Welcome to LPS AP Chemistry!

While many other AP courses take the whole year to cover only a semester of college-level content, this course covers two semesters of college chemistry and is therefore incredibly fast-paced. This summer assignment is designed to make sure you retain certain prerequisite knowledge to make more space and time for learning the new stuff.

The summer assignment focuses on moles, writing equations, net ionic equations, stoichiometry, limiting reactants, and empirical and molecular formula calculations. These are *not* the only topics from honors chemistry that you must retain! They are, however, some of the most fundamental and ones that would take a while to re-teach, which is why they're the focus of the summer assignment.

Throughout the year we will also revisit (and then greatly expand upon) electron configurations and periodic trends, gases, solutions, acids and bases, redox, and more.

If you have any questions while completing the summer assignment, please feel free to email me and I can meet you at school any time in July or August before school starts to provide assistance.

Happy problem-solving!

- Ms. Schroeder

TOPIC: 1.1 MOLES AND MOLAR MASS

ENDURING UNDERSTANDING:

SPQ-1	The mole allows different units to be compared

LEARNING OBJECTIVE:

SPQ-1.A	Calculate quantities of a substance or its relative number of particles using dimensional analysis and the mole concept.

ESSENTIAL KNOWLEDGE:

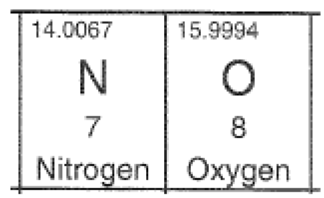
SPQ-1.A.1	One cannot count particles directly while performing laboratory work. Thus, there must be a connection between the masses of substances reacting and the actual number of particles undergoing chemical changes.
SPQ-1.A.2	Avogadro's number ($N_A = 6.022 \times 10^{23}$ particles/mole) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance.
SPQ-1.A.3	Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass in amu of one particle (atom or molecule) or formula unit of a substance will always be numerically equal to the molar mass of that substance in grams. Thus, there is a quantitative connection between the mass of a substance and the number of particles that the substance contains.

EQUATION(S):

	n = m/M moles = mass/molar mass

NOTES:

It is impractical to count atoms as they are so small, so in chemistry we can "count" atoms by weighing them or measuring them in some other way. We need to convert the measurements that we make into numbers of atoms so that we can be sure to react the right amounts of materials. Atomic masses are measured in atomic mass units, amu, which is a relative unit, based on the carbon-12 isotope being assigned a mass of exactly 12 grams per mole. A mole is a term used to describe a group of atoms containing 6.022×10^{23} items. Chemists use moles to discuss amounts of atoms because using the actual amount of atoms is such a large number it is often impractical. You can calculate the mass for one mole of a substance by referring to the periodic table to find the average atomic mass of each atom then adding up the total mass for the formula.



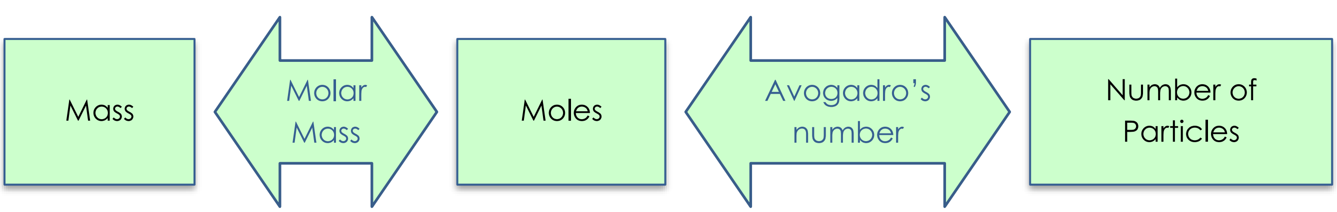
How to calculate Molar Mass:

1) List the atoms
2) Count the atoms
3) Find the mass of each atom from the periodic table
4) Multiply the number of atoms (#2) by the mass of each atom (#3)
5) Add together the values (#4)

Calculate the molar mass of dinitrogen tetroxide:
N_2O_4
N = 2 x 14.0067 = 28.0134
O = 4 x 15.9994 = 63.9976
92.0110 g/mole

Molar mass can be used as a conversion factor to convert between moles and grams. It is unique for each sample.

Avogadro's Number, 6.022×10^{23} particles/mole, is the conversion factor to convert between number of particles (molecules, atoms, formula units, ions) and moles.



I DO:

How many moles of Lead (II) iodide, PbI_2, are there in a 25.0 gram sample?

$25.0\ g\ PbI2 \times \frac{1\ mole}{461.0g} = 0.0542\ mole\ PbI_2$

How many atoms of lead, Pb, are in the sample?

$0.0542\ moles\ PbI_2 \times \frac{1\ mol\ Pb}{1\ mole\ PbI_2} \times \frac{6.022 \times 10^{23}\ atoms\ Pb}{1\ mole\ Pb} = 3.27 \times 10^{22}\ atoms\ Pb$

WE DO:

A 0.244 g sample of calcium carbonate, $CaCO_3$, was recovered from a sample of hard water. How many formula units of $CaCO_3$ were in the sample?

SCAN ME

YOU DO:

1) Methane, CH_4, is the gas commonly found in labs to fuel Bunsen burners.
   a) How many moles of methane are there in a 7.21 gram sample?
   b) How many particles of methane are there in the sample?
   c) How many atoms of hydrogen are found in the sample?

2) Helium, He, is used in balloons, deep sea diving tanks, and in industry. While it is the second most abundant element in the universe, in 2019 there was a shortage of helium which caused the prices to rise. If 150. grams of helium is needed to cool a superconductor, how many atoms of helium are used?

3) If you know the mass and identity of a sample, what other information do you need in order to find the number of each atom in the sample?

4) Given 10.0 gram samples of LiCl, LiBr, LiF and LiI, place the samples in order of least to greatest number of atoms of Lithium, Li.

5) What is the mass of one atom of carbon-12?

6) What is the mass of 2.30×10^{24} particles of water, H_2O?

7) Which is a greater mass, 0.25 moles of carbon dioxide, CO_2, or 1.5×10^{23} particles of carbon monoxide, CO?

TOPIC: 1.3 ELEMENTAL COMPOSITION OF PURE SUBSTANCES

ENDURING UNDERSTANDING:	
SPQ-2	Chemical Formulas identify substances by their unique combination of atoms
LEARNING OBJECTIVE:	
SPQ-2.A	Explain the quantitative relationship between the elemental composition by mass and the empirical formula of a pure substance
ESSENTIAL KNOWLEDGE:	
SPQ-2.A.1	Some pure substances are composed of individual molecules, while others consist of atoms or ions held together in fixed proportions as described by a formula unit.
SPQ-2.A.2	According to the law of definite proportions, the ratio of the masses of the constituent elements in any pure sample of that compound is always the same.
SPQ-2.A.3	The chemical formula that lists the lowest whole number ratio of atoms of the elements in a compound is the empirical formula.
EQUATION(S):	
	N/A

NOTES:

A pure substance is one with constant composition; a pure substance can either be an element or a compound

When dealing with compounds you can assume it follows the law of definite proportion, which states compounds with the same elements in the same proportion are the SAME compound.

