UNIT 2
ATOMIC STRUCTURE AND THE PERIODIC TABLE

PHYSICAL SCIENCE

MRS. VALENTINE

2.1 ATOMIC STRUCTURE AND MODELS

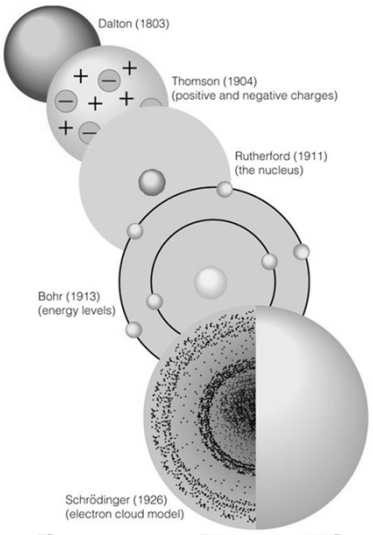
- OBJECTIVE:
  - I will be able to label/draw an atom. I will understand the progression of the atomic models. I will be able to identify differences in isotopes of the same element.

- VOCABULARY:

Electron	Proton	Neutron	Nucleus	Electron Cloud
Dalton Model	Thomson Model	Rutherford Model	Bohr Model	Cloud Model
Orbit	Orbital	Isotopes	Nuclides	Mass Number
Atomic Number				

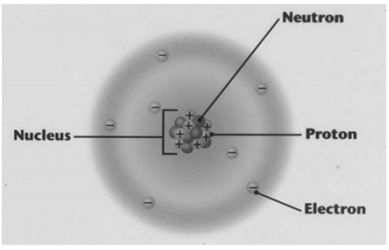
2.1 ATOMIC STRUCTURE AND MODELS

- Atomic Models
  - Dalton's Model (1803) – hard sphere different for each substance
  - Thomson's Model (a.k.a. Plum Pudding Model) – negative particles called electrons surrounded by positive matter
  - Rutherford's Model (1911) – Central positive nucleus surrounded by electrons moving randomly
  - Bohr's Model (1931) – Arranged the electrons in circular orbits with specific energies around the nucleus
  - Schrodinger's Model (1926) – Electrons occupy orbitals (areas of high probability of finding electrons) around nucleus



2.1 ATOMIC STRUCTURE AND MODELS

- Anatomy of an Atom
  - Nucleus
    - Protons – positively charged subatomic particles
      - atomic number – # protons; determines element
    - Neutrons – neutral subatomic particles
    - These two particles are approximately the same size and mass (slightly different)
  - Electron Cloud
    - Electrons – negatively charged subatomic particles (very small; 1/1800 the mass of a proton)
    - Moving at very high speeds
    - Electrons exist in orbitals according to current model



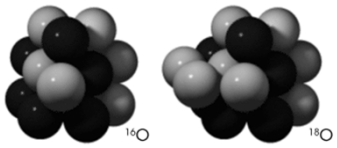
2.1 ATOMIC STRUCTURE AND MODELS

- Isotopes
  - Atoms of the same element with different masses
  - Nuclide – an isotope of an element
  - Different numbers of neutrons; all same properties except mass
  - Mass number is number of protons and neutrons combined
  - Symbols:

Mass number → $^{12}_{6}C$ ← Element symbol

Atomic number →

  - Some isotopes are radioactive (too much energy in nucleus)



2.2 BOHR MODELS AND DOT DIAGRAMS

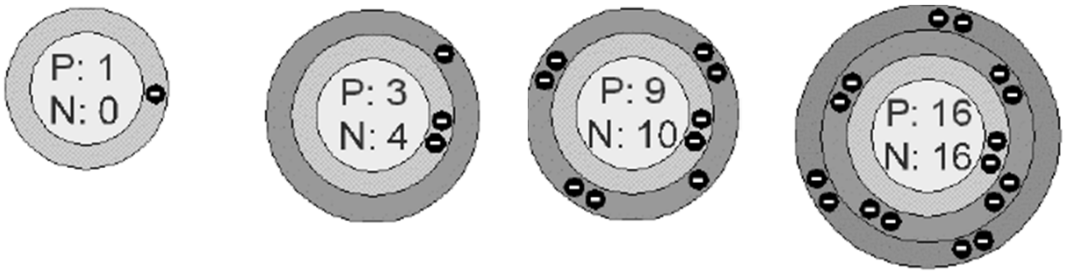
- OBJECTIVE:
  - I will be able to draw and read Bohr models and dot diagrams of the atoms and ions of the first eighteen elements.

