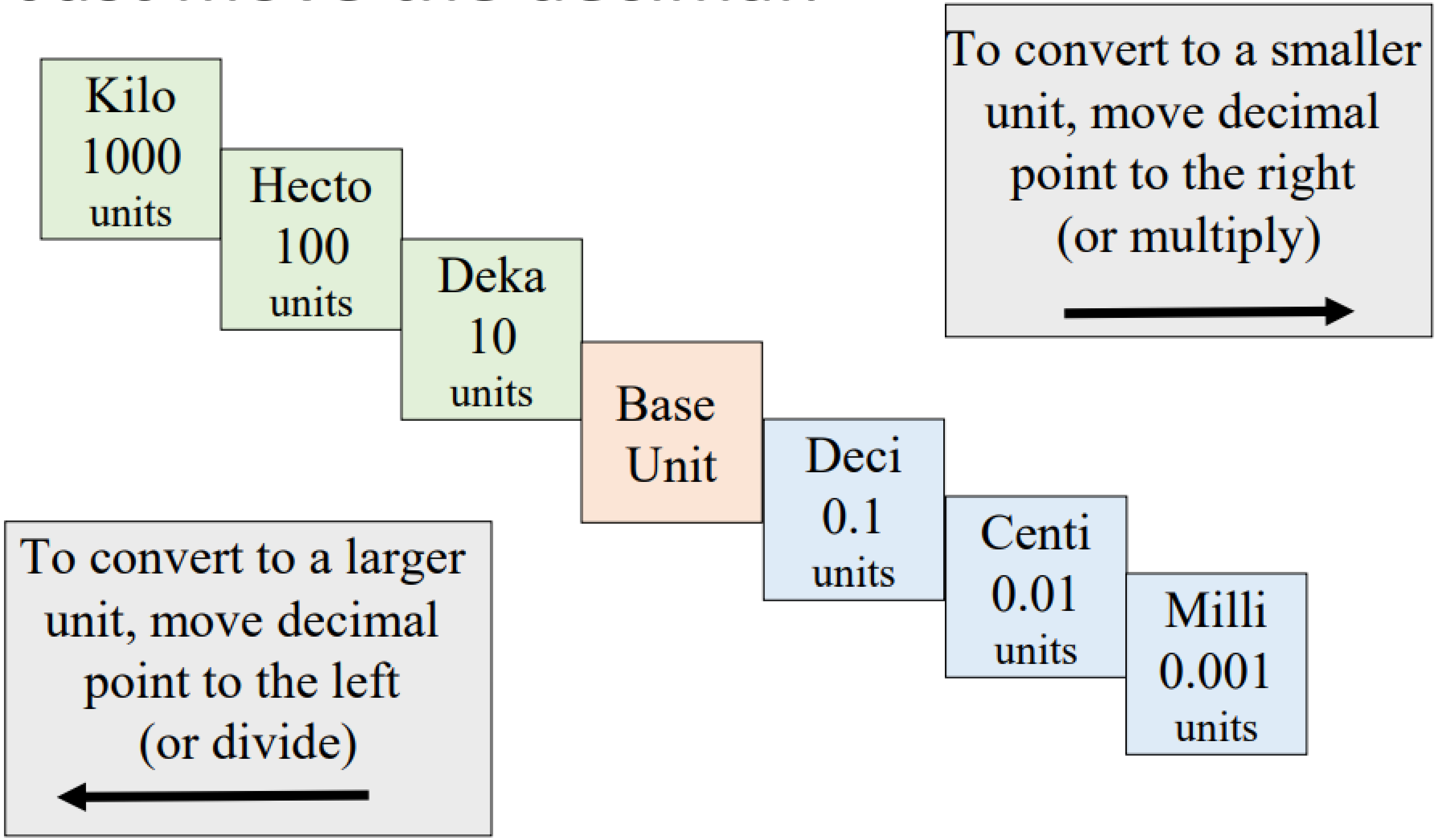
One #	•	Rest of the #s	x	10	Exponent

(telling how many times to move the decimal, and which way to move it!)

Metric System

Converting Metric System

- Just move the decimal!



Metric System

How do I remember the prefixes?

King **H**enry **D**ied **B**y **D**rinking **C**hocolate **M**ilk

K	H	D	B	D	C	M
I	E	E	a	E	E	I
L	C	K	s	C	N	L
O	T	A	e	I	T	L
	O				I	I

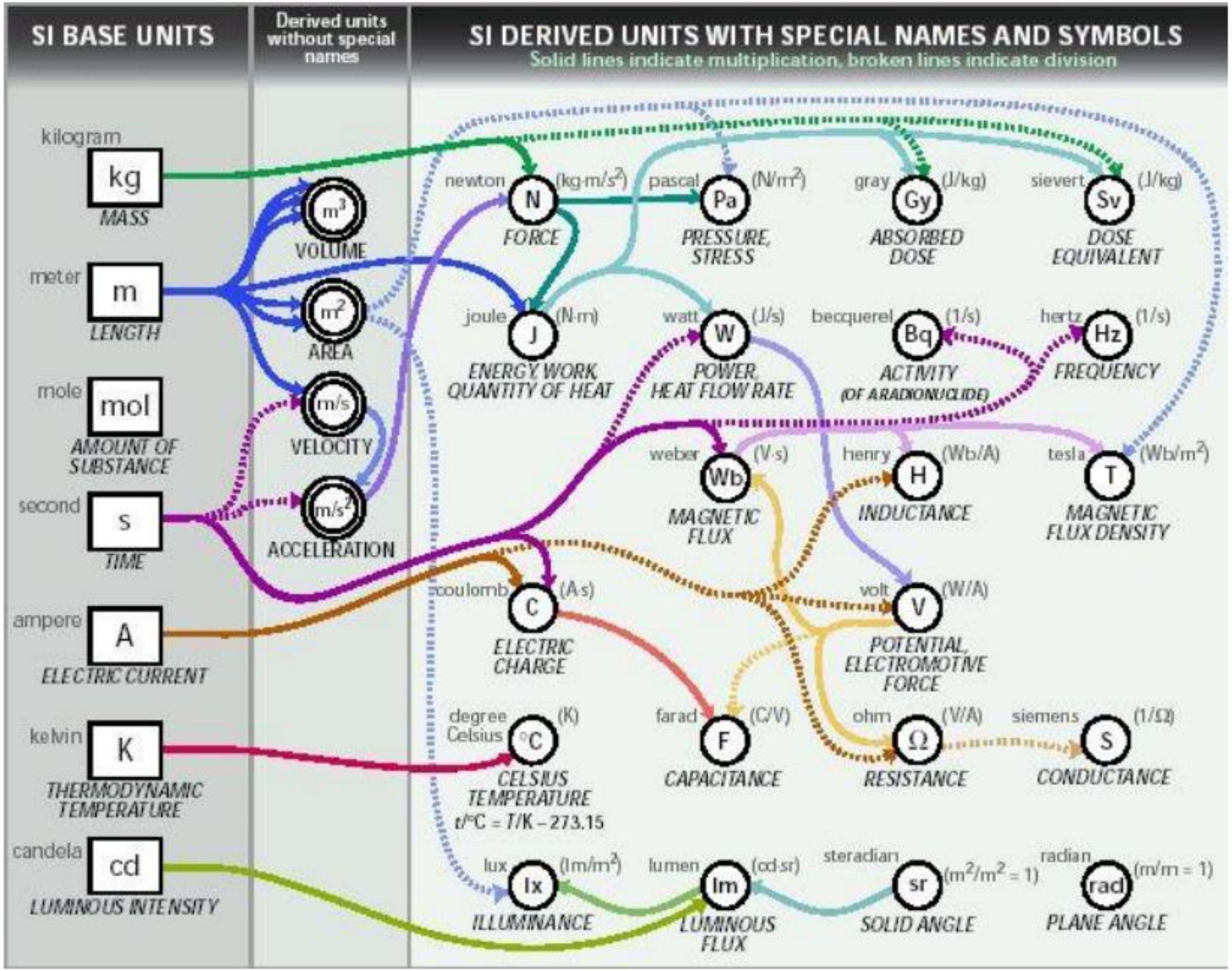
Derived Units

Derived Units

- Made by combining multiple units together
- Examples:

miles/hour	=	speed in our cars in US
cm^3	=	volume
m/s^2	=	acceleration
$kg \cdot m/s^2$	=	newton (measures force)

Derived Units



Remember - Canceling Units

One on top cancels with one on the bottom

$$\frac{\cancel{x}y}{\cancel{x}} = y$$

$$\frac{15\ c\cancel{m}^3}{5\ c\cancel{m}} = 3\ cm^2$$

Dimensional Analysis

Conversion Factors

You can flip conversion factors too

12in = 1ft   24hrs = 1,440min

Just depends on what you are doing

$$\frac{12\text{in}}{1\text{ft}} = 1 \qquad \frac{1\text{ft}}{12\text{in}} = 1$$

$$\frac{24\text{hr}}{1{,}440\text{min}} = 1 \qquad \frac{1{,}440\text{min}}{24\text{hr}} = 1$$

Dimensional Analysis

Line Method

Keeps work neat, tidy, takes less space, easier to grade, a very typical way to show conversions in chemistry. I will always use the line method!

Convert 15years into minutes

$$15yrs\ x \frac{365days}{1\ yr} x \frac{24hrs}{1\ day}\ x \frac{60min}{1hr} = 7.9x106min$$

15 yrs	365 days	24 hr	60 min	= 7.9 x 10^6 min
	1yr	1 day	1 hr	

Dimensional Analysis

Dimensional Analysis with "Derived/Double Units"

Some units are combinations of two or more other units. Like miles per hour (mi/hr). Fix the top unit, then go back and fix the bottom unit

Convert 20mi/hr into in/sec.

20mi	5280ft	12in	1hr	1min
1hr	1mi	1ft	60min	60sec

$= 352 \frac{in}{sec}$

Significant Figures

Nonzero Integers	ALWAYS COUNT as SIGNIFICANT	3456 has 4 sig figs
Leading Zeros	NEVER COUNT as SIGNIFICANT	0.0486 has 3 sig figs
Captive Zeros	ALWAYS COUNT as SIGNIFICANT	16.07 has 4 sig figs.

Significant Figures

Trailing Zeros	AFTER A DECIMAL ALWAYS COUNT as SIGNIFICANT	9.300 has 4 sig figs.
SOMETIMES COUNT as SIGNIFICANT	NO DECIMAL NEVER COUNT as SIGNIFICANT	9300 has 2 sig figs.

Exact Numbers	INFINITE NUMBER of sig figs	1in = 2.54cm 12in = 1ft

Significant Figures

Multiplication & Division	Answer based on **LEAST** number of **SIG FIGS** in the problem	6.38 x 2.0 = *3 SF* *2SF* 12.76 → **13** *(2 sig figs)*
Addition & Subtraction	Answer based on **LEAST** number of **DECIMAL PLACES** in the problem	6.8 + 11.934 = *1DP* *3DP* 18.734 → **18.7** *(3 sig figs)*

Physical and Chemical Properties

• **PHYSICAL PROPERTY** a property that a substance displays without changing its composition. – *Odor, taste, color, appearance, melting point, boiling point, and density*	• **CHEMICAL PROPERTY** a property that a substance displays only by changing its composition via a chemical change/rxn – *Corrosiveness, acidity, and toxicity.*

Properties and Changes

Physical Change

- Alter only the **state or appearance**, but not composition
- The atoms or molecules that compose a substance **do not change their identity** during a physical change.

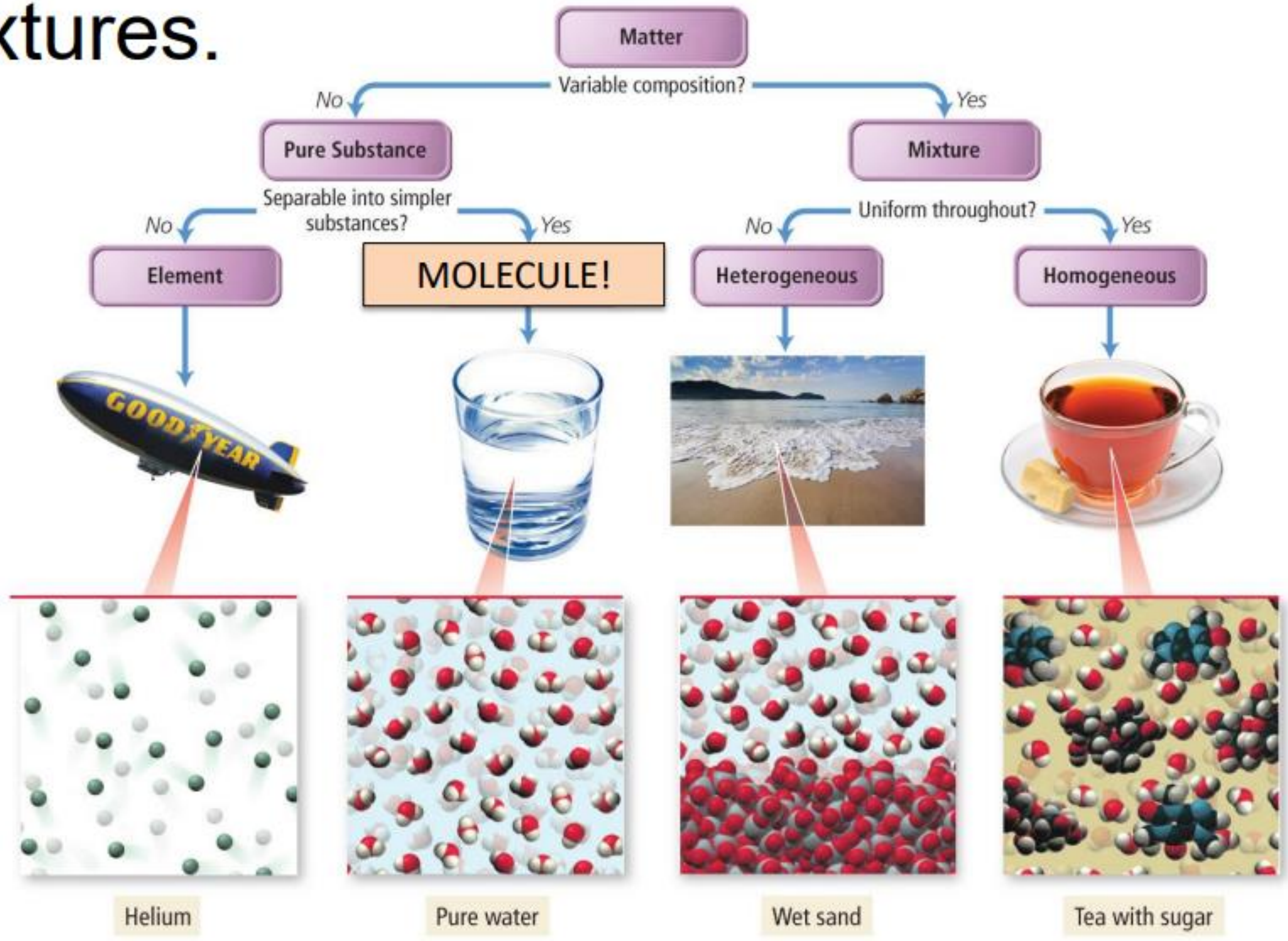
Chemical Change

- Alters the **composition/identity** of the substance
- Atoms rearrange, transforming the original substances into **different substances**.

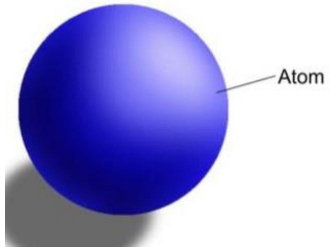
Types of Matter

The Classification of Matter by Components

- Elements, compounds, and types of mixtures.



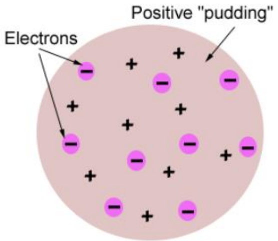
Atomic Models



DALTON'S BILLIARD BALL MODEL

John Dalton

THOMSON'S ATOMIC MODEL

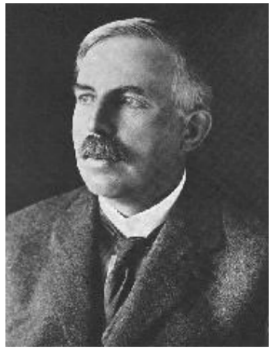


Thomson believed that the electrons were like plums embedded in a positively charged "pudding," thus it was called the "plum pudding" model. We don't usually eat plum pudding in this country, so I like to call it the chocolate chip cookie model.

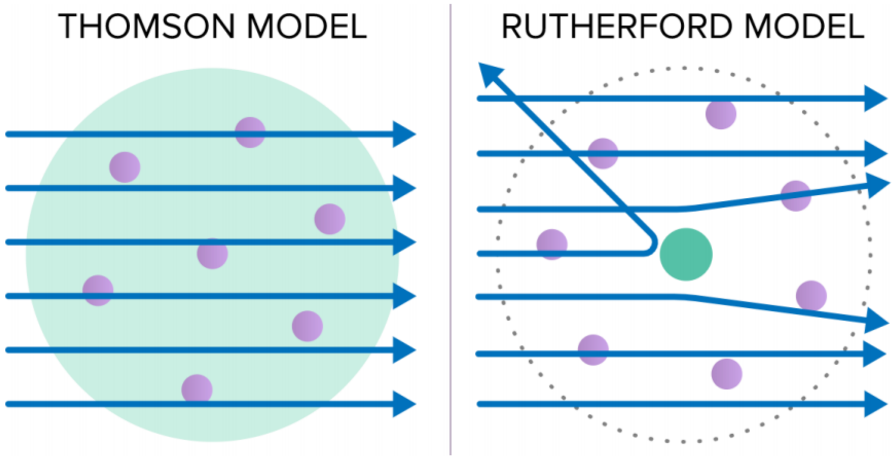
RUTHERFORD'S FINDINGS

1) **Most of the particles passed right through**
2) **A few particles were deflected**
3) **A FEW were *greatly* deflected**

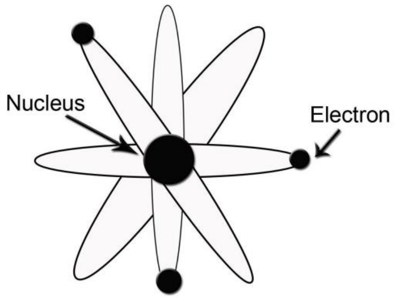
CONCLUSIONS:



- **The nucleus is small**
- **The nucleus is dense**
- **The nucleus is positively charged**
- **The atom is mostly empty space**

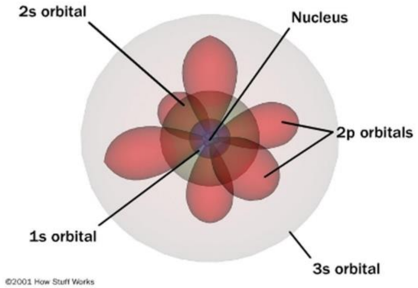


THE BOHR MODEL



The "planet" model because it looks like the planets revolving around the sun. These Electrons have "paths" that they follow around the Nucleus in the center. Usually we DRAW atoms like this but its not accurate!

The Quantum Model



This is a hard model to understand.
The Electrons don't follow paths, they are not objects at all! Instead they are pure charge that has a probability of being somewhere in those orbitals.

Atomic Numbers

ATOMIC NUMBERS

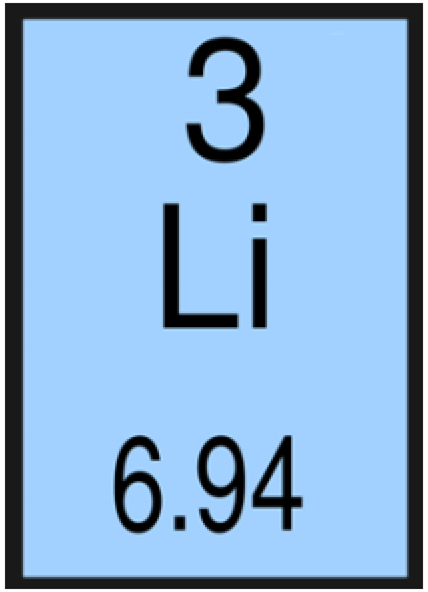
<u>We know:</u> Nucleus has protons (p^+), neutrons (n^0), and electrons(e^-) are on the outside of nucleus

<u>But how many of each???</u>

Atomic Mass Number

(round to the nearest whole #)

# of protons + # of neutrons



Atomic Number

# of protons

# of electrons = # of protons

Atomic Numbers

IONS!

