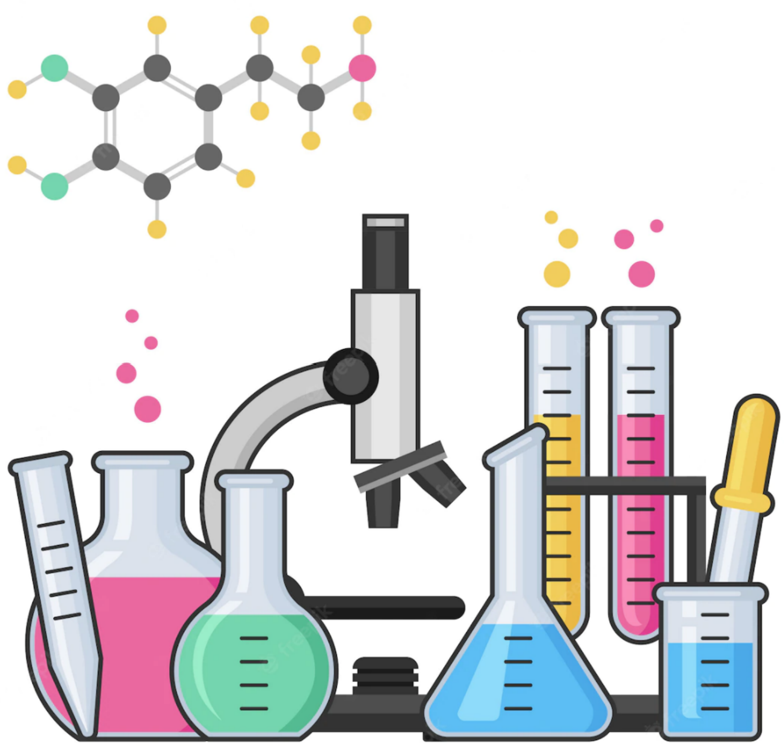
Station #1 : Lab Equipment

A good scientist must be able to use scientific tools to make accurate observations. While studying in Chemistry class, you will be required to use many pieces of lab equipment to help you collect data and to make observations. It is essential that you are able to use each piece of equipment accurately and safely as it is intended.

HINT: think about accuracy. which tools are more accurate if something is not an accurate or precise measure (requires estimation) and does not show detailed units of measure, than it should NOT be used as a tool to measure. Consider the material it s made of. While most glass in a lab is heat-proof, you will also use tools made of ceramic materials to withstand high heat over a direct flame.

TASK: Identify each piece of lab equipment provided at the bench. You will need to

1. Name the equipment
2. Describe it s use measuring/observing/heating
3. Identify the units of measure if applicable



Station #2 : Laboratory Safety

Chemistry II is a lab-based course, and since our classroom IS A LAB it is imperative that we are familiar with the safety features + how to use them. Lab experiments are designed to give you "hands-on" experience and deepen your knowledge of Chemistry. however, working with chemicals has certain potential dangers. Most of these are preventable when students and teachers exercise caution + develop good safety habits. This includes things like reading all instructions ***before*** conducting a lab, wearing the appropriate **p**ersonal **p**rotective **e**quipment, disposing of materials as directed by your teacher and knowing how to use the safety features in the classroom. You will be required to complete *pre-lab work* prior to every laboratory investigation. This will not only familiarize you with the procedure, but it will also outline any potential hazards + how to deal with them so you are prepared.

TASK: Look + move around the classroom and observe safety features of the lab. These are items/tools you do not find in a "normal" classroom. These items are Laboratory specific in case of emergency and to keep you safe

"I imagine this was mentioned in the solvent handling instructions I didn't read."

"Those are the brains of people who thought they were too smart for the lab safety rules. I collect them."

Station #3: Scientific Notation

Regular (expanded) **Notation (RN)-** The standard way that we write our numbers.
Ex: Two Hundred and Eight Million is written – 280,000,000.

Scientific Notation (SN)- A shorthanded way of writing really large or really small numbers. In SN a number is written as the *product* of two factors.
Ex: 280,000,000 can be written in scientific notation as $2.8 x 10^8$.