- VOCABULARY:

Valence Electrons	Dot Diagrams	Ion	Valence Electrons	

2.2 BOHR MODELS AND DOT DIAGRAMS

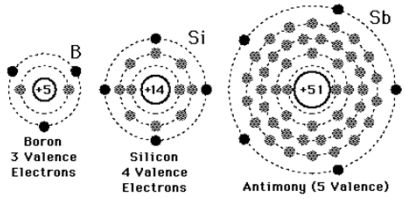
- Inaccurate model for all but hydrogen in terms of how the atoms behave, but Bohr models provide an easy visual of what's going on with the electrons.



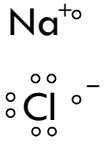
- On the inner most ring, you can only put two electrons
- On the next two rings, you can put up to eight each.
- Always fill the diagrams outward from the nucleus

2.2 BOHR MODELS AND DOT DIAGRAMS

- The electrons on the outer-most occupied ring are called valence electrons.
  - A neutral atom can have between 1 and 8 valence electrons
  - Gained, lost, or shared in order to form compounds.
    - $ve^- < 4$, lose outer electrons
    - $ve^- > 4$ gain outer electrons



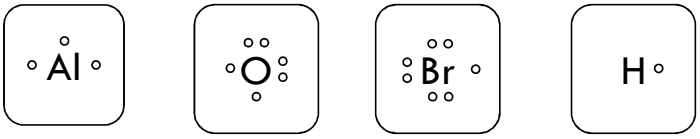
  - An ion is an atom that has gained or lost valence electrons
    - If charge is positive, lose that number of valence electrons
    - If charge is negative, gain that number of valence electrons



  - When atoms have either 8 or 0 valence electrons, they are more stable, or less reactive.

2.2 BOHR MODELS AND DOT DIAGRAMS

- Dot Diagrams
  - Uses the symbol of the element in the middle, surrounded by dots representing valence electrons
  - There are four sides of the symbol: up, down, left, right.
  - Pick a side to start on and put one electron on each side BEFORE doubling up
    - Go in a counter-clockwise direction
    - Stop when you have used all the valence electrons
  - Examples:



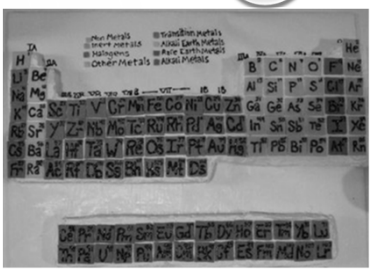
2.3 PERIODIC TRENDS

- OBJECTIVE:
  - I will be able to identify the groups of the periodic table. I will understand the trends of valence electrons, oxidation numbers, and reactivity on the periodic table.

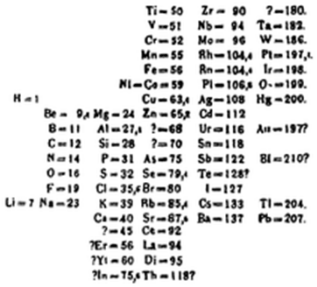
- VOCABULARY:

Oxidation Numbers	Reactivity	Periodic Table	Group	Period
Transition Metals	Actinides	Alkali metals	Alkaline Earth Metals	Halogens
Noble Gases	Lanthanides	Rare Earth Metals		

2.3 PERIODIC TRENDS



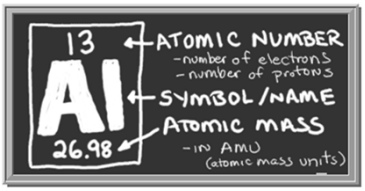
- Periodic Table
  - A chart used to organize the 100+ known elements
  - Mendeleev
    - Created the first periodic table by organizing the elements by their properties
    - Accurate enough to correctly predict the existence of three unknown elements and their properties