Oxygen

O^{-2}

Negative

Anion

Gained electrons

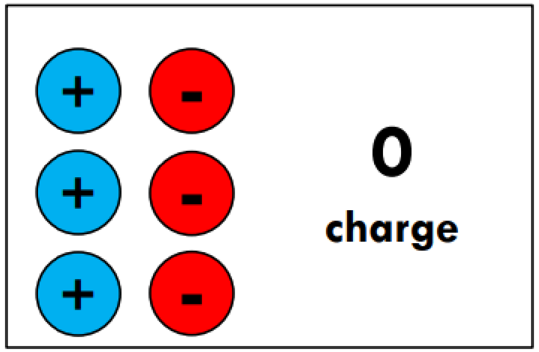
Sodium

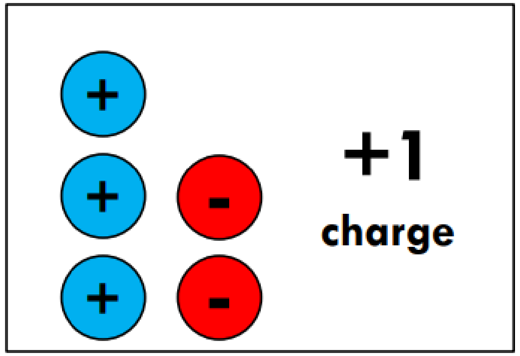
Na^{+1}

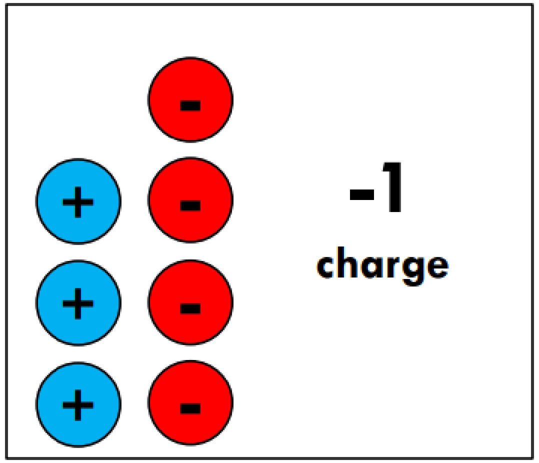
Positive

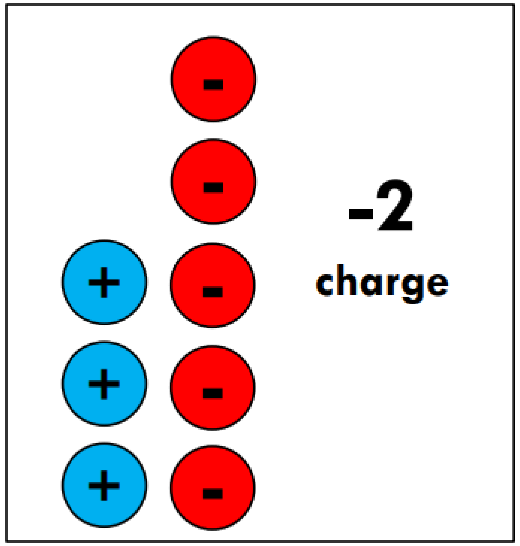
Cation

Took away electrons









Average Mass Calcs.

CALCULATING AVERAGE MASS

$$\text{Avg. Mass} = \left(\begin{array}{l} (\text{Mass}_{\text{Isotope1}} \times \%_{\text{abundance1}}) \\ + (\text{Mass}_{\text{Isotope2}} \times \%_{\text{abundance2}}) \\ + (\text{Mass}_{\text{Isotope3}} \times \%_{\text{abundance3}}) \\ \text{etc...} \end{array} \right)$$

Average Mass Calcs.

FINDING % ABUNDANCE

Same equation, just solving for a different variable!

We can use (x) to represent the $\%_{abundance1}$

We can use (1- x) to represent the $\%_{abundance2}$

BECAUSE:

The total has to add up to 100% right?!

100% is the same as 1 to make the math faster

Unit #2
Nuclear Chemistry **

- Why things are radioactive
- Types of radioactive particles
- Writing and balancing nuclear equations
- Decay series
- Half Life

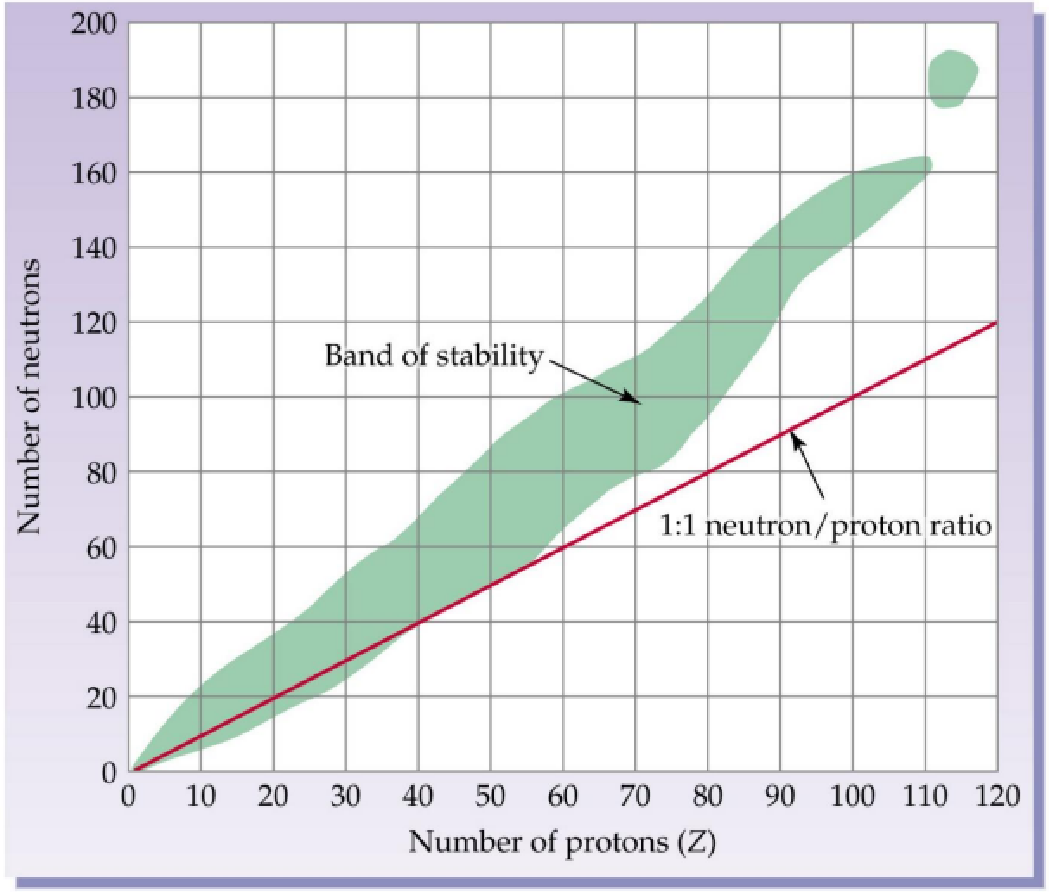
Nuclear Chemistry

What keeps nuclei together?
Why do they fall apart?

- **STRONG FORCE! –** Holds the nucleus together, even though the protons want to repel each other.
- **Too many neutrons? –** Strong force wont be strong enough, like a rubber band that is stretched too far…it will break!
  - **When it breaks, particles come flying out of the nucleus!**
- **Too many neutrons = radioactive!**

Nuclear Chemistry

Band of Stability and Island of Stability



Radioactive particles

Alpha

Composition	Symbol	Charge	Mass
helium nuclei	$^{4}_{2}He$, α	+2	4amu
Shielding	**Approx. Energy**	**Penetrating power**	
Paper, clothing	5 MeV	Low 0.05mm body tissue	

Beta

Composition	Symbol	Charge	Mass
Same as an electron	e^-, β	-1	1/1837th (basically 0)
Shielding	**Approx. Energy**	**Penetrating power**	
Aluminum foil	0.05-1MeV	Moderate 4mm body tissue	

Gamma

Composition	Symbol	Charge	Mass
High energy electromagnetic radiation	γ	0	0
Shielding	**Approx. Energy**	**Penetrating power**	
Lead, Concrete	1MeV	High Penetrates easily	

Writing Nuclear Equations

Alpha

Mass #

$$^{226}_{88}Ra \rightarrow \,^{4}_{2}He + \,^{222}_{86}Rn$$

Atomic #

Beta

Mass #

$$^{97}_{40}Zr \rightarrow \,^{0}_{-1}e + \,^{97}_{41}Nb$$

Atomic #

Writing Nuclear Equations

Sometimes lots of parts! Still just adding/subtracting!

(2 x 1) + 235 = **237**

(3 x 0) + 237 = **237**

$$2\,{}^{1}_{0}n + {}^{235}_{92}U \rightarrow 3\,{}^{0}_{-1}e + {}^{237}_{95}Am$$

(2 x 0) + 92= **92**

(3 x -1) + 95 = **92**

By the way…This is called "neutron bombardment"

Decay Series

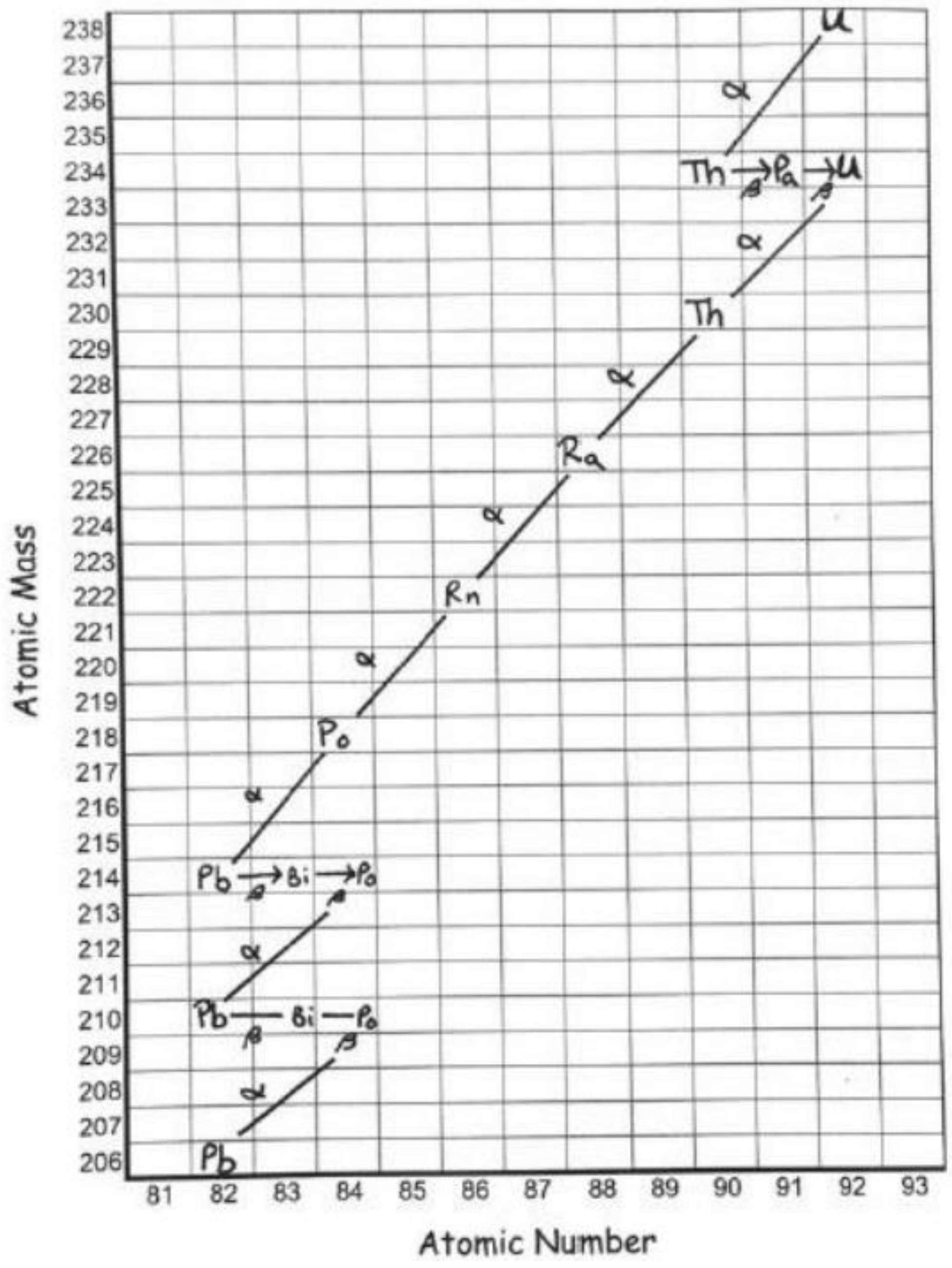
$$U_{92}^{238} \xrightarrow{\alpha} Th_{90}^{234} \xrightarrow{\beta} Pa_{91}^{234} \xrightarrow{\beta} U_{92}^{234}$$

$$\xrightarrow{\alpha} Th_{90}^{230} \xrightarrow{\alpha} Ra_{88}^{226} \xrightarrow{\alpha} Rn_{86}^{222} \xrightarrow{\alpha} Po_{84}^{218}$$

$$\xrightarrow{\alpha} Pb_{82}^{214} \xrightarrow{\beta} Bi_{83}^{214} \xrightarrow{\beta} Po_{84}^{214} \xrightarrow{\alpha} Pb_{82}^{210}$$

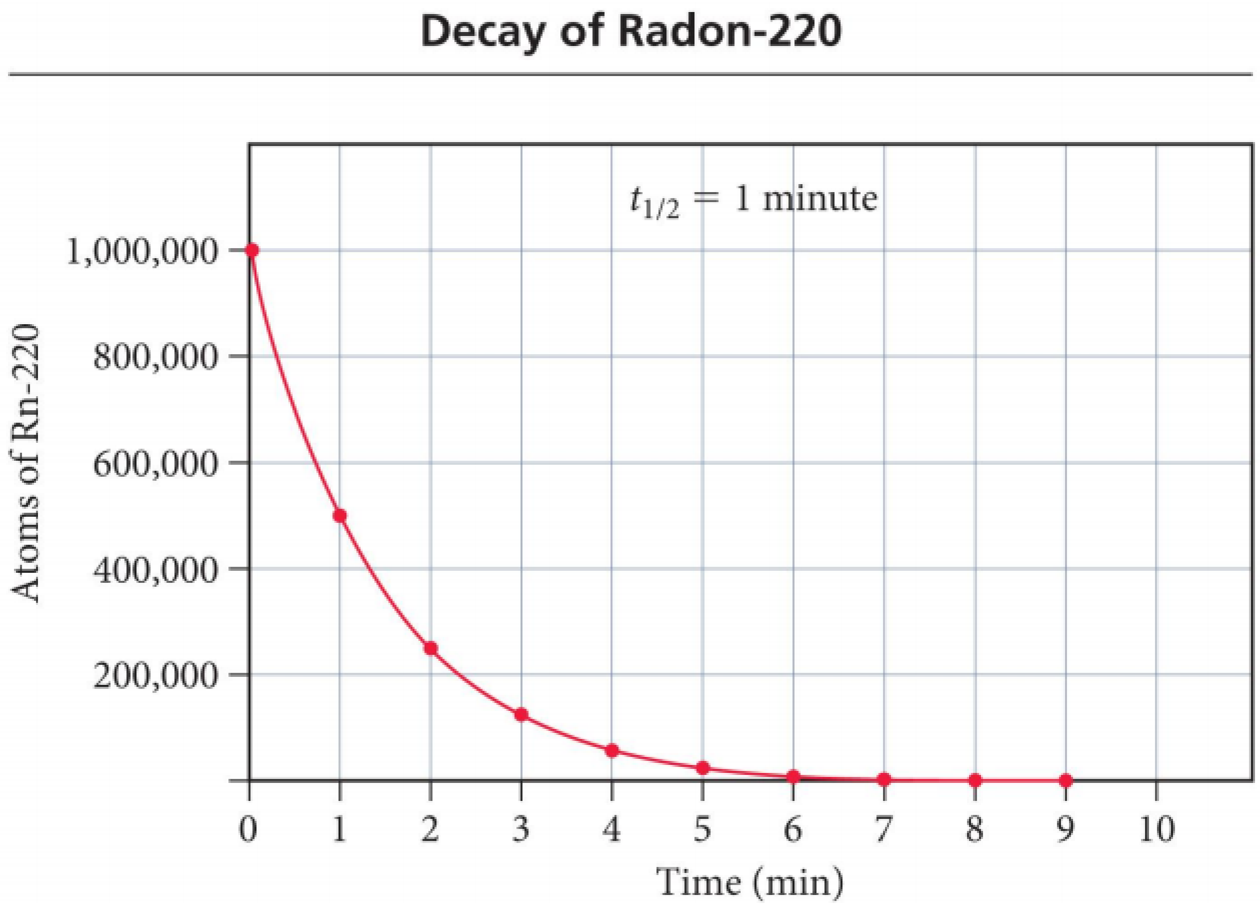
$$\xrightarrow{\beta} Bi_{83}^{210} \xrightarrow{\beta} Po_{84}^{210} \xrightarrow{\alpha} Pb_{82}^{206}$$

Decay Series



Half Life

Half of the radioactive atoms decay each half-life.



Half-Life Equation

- Use a handy dandy equation!

Amount Starting

$$A_E = A_S \times (0.5)^n$$

# of half-lives

Amount Ending

$$n = \frac{t}{h}$$

t = time passed
h = length of one half-life

Solving for % remaining

$$A_E = A_S \times (0.5)^n$$

$$\% \text{ remaining} = \frac{A_E}{A_S} \times 100$$

$$\frac{A_E}{A_S} = (0.5)^n$$

Then multiply your answer by 100 to put it in % format!

Half Life

Solve for Time/Half-life

$$A_E = A_s \times (0.5)^{t/h}$$

Isolate $(0.5)^{t/h}$

$$\frac{A_E}{A_s} = (0.5)^{t/h}$$

Bring down exponent using logs

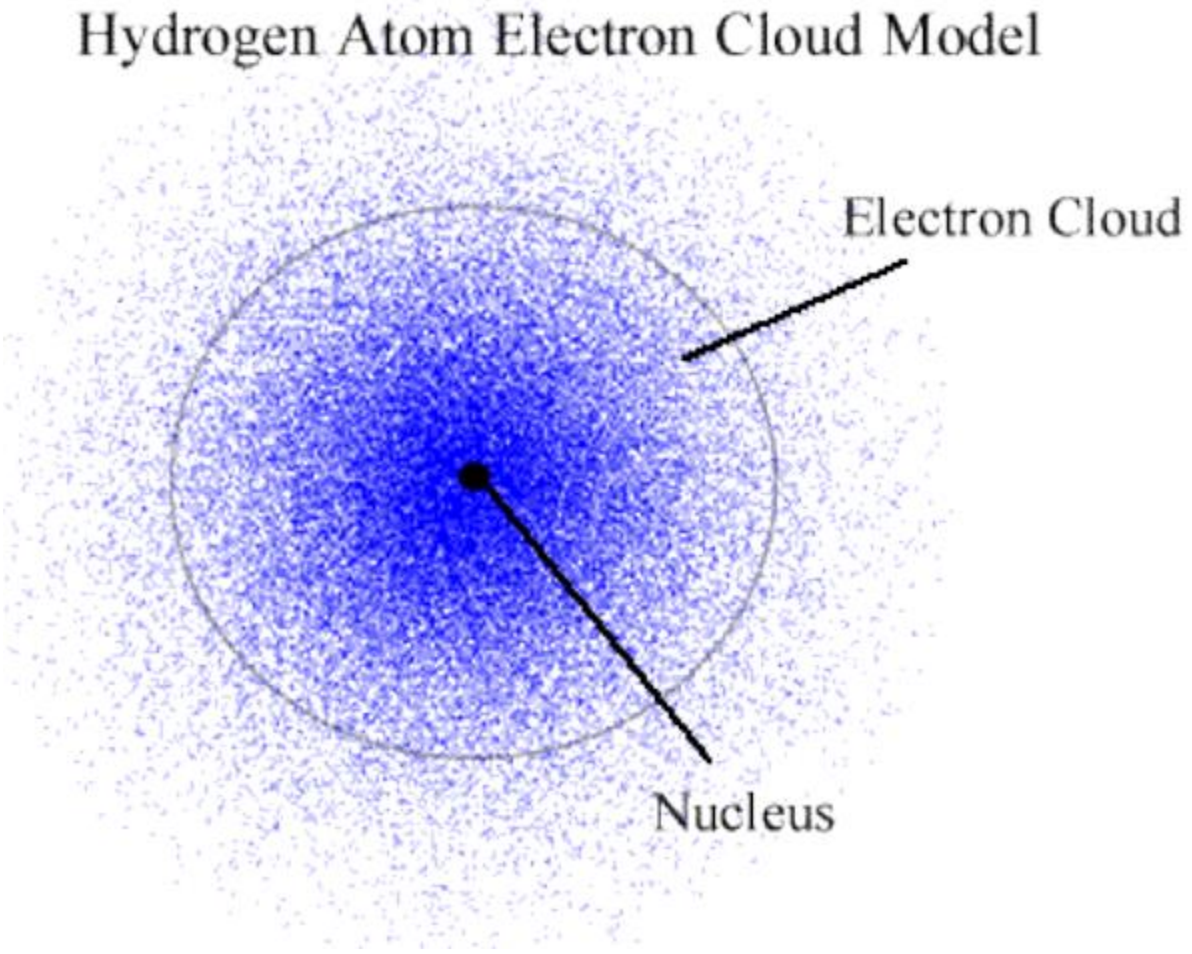
$$\text{Log}\left(\frac{A_E}{A_s}\right) = \frac{t}{h}\ \text{Log}\ (0.5)$$

Plug in your #'s then rearrange for t or h depending on what you want to solve for!