First Factor
A number that is between 1 and 10
It may or may not be a decimal.

$$\underbrace{2.8}\ \times\ \underbrace{10}^{8}$$

Second Factor
Is always a power of 10.
The power of the exponent tells you how many places to move the decimal point.
The sign of the exponent tells you which direction to move it.

Regular Notation → Scientific Notation

If Decimal is moved left *(ie: makes the number smaller)* Exponent will be positive

If Decimal is moved to Right *(ie: makes the number larger)* Exponent will be negative

Regular Notation	How to Change	Scientific Notation
420,000.	Move the decimal after the 4 and before the 2 That is 5 places to the left Multiply 4.2 by 10 to the 5th power	$4.2 x 10^5$
.0000014	Move the decimal after the 1 and before the 4 That is 6 places to the right Multiply 1.4 by 10 to the -6th power	$1.4 x 10^{-6}$

Scientific Notation → Regular Notation

If exponent is Negative, then the number was SMALL *(ie: a decimal number)* in RN. Move decimal to the Left , and add zeros where needed.

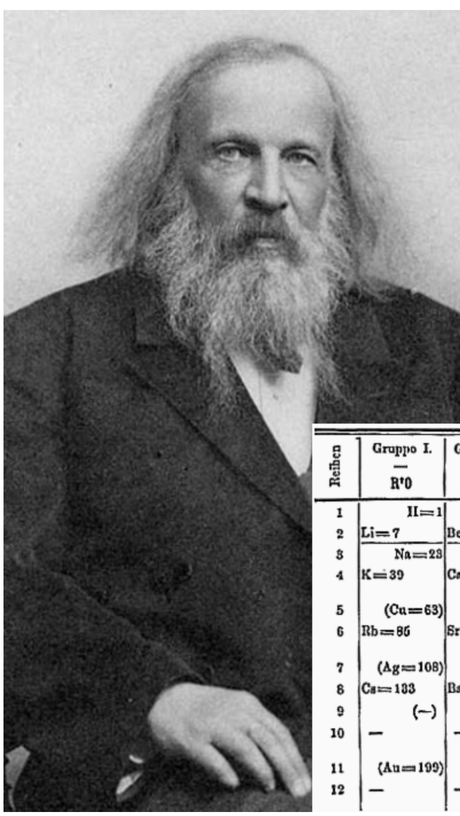
If exponent is Positive, then the number was BIG *(ie: greater than 1)* in RN. Move decimal to the Right + add zeros where needed.

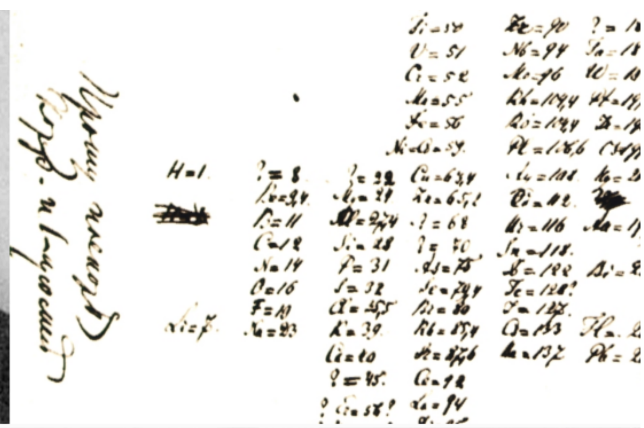
Scientific Notation	How to Change	Regular Notation
7.5×10^5	Exponent is positive 5. Move the decimal 5 places to the right	750,000.
4.2×10^{-3}	Exponent is Negative 3. Move the decimal 3 places to the left.	.0042

Station #4: Periodic Table Trends

The Periodic Table of elements is a series of columns and rows, broadly divided into 2 sections: metals and non-metals., with metals making up about 80 of known elements. As you move from left to right across the periodic table, there is a general trend towards less metallic character, however there is no sharp divide. Instead there is a group of elements, called the metalloids*(often shown as a staircase)* which exhibit some metallic properties and some non-metallic properties. Russian chemist Dmitri Mendeleev, credited with the creation of the periodic table, organized elements into rows and columns in repeating patterns. He noted that the chemical and physical properties of elements recur at regular intervals when elements are listed by increasing Atomic Weight. We call this phenomena The Periodic Law, however we now arrange elements by increasing number of protons*(or Atomic Number)*. You will become *very* familiar with the periodic tabl e and all it has to offer before you leave this course. Can you remember some basic traits about it?