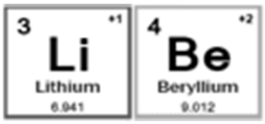
				Ti = 50	Zr = 90	? = 180.
				V = 51	Nb = 94	Ta = 182.
				Cr = 52	Mo = 96	W = 186.
				Mn = 55	Rh = 104,4	Pt = 197,1.
				Fe = 56	Ru = 104,4	Ir = 198.
				Ni = Co = 59	Pl = 106,6	Os = 199.
H = 1				Cu = 63,4	Ag = 108	Hg = 200.
	Be = 9,4	Mg = 24	Zn = 65,2	Cd = 112		
	B = 11	Al = 27,4	? = 68	Ur = 116	Au = 197?	
	C = 12	Si = 28	? = 70	Sn = 118		
	N = 14	P = 31	As = 75	Sb = 122	Bi = 210?	
	O = 16	S = 32	Se = 79,4	Te = 128?		
	F = 19	Cl = 35,4	Br = 80	I = 127		
Li = 7	Na = 23	K = 39	Rb = 85,4	Cs = 133	Tl = 204.	
		Ca = 40	Sr = 87,6	Ba = 137	Pb = 207.	
		? = 45	Ce = 92			
		?Er = 56	La = 94			
		?Yt = 60	Di = 95			
		?In = 75,6	Th = 118?			

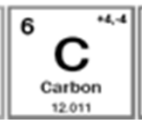
2.3 PERIODIC TRENDS

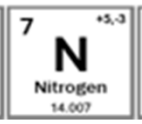
- Reading the blocks of the periodic table
  - Each square has
    - Element symbol
    - Element name
    - Atomic number
    - Atomic mass

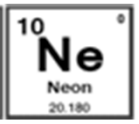


  - Each row is in numerical order of atomic number



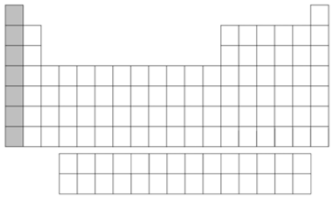






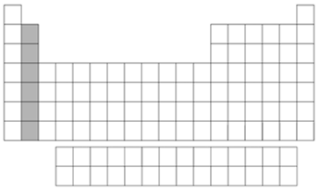
2.3 PERIODIC TRENDS

- Organization of the Periodic Table
  - Groups
    - Columns of the periodic table
    - Numbered 1-18, or IA thru VIIIA for the taller columns and IIIB-XB for the shorter columns
    - Elements are grouped together by having similar properties
    - Specific Groups
      - Alkali Metals
        - Group 1; 1 valence electron
        - Highly reactive metals (most reactive)
        - Soft, gray

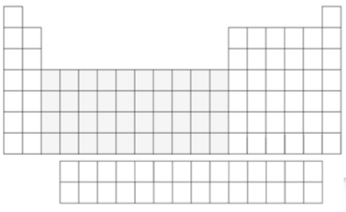


2.3 PERIODIC TRENDS

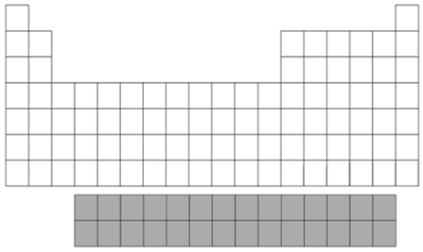
- Alkaline Earth Metals
  - Group 2; 2 valence electrons
  - Second most reactive metals
  - Soft, gray (slightly harder than group 1 metals)



- Transition Metals
  - Groups 3-12
  - Some are reactive, some are not
  - Unique colors for some (such as gold and copper)
  - Most commonly thought of metals are transition metals