Unit #3
Electrons

- Quantum mechanical theory
- Orbital diagrams
- Writing electron configurations
- Noble Gas configuration
- Configuration of ions
- Absorption and emission

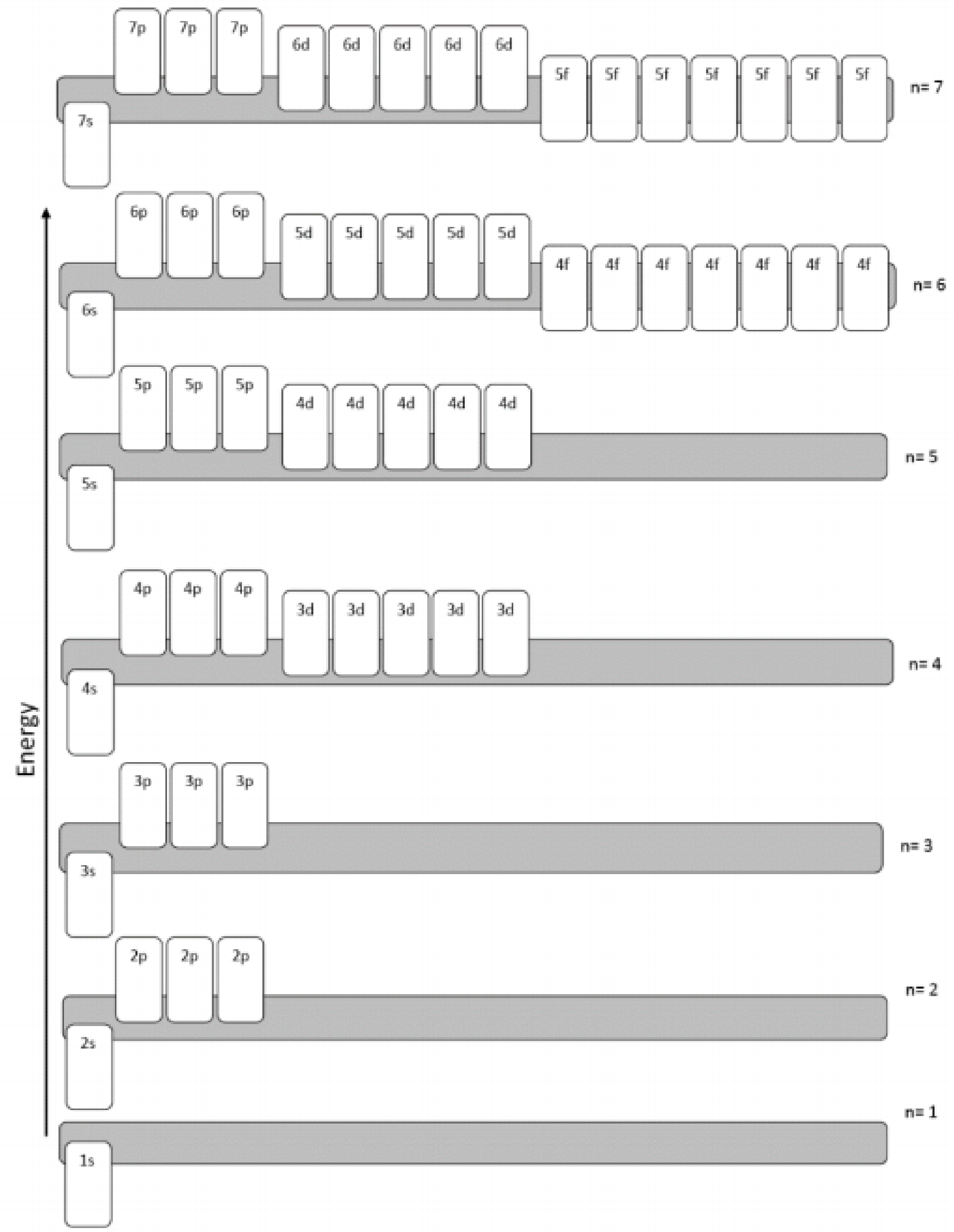
Quantum Mechanical Model



Orbital Diagrams

Orbital Diagram

A chart that shows you the order that the orbitals go in.



Orbital Diagrams

Aufbau Principle

An electron occupies the lowest energy orbital that it can.

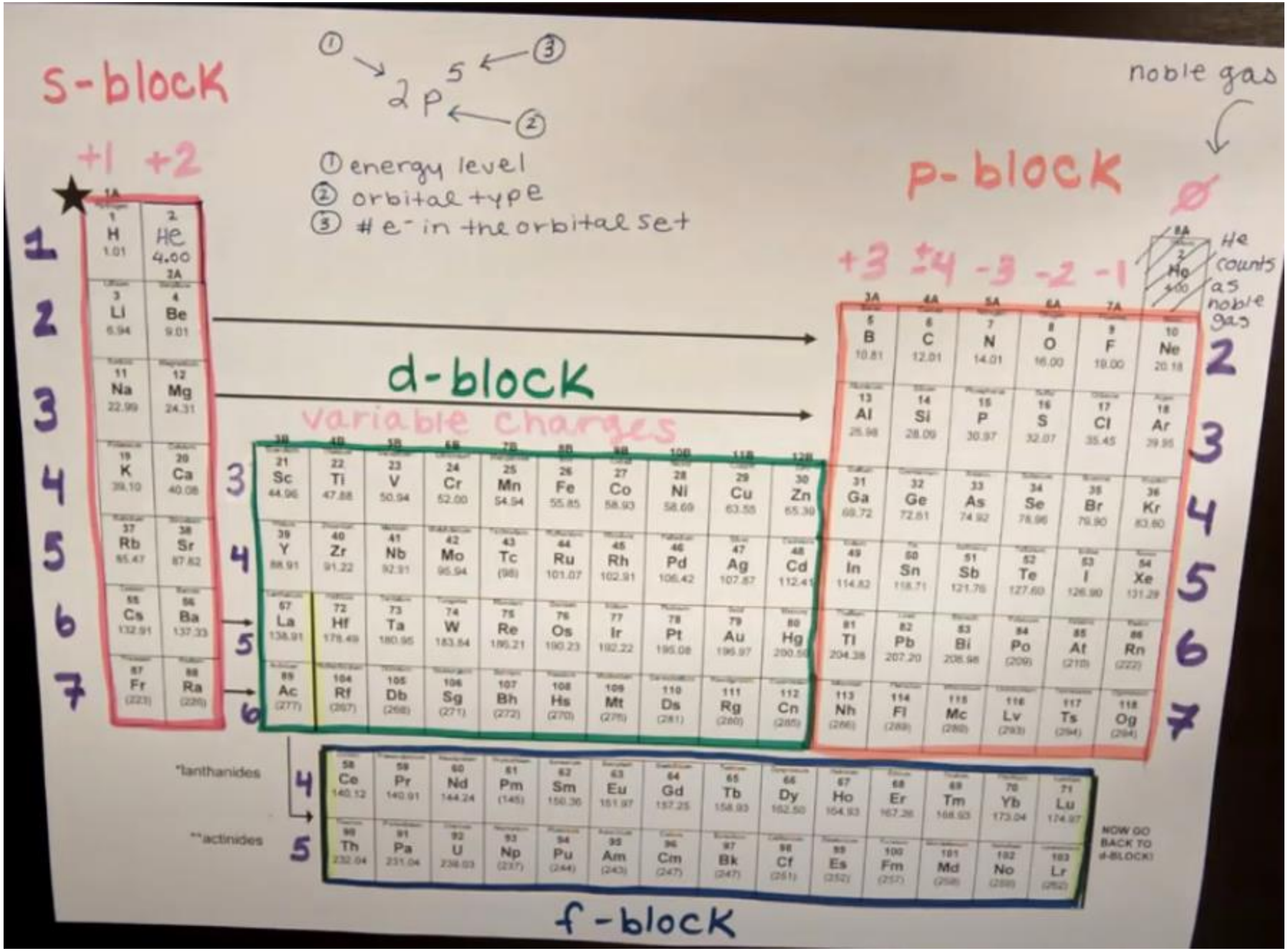
Pauli Exclusion Principle

No two electrons in the same atom can have the same set of 4 quantum numbers

Hund's Rule

Orbitals of equal energy are each occupied by one electron before any orbital is occupied by a second electron.

Writing Electron Config.



Noble Gas Config.

He: $1s^2$	He: $1s^2$	Ne: $1s^2 2s^2 2p^6$
Lithium	**Nitrogen**	**Sodium**
$1s^2$ $2s^1$	$1s^2$ $2s^2 2p^3$	$1s^2 2s^2 2p^6$ $3s^1$
Helium + extra!	Helium + extra!	Neon + extra!
↓	↓	↓
[He] $2s^1$	[He] $2s^2 2p^3$	[Ne] $3s^1$

Noble Gas Configurations!

Config. of Ions

Configuration of Ions

Ga: $1s^2 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10} 4p^1$

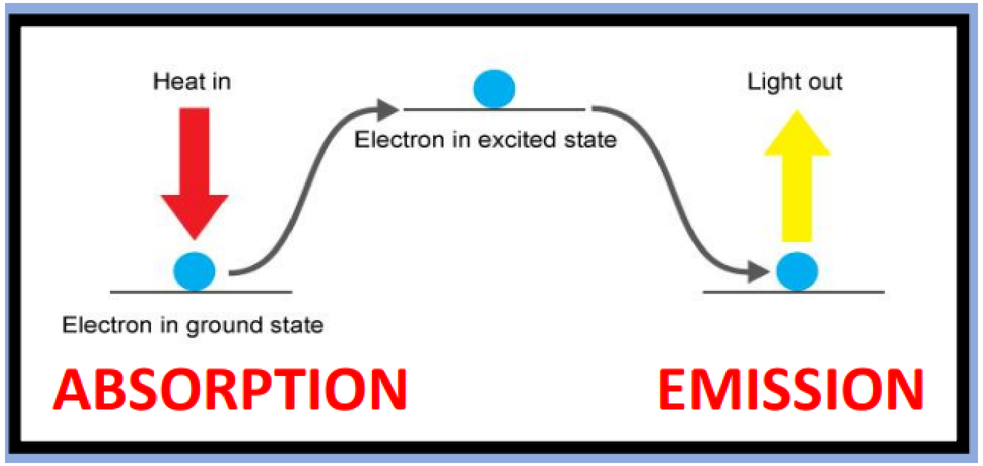
Ga^+: $1s^2 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^{10}$ — Take 4p first

Ga^{2+}: $1s^2 2s^2 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$ — Take 4s next

Ga^{3+}: $1s^2 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^{10}$ — Take last 4s

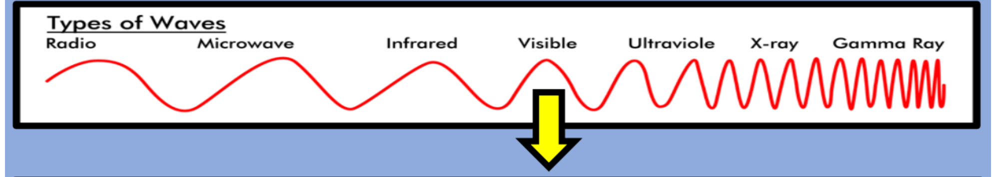
Ga^{4+}: $1s^2 2s^2 2p^6\ 3s^2\ 3p^6\ 3d^9$ — THEN you can take 3d !

Absorption and Emission



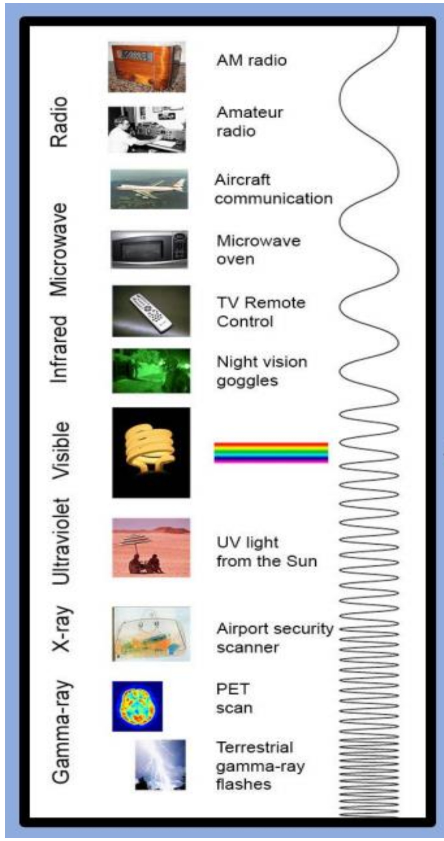
ENERGY SPECTRUM

You can measure the exact wavelength and it can tell you how big the energy gap was that the e- fell from

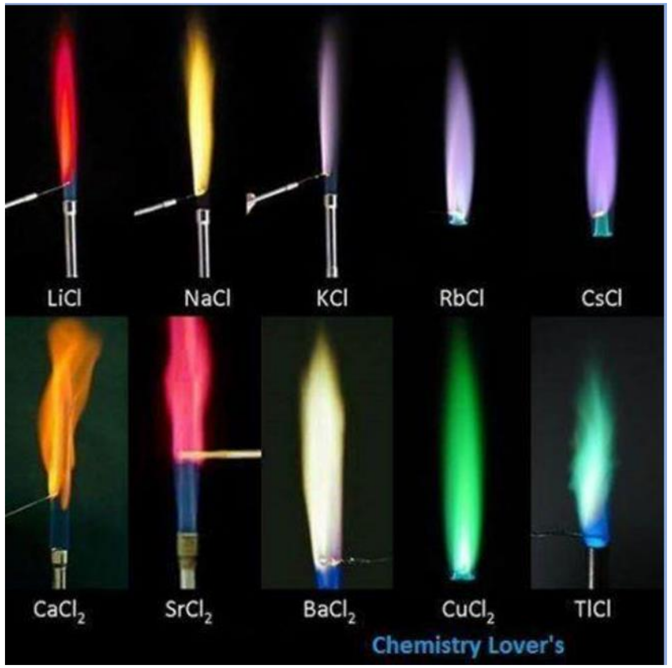


Red Orange Yellow Green Blue Purple

LOW energy — HIGH energy



We can only see this little range here

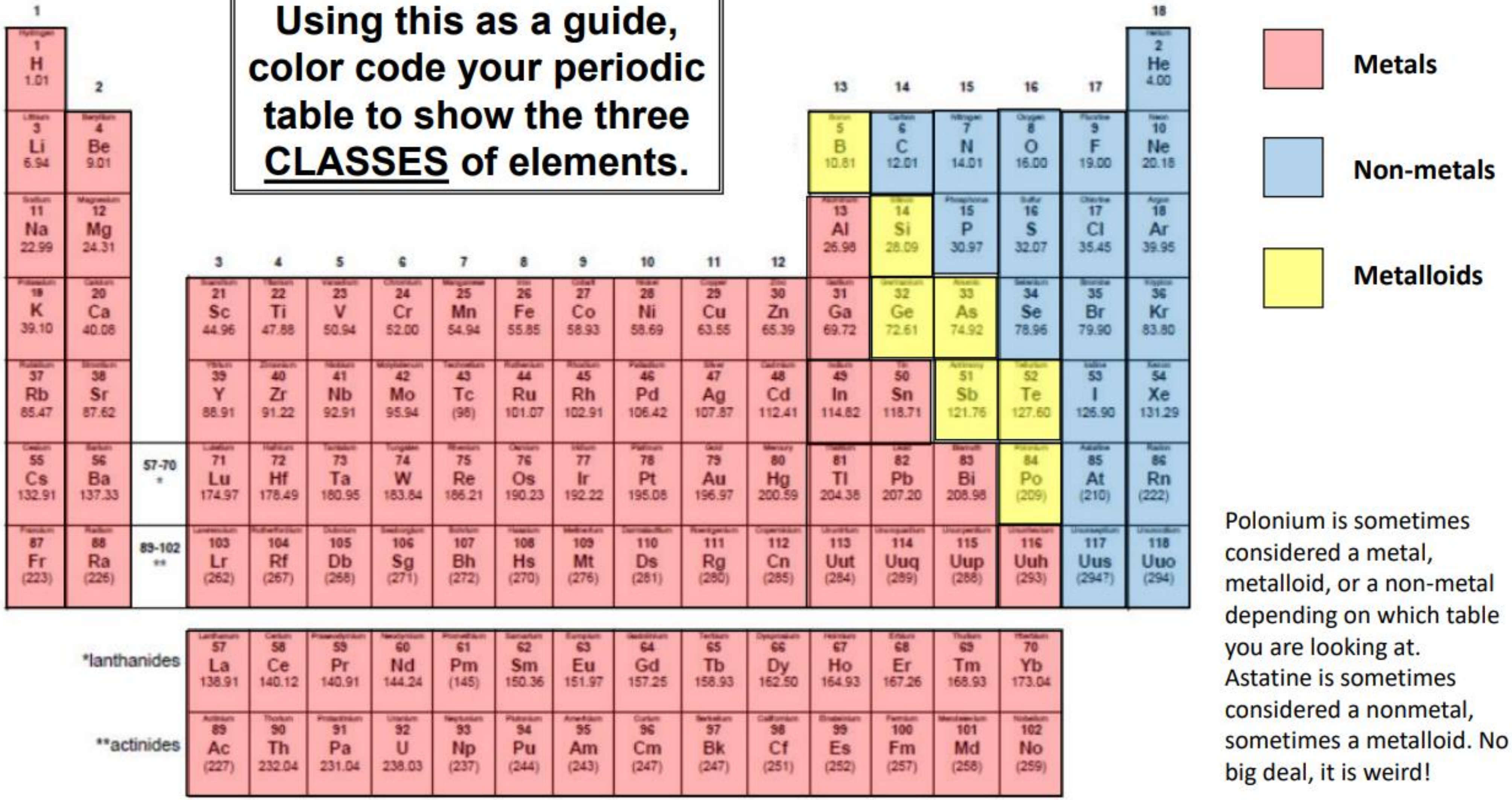


Unit #4
Periodic Table

- Structure of the periodic table
- Periodic trends

Periodic Table Structure

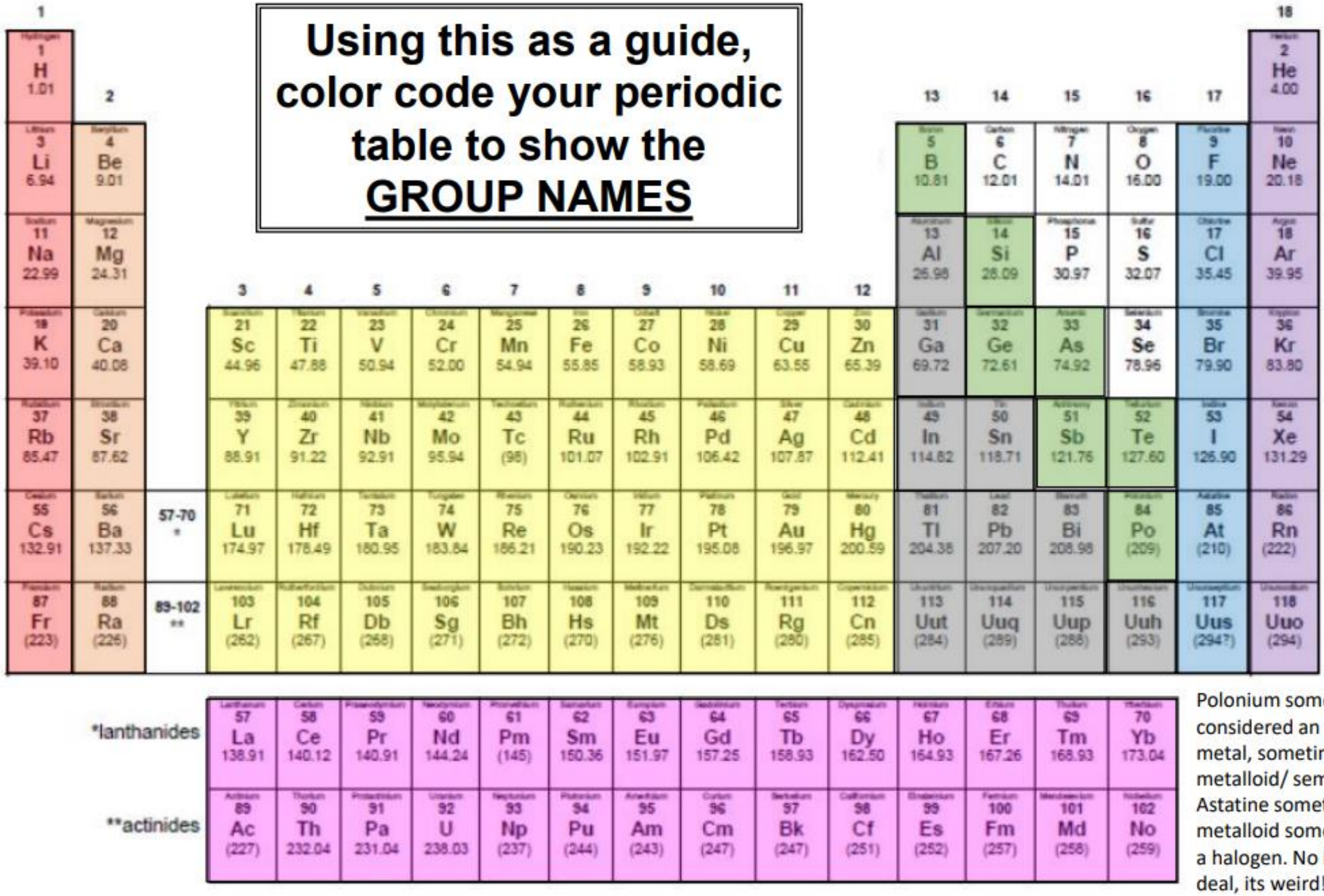
Using this as a guide, color code your periodic table to show the three <u>CLASSES</u> of elements.