Following the law of definite proportion, you can find the percent composition which is the percent by mass of each element that makes up a compound.
To calculate the percent composition, you divide the mass of each element in a compound by the total molar mass of the substance.

In compounds, the **empirical formula** represents the simplest ratio of one element to another in a compound. The **molecular formula** represents the actual formula for the substance.

An example is glucose which has the molecular formula $C_6H_{12}O_6$ but the empirical formula is CH_2O.

<u>To determine the empirical and molecular formula.</u>

1. Determine the *empirical formula* for the compound when given percent of each element
   a. Assume you are given a 100g sample so you can change percent to grams
   b. For each element take grams / molar mass to get moles of each element
   c. Divide each mole value by the lowest of the values
   d. If you are within 0.1 of a whole number round to the whole number, if you are not you must multiply by a factor that gives you whole numbers for all.
   e. The values you found are the subscripts for each element
2. Determine *molecular formula* (can only determine if given molar mass of substance)
   a. Find mass of empirical formula
   b. Molar mass/ empirical formula mass to find factor
   c. Multiply all subscripts in the empirical formula by the value

I DO:

A certain sugar used in treating patients with low blood sugar has the following chemical composition: 40.0 % carbon, 6.70 % hydrogen, and 53.3 percent oxygen. What is the empirical formula?

40.0 % C → 40.0 g C (1 mol/12.011 g C) = 3.33 moles C / 3.33 moles = 1

6.70% H → 6.70 g H (1 mol/1.01 g H) = 6.63 moles H / 3.33 moles = 2

53.3 % O → 53.3 g O (1 mol/16.0 g O) = 3.33 moles O /3.33 moles = 1

CH_2O

The molar mass of the compound is 180 grams/mole. What is the molecular formula of this compound?

C = 1 x 12.01 = 12.01

H = 2 x 1.01 = 2.02

O = 1 x 16.00 = 16.00

30.03 g/mole (30.03 g/mol) *x = 180 g/mol

X = 6 $C_6H_{12}O_6$

WE DO:

a. A compound is found to contain 56.5% carbon, 7.11% hydrogen, and 36.4% phosphorus. Find the empirical formula.

b. If the compound has a molar mass of 170.14 g/mol, what is its molecular formula?

SCAN ME

YOU DO:

1. The most abundant molecule found in the human body is 88.810% oxygen and 11.190% hydrogen. Calculate the empirical formula for this substance.

2. Arginine is one of the amino acids; it is used in the biosynthesis of proteins. Analysis revealed that a sample of arginine was 41.368 % carbon, 8.101% hydrogen, 32.162 % nitrogen and 18.369% oxygen.
   a. What is the empirical formula of arginine?

   b. The molecular weight of arginine is 174.204 grams/mole. What is the molecular formula?

3. The empirical and molecular formulas of urea are the same. 90 % of the world's urea is used for fertilizer. If the percentage composition of the elements in urea are 19.999% carbon, 6.713% hydrogen, 46.646% nitrogen and 26.641% oxygen.

4. A compound containing phosphorus and oxygen is a powerful desiccant. The compound is 43.642% phosphorus and 56.358% oxygen.

a. Calculate the empirical formula for this compound.

b. The molar mass of this compound is 283.889044 g/mol, determine the molecular formula.

5. Emeralds are composed of 4 different elements in a fixed proportion. They are composed of 5.030 % beryllium, 10.040 % Aluminum, 31.351% Silicon and 53.579% oxygen. The empirical and molecular formula are the same.
   a. Calculate the empirical formula.

   b. Calculate the molar mass.

6. Iron can form three different oxides, FeO, Fe_2O_3 and Fe_3O_4. A sample of iron oxide was analyzed and was found to contain 69.943% iron with the rest of the mass from oxygen. Determine the empirical formula to determine the identity of the iron oxide.

7. Serotonin is a chemical that nerve cells produce from an essential amino acid called tryptophan. Tryptophan must enter our body through a balanced diet, and is commonly found in nuts, cheese and red meat. Serotonin is considered to be a natural mood stabilizer as it helps with sleeping, eating and digestion. A sample of serotonin was found to be 6.864% hydrogen, 68.159% carbon, 15.897% nitrogen and 9.079% oxygen. Calculate the empirical formula for serotonin.

TOPIC: 4.1 INTRODUCTION FOR REACTIONS

ENDURING UNDERSTANDING:	
TRA-1	A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.
LEARNING OBJECTIVE:	
TRA-1.A	Identify evidence of chemical and physical changes in matter.
ESSENTIAL KNOWLEDGE:	
TRA-1.A.1	A physical change occurs when a substance undergoes a change in properties but not a change in composition. Changes in the phase of a substance (solid, liquid, gas) or formation/separation of mixtures of substances are common physical changes.
TRA-1.A.2	A chemical change occurs when substances are transformed into new substances, typically with different compositions. Production of heat or light, formation of a gas, formation of a precipitate, and/or color change provide possible evidence that a chemical change has occurred.
EQUATION(S):	
	N/A

NOTES:

Matter is material that occupies space and contains mass. Matter can be organized in many ways and undergo physical and chemical changes.

Homogeneous Mixture: visibly indistinguishable parts

Heterogeneous Mixture: visibly distinguishable parts

Pure Substance: substance with one constant composition

Compound: a substance with constant composition that can be broken down into elements by chemical process

Elements: substance that cannot be decomposed into simpler substances by chemical or physical means

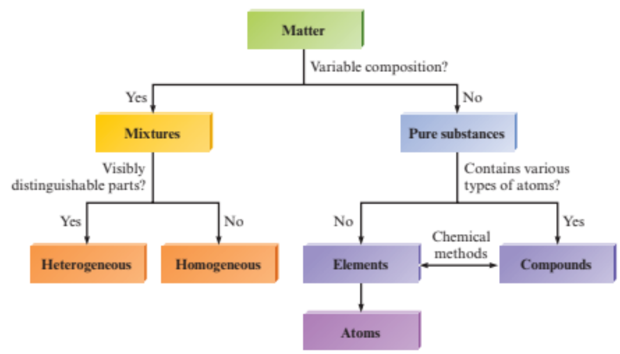
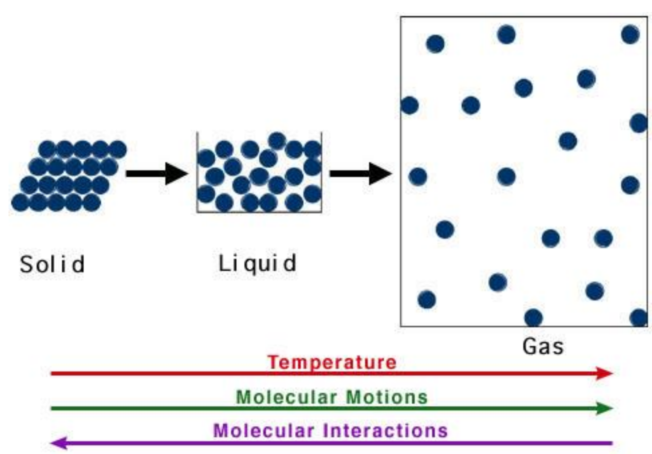