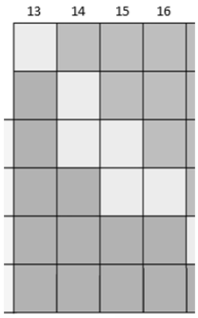


2.3 PERIODIC TRENDS



- Rare Earth Metals
  - Not part of a group (two rows below the periodic table)
  - Lanthanides
    - Top of bottom two rows
    - Soft, malleable, shiny, conductive, difficult to separate
  - Actinides
    - Bottom of bottom two rows
    - Only two are natural (thorium and uranium); all others are synthetic
    - Some only last fractions of a second before they break down

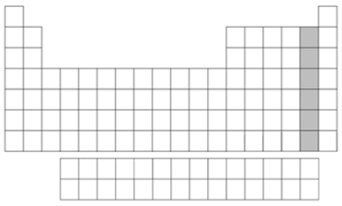
2.3 PERIODIC TRENDS



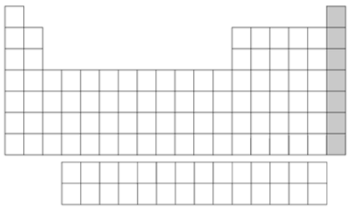
- Mixed Groups
  - Groups 13-16 are considered mixed groups because they have metals, metalloids, and nonmetals in them.
  - The properties for these groups will not be as consistent as other groups are.
  - Named after the first element in each group.
  - The Groups:
    - Boron Group – Group 13; 3valence electrons
    - Carbon Group – Group 14; 4 valence electrons
    - Nitrogen Group – Group 15; 5 valence electrons
    - Oxygen Group – Group 16; 6 valence electrons

2.3 PERIODIC TRENDS

- Halogens
  - Group 17; 7 valence electrons
  - Highly reactive nonmetals (mostly)
  - Pure halogens are dangerous to humans

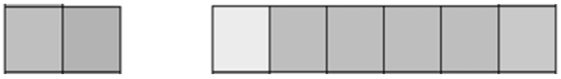


- Noble Gases
  - Group 18; 8 valence electrons
  - Nonreactive
  - Gaseous at room temperature



2.3 PERIODIC TRENDS

- Periods
  - Rows of the periodic table
  - There are seven from top to bottom
  - Elements in a period have different properties from others in the same period

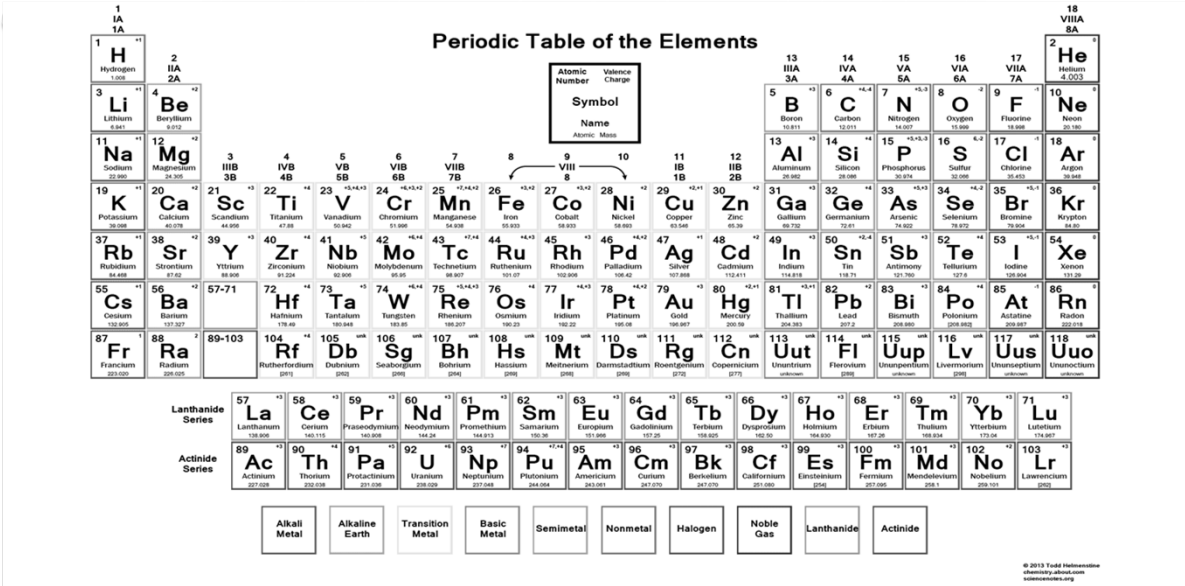


- Valence Electrons
  - The number of valence electrons an element has is related to its group number (for groups 1-2, 13-18)
  - Number of valence electrons equals the ones-place of the group number
  - Examples: Sodium is in group 1, so it has 1 valence electron
    Oxygen is in group 16, so it has 6 valence electrons