Polonium is sometimes considered a metal, metalloid, or a non-metal depending on which table you are looking at. Astatine is sometimes considered a nonmetal, sometimes a metalloid. No big deal, it is weird!

Periodic Table Structure

Using this as a guide, color code your periodic table to show the <u>GROUP NAMES</u>



Polonium sometimes considered an other metal, sometimes a metalloid/ semimetal. Astatine sometimes a metalloid sometimes a halogen. No big deal, its weird!

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Other Metals
- Rare Earth Metals
- Metalloids/ Semimetals
- Other Non-metals
- Halogens
- Noble Gases

Periodic Table Structure

Things in the same period have:

Increasing atomic # and mass L→R

Same number of energy levels

- Period 1 has 1 level
- Period 2 has 2 levels etc…

Things in the same group have:

Increasing atomic # and mass ↓

Same number of valence electrons

- Exceptions: d and f block

Similar physical and chemical properties

- b/c they have same # of valence e^-s

Valence Electrons:

Outer electrons

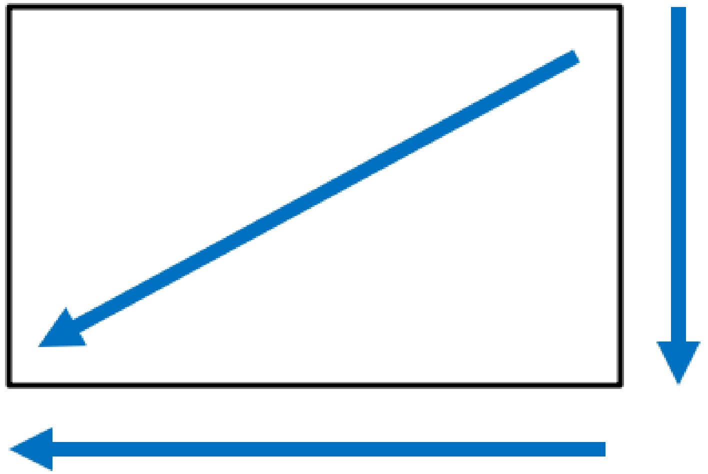
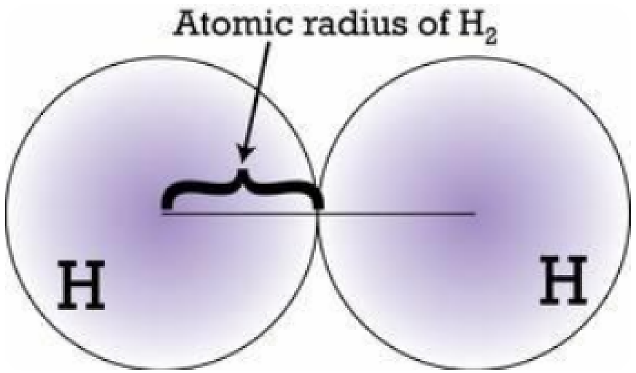
Matches the "A" column number

1A has 1 v.e^-, 2A has 2v.e^-, etc.

d and f blocks don't follow rules

Periodic Trends

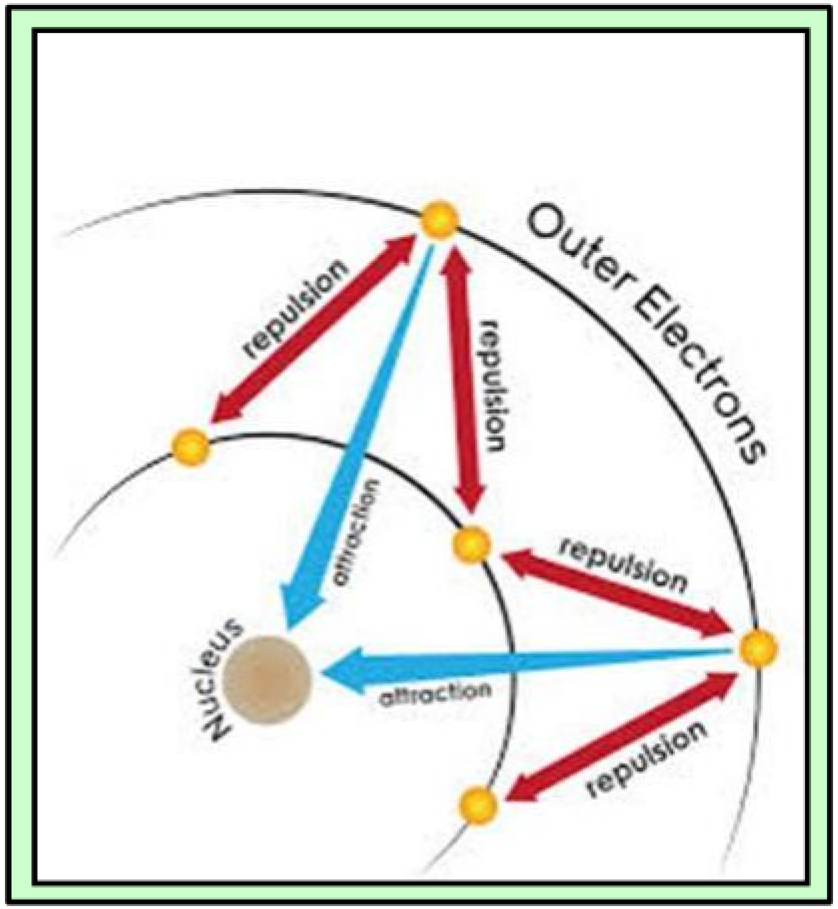
ATOMIC RADIUS

What	How
• ½ the distance between two bonded nuclei • Cant measure to the edge b/c orbitals aren't tangible!	
	

Periodic Trends

Effective Nuclear Charge (Z_{eff})

The relative attraction the valence electrons have for the protons in the nucleus



Shielding Effect

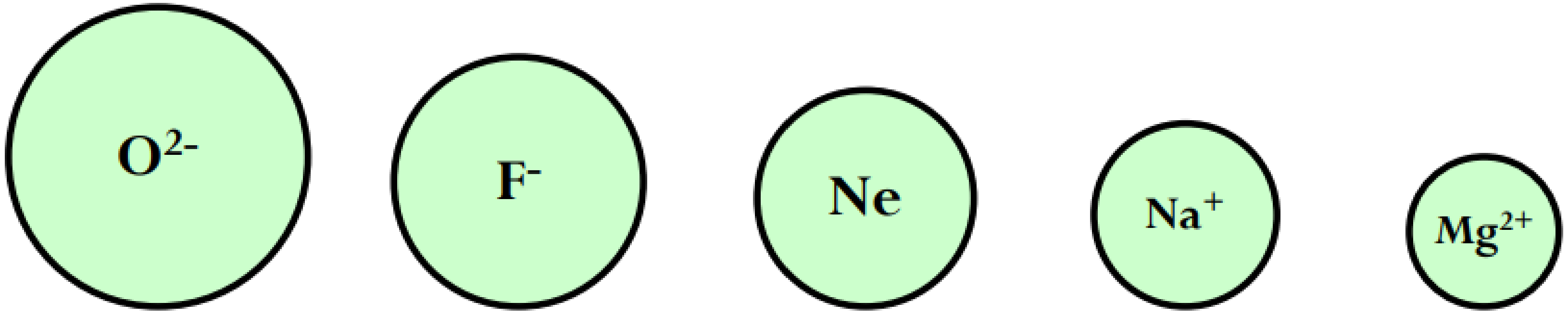
The inner shell electrons repel the outer valence electrons – keeps the valence e- from "feeling" the nucleus. More repulsion results in less attraction between nucleus and valence e-.

Periodic Trends

Isoelectric Species

Atoms/Ions that have the same number of e-

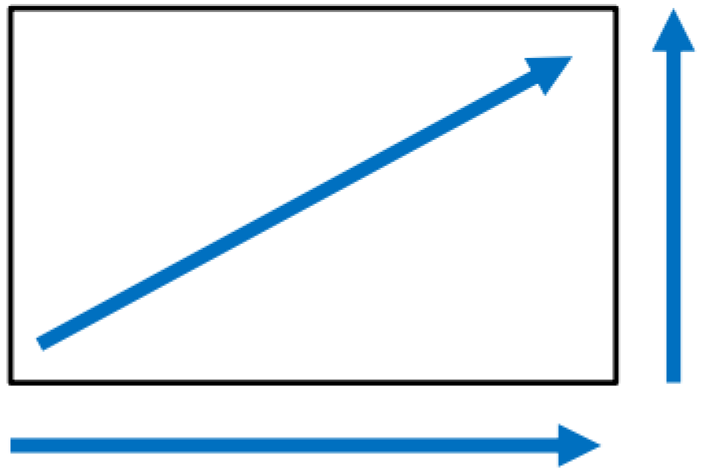
All these examples are $1s^2 2s^2 2p^6$



Increased protons can pull harder on the valence electrons – greater effective nuclear charge – so the radius is smaller even though they have the same number of electrons and energy levels

Periodic Trends

IONIZATION ENERGY

What	How
The energy required to remove on electron from a neutral atom of an element	 Noble Gases are HIGHEST! They REALLY don't want to let go of an e-

Periodic Trends

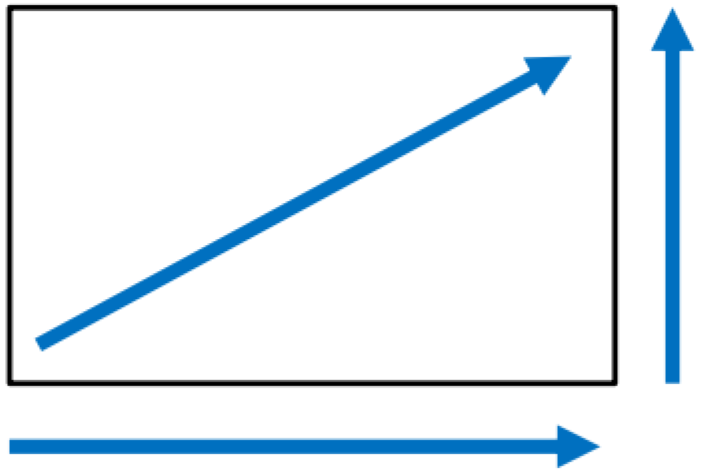
Subsequent Ionizations

Every time you take an e- away it gets harder to take the next one. Radius is getting smaller, so nucleus can pull harder on the valence - harder to remove the next one. HUGE LEAP in I.E. once it's achieved noble gas configuration – why would it want to lose another one?!

Element	IE_1	IE_2	IE_3	IE_4
Na	496	4560		
Mg	738	1450	7730	
Al	578	1820	2750	11,600

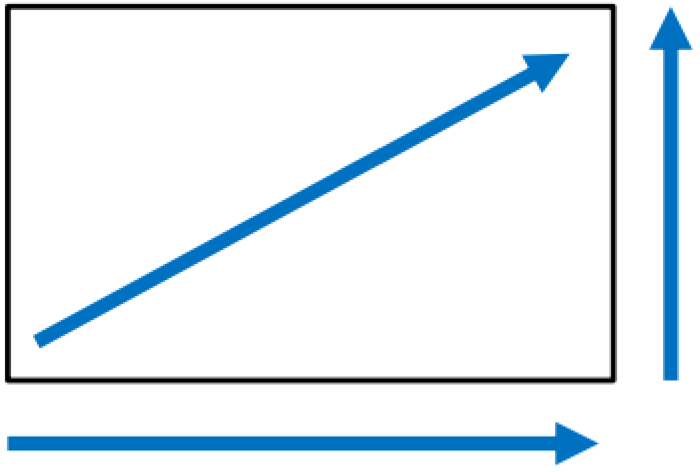
Periodic Trends

ELECTRONEGATIVITY

What	How
A measure of the ability of an atom in a chemical compound to attract electrons from another atom in the compound	
How strongly can one atom pull on the electrons being shared in a bond.	Noble Gases are LOWEST! They DON'T CARE about attracting electrons!

Periodic Trends

ELECTRON AFFINITY

What	How
How much energy is released when the atom gains an electron to make a negative ion. *How much stability does it gain once it is an anion. More energy released – more stable.*	 Noble Gases are LOWEST! They DON'T CARE about attracting electrons!

Periodic Trends

REACTIVITY

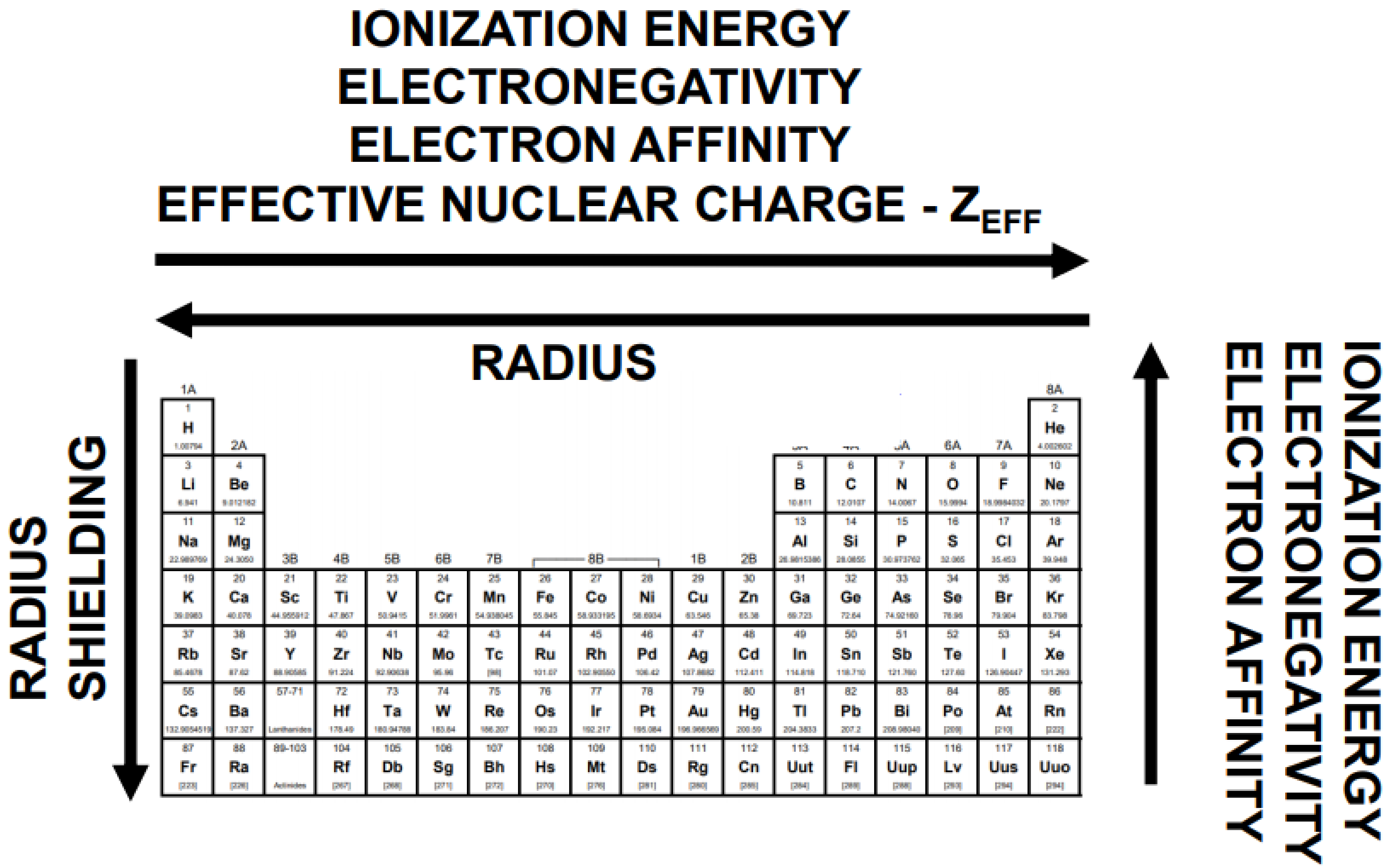
What	How
Elements in the same group have similar types of behaviors because they have the same number of valence e- BUT The MAGNITUDE of their reactions changes!	 Metals and Non-metals are opposite trends! Noble gases are “INERT” or non-reactive

Periodic Trends

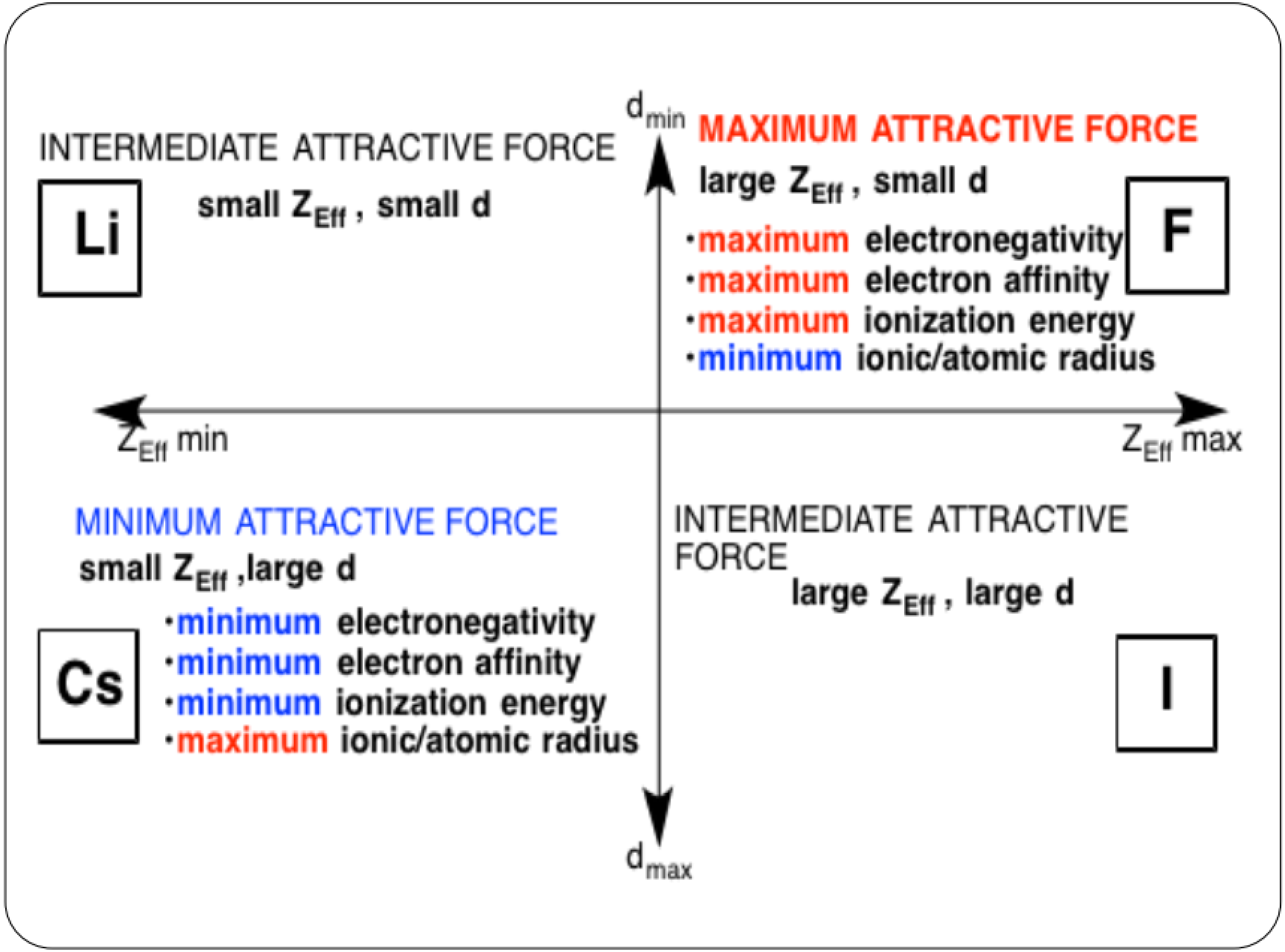
REACTIVITY

What	How
Elements in the same group have similar types of behaviors <u>because they have the same number of valence e-</u> BUT The MAGNITUDE of their reactions changes!	 Metals and Non-metals are opposite trends! Noble gases are "INERT" or non-reactive