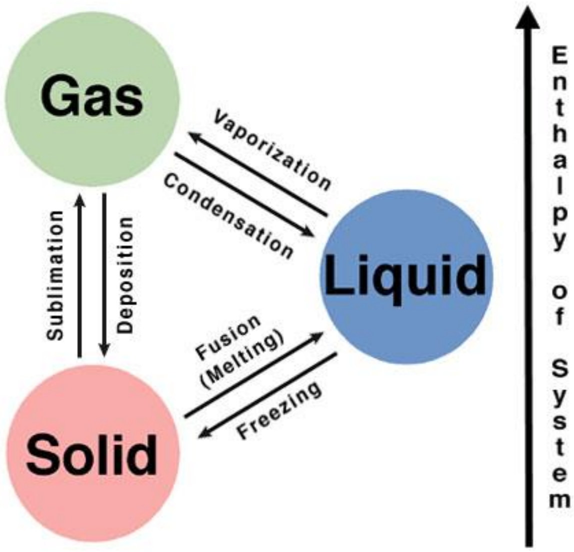
Photo: Zumdahl Chemistry Book

Physical Change: physical property of a substance changes without changing the composition.
There are several types of physical reactions that can take place.

This schematic diagram shows the differences in physical properties and particle arrangement between a substance in the solid, liquid, and gas phases. In a solid, the particles are packed in a rigid configuration, giving the substance a definite shape and size. In a liquid, the particles are close together but may move with respect to one another, giving the substance a definite volume but a fluid shape. In a gas, the particles may occupy the entire volume of the container, so that their shape and volume are both defined by the container.
http://www.chemistry.wustl.edu/~edudev/LabTutorials/CourseTutorials/bb/Thermochem/Phase.htm



You should be familiar with the names for the different phase changes as shown below.



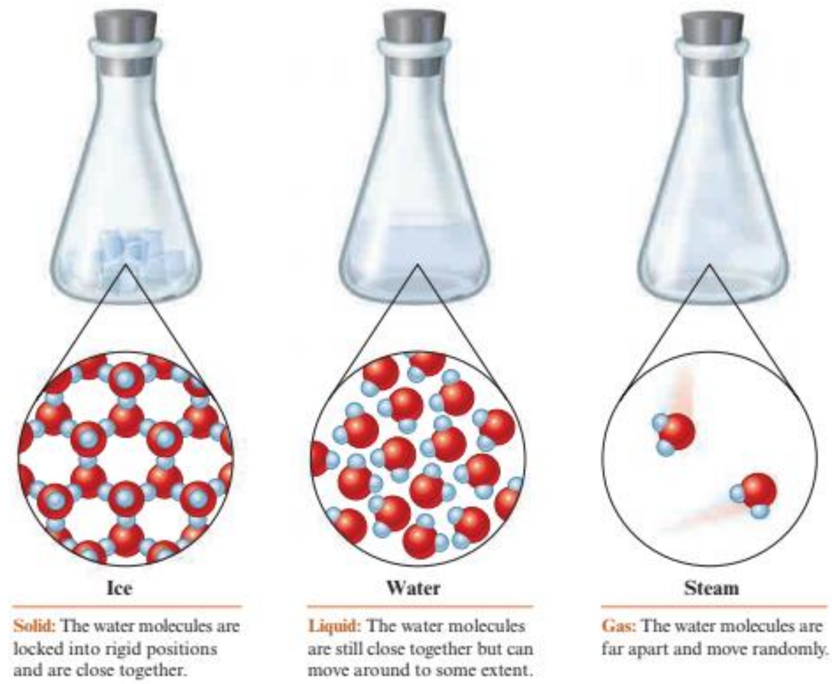
Other examples of physical changes include separations of mixtures. This can be achieved through distillation which separates substances based on differences in boiling points, filtration which separates substances based on particle size or chromatography which uses differences in intermolecular forces to separate substances.

Another type of physical change is deformation of the substance. This can be through cutting, denting, tearing, stretching etc.

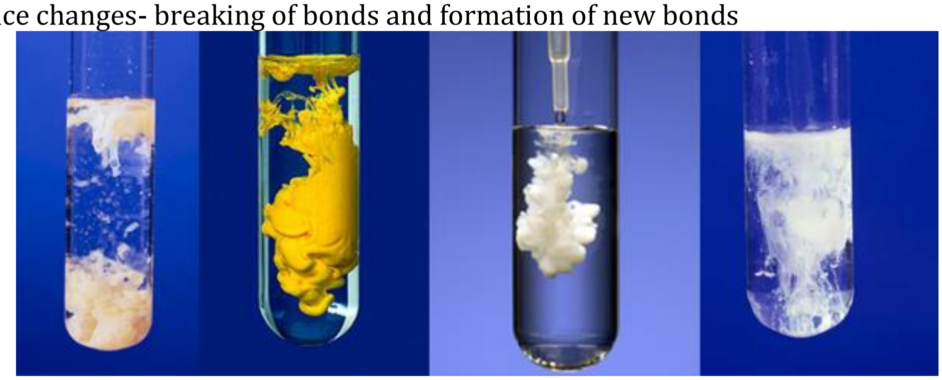
Making solutions is another example of a physical change.

The key feature of a physical change is that the atoms are not rearranged. The physical properties (shape, color, texture, flexibility, density, and mass) are changed. Physical changes are usually reversible.

Photo: Zumdahl Chemistry Book



Chemical Change: property of a substance changes- breaking of bonds and formation of new bonds



http://chemskills.com/?q=chemical_equations
https://www.thoughtco.com/combustion-reactions-604030

Evidence of chemical reactions include:

- Production of a precipitate (a substance of a new phase, such as the solids forming in the test tubes above)
- Color Change
- Light
- Change in temperature
- Sounds
- Evolution (production) of a gas
- Formation of a new substance with new properties

Chemical changes are often very difficult to reverse.

There are a few basic types of reactions that we see in chemistry.

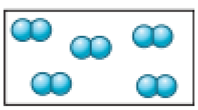
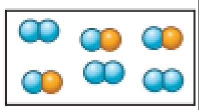
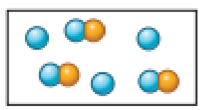
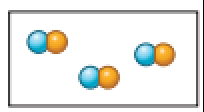
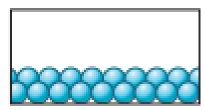
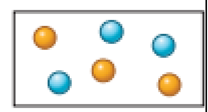
Composition (synthesis)	Decomposition	Single Ionic Replacement	Double Ionic Replacement	Combustion of a hydrocarbon (or a metal)
$A + B \rightarrow AB$	$AB \rightarrow A + B$	$A + BC \rightarrow AC + B$	$AB + CD \rightarrow AD + CB$	C_xH_y (with or without O) + $O_2 \rightarrow CO_2 + H_2O$ $M + O_2 \rightarrow M_xO_y$
$Na + Cl_2 \rightarrow NaCl$	$KClO_3 \rightarrow KCl + O_2$	$Mg + HCl \rightarrow MgCl_2 + H_2$	$LiCl + AgNO_3 \rightarrow LiNO_3 + AgCl$	$C_3H_8 + O_2 \rightarrow CO_2 + H_2O$ $Mg + O_2 \rightarrow MgO$

Double Ionic Replacement includes acid/base neutralization and precipitation reactions.