2.3 PERIODIC TRENDS

- Oxidation Numbers
  - Oxidation number is the number of electrons that an atom gains or loses when it becomes an ion.
  - Equal to the ion's charge
  - For metals, the number of valence electrons equals the oxidation number, because metals lose their electrons when they form ions (subtracting a negative leaves a positive charge)
  - For nonmetals, the oxidation number equals the number of electrons the nonmetal will gain when they form ions.
    - To find this value, subtract eight from the number of valence electrons.
    - This will be a negative number because nonmetals gain negative electrons

2.3 PERIODIC TRENDS



2.4 IONIC COMPOUNDS

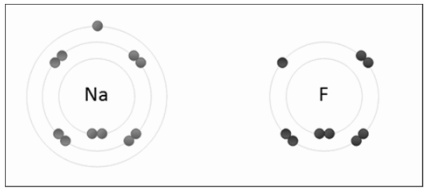
- OBJECTIVE:
  - I will be able to identify ionic compounds based upon their composition. I will understand the general properties of ionic compounds.

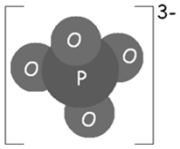
- VOCABULARY:

Ionic Compound	Ionic Bond	Anion	Cation	Polyatomic Ions
Crystal				

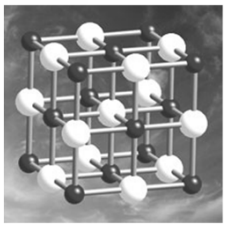
2.4 IONIC COMPOUNDS

- Composition
  - Ionic bonds form when ions of opposite charges attract each other.
    - Cations are ions with a positive charge
    - Anions are ions with a negative charge
  - Electrons are transferred
  - Occur between a nonmetal and a metal
  - Ionic compounds are always neutral, meaning that the total positive charge is equal to the total negative charge
  - Polyatomic Ions
    - Made of two or more atoms bonded together
    - Work as a single unit, behaving in the same way that monatomic ions do