TASK: answer the questions in your students booklet, using the Periodic Table provided.





Reihen	Gruppo I. — R^2O	Gruppo II. — RO	Gruppo III. — R^2O^3	Gruppo IV. RH^4 RO^2	Gruppo V. RH^3 R^2O^5	Gruppo VI. RH^2 RO^3	Gruppo VII. RH R^2O^7	Gruppo VIII. — RO^4
1	H=1							
2	Li=7	Be=9,4	B=11	C=12	N=14	O=16	F=19	
3	Na=23	Mg=24	Al=27,3	Si=28	P=31	S=32	Cl=35,5	
4	K=39	Ca=40	—=44	Ti=48	V=51	Cr=52	Mn=55	Fe=56, Co=59, Ni=59, Cu=63.
5	(Cu=63)	Zn=65	—=68	—=72	As=75	Se=78	Br=80	
6	Rb=85	Sr=87	?Yt=88	Zr=90	Nb=94	Mo=96	—=100	Ru=104, Rh=104, Pd=106, Ag=108.
7	(Ag=108)	Cd=112	In=113	Sn=118	Sb=122	Te=125	J=127	
8	Cs=133	Ba=137	?Di=138	?Ce=140	—	—	—	— — — —
9	(—)	—	—	—	—	—	—	
10	—	—	?Er=178	?La=180	Ta=182	W=184	—	Os=195, Ir=197, Pt=198, Au=199.
11	(Au=199)	Hg=200	Tl=204	Pb=207	Bi=208	—	—	
12	—	—	—	Th=231	—	U=240	—	— — — —

PERIODIC TABLE OF THE ELEMENTS

A ← → B

Atomic Number →	22
Symbol →	Ti
Name →	Titanium
Atomic Mass →	47.9
Ion charge(s) →	4+ 3+

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 + H Hydrogen 1.0																1 – H Hydrogen 1.0	2 0 He Helium 4.0
3 + Li Lithium 6.9	4 2+ Be Beryllium 9.0											5 B Boron 10.8	6 C Carbon 12.0	7 3– N Nitrogen 14.0	8 2– O Oxygen 16.0	9 – F Fluorine 19.0	10 0 Ne Neon 20.2
11 + Na Sodium 23.0	12 2+ Mg Magnesium 24.3											13 3+ Al Aluminium 27.0	14 Si Silicon 28.1	15 3– P Phosphorus 31.0	16 2– S Sulfur 32.1	17 – Cl Chlorine 35.5	18 0 Ar Argon 39.9
19 + K Potassium 39.1	20 2+ Ca Calcium 40.1	21 3+ Sc Scandium 45.0	22 4+ 3+ Ti Titanium 47.9	23 5+ 4+ V Vanadium 50.9	24 3+ 2+ Cr Chromium 52.0	25 2+ 3+ 4+ Mn Manganese 54.9	26 3+ 2+ Fe Iron 55.8	27 2+ 3+ Co Cobalt 58.9	28 2+ 3+ Ni Nickel 58.7	29 2+ 1+ Cu Copper 63.5	30 2+ Zn Zinc 65.4	31 3+ Ga Gallium 69.7	32 4+ Ge Germanium 72.6	33 3– As Arsenic 74.9	34 2– Se Selenium 79.0	35 – Br Bromine 79.9	36 0 Kr Krypton 83.8
37 + Rb Rubidium 85.5	38 2+ Sr Strontium 87.6	39 3+ Y Yttrium 88.9	40 4+ Zr Zirconium 91.2	41 3+ 5+ Nb Niobium 92.9	42 2+ 3+ Mo Molybdenum 95.9	43 7+ Tc Technetium (98)	44 3+ 4+ Ru Ruthenium 101.1	45 3+ 4+ Rh Rhodium 102.9	46 2+ 4+ Pd Palladium 106.4	47 + Ag Silver 107.9	48 2+ Cd Cadmium 112.4	49 3+ In Indium 114.8	50 4+ 2+ Sn Tin 118.7	51 3+ 5+ Sb Antimony 121.8	52 2– Te Tellurium 127.6	53 – I Iodine 126.9	54 0 Xe Xenon 131.3
55 + Cs Cesium 132.9	56 2+ Ba Barium 137.3	57 3+ La Lanthanum 138.9	72 4+ Hf Hafnium 178.5	73 5+ Ta Tantalum 180.9	74 6+ W Tungsten 183.8	75 4+ 7+ Re Rhenium 186.2	76 3+ 4+ Os Osmium 190.2	77 3+ 4+ Ir Iridium 192.2	78 4+ 2+ Pt Platinum 195.1	79 3+ 1+ Au Gold 197.0	80 2+ 1+ Hg Mercury 200.6	81 1+ 3+ Tl Thallium 204.4	82 2+ 4+ Pb Lead 207.2	83 3+ 5+ Bi Bismuth 209.0	84 2+ 4+ Po Polonium (209)	85 – At Astatine (210)	86 0 Rn Radon (222)
87 + Fr Francium (223)	88 2+ Ra Radium (226)	89 3+ Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (272)	112 Uub Ununbium (285)	113 Uut Ununtrium (284)	114 Uuq Ununquadium (289)	115 Uup Ununpentium (288)	116 Uuh Ununhexium (292)	117 Uus Ununseptium (?)	118 Uuo Ununoctium (294)