All of these can be considered RedOx (Oxidation-Reduction) reactions except for double ionic replacement reactions. We will discuss this in more depth later in the unit.

I DO:

Using the images below, describe the types of matter and states of matter present.

Images from Zumdahl 9th Edition	 i	 ii	 iii	 iv	 v	 vi
Types of matter	Element	Mixture of an element and a compound	Mixture of an element and a compound	Compound	Element	Mixture of Elements
States of matter	Gas	Gases	Gases	Gases	Solid	Gases

WE DO:

SCAN ME

For each of the following examples, decide if a chemical or physical change has taken place.

1) Over time, solutions of iodine and water gradually lose color as the iodine evaporates.

2) When a drop of acid landed on the chemistry teacher's pants, a small hole appeared.

3) When a solution of lead (II) nitrate and a solution of sodium chloride are mixed a cloudy white precipitate forms.

4) At Halloween many people use Dry Ice, solid carbon dioxide, in their decorations. It sublimes into a gas and creates a foggy effect.

YOU DO:

1) Make a molecular-level (microscopic) drawing for the following:

a) A homogeneous mixture of a gaseous diatomic element and a gaseous compound.	b) A homogeneous mixture of two gaseous compounds.	c) A heterogeneous mixture of a gaseous element and a solid compound.

2) When 100.0 mL of a 0.50 M solution of hydrochloric acid, HCl, at 22.0°C reacts with 2.00 grams of sodium hydroxide, NaOH, the temperature increases by 12.5°C. What type of reaction (physical or chemical) takes place? How do you know?

3) Identify each of the following as chemical or physical change:
   a) $2H_2O\ (g) \rightarrow 2H_2\ (g) + O_2\ (g)$
   b) $NH_4Cl\ (s) \rightarrow NH_3\ (g) + HCl\ (g)$
   c) $H_2O\ (s) \rightarrow H_2O\ (l)$
   d) $C_8H_8\ (l) \rightarrow 2C_4H_4\ (g)$
   e) $2Al_2O_3\ (s) \rightarrow 4Al\ (s) + 3O_2\ (g)$
   f) $C_3H_6O\ (l) \rightarrow C_3H_6O\ (g)$
   g) $NaHCO_3\ (s) + HCH_3COO\ (aq) \rightarrow CO_2\ (g) + H_2O\ (l) + NaCH_3COO\ (aq)$

4) For each of the following descriptions, decide if the material is likely to be a mixture or a pure compound or element, and then decide if the process is a chemical or a physical change.
   a) A clear, colorless, crystalline solid is heated. A pale yellow-green gas is given off and a shiny, malleable metal was left behind.
   b) A brown liquid is heated and a colorless, aromatic liquid is produced along with a clear, colorless liquid while a brown liquid is left behind in the container.
   c) Adding sugar to tea causes the tea to taste sweeter.
   d) A shiny, dark gray metal and a clear colorless gas combine to form a flaky orange solid.

TOPIC: 4.2 NET IONIC EQUATIONS

ENDURING UNDERSTANDING:

TRA-1	A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.

LEARNING OBJECTIVE:

TRW-1.B	Represent changes in matter with a balanced chemical or net ionic equation: a. For physical changes. b. For given information about the identity of the reactants and/or product. c. For ions in a given chemical reaction.

ESSENTIAL KNOWLEDGE:

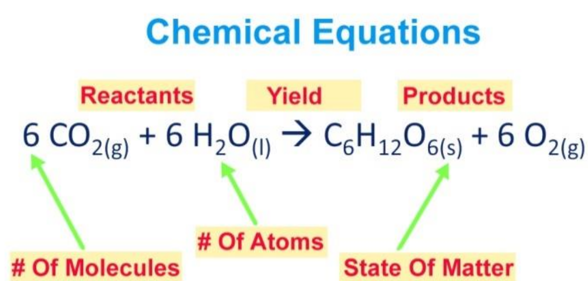
TRA-1.B.1	All physical and chemical processes can be represented symbolically by balanced equations.
TRA-1.B.2	Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass is conserved in chemical reactions.
TRA-1.B.3	Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used.

EQUATION(S):

	N/A

NOTES:

All physical and chemical processes can be represented symbolically by balanced equations.
Chemical equations represent chemical changes. These changes are the result of a rearrangement of atoms into new combinations; thus, any representation of a chemical change must contain equal numbers of atoms of every element before and after the change occurred. Equations thus demonstrate that mass is conserved in chemical reactions.



A balanced equation is a short-hand way to describe the changes that occur in a chemical reaction. They follow the law of conversation of matter/mass that states that in any chemical or physical reaction no matter can be created or destroyed. The number of each type of atom is the same on both sides of the arrow. Coefficients are used to change the number of each particle in the reaction. The subscripts are NEVER changed to balance a chemical equation.

https://www.scienceabc.com/wp-content/uploads/2019/11/chemical-reactant.jpg?ezimgfmt=ng:webp/ngcb37

https://www.mikeblaber.org/oldwine/chm1045/notes/Stoich/Equation/balance4.gif

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

C=1		C=1
H=4	=	H=4
O=4		O=4

We can include the states of matter in the equation to provide more information. In a physical reaction, only the states of matter change.

Solid = (s)
Liquid = (l)
Gas = (g)
Aqueous Solution = (aq)

When writing a chemical equations there are 7 diatomic elements that you should know: H_2, N_2, O_2, F_2, Cl_2, Br_2 and I_2. They are all found in their diatomic form in nature.

The steps to balancing an equation (using the guess and check method) are as follows:

1) Write out the equation
2) Count the atoms on each side of the equation
3) Compare the counts, if they are the same then stop, if they are different then continue to 4.
4) Change a coefficient to make one element correct
5) Recount the atoms
6) Compare the counts, if they are the same then stop, if different return to 4.

Balanced molecular, complete ionic, and net ionic equations are differing symbolic forms used to represent a chemical reaction. The form used to represent the reaction depends on the context in which it is to be used.

When you have mastered writing a balanced equation you can then write an overall ionic equation. Overall ionic equations show how ionic compounds dissociate into their ions when they dissolve in water. If you have solutions of an ionic compound (particularly any **sodium, potassium, ammonium, and nitrate salts**) they should be written as their ions if you are showing an overall ionic equation.

Example:

Precipitation Reaction	
Balanced Chemical Equation:	$Pb(NO_3)_{2\ (aq)} + 2\ NaCl_{\ (aq)} \rightarrow 2\ NaNO_{3(aq)} + PbCl_{2(s)}$
Overall Ionic Equation:	$Pb^{2+}{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + 2\ Na^+{}_{(aq)} + 2\ Cl^-{}_{\ (aq)} \rightarrow 2\ Na^+{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + PbCl_{2(s)}$

NOTE: The only change is for substances that are aqueous and ionic.
Precipitation reactions are a form of double ionic replacement reactions and follow the format of:
AB + CD → AD + CB, where the positive and negative ions switch partners.