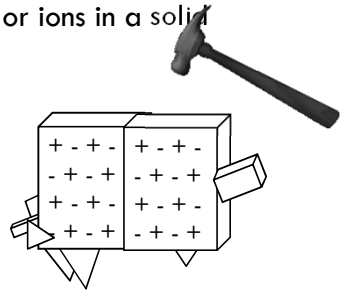




2.4 IONIC COMPOUNDS

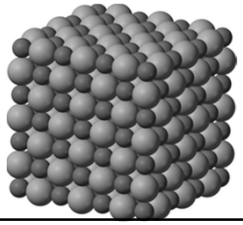


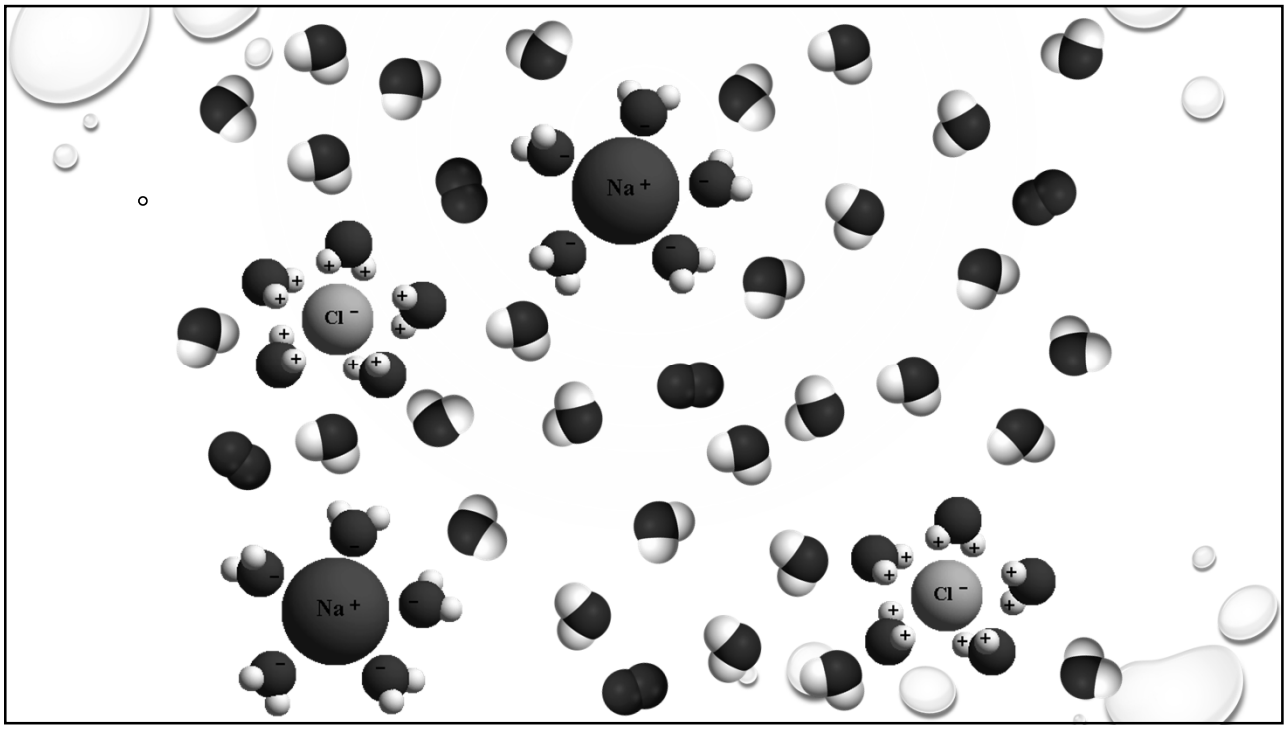
- Properties
  - Crystal Shape
    - Ions are packed together in an alternating pattern
    - Crystal
      - an orderly, three-dimensional arrangement of atoms or ions in a solid
      - tend to have similar shape for a single compound
      - different shapes for different compound
    - Break into like-shapes when struck by a hammer due to alternating ions



2.4 IONIC COMPOUNDS

- High Melting Points
  - Bonds must be broken to melt an ionic solid
  - Ex: NaCl – 801C mp
- Electrical Conductivity
  - Ions have electric charge, but as a solid, they cannot conduct electricity
  - Bound too tightly together
  - When dissolved in water, they break apart and separate, allowing electrons to pass through
  - The same principle applies to liquid ionic substances





2.5 IONIC NOMENCLATURE

- OBJECTIVE:
  - I will be able to name ionic compounds from their formulas and write the formulas of ionic compounds from their names.

- VOCABULARY:

Nomenclature				

2.5 IONIC NOMENCLATURE

- Formula to Name
  - Reading Formulas
    - The formula of any compound lists the elements that are bonded by their symbols.
    - For ionic compounds, the metal is listed first followed by the nonmetal.
    - Subscripts after each symbol indicate how many of the ions are present in the simplest whole-number ratio.

$NaCl$

The sodium (Na^+) and chloride (Cl^-) in this compound are in a 1:1 ratio

$Ca(NO_3)_2$

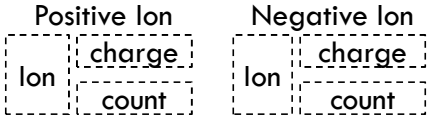
The calcium (Ca^{2+}) and nitrate (NO_3^-) in this compound are in a 1:2 ratio

2.5 IONIC NOMENCLATURE

- Naming Formulas
  - Name the cation first without changing its name. The subscript is not part of the name.
  - If the cation is a transition metal or has more than one oxidation number, include the oxidation number as Roman numerals in parentheses after the name.
  - Name the anion by changing the suffix to "-ide".
    - Exception: if the anion is a polyatomic ion, keep the name as is.
  - Example:
    - $FeBr_3$ iron(III) bromide
    - K_2S potassium sulfide
    - $LiNO_3$ lithium nitrate