Periodic Trends



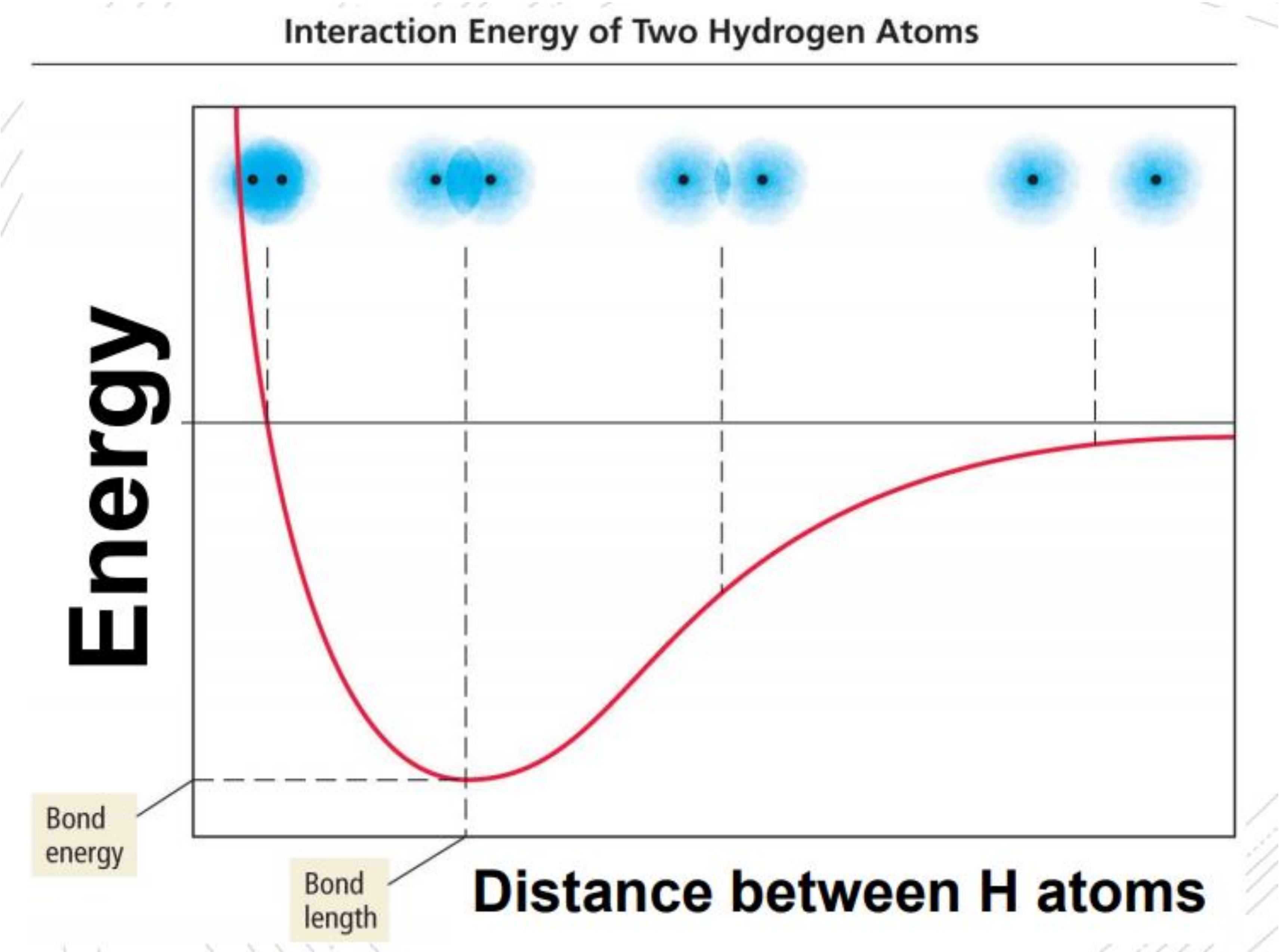
Periodic Trends



Unit #5
Bonding and Structure

- Why bonds form
- Types of bonds
- Naming formulas
- Writing neutral formulas
- Lewis structures
- VSPER
- Hybridization
- Polarity
- Intermolecular forces

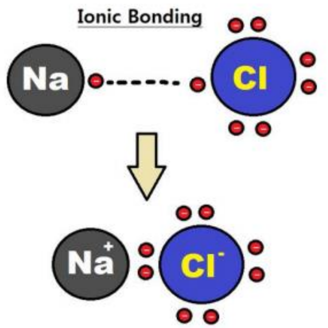
Why Bonds Form



Types of Bonds

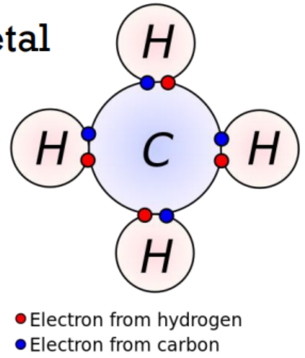
Ionic Bonds

- Transfer of electrons - makes charges
- Electrostatic bond between a positive charge and a negative charge
- Metal + Nonmetal
  Ca^{2+} O^{2-}
- Polyatomic Ions, even if nonmetals
  NH_4^+, SO_4^{2-}



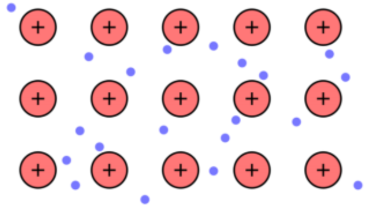
Covalent Bonds

- Atoms can't fully transfer electrons, so they share them
- Nonmetal + Nonmetal
  CH_4



Metallic Bonds

- Electrons "detach" from the atoms they came from
- Creates a "sea of electrons" that can flow when a charge is applied



Naming formulas

Naming Ionic Compounds

- **Cation first, then anion**
- **Monatomic cation = name of the element**
  - Ca^{2+} = calcium ion
- **Monatomic anion = root + -ide**
  - Cl^{-} = chloride
  - $CaCl_2$ = calcium chloride

With Polyatomic Ions

- Poly atomic ions always keep their special names, don't change them!
  - $K_3(PO_3)$
  - Potassium phosphite

Metals with variable charges

- Some metal forms more than one cation
- **Use Roman numeral in name**
  - **$PbCl_2$**
    - Pb^{2+} is cation
    - $PbCl_2$ = lead(II) chloride
  - **FeO**
    - Fe^{2+} is cation
    - FeO = Iron(II) oxide

Naming formulas

Naming Covalent Molecules

- Two (or more) nonmetals
- All elements keep their normal names EXCEPT the last element changes its ending to -ide
- Use prefixes
- NEVER use "mono" for the first element!

number of atoms	prefix
1	mono
2	di
3	tri
4	tetra
5	penta
6	hexa
7	hepta
8	octa
9	nona
10	deca

- **Double vowels** – when using prefixes we don't like some double vowel combos – drop the last vowel from the prefix portion of the name
  - Any double vowel with an I is ok!
    - Diiodide = ok
    - Pentaiodide = ok
    - Monoiodide = ok
    - Monooxide = no! → monoxide

Naming formulas

Naming Metallic Substances

SUPER EASY….

- Name the metal. The end.
- Cu
- Copper

Naming formulas

Odds and Ends

Are the exceptions? Weird rules? YES. ALWAYS.

- **Diatomic elements** – some elements come as a pair and not by themselves

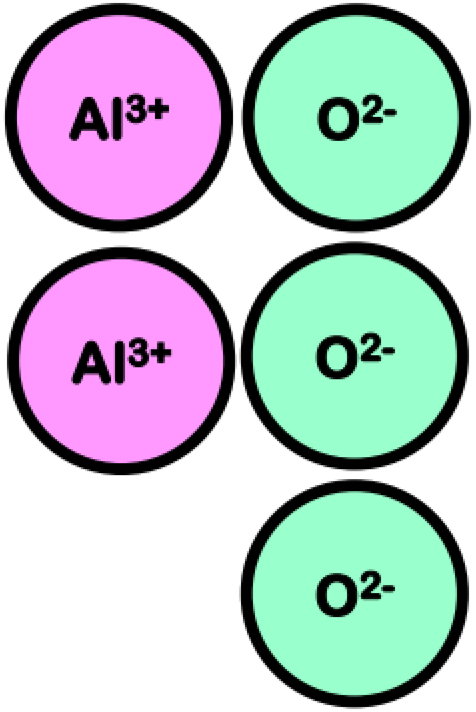
H_2, N_2, O_2,
F_2, Cl_2, Br_2, I_2

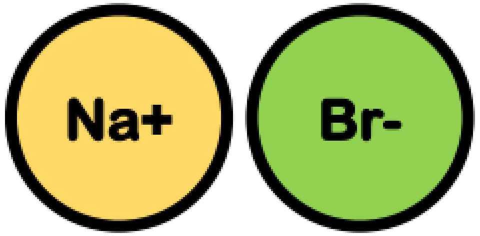
Horses Need
Oats For Clear
Brown "Eyes"

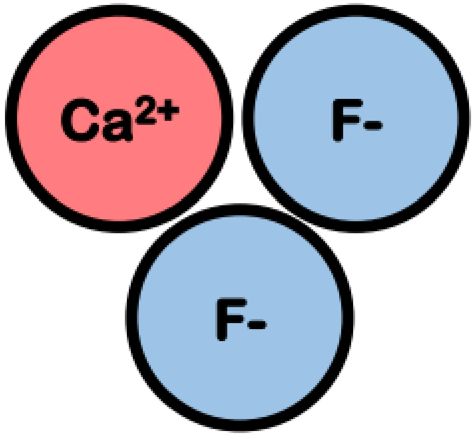
Neutral Formulas

Neutral Compounds

- We need our compounds to be "electrically neutral"
  - Charges need to cancel out
  - Not always a 1:1 ratio!







Neutral Formulas

Barium Fluoride

Ba^{2+} F^{-}

1 2

BaF_2

Neutral Formulas

Barium Nitrate

Ba^{2+} $(NO_3)^{-}$

1 2

$Ba(NO_3)_2$

Naming formulas

Ammonium Sulfate

$(NH_4)^+$ $(SO_4)^{2-}$

2 1

$$(NH_4)_2(SO_4)$$

Neutral Formulas

Iron(III) Chloride

Fe^{3+} Cl^{-}

1 3

$FeCl_3$

Neutral Formulas

Magnesium Carbonate

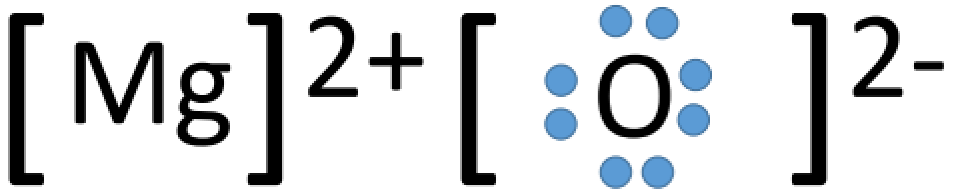
$$Mg^{2+} \quad (CO_3)^{2-}$$

2 2

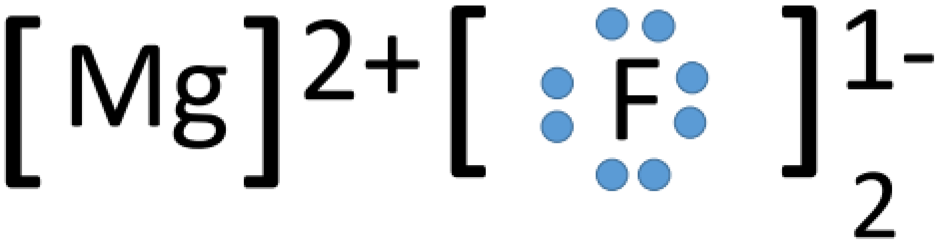
$$Mg_{2}(CO_3)_{2}$$

Ionic Compounds

Super easy! Just draw the cation and anion next to each other. Done!



More than one of a particular ion? Then just add a subscript outside the brackets!



Lewis Structures

Covalent Molecules

Covalent molecules will share electrons – they each donate one (or more) to a shared bond. **Do NOT just randomly throw dots all over your paper!!!!** **No "guessing and checking" allowed!** Follow a **systematic set of steps** so you never make mistakes!

STEPS

1) **Count & sum ve-**
2) **Place your atoms**
3) **Bond all atoms w/ a single bond**
4) **Give all atoms a full shell**
5) **Re-count the ve- you used**
6) **Used too few? Put extra on the central atom**
7) **Used to many ve-? Then try double or triple bonds to fix if needed**

Lewis Structures

PLACEMENT "RULES"

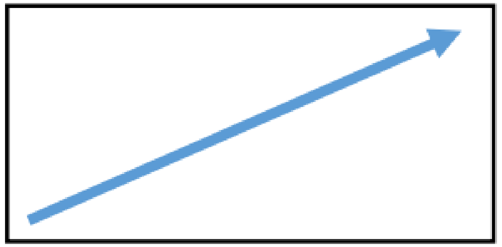
1) Hydrogen *always* goes on the outside of the molecule

- it is a "dead end"
- it "terminates" the molecule
- it "caps off" the molecule
- Because it can only make 1 bond

H	H	O	***no!***
H	O	H	***yes!***

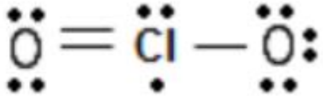
2) The *least* electronegative atom goes in the inside/center

- except for hydrogen!

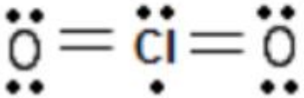


3) Symmetry is good!

- When possible!



Fine but not great



Better! Symmetrical!

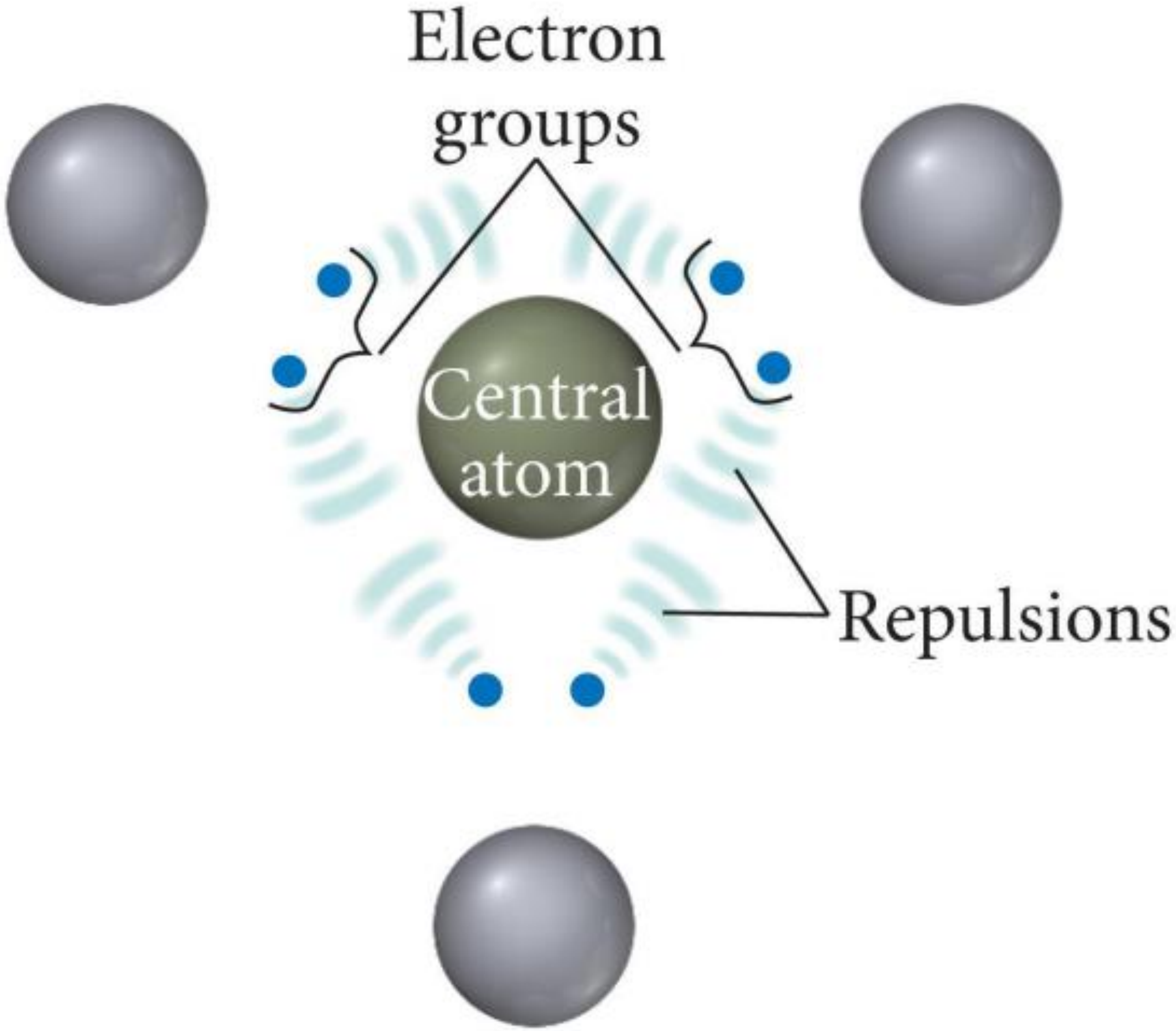
VSEPR

VSEPR Model

(Valence Shell Electron Pair Repulsion)

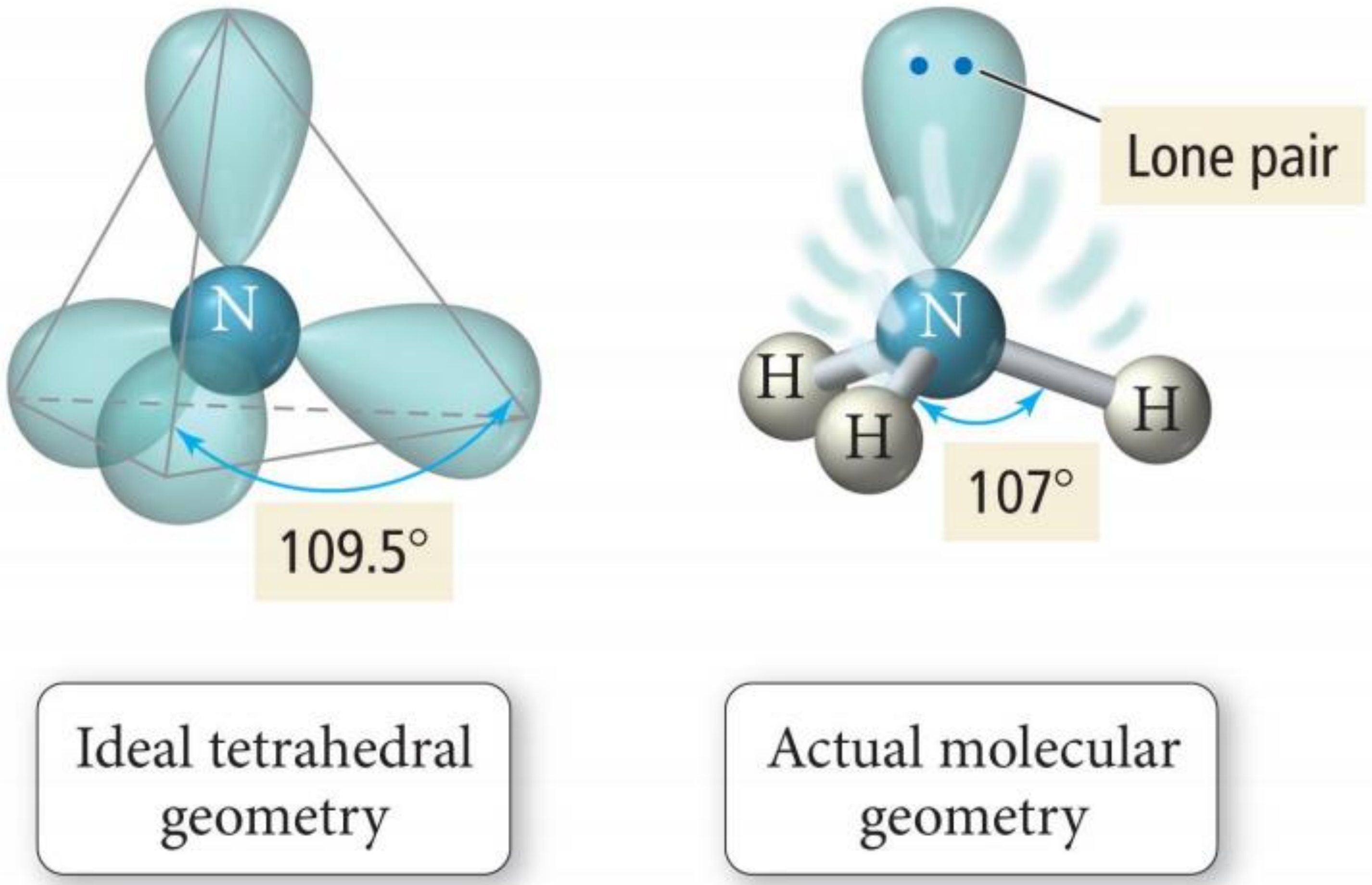
- The structure around a given atom is determined *mostly* by minimizing electron pair repulsions.
- They try to maximize the distance between electrons

VSEPR



VSEPR

Bond Angle Distortion from Lone Pairs

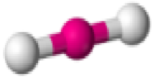
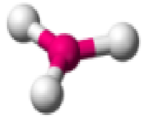
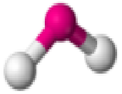
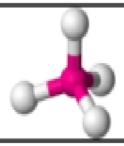
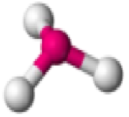
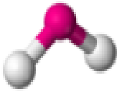


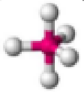
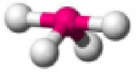
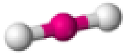
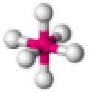
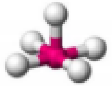
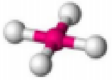
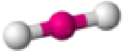
VSEPR – AXE Method

- The A represents the central atom.
- The X represents how many bonded atoms.
- The E represents the number of lone electron pairs present on the central atom.
- The sum of X and E, sometimes known as the steric number.

VSEPR

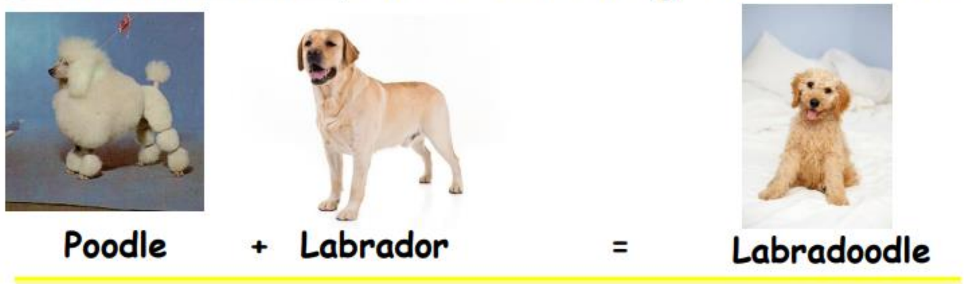
Predicting Molecular Geometry and Hybridization

Electron Groups	Bonding Groups	Lone Pairs	Electron Geometry *(Hybridization)*	Molecular Geometry *(VSEPR class)*	Approximate Bond Angles	Geometry Examples
2	2	0	Linear *(sp)*	Linear *(AX_2)*	180	
3	3	0	Trigonal Planar *(sp^2)*	Trigonal Planar *(AX_3)*	120	
	2	1		Bent *(AX_2E)*		
4	4	0	Tetrahedral *(sp^3)*	Tetrahedral *(AX_4)*	109.5	
	3	1		Trigonal Pyramidal *(AX_3E)*		
	2	2		Bent *(AX_2E_2)*		

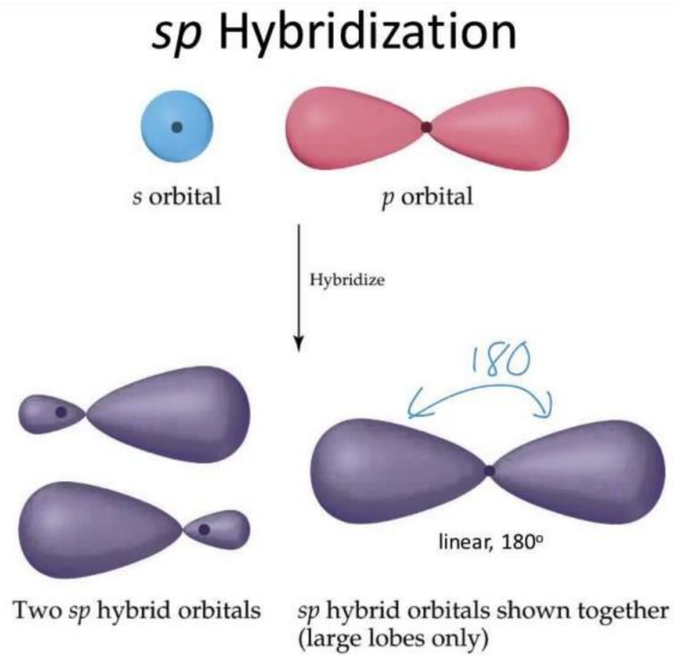
Electron Groups	Bonding Groups	Lone Pairs	Electron Geometry *(Hybridization)*	Molecular Geometry *(VSEPR class)*	Approximate Bond Angles	Geometry Examples
5	5	0	Trigonal Bipyramidal *(sp^3d)*	Trigonal Bipyramidal *(AX_5)*	120 (in plane) 90 (above and below)	
	4	1		Seesaw *(AX_4E)*		
	3	2		T-Shaped *(AX_3E_2)*		
	2	3		Linear *(AX_2E_3)*	180	
6	6	0	Octahedral *(sp^3d^2)*	Octahedral *(AX_6)*	90	
	5	1		Square Pyrimidal *(AX_5E)*		
	4	2		Square Planar *(AX_4E_2)*		
	3	3		T-Shaped *(AX_3E_3)*		
	2	4		Linear *(AX_2E_4)*		

Hybrid-ization

Hybridization - The Blending of Orbitals

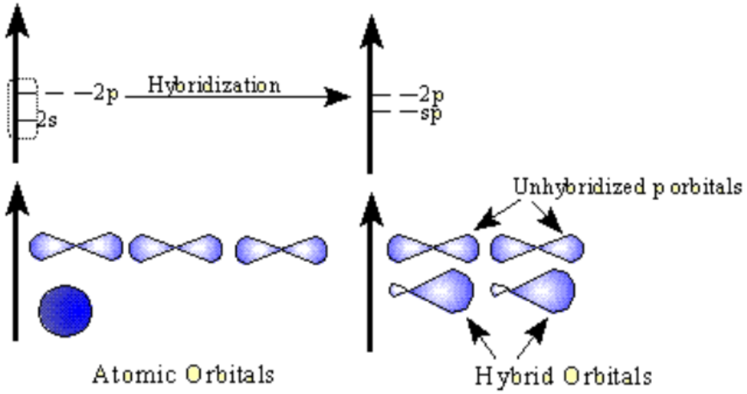


Hybridization is the combining of two or more orbitals of nearly equal energy within the same atom into orbitals of equal energy.



sp Hybrid Orbitals

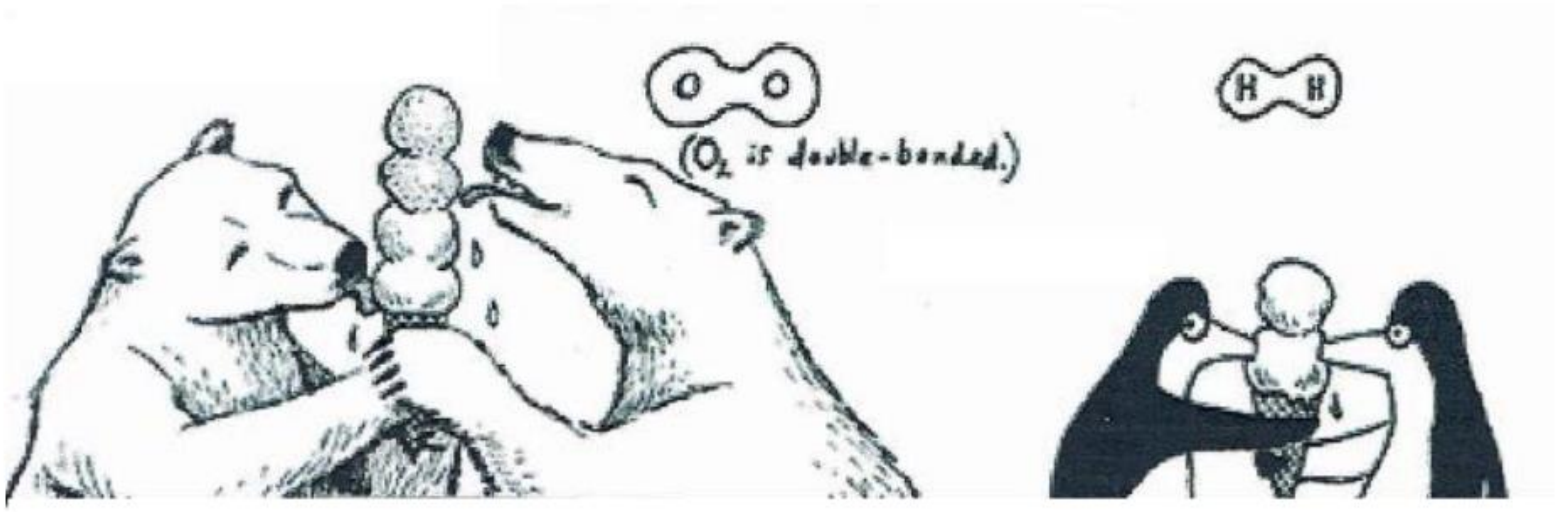
One s orbital combines with one p orbital
Two p orbitals are left the same



Polarity

What's happening inside covalent molecules like O_2 or H_2?

Electrons are shared *equally*



Polarity

<u>**Example:**</u> HF

HF is covalent but electrons are <u>*not*</u> shared equally

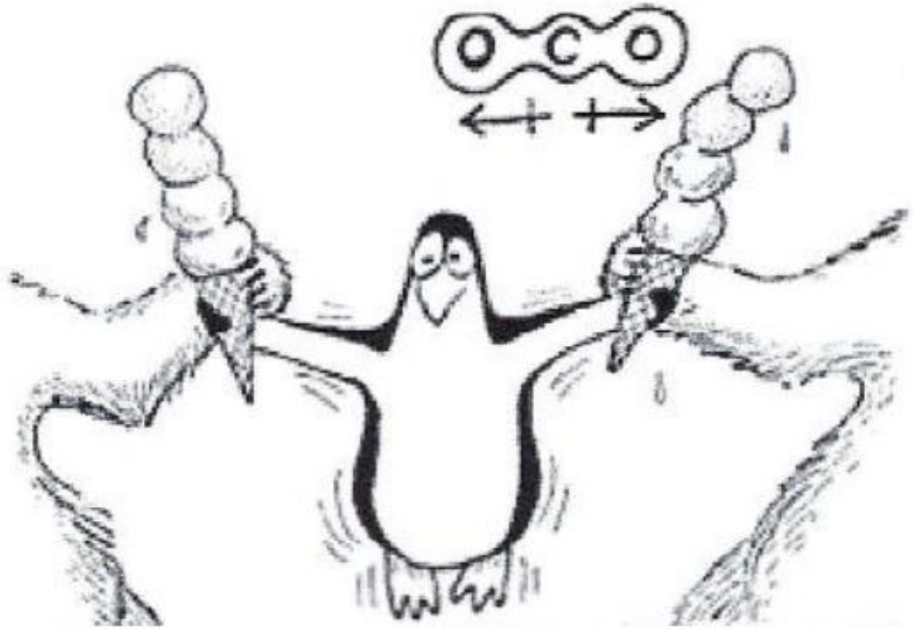
Molecules become *POLAR* when electrons are not shared equally

Polarity

Symmetry…the pole destroyer!

CO_2

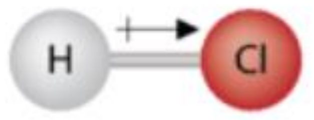
Has 1 carbon surrounded by 2 electronegative Oxygens, but is NOT polar?!?!

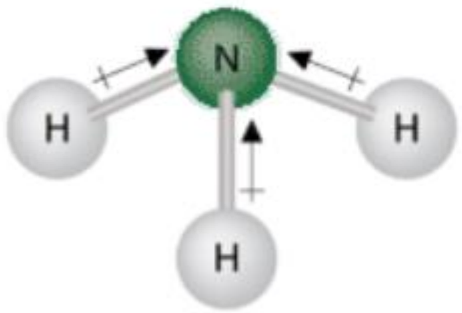


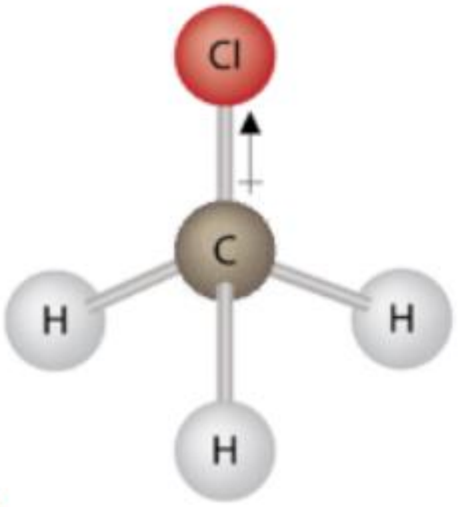
Electron density is still SYMETRICAL which makes it non-polar

Careful about polar BOND versus polar MOLECULE

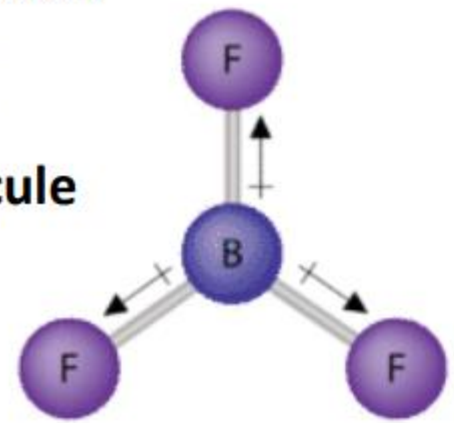
Polar bond AND Polar molecule

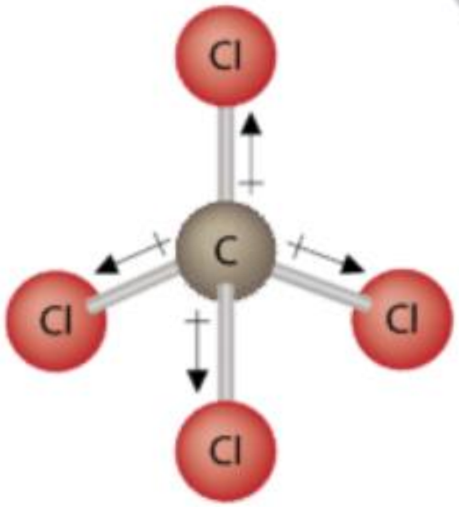






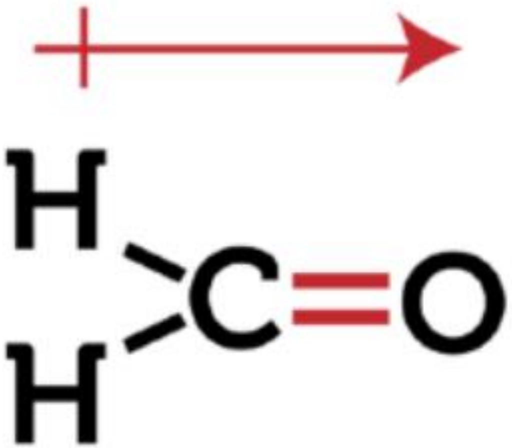
Polar bond AND NON-polar molecule

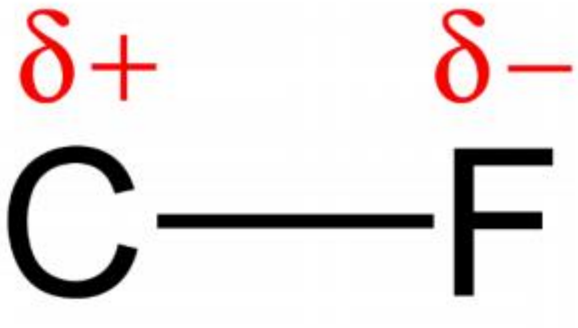


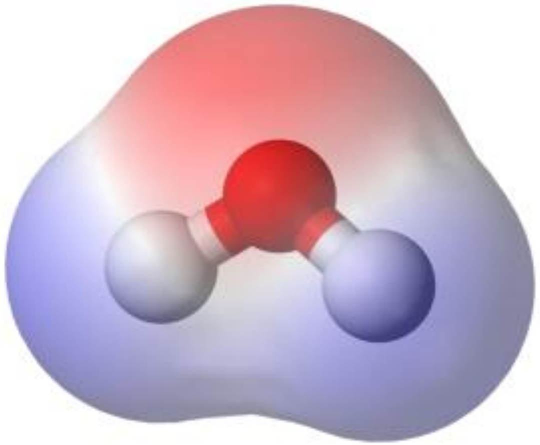


Polarity

Three ways to diagram "dipoles"







IMFs

Vocabulary

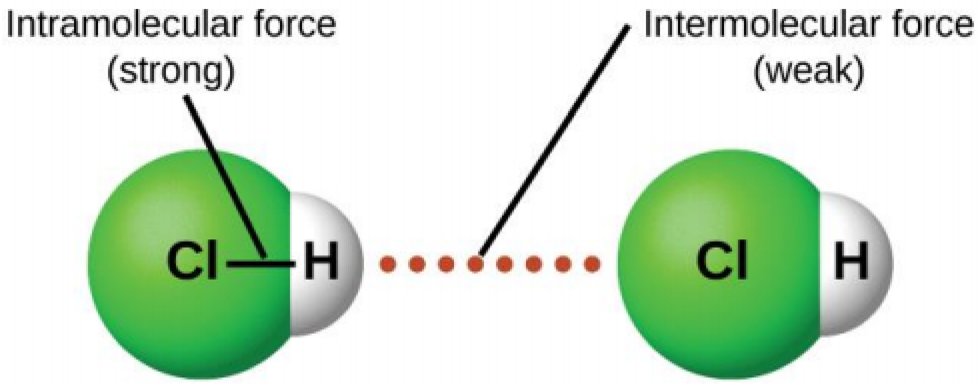
INTRAmolecular Forces

Forces holding together the atoms **INSIDE** a molecule or compound.

Types: Ionic forces, covalent forces

INTERmolecular Forces

Attractions or repulsions which act **between neighboring molecules**

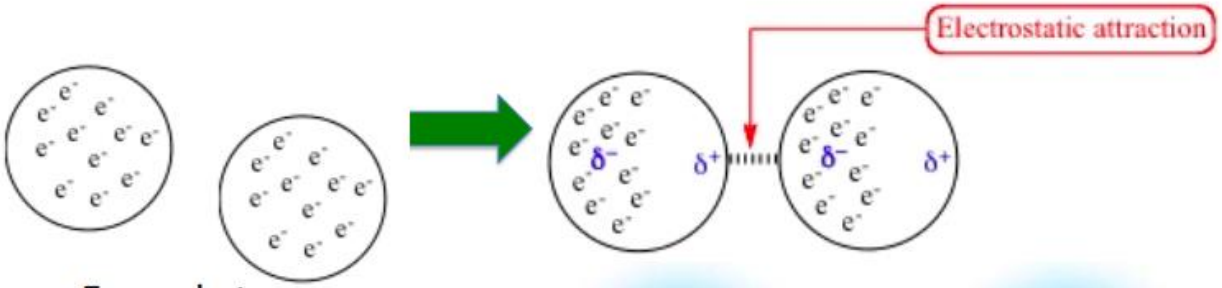


IMFs

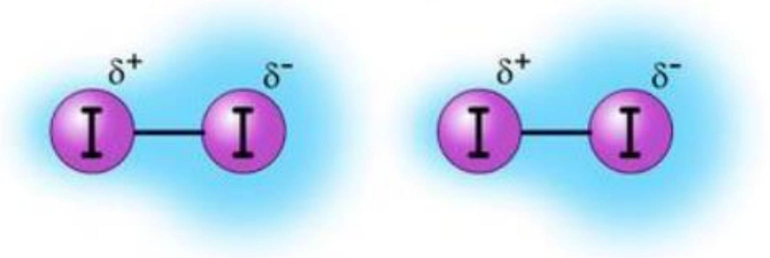
London Dispersion Forces

VERY WEAK and TEMPORARY!!!!

Caused by **temporary unequal** electron distribution that makes weak and temporary dipoles. Also called "instantaneous dipole"



Example I_2



London Dispersion Forces Continued…

EVERYTHING HAS LONDON DISPERSION FORCES BECAUSE EVERYTHING HAS ELECTRONS!

Bigger molecules will have more LDFs – more surface area to get temporary unequal electrons

C_8H_{18} will have more LDFs than C_3H_8

IMFs

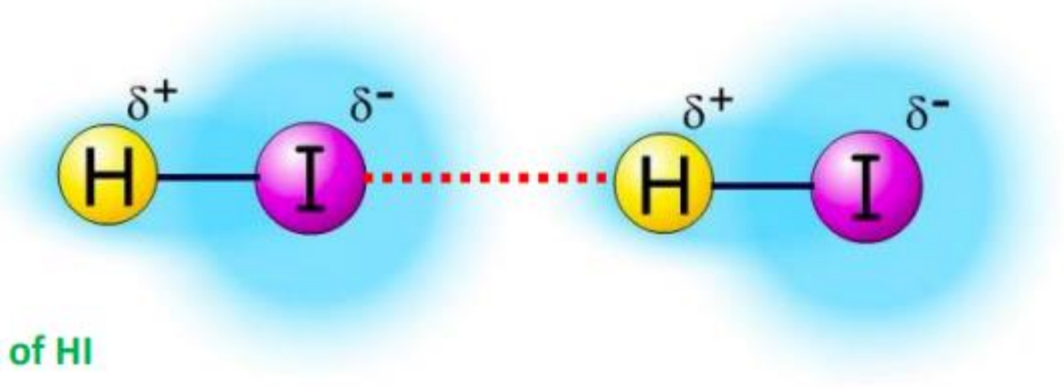
Dipole - Dipole

ONLY OCCURS IN POLAR MOLECULES

Partially negative portion of one polar molecule

attracted to

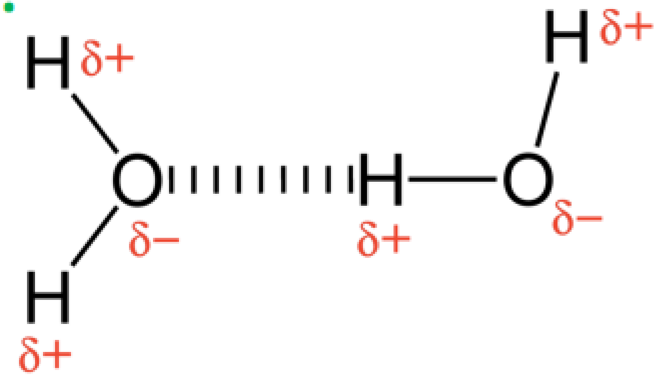
Partially positive portion of the second polar molecule



Example:
2 molecules of HI

Hydrogen Bonding

A TYPE OF DIPOLE-DIPOLE!
(Strongest Kind of IMF!)



Must have:
"H-NOF:"

ATTRACTION BETWEEN:

the partially negative part of a *lone pair* on an N, O, or F, atom (−)	········	(+) Hydrogen end of an O-H, N-H, or F-H bond

IMFs

Some properties that relate to intermolecular forces

Boiling point Melting point Viscosity Surface tension	When you increase IMFs Properties increase too! More forces=higher props	
Miscibility (Mixing)	"Like dissolves like"	
	Polar with polar	Non-polar with non-polar

Bulk Solids

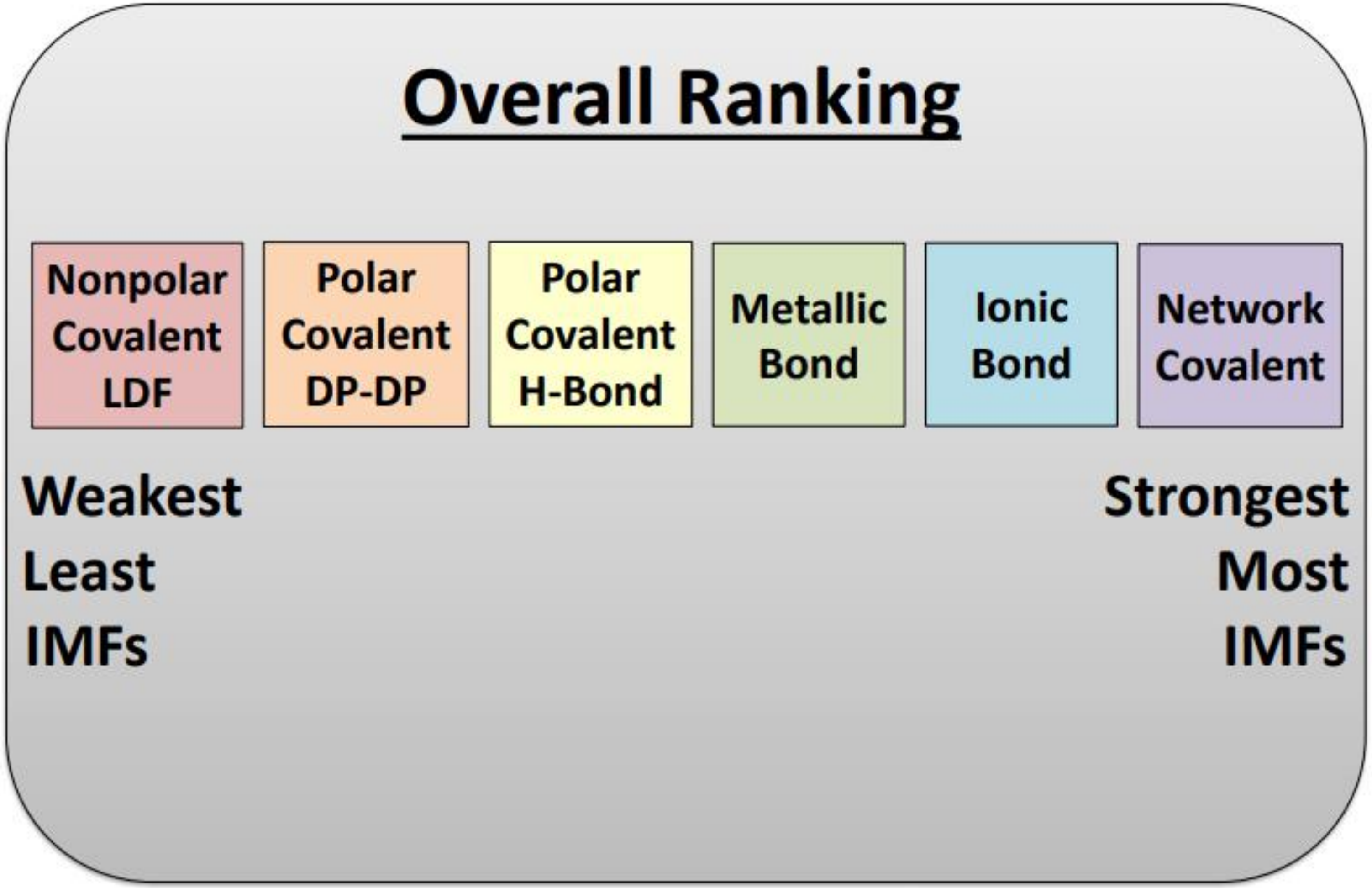
Interactions in solids

COMBINATION OF:
intramolecular AND intermolecular forces in a "large" or "bulk" scale

3 TYPES
Metallic *(weakest)*
Ionic Lattice *(middle)*
Network covalent *(strongest)*

Bulk solids have very high melting/boiling points because there are so many inter and intra molecular forces holding the atoms close together

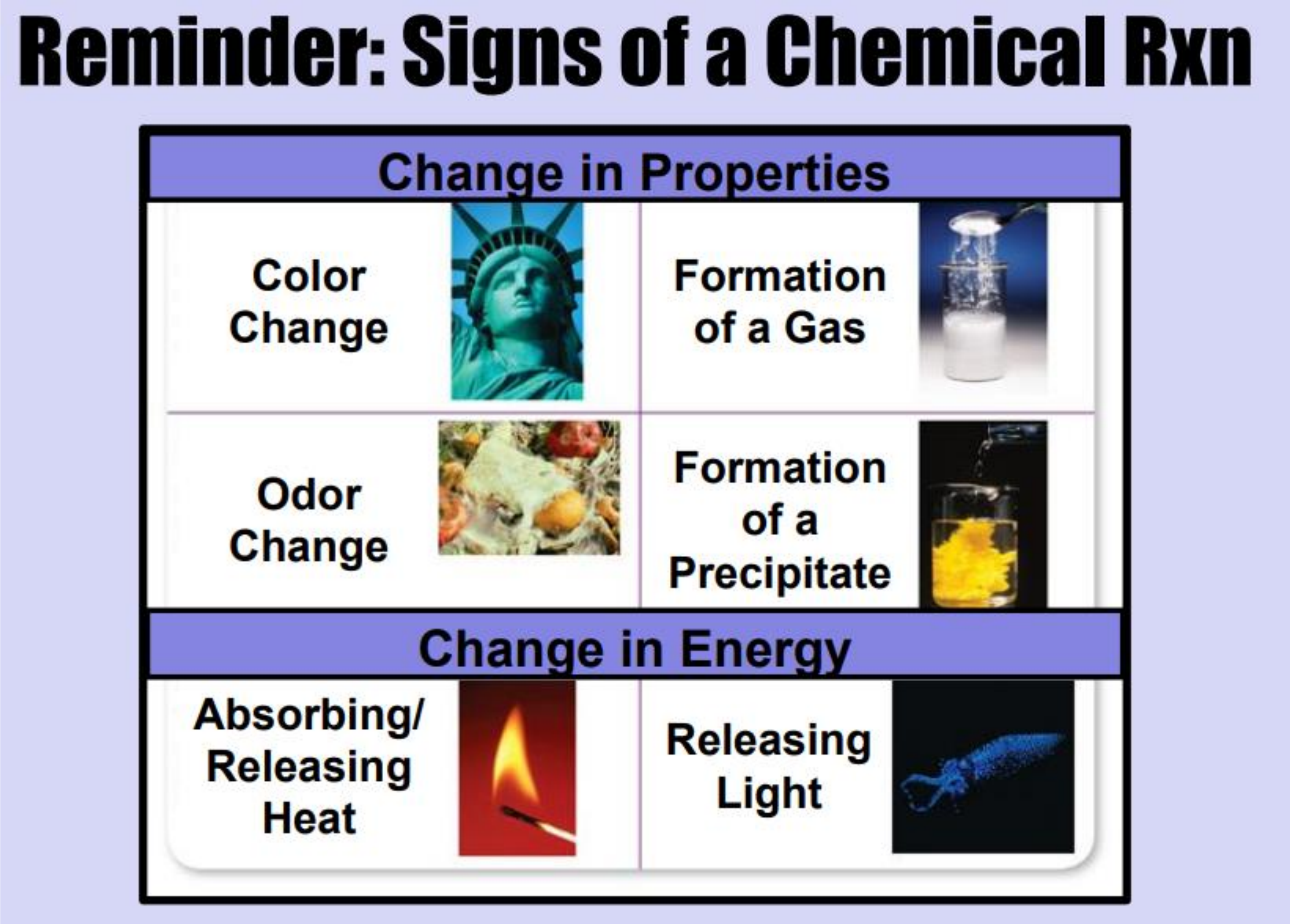
IMFs


Overall Ranking
Nonpolar Covalent LDF
Polar Covalent DP-DP
Polar Covalent H-Bond
Metallic Bond
Ionic Bond
Network Covalent
Weakest Least IMFs
Strongest Most IMFs

Unit #6
Reactions

- Signs of a chemical reaction
- Balancing equations
- Types of reactions
- Predicting products
- Net ionic equations

Reactions


Reminder: Signs of a Chemical Rxn
Change in Properties
Color Change
Formation of a Gas
Odor Change
Formation of a Precipitate
Change in Energy
Absorbing/ Releasing Heat
Releasing Light

Law of Conservation of Mass

In normal chemical reactions *(not nuclear rxns),*

- Total mass of reactants is equal to total mass of products
- Nothing can magically appear
- Nothing can magically disappear

Science not Magic!

Reactions

Diatomic Gases

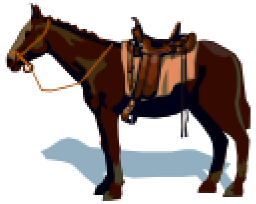
H_2 Cl_2

N_2 Br_2

O_2 I_2

F_2

Horses Need Oats For Clear Brown "Eyes"



Reactions

Rules for Balancing

1) Write the skeleton equation

2) Count atoms on each side of arrow
(look at the subscripts & the coefficients!)

3) Change coefficients so the atoms are balanced; ***NEVER*** *change subscripts!*

4) Make sure coefficients are in lowest ratio possible

5) Check your work!

USE PENCIL!!!

Tips for Balancing that (sometimes) Help!

K

- Stuck? Erase and start over!
- Try to balance atoms that appear in the fewest number of places first
- Try to leave any diatomics until the end
- Oxygens are often the hardest to balance
- Try to balance polyatomic ions as a “chunk”
- Combustion reactions – put a “2” in front of the hydrocarbon and THEN count & balance (may need to reduce your coefficients at the end, but it makes it easier!)

Reactions

#1

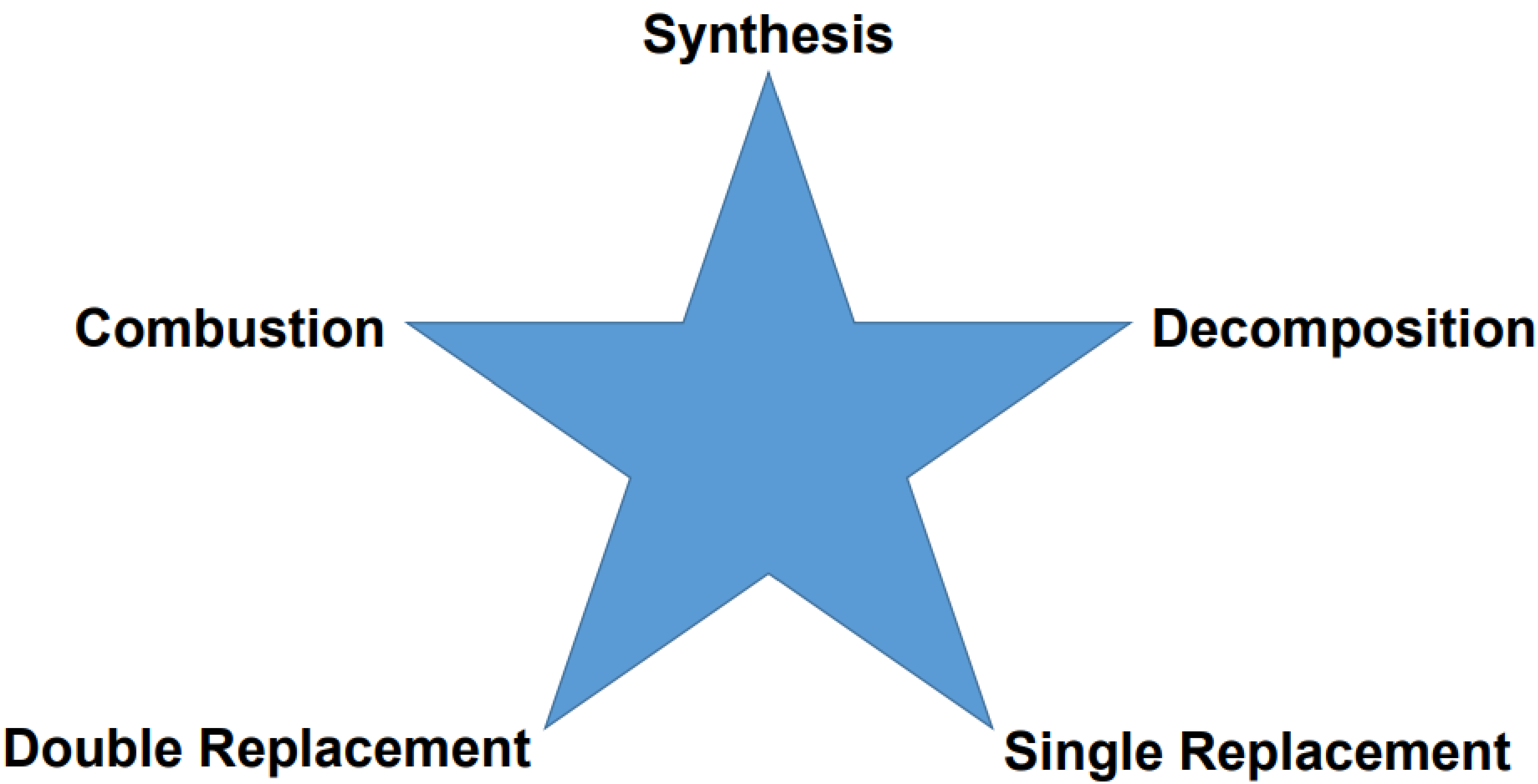
Count each atom – BEFORE, DURING, and AFTER!

__2__ ZnS (aq) + ______ O_2 (g) → __2__ ZnO (aq) + __2__ S (s)

Zn:	~~1~~	2	2
S:	~~1~~	2	2
O:	2		2

Zn:	~~1~~	2	2
S:	~~1~~	2	2
O:	~~1~~	2	2

Reactions


Synthesis
Combustion
Decomposition
Double Replacement
Single Replacement

Reactions

Synthesis

Two things combining into one

Example:

$X + Y \rightarrow XY$

$O_2 + C \rightarrow CO_2$

What to look for:

More reactants than products

Reactions

Decomposition

One thing falling apart into two

Example:

$XY \rightarrow X + Y$

$CaCO_3 \rightarrow CaO + CO_2$

What to look for:

More products than reactants

Reactions

Combustion

Burning

Example:

(almost always a hydrocarbon)

Hydrocarbon + O_2 → CO_2 + H_2O

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

What to look for: ***(Usually)***

Reactants = Hydrocarbon and O_2

Products = CO_2 and H_2O

Single Replacement

Swapping one element

Example:

A + BC → AC + B

$2Al + 3Pb(NO_3)_2 \rightarrow 2Al(NO_3)_3 + 3Pb$

What to look for:

Reactants =1 element and 1 compound

Products = 1 element and 1 compound, but different ones

Reactions

Double Replacement

Swapping two elements

Example:

AB + CD → AD + CB

$AgNO_3 + KCl \rightarrow AgCl + KNO_3$

What to look for:

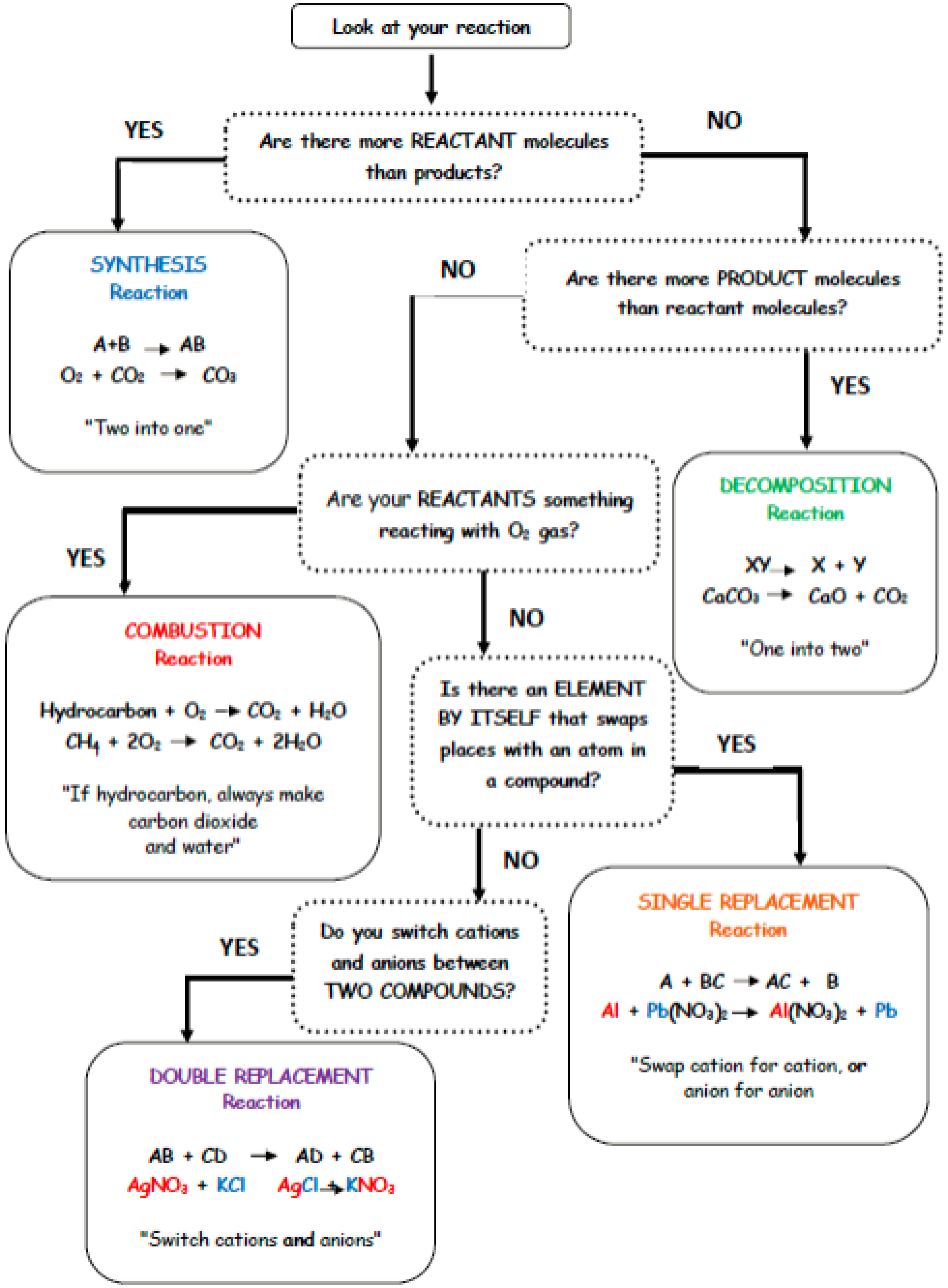
Reactants = 2 Compounds

Products = 2 Compounds but different ones

For Replacement Rxns

- *If element is a cation, replace it with the other cation. If it is an anion, replace it with the other anion*
- *All neutral compounds need to have a cation and anion when finished (IN THAT ORDER)*
- *You need NEW subscripts – cross over FROM SCRATCH*
- *Careful about diatomic elements in single replacements – they need to be diatomic!*

Reactions



Look at your reaction
Are there more REACTANT molecules than products?
YES
NO
SYNTHESIS Reaction
A+B → AB
O_2 + CO_2 → CO_3
"Two into one"
Are there more PRODUCT molecules than reactant molecules?
NO
YES
DECOMPOSITION Reaction
XY → X + Y
$CaCO_3$ → CaO + CO_2
"One into two"
Are your REACTANTS something reacting with O_2 gas?
YES
NO
COMBUSTION Reaction
Hydrocarbon + O_2 → CO_2 + H_2O
CH_4 + 2O_2 → CO_2 + 2H_2O
"If hydrocarbon, always make carbon dioxide and water"
Is there an ELEMENT BY ITSELF that swaps places with an atom in a compound?
YES
NO
SINGLE REPLACEMENT Reaction
A + BC → AC + B
Al + $Pb(NO_3)_2$ → $Al(NO_3)_2$ + Pb
"Swap cation for cation, or anion for anion
Do you switch cations and anions between TWO COMPOUNDS?
YES
DOUBLE REPLACEMENT Reaction
AB + CD → AD + CB
$AgNO_3$ + KCl AgCl → KNO_3
"Switch cations and anions"

Reactions

Solubility Chart

- Na_2O
  SOLUBLE b/c it has Na^+ in it!
- $Mg(OH)_2$
  INSOLUBLE b/c OH^- insoluble and Mg^{2+} not one of the exceptions

Solubility of Some Ionic Compounds in Water

Always Soluble		
Alkali metals = Li^+, Na^+, K^+, Rb^+, Cs^+ Ammonium = NH_4^+ Acetate = $C_2H_3O_2^-$ Chlorate = ClO_3^- Nitrate = NO_3^- Perchlorate = ClO_4^-		AAA CNP
Generally Soluble		
Cl^-, Br^-, I^-	Soluble *except*: Ag^+, Pb^{2+}, Hg_2^{2+}	AP-H
F^-	Soluble *except*: Ca^{2+}, Ba^{2+}, Sr^{2+}, Pb^{2+}, Mg^{2+}	CBS-PM
Sulfate = SO_4^{2-}	Soluble *except*: Ca^{2+}, Ba^{2+}, Sr^{2+}, Pb^{2+}	CBS-P
Generally Insoluble		
O^{2-}, OH^-	Insoluble *except*: Alkali metals and NH_4^+	AA
	Somewhat soluble: Ca^{2+}, Ba^{2+}, Sr^{2+}	CBS
CO_3^{2-} S^{2-}, SO_3^{2-} PO_4^{3-} CrO_4^{2-}, $Cr_2O_4^{2-}$	Insoluble *except*: Alkali metals and NH_4^+	AA

Not Soluble = forms precipitate **Soluble** = dissolves in water (aqueous)

Reactions

NOT DONE!!!! NEED TO THINK ABOUT PHASES!

The Balanced Equation

$$2Al + 3Pb(NO_3)_2 \rightarrow 3Pb + 2Al(NO_3)_3$$

The Overall Equation

$$2Al_{(s)} + 3Pb(NO_3)_{2(aq)} \rightarrow 3Pb_{(s)} + 2Al(NO_3)_{3(aq)}$$

The Complete Ionic Equation

$$2Al_{(s)} + 3Pb^{2+}_{(aq)} + \cancel{6NO_3^-}_{(aq)} \rightarrow 3Pb_{(s)} + 2Al^{3+}_{(aq)} + \cancel{6NO_3^-}_{(aq)}$$

Spectator Ions

The Net Ionic Equation

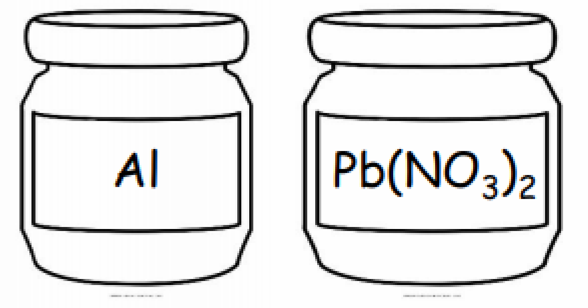
$$2Al_{(s)} + 3Pb^{2+}_{(aq)} \rightarrow 3Pb_{(s)} + 2Al^{3+}_{(aq)}$$

Reactions

Particulate Diagrams help our brains!

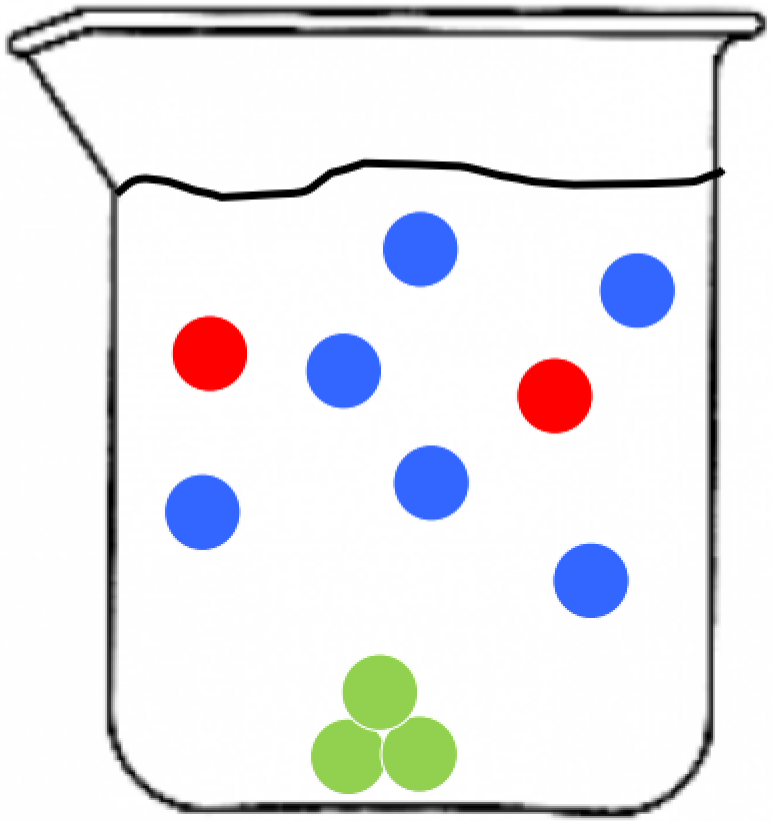
The Balanced Equation

$$2Al + 3Pb(NO_3)_2 \rightarrow 3Pb + 2Al(NO_3)_3$$



Jars of chemicals in stock room

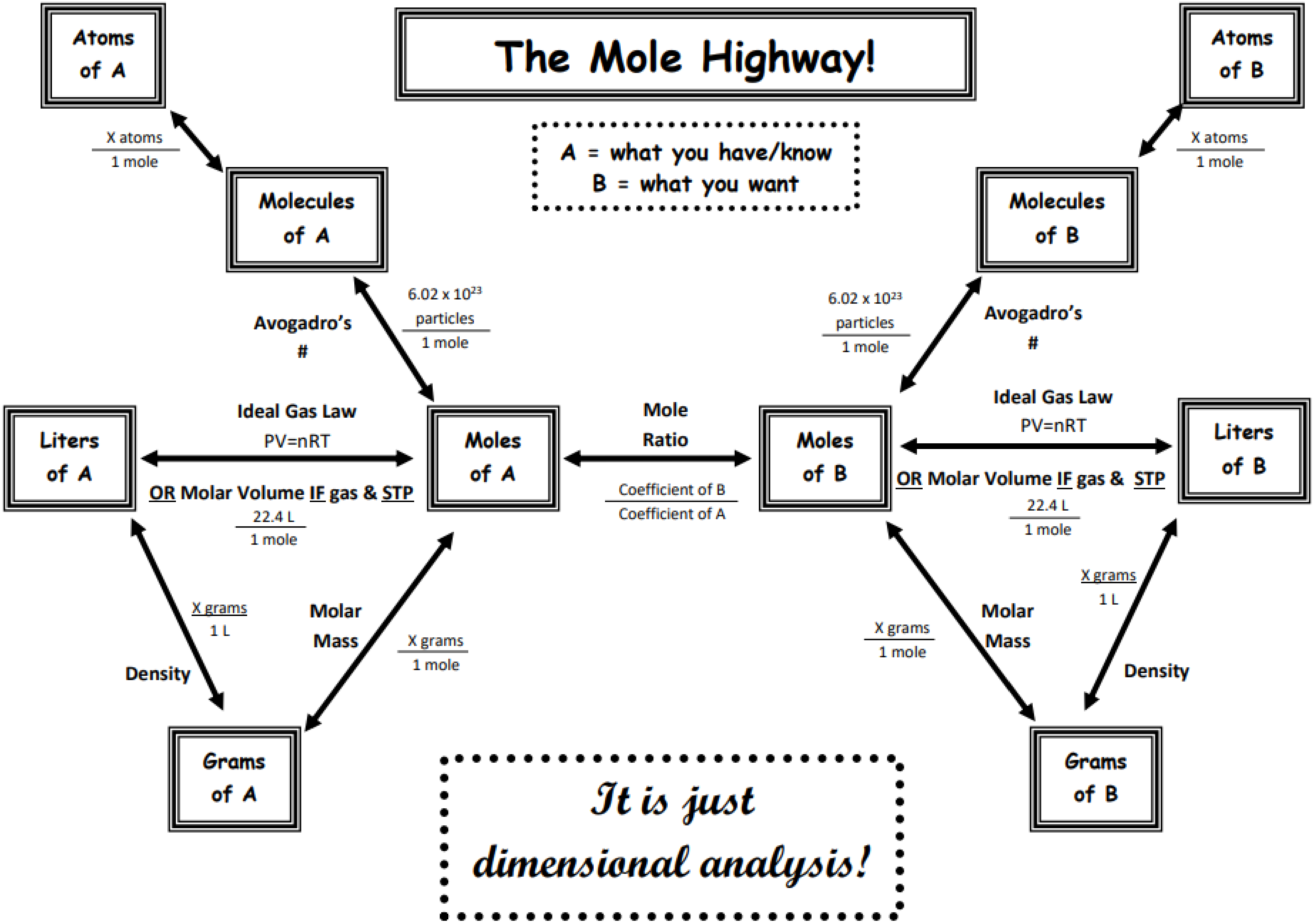
Dump into beaker...



Unit #7
Stoichiometry

- The mole
- Molar mass
- Molar conversions
- Mole ratio
- Stoichiometry

Stoich.

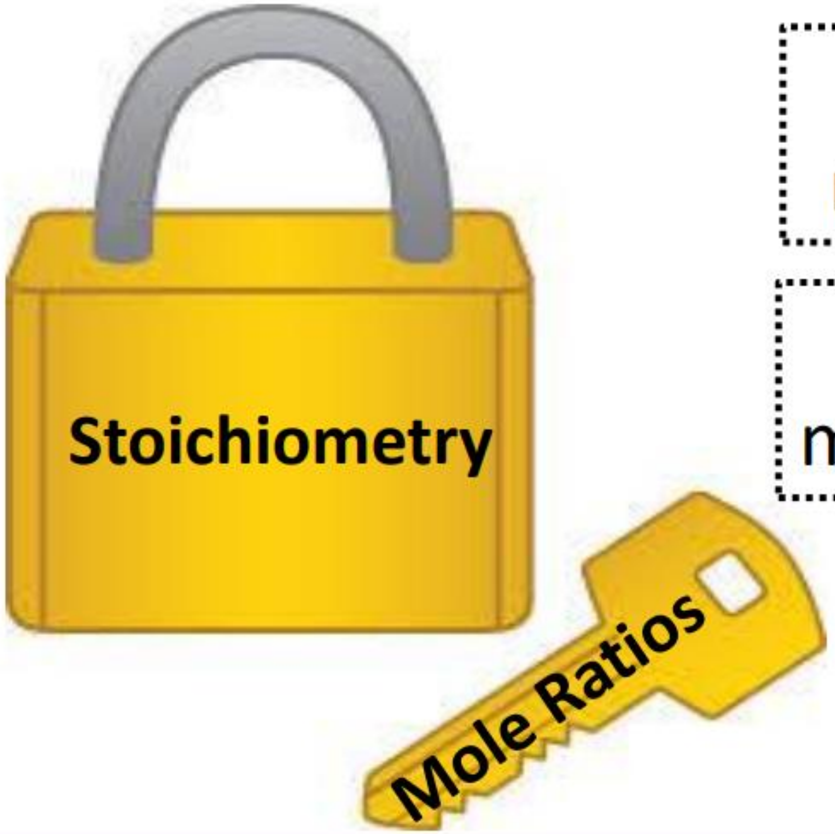


The Mole Highway!
A = what you have/know
B = what you want
Atoms of A
X atoms / 1 mole
Molecules of A
Avogadro's #
6.02 x 10^23 particles / 1 mole
Liters of A
Ideal Gas Law
PV=nRT
OR Molar Volume IF gas & STP
22.4 L / 1 mole
Moles of A
Mole Ratio
Coefficient of B / Coefficient of A
Moles of B
Density
X grams / 1 L
Molar Mass
X grams / 1 mole
Grams of A
Atoms of B
X atoms / 1 mole
Molecules of B
6.02 x 10^23 particles / 1 mole
Avogadro's #
Ideal Gas Law
PV=nRT
OR Molar Volume IF gas & STP
22.4 L / 1 mole
Liters of B
X grams / 1 L
X grams / 1 mole
Molar Mass
Density
Grams of B
It is just dimensional analysis!

Stoich.

Mole Ratios

The "KEY" to stoichiometry!



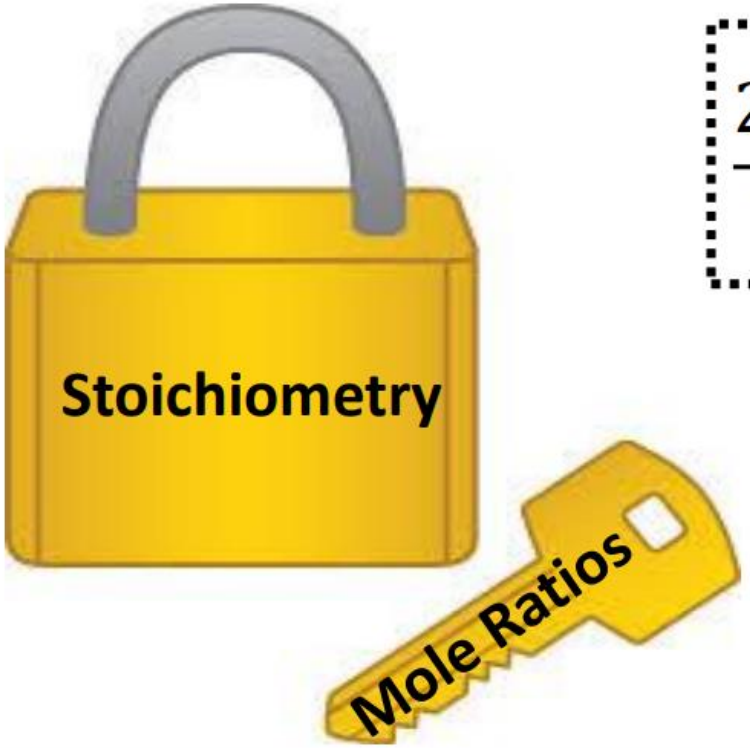
If I have 3 moles of this, how many moles of that do I have?

If I have 2 moles of this, how many moles of that can I make?

Stoich.

Mole Ratios

$$2H_2 + O_2 \rightarrow 2H_2O$$



$$\frac{2\ moles\ H_2}{1\ mole\ O_2}$$

$$\frac{2\ moles\ H_2}{2\ moles\ H_2O}$$

$$\frac{1\ mole\ O_2}{2\ moles\ H_2O}$$

Stoich.

Mole Ratios

You can flip all mole ratios

$$\frac{2\ moles\ H_2}{1\ mole\ O_2} \rightarrow \frac{1\ mole\ O_2}{2\ moles\ H_2}$$

$$\frac{2\ moles\ H_2}{2\ moles\ H_2O} \rightarrow \frac{2\ moles\ H_2O}{2\ moles\ H_2}$$

$$\frac{1\ mole\ O_2}{2\ moles\ H_2O} \rightarrow \frac{2\ moles\ H_2O}{1\ mole\ O_2}$$

Stoich.

Q #2

$N_2 + 3H_2 \rightarrow 2NH_3$

75 grams $NH_3 \rightarrow$? g H_2

Pathway:

grams A → moles A → moles B → grams B

Molar mass of A	Mole Ratio	Molar mass of B
$\frac{X\ g\ A}{1\ mole\ A}$	$\frac{moles\ B}{moles\ A}$	$\frac{X\ g\ B}{1\ mole\ B}$

Stoich.

Q #2

$N_2 + 3H_2 \rightarrow 2NH_3$

75 grams NH_3 → ? g H_2

75 g NH_3	1 mole NH_3	3 mole H_2	2.02 g H_2
	17.03 g NH_3	2 mole NH_3	1 mole H_2

= 13.34 g H_2

Unit #8
Advanced Chemical Ratios

- Limiting reagent stoichiometry
- Percent composition
- Empirical formulas
- Combustion analysis

Unit #9
Gas Laws

- KMT theory
- Basic gas law equations
- Ideal gas law equation
- Dalton’s law of partial pressures **
- Gas stoichiometry **

<u>Unit #10</u>
Thermochemistry *

- Specific heat
- Calorimetry
- Heating/cooling curves

Unit #11
Solutions *

- Solution vocabulary
- Solubility
- Solutions calculations

Unit #12
Kinetics *

- Rate affecting factors
- Rate expressions
- Average rates
- Instantaneous rates
- Rate laws
- Method of initial rates

Unit #13
Equilibrium *

- Le Chatelier’s principle
- Equilibrium constant
- Equilibrium quotient
- ICE Tables

Unit #14
Acids and Bases *

- Acid Base concepts
- pH calculations
- Strong acids and bases
- Self ionization of water
- Weak acids and bases **
- Salts **
- Titrations **

Unit #15
Redox (part of Summer Assignment always)

- Oxidation number
- Oxidation vs reduction
- Oxidizer vs reducer
- Writing half reactions
- Balancing redox reactions in an acidic or basic solution