Dissolution Example (Ionic and strong acids/bases)	
Balanced Chemical Equation:	$NaCl_{\ (s)} \rightarrow NaCl_{\ (aq)}$
Overall Ionic Equation:	$NaCl_{(s)} \rightarrow Na^+{}_{(aq)} + Cl^-{}_{\ (aq)}$

Dissolution Example (Nonionic and weak acids/bases)	
Balanced Chemical Equation:	$C_6H_{12}O_{6\ (s)} \rightarrow C_6H_{12}O_{6\ (aq)}$
Overall Ionic Equation:	$C_6H_{12}O_{6\ (s)} \rightarrow C_6H_{12}O_{6\ (aq)}$

The final way to write a reaction is to write a net ionic equation. The net ionic equation only shows the particles that change in the reaction. It cancels out the spectator ions. A spectator ion is one that isn't involved in the reaction and stays the same phase throughout.
In the example below, the sodium ions and the nitrate ions are the same phase throughout the reaction and are unchanged, they should be cancelled out to create a net ionic equation.

Precipitation Reaction	
Balanced Chemical Equation:	$Pb(NO_3)_{2\ (aq)} + 2\ NaCl_{\ (aq)} \rightarrow 2\ NaNO_{3(aq)} + PbCl_{2(s)}$
Overall Ionic Equation:	$Pb^{2+}{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + 2\ Na^+{}_{(aq)} + 2\ Cl^-{}_{\ (aq)} \rightarrow 2\ Na^+{}_{(aq)} + 2\ NO_3^-{}_{(aq)} + PbCl_{2(s)}$
Net Ionic Equation:	$Pb^{2+}{}_{(aq)} + \cancel{2\ NO_3^-}{}_{(aq)} + \cancel{2\ Na^+}{}_{(aq)} + 2\ Cl^-{}_{\ (aq)} \rightarrow \cancel{2\ Na^+}{}_{(aq)} + \cancel{2\ NO_3^-}{}_{(aq)} + PbCl_{2(s)}$ $Pb^{2+}{}_{(aq)} + 2\ Cl^-{}_{\ (aq)} \rightarrow PbCl_{2(s)}$

I DO:

A solution of ammonium carbonate, $(NH_4)_2CO_3$, reacts with a solution of silver nitrate, $AgNO_3$, to form a white silver carbonate precipitate as shown in the image.

Write the balanced chemical equation:

$(NH_4)_2CO_{3(aq)} + 2\ AgNO_{3(aq)} \rightarrow Ag_2CO_{3(s)} + 2\ NH_4NO_{3(aq)}$

Write the overall ionic equation:

$2NH_4^+{}_{(aq)} + CO_3^{2-}{}_{(aq)} + 2\ Ag^+{}_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow Ag_2CO_{3(s)} + 2NH_4^+{}_{(aq)} + 2NO_3^-{}_{(aq)}$

Identify the spectator ions:

$2NH_4^+{}_{(aq)} + 2NO_3^-{}_{(aq)}$

Write the net ionic equation:

$CO_3^{2-}{}_{(aq)} + 2\,Ag^+{}_{(aq)} \rightarrow Ag_2CO_{3(s)}$

https://ichef.bbci.co.uk/images/ic/320xn/p01l3x75.jpg

WE DO:

Copper (II) nitrate, $Cu(NO_3)_2$, solution reacts with potassium hydroxide, KOH, to form a blue precipitate of copper (II) hydroxide.

Write the balanced chemical equation:

Write the overall ionic equation:

Identify the spectator ions:

Write the net ionic equation:

https://woelen.homescience.net/science/chem/solutions/cuIIoh.jpg

SCAN ME

YOU DO:

1) Balance the following equations:
   a. $Na + Br_2 \rightarrow NaBr$
   b. $HClO_3 \rightarrow ClO_2 + H_2O + O_2$
   c. $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$
   d. $Sb_2S_3 + HCl \rightarrow SbCl_3 + H_2S$
   e. $Al + HCl \rightarrow AlCl_3 + H_2$

2) Write net ionic equations for the reaction that occurs when aqueous solutions of ammonium sulfate, $(NH_4)_2SO_4$, and barium nitrate, $Ba(NO_3)_2$ react to form a white precipitate.
   a. Write the balanced chemical equation:
   b. Write the overall ionic equation:
   c. Identify the spectator ions:
   d. Write the net ionic equation:

3) Write net ionic equations for the reaction that occurs when aqueous solutions of Lithium hydroxide, LiOH, with hydrobromic acid, HBr, undergo a neutralization reaction that produces salt and water.
   a. Write the balanced chemical equation:
   b. Write the overall ionic equation:
   c. Identify the spectator ions:
   d. Write the net ionic equation

4) Write net ionic equations for the reaction that occurs when aqueous solutions of potassium nitrate, KNO_3, and potassium hydroxide, KOH, are combined. A clear solution results.
   a. Write the balanced chemical equation:
   b. Write the overall ionic equation:
   c. Identify the spectator ions:
   d. Write the net ionic equation

5) In some rare cases, two different precipitates can form in the same reaction.
   $Ba(OH)_{2(aq)} + MgSO_{4(aq)} \longrightarrow BaSO_{4(s)} + Mg(OH)_{2(s)}$

Write the overall and net ionic equation (it is the same reaction) for the reaction above.

6) When zinc metal, Zn, is added to hydrochloric acid, HCl, the rapid production of hydrogen gas, H_2, occurs.

   a. Write the balanced chemical equation:
   b. Write the overall ionic equation:
   c. Identify the spectator ions:
   d. Write the net ionic equation:

https://media.sciencephoto.com/image/a5000309/800wm

7) Dry ice is solid carbon dioxide, CO_2, which will sublimate at room temperature. Write the balanced chemical equation that represents the phase change of dry ice.

https://prd-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/styles/full_width/public/thumbnails/image/wss-cycle-sublimation-dryice.jpg

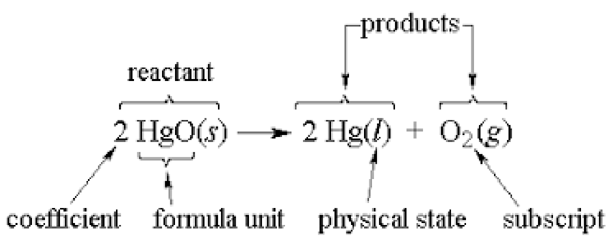
8) Water is seen here on earth in all three states of matter. Write the balanced chemical equation that shows:
   a. Liquid water freezing
   b. Boiling
   c. Ice melting
   d. Snowflakes forming from water vapor in the clouds

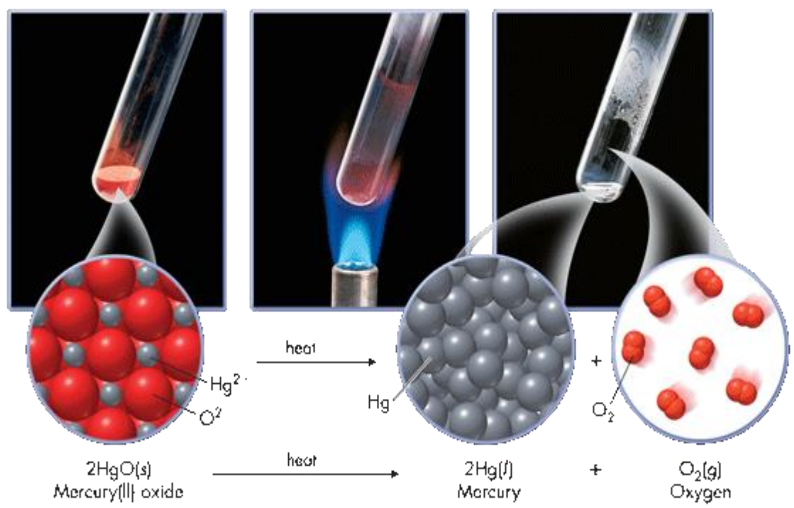
Topic: 4.3 Representation of Reactions

Enduring Understanding:	
TRA-1	A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.
Learning Objective:	
TRA-1.C	Represent a given chemical reaction or physical process with a consistent particulate model.
Essential Knowledge:	
TRA-1.C.1	Balanced chemical equations in their various forms can be translated into symbolic particulate representations.
Equation(s):	
N/A	

Notes:

There are many important pieces of information that are conveyed in a chemical reaction.





Chemists often create particulate models to represent reactions on a molecular level as way to visualize the changes that take place as the atoms rearrange.

Ken Karp/Addison Wesley

<u>Important Parts of a Representation</u>

1. Relative location
    a. Phase or State of matter
        i. Solid particles should be in close contact in an order that maximizes attractions and minimizes repulsions.
        ii. Liquid particles should be close but show some disorder (movement) but majority of particles with attractions and repulsions correctly.
        iii. Gas particles should be spread out as far as possible to fill the space they are in.
        iv. Aqueous solutions- sometimes only show the solute particles- ions should be dissociated and include charge. Solvent (water) particles when included should be oriented with the dipoles in the correct direction to maximize attractions and minimize repulsions with solvent and solute particles. Consider if the substance will ionize or not, if ions are present, orient the water molecules correctly.

	Solid	Liquid	Gas
Arrangement of particles	Close together Regular pattern	Close together Random arrangement	Far apart Random arrangement
Movement of particles	Vibrate on the spot	Move around each other	Move quickly in all directions
Diagram			

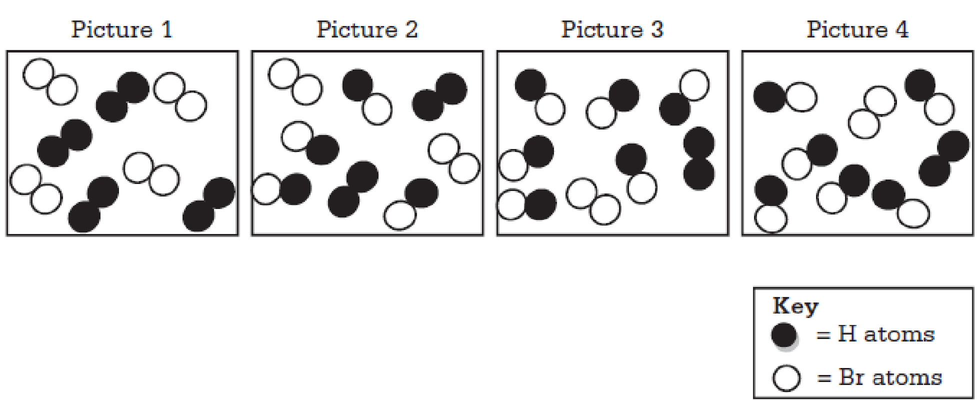
https://sciencetallis.weebly.com/3-particle-model-of-matter.html

b. Context clues
   i. Surface or interstices of an alloy
   ii. Precipitate (solid particles should be at the bottom once they have settled. A few may remain throughout)
   iii. Interfaces-where two different substances meet (water and air)

2. Amount
   a. Use the proper number of atoms of each element when given a formula
   b. Use relative amounts of atoms when given a quantity (mol, concentration, coefficient in equation, etc.)
   c. Observe the law of conservation of mass (keep the same number of each type of atom present before and after the reaction, just rearrange them appropriately).
3. Species
   a. Use distinct shapes, symbols, colors, or shades to identify atoms/ions of different elements. Use a key or elemental symbol from periodic table
   b. Show charges and align them appropriately
      i. Use partial charges on polar molecules if there are intermolecular forces (IMF)
      ii. Make sure the charges and dipole moments align properly to maximize attractions and minimize repulsions
   c. Use appropriate sizing
      i. Atoms of the same element should be roughly the same size
      ii. Atoms of different elements should follow atomic/ionic trends on periodic table for relative size

I DO:

The pictures below show the process of a reaction as H_2 and Br_2 react. This reaction doesn't go to completion; rather it reaches a state of equilibrium.



A) What are the formulas for the reactants (Picture 1)?

H_2 and Br_2

B) What is the formula for the product?

HBr

C) What is the balanced equation for the reaction? (include states of matter)

$H_{2(g)} + Br_{2(g)} \rightarrow 2\ HBr_{(g)}$

D) What is the difference between picture 2 and picture 3?

More of the HBr was formed.

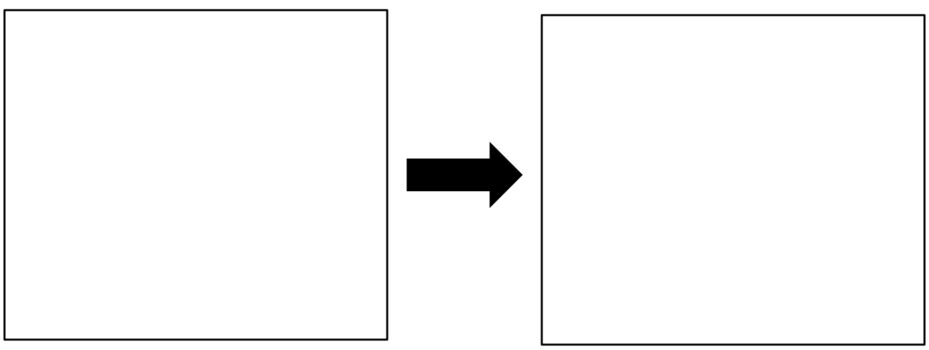
E) What do you notice about the total atoms of each element in all of the pictures? What concept does this represent?

The total number of each type of atom is consistent throughout; this demonstrates the law of conservation of matter/mass.

https://apcentral.collegeboard.org/pdf/ap-chemistry-guided-inquiry-activities-curriculum-module.pdf?course=ap-chemistry

WE DO:

Draw the representation of 4 molecules of hydrogen and 4 molecules of oxygen completely reacting to form water.



SCAN ME

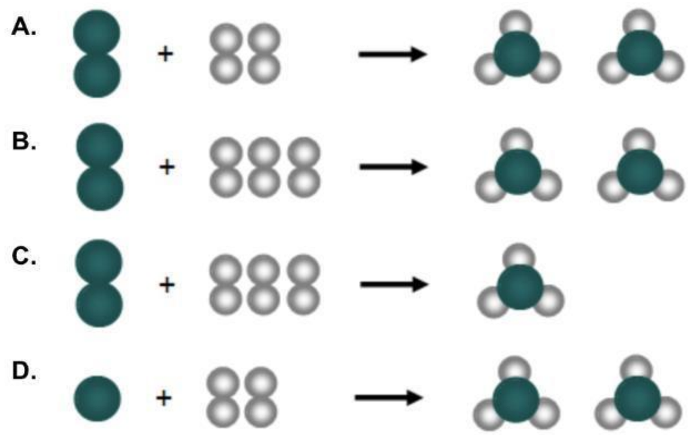
YOU DO:

1) Write the balanced equation and draw the particulate representation of the following chemical reaction:

Sodium metal reacts with chlorine gas to produce sodium chloride

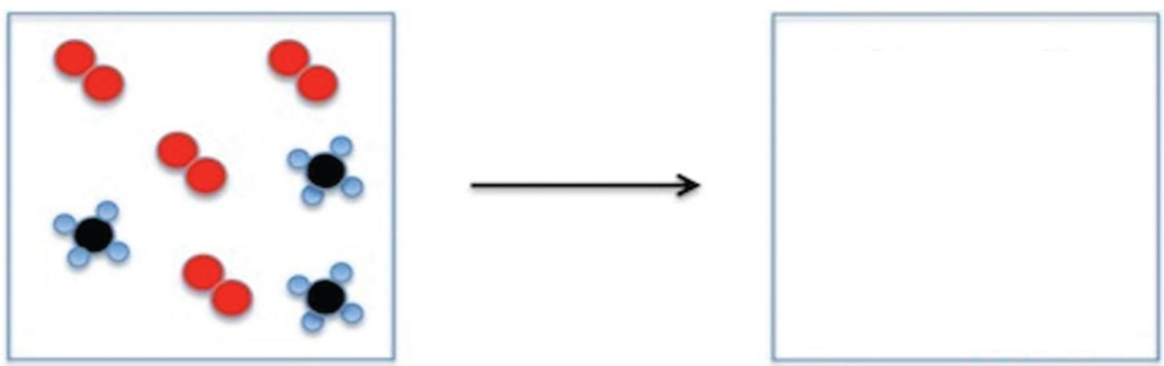
2) Draw the complete decomposition of 4 molecules of hydrogen peroxide (H_2O_2) into water and oxygen gas.

3) Which of following correctly depicts the reaction of nitrogen reacting with hydrogen to form ammonia (NH_3)?

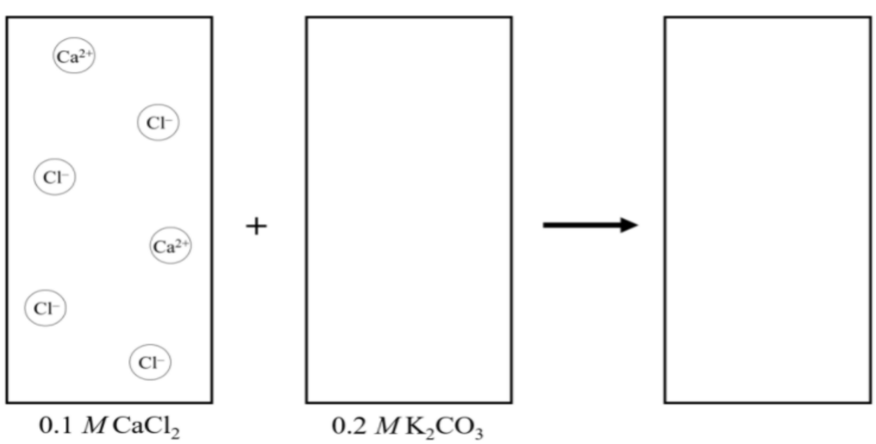


https://us-static.z-dn.net/files/d98/02d95540642498301b11bddfe873b1f3.png

4) Complete the particulate representation of the combustion of methane (CH_4) with oxygen to form carbon dioxide (CO_2) and water.



5) Below is a reaction of calcium chloride solution ($CaCl_2$) and potassium carbonate (K_2CO_3). Draw the reactant with the appropriate amount of K_2CO_3, particles in the empty box. The product calcium carbonate ($CaCO_3$) forms a precipitate. Draw the appropriate example of the precipitate and the ions that remain in the solution. Add two water molecules around each ion in the solution.



TOPIC: 4.5 STOICHIOMETRY

ENDURING UNDERSTANDING:	
SPQ-4	When a substance changes into a new substance, or when its properties change, no mass is lost or gained.
LEARNING OBJECTIVE:	
SPQ-4.A	Explain changes in the amounts of reactants and products based on the balanced reaction equation for a chemical process.
ESSENTIAL KNOWLEDGE:	
SPQ-4.A.1	Because atoms must be conserved during a chemical process, it is possible to calculate product amounts by using known reactant amounts, or to calculate reactant amounts given known product amounts.
SPQ-4.A.2	Coefficients of balanced chemical equations contain information regarding the proportionality of the amounts of substances involved in the reaction. These values can be used in chemical calculations involving the mole concept.
SPQ-4.A.3	Stoichiometric calculations can be combined with the ideal gas law and calculations involving molarity to quantitatively study gases and solutions.
EQUATION(S):	
	$\% \, Yield = \frac{Actual\ mass\ obtained}{Calculated\ Mass} \, x \, 100\%$

NOTES:

Stoichiometry is the term used to describe conversions that involve mole ratios from a balanced chemical equation. Before performing any calculations you must have a properly balanced chemical equation, which will ensure that atoms and mass are conserved.

Each stoichiometry problem is different, so it is imperative that you read the problem to determine what you are being asked to find out and what you already know.

The coefficients from the balanced equation will be used to create the mole ratio, which is the bridge between given quantities and desired (want) quantities. The term "stoichiometric ratio" means that you have the ratio of moles in the problem matches the ratio in the balanced equation.

In some cases you will be given information about more than one of the reactants. This signals that you will have a limiting reagent in the problem. The limiting reagent is the reactant that runs out first and the excess reactant is the one is not completely consumed. Conceptually it is often easier to consider how much product each reacting particle can produce separately, and then compare the values, reporting the answer that produces the least.

In a lab situation the predicted amount of product might not be produced, so one can calculate the percent yield by comparing the experimental value to the predicted value. Often the actual yield is different from the theoretical yield. That is normal; in the lab the goal is always to get your actual yield as close as possible to the theoretical yield.

We use the term **Theoretical Yield (or predicted value or calculated mass)** to describe how much you should be able to make based on the amounts given in the problem.

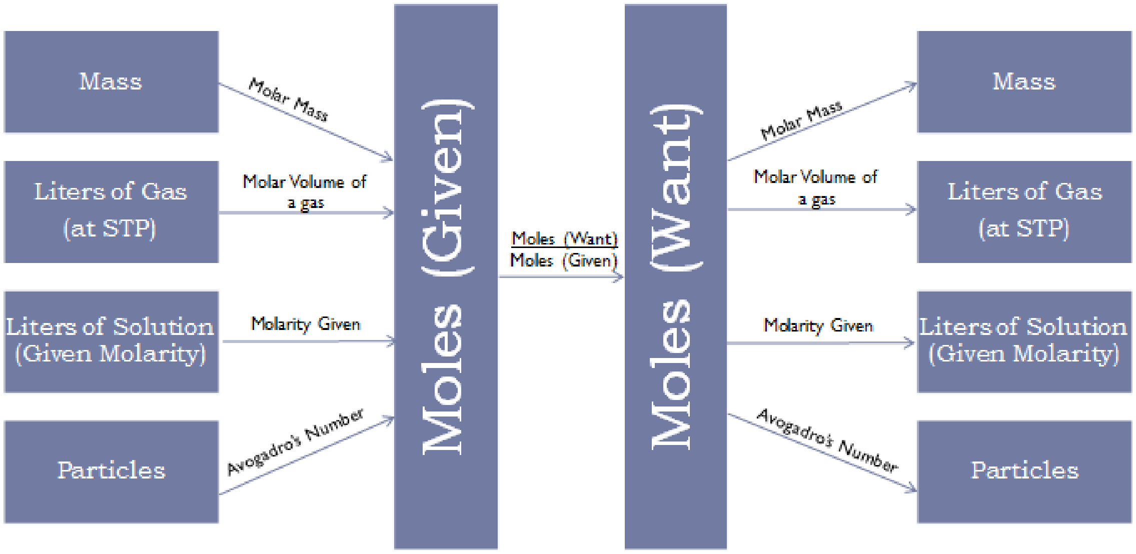
We use the term **Actual Yield (or experimental yield or actual mass obtained)** to describe the amount that you actually make in the experiment.

Percent Yield is a way to describe how close your experimental yield was to the amount predicted.

$$\textbf{Percent Yield} = \frac{\textbf{Actual Yield}}{\textbf{Theoretical Yield}} \times 100$$

Stoichiometry Map

Make sure that you have a balanced equation before you begin!
Start on the left and work to the right.



Useful Information:

Avogadro's Number is 6.022×10^{23} particles /1 Mole
Molar Volume of a Gas at STP is 22.4 Liters/1 Mole
Molarity needs to be provided in the problem (moles/1 L)
Molar Mass is calculated using the periodic table and the chemical formula. (grams/1 mole)

Stoichiometry Example:
How many grams of water can be produced by decomposing 1.0 grams of hydrogen peroxide, according to the balanced equation below?

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

Mass of Known → Molecular Weight of Known → Stoichiometric Ratio → Molecular Weight of Unknown → Mass of Unknown

$$1.0\ g\ H_2O_2\ X\ \frac{1\ mole\ H_2O_2}{34.0147\ g\ H_2O_2}\ X\ \frac{2\ mole\ H_2O}{2\ mole\ H_2O_2}\ X\ \frac{18.0152\ g\ H_2O}{1\ mole\ H_2O} = 0.53\ g\ of\ H_2O$$

https://link.springer.com/referenceworkentry/10.1007%2F978-3-319-39312-4_45

Limiting Reagent Example:
The reaction between iron and oxygen produces rust, iron (III) oxide, Fe_2O_3.
If you were to react 15 grams of iron with 6.5 L of oxygen gas at STP, how many grams of rust would form?
We will treat each reactant separately, and then compare to find the limiting reagent and the theoretical yield of rust in grams. Start with a balanced equation:

$$4\ Fe_{(s)} + 3\ O_{2\ (g)} \rightarrow 2\ Fe_2O_{3\ (s)}$$

$$\frac{15\ grams\ Fe}{1} \times \frac{1\ mole\ Fe}{55.85\ grams\ Fe} \times \frac{2\ moles\ Fe_2O_3}{4\ moles\ Fe} \times \frac{159.69\ grams\ Fe_2O_3}{1\ moles\ Fe_2O_3} = 21\ grams\ Fe_2O_3 ✓$$

$$\frac{6.5\ L\ O_2}{1} \times \frac{1\ mole\ O_2}{22.4\ L\ O_2} \times \frac{2\ moles\ Fe_2O_3}{3\ moles\ O_2} \times \frac{159.69\ grams\ Fe_2O_3}{1\ moles\ Fe_2O_3} = 31\ grams\ Fe_2O_3 ✗$$

The smaller value is the one is the correct answer. So, 21 grams of Fe_2O_3 will form from a reaction between 15 grams of iron and 6.5 Liters of oxygen gas. You can also find out that the iron was the limiting reagent and the oxygen was excess.

I DO:

What is the percent yield in the reaction between 46.1 g of cesium and 13.4 g of oxygen if 28.3 g of cesium oxide (Cs_2O) are collected?

$$4Cs + O_2 \rightarrow 2\ Cs_2O$$

$$\frac{46.1\ grams\ Cs}{1} \times \frac{1\ mole\ Cs}{132.9\ grams\ Cs} \times \frac{2\ moles\ Cs_2O}{4\ moles\ Cs} \times \frac{281.8\ grams\ Cs_2O}{1\ moles\ Cs_2O} = 48.9\ g\ Cs_2O$$

$$\frac{13.4\ grams\ O_2}{1} \times \frac{1\ mole\ O_2}{32.0\ grams\ O_2} \times \frac{2\ moles\ Cs_2O}{1\ moles\ O_2} \times \frac{281.8\ grams\ Cs_2O}{1\ moles\ Cs_2O} = 236\ g\ Cs_2O$$

Compare 236 grams with 48.9 grams, 48.9 grams are the smaller amount.
Therefore, Cs is the limiting reagent, O_2 is excess and 48.9 g Cs_2O is the theoretical yield.

$$\%\ \text{yield} = \frac{28.3\ grams}{48.9\ grams} \times 100$$

$$\%\ \text{yield} = 57.9\%$$

WE DO:

How much excess reactant is left over when 50 mL of .250 M iron (III) chloride ($FeCl_3$) is reacted with 50 mL of .250 M sodium carbonate (Na_2CO_3) solution?

SCAN ME

YOU DO:

1) How many grams of lead product would theoretically be produced between 17.0 g potassium iodide, KI, and 25.0 g of lead (II) nitrate, $Pb(NO_3)_2$?

2) How much excess reactant is left over when 17.0 g of potassium hydroxide (KOH) reacts with 20.0 g of iron (III) nitrate ($Fe(NO_3)_3$)?

3) Medicinal "ether" is produced when ethyl alcohol is treated with an acid. How many grams of medicinal "ether" ($C_4H_{10}O$) would you produce with 50.0 g of ethyl alcohol (C_2H_6O) if the percent yield is 85%?

$$2\ CH_3CH_2OH \rightarrow H_2O + CH_3CH_2OCH_2CH_3$$

4) A 8.15 g sample containing hydrogen peroxide (H_2O_2) decomposes to form water and oxygen. The temperature and pressures conditions in the lab were 21.2°C and 761.4 torr, respectively. The oxygen gas is collected over a sample of water at 21.2°C; the vapor pressure of water at that temperature is 18.9 torr. When the water level inside and outside of the tube is equal the volume of of gas is recorded as 176.23 mL.

a) Write and balance the equation for the decomposition reaction

b) What is the partial pressure of the oxygen gas?

c) Assuming no deviation from ideality, how many moles of oxygen gas were produced?

d) What was the mass of hydrogen peroxide that reacted?

e) What is the percent by mass of the hydrogen peroxide from the original sample?

5) A 25.0 mL sample of 0.25 M potassium carbonate (K_2CO_3) solution is added to 30.0 mL of a 0.40 M barium nitrate ($Ba(NO_3)_2$) solution. What is the concentration of the excess metal ion after the precipitation reaction is complete?