2.5 IONIC NOMENCLATURE

- Name to Formula
  - From each part of the name, write the symbol for the corresponding ion.
  - If one of the ions is polyatomic, put its symbol in parentheses before you continue.
  - To ensure that the formula is neutral, take the charge of the cation and make it the subscript of the anion. Take the absolute value of the charge of the anion and make it the subscript of the cation.
  - Simplify the new subscripts, as ionic formulas are in the simplest whole-number ratio.
  - Examples:
    - Calcium fluoride CaF_2
    - Iron(III) carbonate $Fe_2(CO_3)_3$
    - Strontium Oxide SrO



2.6 MOLECULAR COMPOUNDS

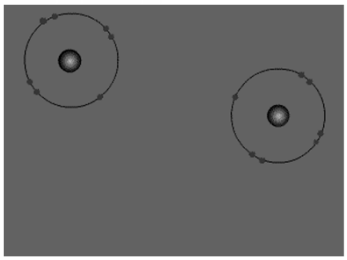
- OBJECTIVE:
  - I will be able to identify molecular compounds based upon their composition. I will understand the general properties of molecular compounds.

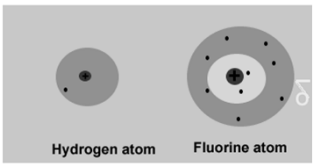
- VOCABULARY:

Molecular Compound	Covalent Bond	Polar	Nonpolar	Double Bond
Triple Bond				

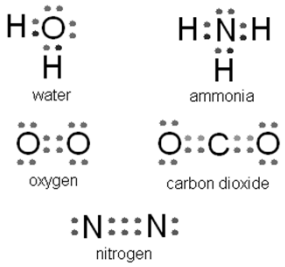
2.6 MOLECULAR COMPOUNDS

- Composition
  - A covalent bond is a bond formed when two atoms share electrons
  - Made of two or more nonmetals

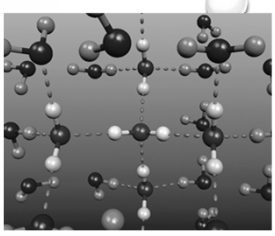




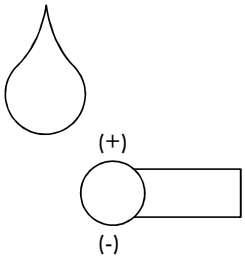
  - Multiple Bonds
    - Double bonds – two pairs of shared electrons
    - Triple bonds – three pairs of shared electrons



2.6 MOLECULAR COMPOUNDS



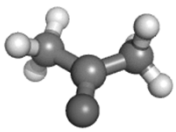
- Molecular compounds have covalently bonded atoms
  - Exist as separate molecules
  - Interactions between molecules are weaker than ionic bonds
  - Nonpolar molecules share electrons evenly
  - Polar molecules have an uneven share of electrons (a partially positive and a partially negative end)
  - Soap works using polarity:

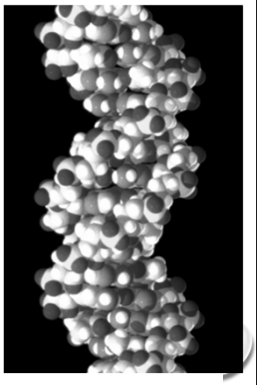


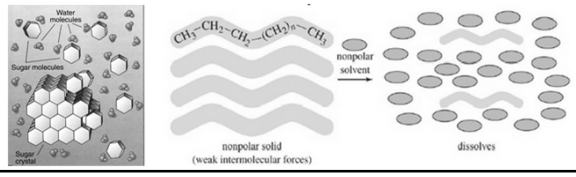
- ☐ Water (polar)
- ☐ Soap – polar end
- ☐ Soap – nonpolar end
- ☐ Dirt (nonpolar)

2.6 MOLECULAR COMPOUNDS

- Properties
  - Molecules can be small (two atoms – ex: CO) to huge (millions of atoms – ex: DNA)
  - Have low melting points and boiling points
  - Poor conductors of electricity
  - When molecular compounds dissolve, molecules separate from one another, but remain individual units
  - Polar substance dissolve in polar solvents while nonpolar substance dissolve in nonpolar solvents.