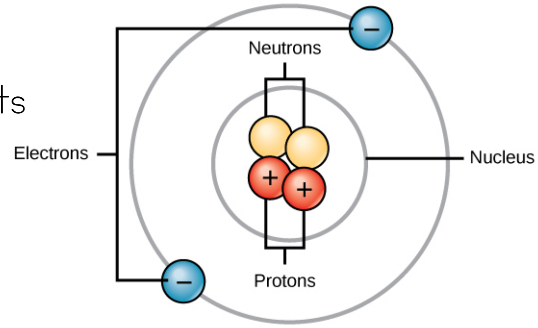
58 3+ 4+ Ce Cerium 140.1	59 3+ 4+ Pr Praseodymium 140.9	60 3+ Nd Neodymium 144.2	61 3+ Pm Promethium (145)	62 3+ 4+ Sm Samarium 150.4	63 3+ 2+ Eu Europium 152.0	64 3+ Gd Gadolinium 157.3	65 3+ 4+ Tb Terbium 158.9	66 3+ Dy Dysprosium 162.5	67 3+ Ho Holmium 164.9	68 3+ Er Erbium 167.3	69 3+ 2+ Tm Thulium 168.9	70 3+ 2+ Yb Ytterbium 173.0	71 3+ Lu Lutetium 175.0
90 4+ Th Thorium 232.0	91 5+ 4+ Pa Protactinium 231.0	92 6+ 4+ 5+ U Uranium 238.0	93 5+ 3+ 4+ 6+ Np Neptunium (237)	94 4+ 6+ 3+ 5+ Pu Plutonium (244)	95 3+ 4+ 5+ 6+ Am Americium (243)	96 3+ Cm Curium (247)	97 3+ 4+ Bk Berkelium (247)	98 3+ Cf Californium (251)	99 3+ Es Einsteinium (252)	100 3+ Fm Fermium (257)	101 2+ 3+ Md Mendelevium (258)	102 2+ 3+ No Nobelium (259)	103 3+ Lr Lawrencium (262)

Based on mass of C-12 at 12.00.

Any value in parentheses is the mass of the most stable or best known isotope for elements which do not occur naturally.

Station #5: Subatomic Particles

A substance that cannot be broken down into simpler substances by chemical means, is an **element**. An elements is *composed of atoms* of the same type, with the same number of protons and neutrons in their nucleus. When atoms gain (negative charge) or lose electrons (positive charge) they become electrically charged particles called **ions.** Ions can be positively or negatively charged, and some ions form charges in more than one way *(ie: multiple charges)*



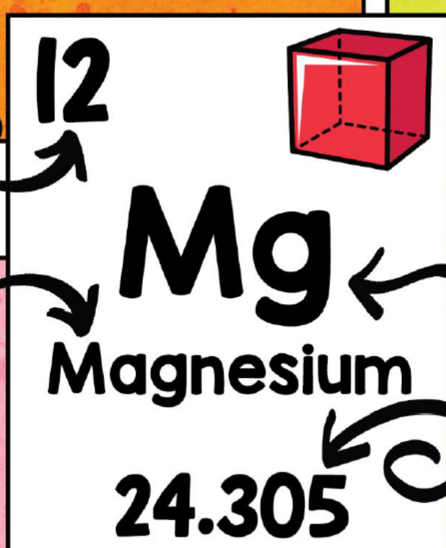
29 2+ 1+ **Cu** Copper 63.5	12 2+ **Mg** Magnesium 24.3	15 3– **P** Phosphorus 31.0

ATOMIC NUMBER

Every element has a unique Atomic Number. It indicates the total number of protons in the nucleus of the atom. Normal atoms are electrically neutral, same number of protons as electrons. So it is also the number of electrons.

SYMBOL

Every elements is abbreviated using a unique symbol of one or two letters. The first letter is always capitalized and if there is a second letter, it is lower case. Some are based on other languages, for example the symbol Fe is iron from the Latin "ferrium."



ELEMENT NAME

Every element has a unique name. Many element names are very old and are based on other languages. Chlorine is named after "khloros," the Greek work for "yellowish green" Newly discovered elements are named by the discoverer, but must be approved by an international committee.

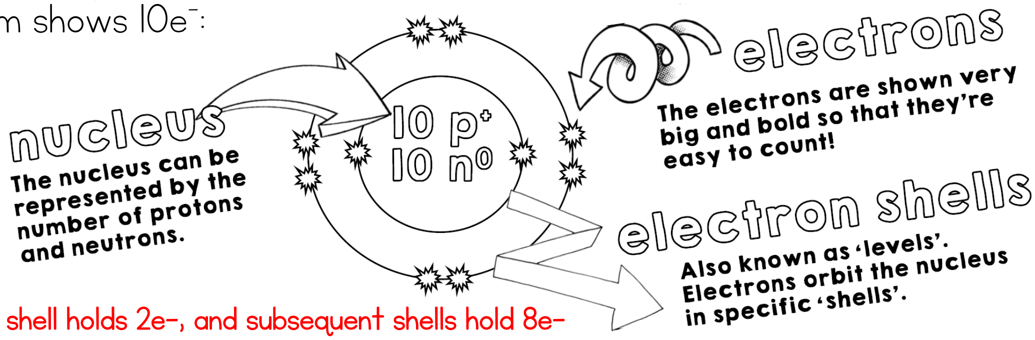
ATOMIC MASS

Atomic mass is the mass of the protons and the neutrons in an atom. Every proton and neutron has a mass of one AMU. Electrons do NOT count towards the mass because they are tiny. The mass can be shown with a decimal because it is an average mass of the isotopes of that element.

TASK: answer the questions in your student booklet

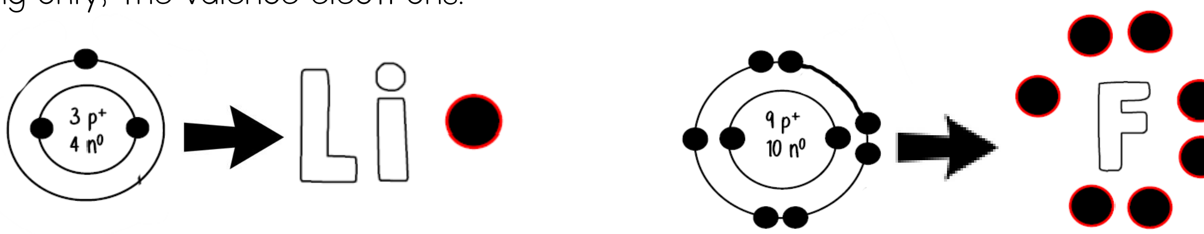
Station #6: Atomic Diagrams

The electronic configuration of an element is an ordered list of the number of electrons in each shell. The electron configuration of an atom is determined by the atomic number, which is the same as the number of protons (and electrons **IF** it s a neutral atom, **notan ion**). You may recall Noble Gases are **inert**, or do not react. This is due to their **stable electronic configuration** of 8 electrons in their outermost shell. Atoms*become more stable* when they achieve an electron configuration that is the same as a noble gas by gaining or losing electrons *(ie: becoming a charged ion)*. Scientific diagrams help us to illustrate electron configurations to better understand bonding and chemical reactions. **Bohr Diagrams** show how many electrons are in each shell surrounding the nucleus, as well as the positive nuclear charge *(or the number of protons and neutrons in the center of the atom).* For example, this Bohr diagram for the Neon atom shows 10e$^-$:



recall, the first shell holds 2e–, and subsequent shells hold 8e–

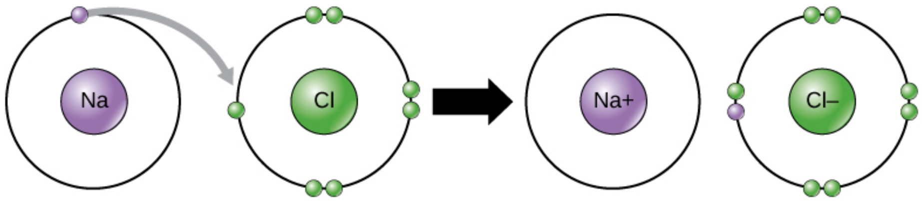
Another useful diagram is the Lewis Dot Diagram, or electron dot diagram. In these diagrams, only the valence, or electrons in the outermost shell are shown. These electrons are the highest energy electrons and indicate the atoms reactivity with other atoms. In other words, these are the electrons involved in chemical reactions. For example, see how the Bohr Diagrams are converted into Lewis Dot Diagrams by drawing only, the valence electrons.

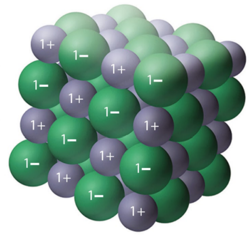


TASK: using the information provided, answer the questions in your student booklet

Station #7: Ionic + Covalent Bonds

Ions are atoms or molecules with an electrical charge. A **cation** *(a positive ion)* forms when a neutral **metal** atom loses one or more electrons from its valence shell, and an **anion** *(a negative ion)* forms when a neutral **non-metal** atom gains one or more electrons in its valence shell. Compounds made up of ions are called **ionic compounds** *(or salts)*, and their ions are held together by ionic bonds: *electrostatic forces of attraction between oppositely charged cations and anions*. For example: The Na atom gives an e^- to the chlorine atom, making them both ions (Na^+ and Cl^-) and forming an ionic bond.

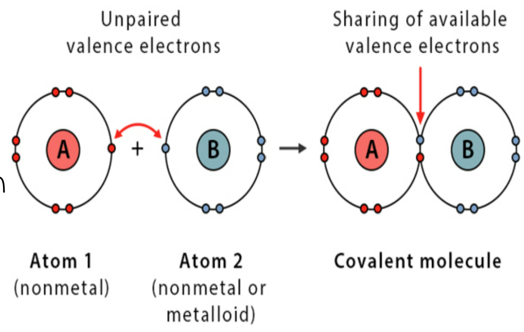




Solid sodium chloride, NaCl
(Net charge 0)

Ionic solids exhibit a crystalline structure and tend to be rigid and brittle; they also tend to have high melting and boiling points, which suggests that **ionic bonds are very strong.** Ionic solids are also poor conductors of electricity for the same reason the strength of ionic bonds prevents ions from moving freely in the solid state. Most ionic solids, however, dissolve easily in water. Once dissolved or melted, ionic compounds are excellent conductors of electricity and heat because the ions can move about freely.

Covalent Bonds result from the mutual attraction of 2+ non-metal atoms for a shared pair of electrons. Covalent compounds exhibit different physical properties than ionic compounds. Because the attraction between molecules, which are electrically neutral, is weaker than that between electrically charged ions, covalent compounds generally have much lower melting and boiling points than ionic compounds. In fact, many covalent compounds are liquids or gases at room temperature, and, in their solid states, they are typically much softer than ionic solids. If covalent compounds are dissolved in water, they have very weak conductivity. As pure substances they are poor conductors of electricity in any state (pure liquid, solid, or gas).



Station #8: Naming Compounds

Ionic Compounds are compounds that are composed of positive ions and negative ions. A **chemical formula** indicates the ratio of atoms present in the ionic formula. The chemical name of an ionic compound always has 2 parts:

- metal *(positively charged cation)*
- non-metal *(negatively charged anion)*

In the formula of an ionic compound, the subscript indicates the ratio of ions. **REMEMBER:** some metals are *multivalent*, meaning they can form more than 1 type of ion. *polyatomic* ions are molecules that carry an electric charge.

Writing Compound Names

Ionic Bonds
(a bond between a metal and a nonmetal)

Naming a Binary Ionic Compound
(two elements with no transition metals)

$NaCl$
sodium → sodium
chlorine → chlor**ide**
sodium chloride

K_2O
potassium → potassium
oxygen → ox**ide**
potassium oxide

Naming a Compound with a Transition Metal

$FeCl_2$
iron → iron (II)
chlorine → chlor**ide**
iron (II) chloride

Ag_2S
silver → silver (I)
sulfur → sulf**ide**
silver (I) sulfide

you can figure out this number based on the number of atoms of the second element

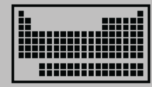
Naming a Compound with a Polyatomic Ion

$(NH_4)_2S$
ammonium
sulfur → sulf**ide**
ammonium sulfide

$Ca(ClO_3)_2$
calcium
chlorate
notice that we don't change the ending of polyatomic ions
calcium chlorate

Element or Polyatomic Ion?

Elements are found on the **periodic table.**



Elements look like this:
H K O — one capital letter
OR
Cu Ag — one capital letter and one lowercase letter

Polyatomic ions are groups of two or more elements.
ClO_3 NH_4 OH
They stick together.

Writing Compound Names

Covalent Bonds
(a bond between two nonmetals)

N_2O_5
nitrogen → nitrogen → (How many?) **di**nitrogen
oxygen → ox**ide** → (How many?) **pent**oxide
dinitrogen pentoxide

CO
carbon → carbon → carbon
oxygen → ox**ide** → (How many?) **mon**oxide
carbon monoxide

SiF_4
silicon → silicon → silicon
fluorine → fluor**ide** → (How many?) **tetra**fluoride
Notice that we don't use the prefix *mono-* here. That's because it's the first element in the compound.
silicon tetrafluoride

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

If the element starts with a vowel, you may need to drop the *o-* or *a-* at the end of your prefix.

penta- → **pent**oxide
di- → **di**oxide
tetra- → **tetr**oxide
hexa- → **hex**oxide

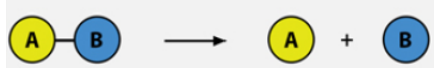
Covalent Compounds or molecules are composed of 2+ non-metal atoms that share electrons. In these compounds the precise number of atoms of each element in the molecule is shown by the chemical formula and the name. A ***prefix code*** indicates the number of atoms of each element that appears in the formula. Prefixes are the words that go ***infront*** of the name of the element. As with ionic compounds, the first part of the name is in full, while the second elements ending is changed to **"- ide"**.

Station #9: Classifying Chemical Reactions

Classifying types of chemical reactions can help scientists to find out how reactions work and to predict products. By understanding how one chemical reaction works, chemists can infer and make hypotheses about how other reactions with similar reactant species will behave. There are 5 main types of chemical reactions you should be familiar with. ***A synthesis*** reaction occurs when simple compounds combine to make a single, more complex compound as a product. In a ***decomposition*** reaction, the reverse appears to occur. complex compound or molecule is broken down into 2 or more simpler products. Decomposition reactions almost always require an energy input such as electricity or heat.

1. Combination or Synthesis Reaction

2. Decomposition Reaction



In a ***Single displacement/replacement*** reaction a single element replaces an element in an ionic compound. Recall:metal elements replace cations, and non-metals replace anions in the compound. A ***Double displacement/replacement*** reaction occurs when the + cations of **two compounds** react and switch places. In a ***combustion*** reaction a hydrocarbon compound reacts with oxygen in order to produce water vapor, carbon dioxide and also heat. Combustion reactions have characteristic reactants and products in addition to being exothermic *(release energy, in this case heat)*. You may also have studied ***neutralization*** reactions. These are technically double replacement reactions, however specifically between and acid and a base, to produce a water and ionic salt product.

3. Single-replacement Reaction

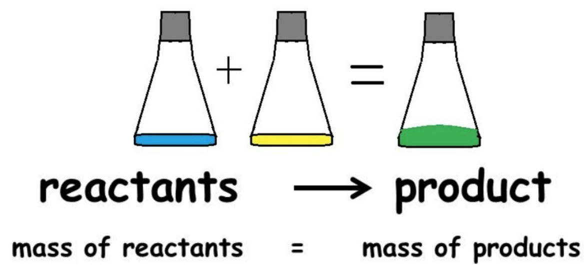
4. Double-replacement Reaction

5. Combustion Reaction

Station #10: Balancing Chemical Reactions

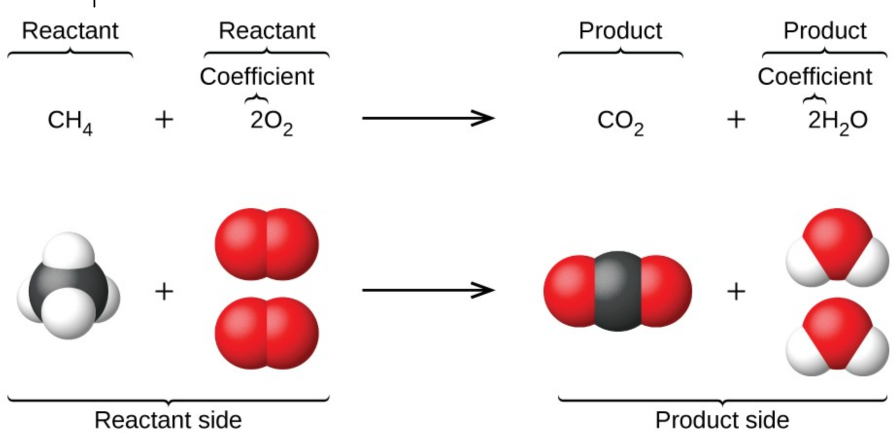
A chemical reaction is a change that takes place when one or more substances *(reactants)* form one or more ***new substances*** *(products).* When observing chemical reactions one can tell if a chemical change has taken place when witnessing characteristics such as: a color change, a precipitate (solid) formation, an energy change (endothermic/exothermic), a gas (bubbles) produced or perhaps an odor. It is one thing to know a chemical reaction has occurred, and another to document the change with appropriate scientific language. Chemists use word equations or balanced chemical reactions to illustrate this.

"Matter is neither created, nor destroyed." this famous statement *(referred to as the Law of Conservation of Matter)* was made by French Chemist Antoine Lavoisier in 1789 essentially means the mass of reactants = the mass of products.



In other words, the mass of any one element at the beginning of a reaction will equal the mass of that element at the end of the reaction. No new matter is created or destroyed in a chemical reaction; atoms are just rearranged as bonds are broken and reformed and new products made. This means that when matter is conserved, the number of individual atoms of each kind are also conserved. ***The Law of Conservation of Atoms*** states the number of each atom in the reactants must equal the number of each atom in the products.

Balancing a chemical equation (shown right) requires the placement of ***coefficients*** infront of reactant and/or product species; this multiplies the entire chemical species that follows it.



It is critical to remember balancing must always involve the placement of coefficients and **NEVER the changing of subscripts.**
Altering the subscripts will give an ***incorrect formula*** for a substance.