2.7 MOLECULAR NOMENCLATURE

- OBJECTIVE:
  - I will be able to name molecular compounds from their formulas and write the formulas of molecular compounds from their names.

2.7 MOLECULAR NOMENCLATURE

- Formula to Name
  - Reading Formulas
    - For molecular compounds, the subscripts after each symbol indicate how many atoms of that element are in each molecule.
    - Subscripts are NOT simplified to their simplest whole-number
    - Examples:

$C_3H_{10}O$

In each molecule of this compound, there are three atoms of carbon, ten atoms of hydrogen, and one of oxygen

N_2O_4

In each molecule of this compound, there are two atoms of nitrogen and four atoms of oxygen

2.7 MOLECULAR NOMENCLATURE

- Naming Formulas
  - For molecular compounds, the subscripts are part of the name as a prefix before each element's name.
    - Prefixes

Number	Prefix		Number	Prefix
1	mono		6	hexa
2	di		7	hepta
3	tri		8	octa
4	tetra		9	nona
5	penta		10	deca

    - If the element's name begins with an "o" or an "a", then the prefix drops the "o" or "a" from the end

2.7 MOLECULAR NOMENCLATURE

- The first element
  - Uses the appropriate numerical prefix from above with the exception of "mono."
  - keeps its full name
- The second element listed still uses the prefix, but changes its suffix to "-ide"
- Examples:
  - C_3H_8 tricarbon octahydride
  - N_2O_5 dinitrogen pentoxide
  - CBr_4 carbon tetrabromide

2.7 MOLECULAR NOMENCLATURE

- Name to Formula
  - Pick out the elements in the compound, and use the prefixes to determine how many atoms of each element there are.
  - List them in the same order as the name.
  - Examples:
    - Tetranitrogen monoxide N_3O
    - Diboron hexahydride B_2H_6
    - Iodine heptafluoride IF_7

2.8 METALLIC BONDS

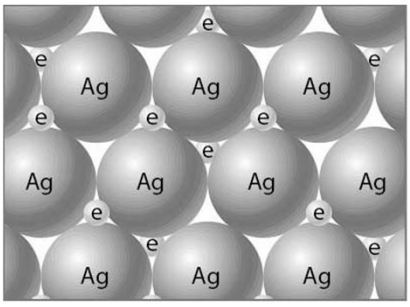
- OBJECTIVE:
  - I will understand the properties of metallic bonds.

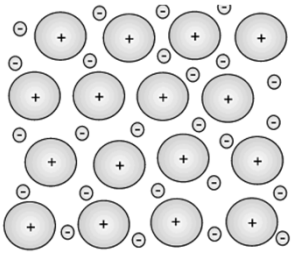
- VOCABULARY:

Metallic Bond	Sea of Electrons			

2.8 METALLIC BONDS

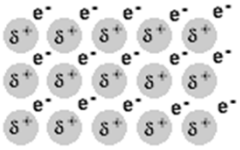
- The force that holds atoms together in a metallic substance
- Atoms are closely packed
- Outermost energy levels overlap between atoms
- Valence electrons are non-localized, moving freely throughout the space between nuclei





2.8 METALLIC BONDS

- Sea of Electrons – the body of delocalized electrons that surround positive metal ions in metallic bonds
  - allows atoms to move past each other easily without breaking bonds (explains malleability and ductility)



  - allows electrons through the network easily (good conductors of electricity)
  - light cannot penetrate the metal surface (luster)

2.9 MIXED NOMENCLATURE

- OBJECTIVE:
  - I will be able to identify if a substance is ionic, molecular, or metallic, and then I will be able to name it or write its formula accordingly.

2.9 MIXED NOMENCLATURE

- Always determine the type of substance first!
- Then use the appropriate nomenclature system
- Examples: