Isotope: An atom of an element that has the same number of protons as the element, but different numbers of neutrons.

Example Oxygen

$\left.$| 16 <br> O <br> 8 |
| :---: |$\quad$| 17 |
| :---: |
| O |
| 8 | \right\rvert\, | 18 |
| :---: |
| O |
| 8 |


| Isotopic | $99.759 \%$ | $0.037 \%$ | $0.204 \%$ |
| :--- | :--- | :--- | :--- |
| Abundance: |  |  |  |

Abundance:
$\qquad$ : the relative quantities of isotopes in a natural sample of an element, expressed as percentages.

Determining percent $=$ the number of oxygen 16 atoms $\quad \times 100 \%$
Number of oxygen atoms, 16, 17, and 18

A $\qquad$ average is used to determine the relative atomic mass of each element on the periodic table.

Avg Atomic Mass =

Calculate the Average Atomic mass for oxygen.

Question: Chlorine has 2 isotopes, $\mathrm{Cl}-35$ and $\mathrm{Cl}-37$, If $\mathrm{Cl}-35$ has an isotopic abundance of $75.78 \%$, determine the average atomic mass for chlorine.
*Atomic Mass and Molecular Mass

| Atomic Mass | The mass of one atom of an element, expressed in atomic mass <br> units, amu or $u$ |
| :--- | :--- |
| Molecular Mass | The mass of one molecule, expressed in amu, or $u$ |
| Formula Unit | The mass of one formula unit of an ionic compound, expressed in <br> amu or $u$ |

## Practice:

a) What is the mass of one iron atom?
b) What is the mass of one Uranium atom?
c) What is the mass of one carbon dioxide molecule?
d) What is the mass of one carbon tetrachloride molecule?
e) What is the mass of one calcium chloride formula unit?
f) What is the mass of ammonium phosphate?

## SCH 4CI The Mole and Molar Mass

Since atoms and molecules are so small, chemists always work with extremely large numbers of chemical entities. It can be compared to chefs who also use large quantities of food items.

For Example... Lets pretend to make an omelette

| Number of omelettes | Recipe |
| :--- | :--- |
| 1 | 2 eggs +3 mushrooms +1 pepper $\rightarrow 1$ omelette |
| 2 | $\ldots \ldots$ eggs $+\ldots \ldots$ mushrooms $+\ldots$ peppers $\rightarrow 2$ omelettes |
| 12 (dozen) | $\ldots \quad$ eggs $+\ldots \ldots$ mushrooms $+\ldots \ldots$ peppers $\rightarrow 12$ omelettes |
| Term dozen |  |

In 1811, a chemist named Amedeo Avogadro realized that any convenient macroscopic quantity of matter must contain an enormous number of chemical entities. Chemists do not use the term dozen they use the term Mole.

1 mole $=6.02 \times 10^{23}$ entities

This number $6.02 \times 10^{23}$, is referred to as Avogadro's Number, Na

Mole = $\qquad$ $\mathrm{mol}=$ $\qquad$ symbol for mole $=$ $\qquad$


If there are 2 mols of sodium chloride, calculate how many molecules of sodium chloride would there be?

## Figure 5

One mole of eggs would cover the entire surface of Earth to a depth of over 60 km .

## Moles and Chemical Equations:

| Individual Entities | $-\ldots \mathrm{H}_{2(\mathrm{~g})}+\ldots \ldots \mathrm{O}_{2(\mathrm{~g})} \rightarrow \ldots \ldots \mathrm{H}_{2} \mathrm{O}_{(\mathrm{l})}$ |
| :--- | :--- |
| Multiples of $6.02 \times 10^{23}$ | $-\quad \mathrm{H}_{2(\mathrm{~g})}+\ldots \quad \mathrm{O}_{2(\mathrm{~g})} \rightarrow \quad$ |
| Multiples of a mole | $-\quad \mathrm{H}_{2(\mathrm{~g})}+\ldots \mathrm{O}_{(\mathrm{l})}$ |

## Molar Mass of Molecules and Ionic Compounds

Molar mass, the mass, in grams of one mole of a chemical entity, $\mathbf{M}$

| Calculate the molar mass of water | Calculate the molar mass of iron (III) chloride |
| :--- | :--- |
| What is the mass of 2 mol of water? | What is the mass of 4 mol of iron (III) chloride? |
| General Equation: | If there is 100 g of iron (III) chloride, how many <br> moles is there? |

Table 5 Quantity Symbols and Units

| Symbol | Quantity | Unit |
| :--- | :--- | :--- |
| $n$ | amount (in moles) | mol |
| $m$ | mass | $\mathrm{mg}, \mathrm{g}, \mathrm{kg}$ |
| $M$ | molar mass | $\mathrm{g} / \mathrm{mol}$ |
| $N$ | number of entities | atoms, ions, formula units, molecules |
| $N_{\mathrm{A}}$ | Avogadro's constant, $6.03 \times 10^{23}$ | - |

## Mole Calculations



## Converting from mass to moles

1. Determine how many moles is 500 g of sodium chloride?
2. How many moles is 25 g of glucose, $\mathrm{C}_{6} \mathrm{H}_{12} \mathrm{O}_{6}$ ?

## Converting from number of atoms/molecules to moles

3. A sample contains $5.6 \times 10^{25}$ carbon atoms, how many moles is this?
4. A sample contains 90 helium atoms, how many moles is this?

Mass
Moles
Molecules

Practice:

1. How many atoms of gold are in 275.8 g nuggat of pure gold?
2. How many water molecules are in a 750 g sample of water?
3. Sand is composed of silicon dioxide, $\mathrm{SiO}_{2(\mathrm{~s})}$, How many atoms of oxygen are in a bag of pure sand, which contains 1.00 kg of silicon dioxide?

|  | Is the mass percent of an element in a compound |
| :--- | :--- |
|  | Is the mass percent of each element in a compound |

Since the ratio of elements in a chemical formula are the same, Louis Proust was able to develop the ....

Law of Definite Proportions: the elements in a chemical compounds are always present in the same proportions by mass.

## Practice:

Determine the mass percent of...
a) Carbon in Carbon dioxide
b) Carbon in carbon tetrachloride

Determine the percentage composition for NaOCl , bleach

Determine the percentage composition for $\mathrm{C}_{8} \mathrm{H}_{8} \mathrm{O}_{3}$

Using the following "raw" data and the formula below, determine if the information is describing the same substance by determining the percent composition of each and comparing the results.
a) Raw Data
b) $\mathrm{C}_{6} \mathrm{H}_{12}$
mass of sample: 35.8 g
mass of carbon in sample: 30.10 g mass of hydrogen in sample: 5.70 g

SUMMARY - Determining Percentage Composition from...

| Chemical Formula | MASS data (raw data) |
| :--- | :--- |
| 1) Calculate the molar mass of the <br> compound, this becomes the sample <br> mass | 1) Measure the mass of each <br> elements in the sample |
| 2) use periodic table to determine the <br> mass of each element in 1 mol of <br> compound | 2) Measure the mass of the total <br> sample |
| 3) Calculate the mass percent of <br> each of the elements in the <br> compound. | 3) Calculate the mass percent of <br> each element by dividing the mass of <br> each element by the total mass of the <br> sample |

SCH 4CI Percent Composition Practice - Answer the questions on a separate piece of paper.

1. Calculate the mass percent of oxygen in iron (II) oxide, FeO.
2. Calculate the mass percent of nitrogen in dintirogen tetraoxide, $\mathrm{N}_{2} \mathrm{O}_{4}$.
3. A 650 mg sample is analyzed and found to contain 52.0 mg of hydrogen. What is the mass percent of hydrogen in the sample?
4. Which substance has the greater mass percent of chromium? Chromic acid, $\mathrm{H}_{2} \mathrm{CrO}_{4}$ or dichromic acid, $\mathrm{H}_{2} \mathrm{Cr}_{2} \mathrm{O}_{7}$, complete the calculation to validate your answer.
5. Many metals are refined from sulphide mineral deposits that were laid down by volcanoes billions of years ago. Name the following compounds and list the sulphide compounds in order from greatest to least mass percent of sulphur, $\mathrm{PbS}, \mathrm{ZnS}$ and $\mathrm{Cu}_{2} \mathrm{~S}$.
6. What is the percentage composition of silver oxide, $\mathrm{Ag}_{2} \mathrm{O}$ ?
7. What is the percentage composition of strontium nitrate, $\mathrm{Sr}\left(\mathrm{NO}_{3}\right)_{2}$ ?
8. A 19.6 g sample of compound A contains, 16.1 g of nitrogen and 3.5 g of hydrogen. Determine the percentage composition of the compound.
9. A 15 g sample of compound D contains 7.22 g of nickel, 2.53 g of phosphorous and 5.25 g of oxygen, determine the percentage composition.
10. Acetylene, $\mathrm{C}_{2} \mathrm{H}_{2}$, is made up of two carbon atoms and two hydrogen atoms. Explain why acetylene does not contain $50 \%$ of each element by mass?

Activity 6.1 Mass Percent of oxygen, page 260 - Complete Procedure and answer Questions

| Empirical Formula | A formula that shows the smallest whole-number ratio of the <br> elements in a compound |
| :--- | :--- |
| Molecular Formula | The formula for a compound that shows the number of atoms <br> of each element that make up a molecule of that compound |

For example Benzene $\mathrm{C}_{6} \mathrm{H}_{6} \ldots$ Molecular formula is
Empirical formula is

How to calculate the empirical Formula

## Step 1: List given values.

Step 2: Convert the percent of each element into grams, assuming the sample is 100 g Step 3: Convert mass ( m ) into Amount in moles ( n )
Step 4: Calculate Lowest Whole-Number Ratio (Divide by smallest number of moles, from step 3).

The percentage composition of a compound was found to be $69.9 \%$ iron and $30.1 \%$ oxygen. What is the empirical formula of the compound?

## Determining the molecular formula

*In order to determine the molecular formula the molar mass of the complete compound must be given.
*This information can be determined using a mass spectrometer

## To determine the Molecular Formula

-follow steps 1-4 and add
Step 5: determine the whole number multiple by dividing the Molar mass of the Molecular formula divided by the Molar mass of the empirical formula
Step 6: multiply the "whole number multiple" to the subscripts in the empirical formula
Q - Determine the molecular formula for a sugar, whose Molar mass is $150 \mathrm{~g} / \mathrm{mol}$ and the empirical formula is $\mathrm{CH}_{2} \mathrm{O}$

1) Determine the Molar mass of E.F.
2) Determine the whole number multiple
3) Apply multiple to E.F.

Q - A fat that is used to make soap contains $76.5 \% \mathrm{C}, 12.2 \% \mathrm{H}$ and $11.3 \% \mathrm{O}$ by mass. Determine the molecular formula of the fat if its molar mass is $706.3 \mathrm{~g} / \mathrm{mol}$.

## Part 1 Calculating Percent Concentrations, m/v, m/m, v/v

|  | -Measurement of a quantity of a chemical entity |
| :--- | :--- |
|  | -is the quantity of solute per unit quantity of solution <br> -can be expressed in a variety of ways |


(a) dilute solution

(b) concentrated solution

## Define the following terms:

-solute:
-solvent:
-solution:

Mass/Volume Percent

Practice: A solution contains 21.4 g of sodium nitrate, dissolved I 250 mL of solution. Determine the percent ( $\mathrm{m} / \mathrm{v}$ ) concentration of the solution.

## Mass Percent

$$
\text { Percent }(\mathrm{m} / \mathrm{m})=\frac{\text { Mass solute }(\mathrm{g})}{\text { Mass of solution }(\mathrm{g})} \times 100 \%
$$

Practice: Find the mass of pure silver in a sterling silver ring that has a mass of 6.45 g and the $\mathrm{m} / \mathrm{m} \%$ is $95.5 \%$.

## Percent $(V / V)=$ Volume of solute (mL) $\quad X 100 \%$ Volume of Solution (mL)

Practice: Rubbing alcohol is sold in pharmacies with a $\mathrm{v} / \mathrm{v}$ concentration of $70 \%$. What volume of alcohol is present in 500 mL bottle of rubbing alcohol.

Practice: Acetic acid is a liquid at room temperature. How much pure water should be add to 15.0 mL of pure acetic acid to make a $5.00 \%(\mathrm{v} / \mathrm{v})$ solution of acetic acid? Assume that the total volume of the solution equals the sum of the volumes of the water and the acetic acid.

## MORE Practice!!!! YES do these questions!

1. A student carefully evaporated all the water from an 80.0 mL salt solution. She found that the mass of the residue from the sample was 1.40 g . Calculate the percent ( $\mathrm{m} / \mathrm{v}$ ) concentration of the salt solution.
2. What volume of $5.0 \%(\mathrm{~m} / \mathrm{v})$ solution of sodium chloride can be made using 40 g of NaCl ?
3. How would you prepare 400 mL of a $3.5 \%(\mathrm{~m} / \mathrm{v})$ solution of sodium acetate?
4. Calculate the percent ( $\mathrm{m} / \mathrm{m}$ ) concentration of a solution that contains 11 g of pure sodium hydroxide in 75 g of solution.
5. a) How much chromium, nickel and iron would you need to make a $500 \mathrm{~kg}(500000 \mathrm{~g})$ batch of $18 / 8$ stainless steel, which is made with $18 \%(\mathrm{~m} / \mathrm{m})$ chromium and $8 \%(\mathrm{~m} / \mathrm{m})$ nickel in iron?
b) Identify which metals are the solute and which metal is the solvent
c) When a metal is mixed with another metal this is called an $\qquad$ .
6. If 80 mL of ethanol is diluted with water to a final volume of 500 mL , what is the percent ( $\mathrm{v} / \mathrm{v}$ ) concentration of ethanol in the solution?
7. A particular brand of windshield washer fluid contains $40 \%(\mathrm{v} / \mathrm{v})$ methanol. How much pure methanol does a 4.0 L container of this fluid contain? Note: $4.0 \mathrm{~L}=4000 \mathrm{~mL}$.
8. Your teacher has 3.0 L of a $15 \%(\mathrm{v} / \mathrm{v})$ solution of sulfuric acid. What will the volume of the solution be if the solution is diluted to $10 \%(\mathrm{v} / \mathrm{v})$ ? Hint: Determine the volume of the solute first, then solve for the volume of the solution with a $10 \%(\mathrm{v} / \mathrm{v})$.

|  | -The concentration of a solution expressed as moles of solute <br> that is dissolved in one litre of solution |
| :--- | :--- |

## Formula:

$$
\mathrm{C}=\frac{\mathrm{n}}{\mathrm{~V}}
$$

## Practice:

-If 0.18 mol of sodium chloride was dissolved in 300 mL of water, calculate the molar concentration for the solution.
-If 25 g of sodium chloride is dissolved in 1400 mL of water, calculate the molar concentration of the solution.
-What mass of calcium chloride is dissolved in 400 mL of a .65 M of calcium chloride solution?
-Concentrations in parts per million (ppm) can be expressed using a variety of units. When solving a problem choose the units that match the information given in the problem. For aqueous solutions,
$1 \mathrm{ppm}=1 \mathrm{~g} / 10^{6} \mathrm{~mL}$
$=1 \mathrm{~g} / 1000 \mathrm{~L}$
$=1 \mathrm{mg} / \mathrm{L}$
Note: $1 \mathrm{~g}=1000 \mathrm{mg}$

## DID you Know?

$-1 \mathrm{ppm}=$ approximately 1 drop in a full bathtub
$-1 \mathrm{ppb}=$ approximately 1 drop is a full swimming pool
-1 ppt = approximately 1 drop in 1000 swimming pools

## Practice:

-In a chemical analysis, 0.005 g of oxygen was measured in 2500 mL , Calculate the ppm.

## More Practice Questions:

1. Household bleach is an aqueous solution that contains 5.25 g sodium hypochlorite, NaOCl per 100 mL of solution. Determine the molar concentration of sodium hypochlorite in bleach.
2. A stock solution of hydrochloric acid, HCl , is made my dissolving 7.66 g of HCl in enough distilled water to produce 1.50 L of solution. Calculate the molar concentration.
3. What amount of silver nitrate, $\mathrm{AgNO}_{3}$ is in 50.0 mL of a $0.570 \mathrm{~mol} / \mathrm{L}$ solution?
4. What amount of potassium hydroxide, KOH , is in a sample of 30 mL with a concentration of $0.0176 \mathrm{~mol} / \mathrm{L}$ ?
5. Seawater contains approximately $0.055 \mathrm{~mol} / \mathrm{L}$ of magnesium chloride, $\mathrm{MgCl}_{2}$. What volume of seawater contains 4.1 mol of magnesium chloride?
6. How many litres of a 0.0020 M of sodium dichromate solution, $\mathrm{Na}_{2} \mathrm{Cr}_{2} \mathrm{O}_{7}$ contains 5.0 mol of sodium dichromate?
7. Copper is an element that is required in very small concentrations in the bodies of all animals. What is the concentration of copper in parts per million, if 1.0 L of drinking water contains $3.0 \times 10^{-5} \mathrm{~g}$ of copper?

| Dilution |  |
| :--- | :--- |

Experiments sometimes require several concentrations of the same solution. If you begin with a solution of known concentration (stock solution), you can prepare a solution of lower concentration by dilution. Diluting a stock solution is faster and a more accurate way to make lower concentrations of a solution than making different concentrations from scratch.


## Practice:

If a solution has an initial volume of 65 mL and an initial concentration of 0.85 M , what is the new concentration if 150 mL of water is added.

Step 1 find moles in initial sol'n
Step 2 Find new conc with new final volume

## Dilution Equation:

## Practice:

You are asked to dilute a 1.75 M copper (II) sulphate solution to make 250 mL of 0.55 M copper (II) sulphate solution. What volume of 2.0 M stock solution would be needed?

## More Practice:

1. A lab technician dilutes 45.5 mL of a 1.50 M sodium sulphate solution to a final volume of 200.0 mL . What is the concentration of the diluted solution?
2. Another lab technician dilutes 50 mL of a 3.50 M nitric acid solution to a 2.50 M nitric acid solution. What is the final volume?
3. Calculate the final concentration of a glucose solution if 240 mL of $15 \% \mathrm{~m} / \mathrm{v}$ glucose is diluted with water to 300.0 mL
4. A laboratory technician needs to make 500.0 mL of a 0.100 M sulphuric acid solution. What volume of 16.0 M sulphuric acid does the technician need to use?
5. Calculate the final concentration of a 0.400 M barium chloride solution when 125 mL of the solution is diluted by adding 500 mL of distilled water.

## SUMMARY

## Concentration of a Solution Equations

## Type

percentage $\mathrm{V} / \mathrm{V}$
percentage $\mathrm{W} / \mathrm{V}$

## Equation

$c=\frac{v_{\text {solute }}}{v_{\text {solution }}} \times 100 \%$
$c=\frac{m_{\text {solute }}}{v_{\text {solution }}} \times 100 \%$
$c=\frac{m_{\text {solute }}}{v_{\text {solution }}} \times 100 \%$
$c=\frac{n_{\text {solute }}}{v_{\text {solution }}} \times 100 \%$
molar

Units
\% V/V
\% W/V
$\mathrm{mg} / \mathrm{L}=\mathrm{ppm}$
$\mu \mathrm{g} / \mathrm{L}=\mathrm{ppb}$
$n g / L=p p t$

| Stoichiometry | -Mathematical procedures for calculating the quantities of <br> reactants and products involved in chemical reactions |
| :--- | :--- |
| Mole Ratio | -The ratio of the amount in moles, of reactants and products in a <br> chemical reaction |

*The coefficients in a balanced chemical reaction indicate a variety of things;

1) how many molecules react
2) how many molecules are produced
3) also indicate the molar ratios of $R$ and $P$
4) can be used to determine the mass of $R$ and $P$ required or produced ... Using the mole ratio is stoichiometry!

## Making Cookies ©



Write the equation to make 24 cookies

Use the mole ratio to determine the following;
a) how many cookies will be made if 4 eggs are used?
b) How many cookies will be made if 3 cups of chocolate chips are used?
c) How many cups of flour will produce 72 cookies?
d) How many eggs are needed to make 36 cookies?
e) What amount of flour, eggs and chocolate chips are needed to make 100 cookies?

# Let's apply stoichiometry to Chemical Equations using chemical Formulas ... © <br> Write the Balanced Chemical Equation for the formation of water. <br> Balanced Chemical Equation: 

Mole Ratio:

## Use the mole ratio to determine the following;

a) If there are 8 molecules of oxygen gas, how many hydrogen molecules are needed?
b) If there are 2 moles of hydrogen gas, how many moles of oxygen are required?
c) If there are 10 moles of hydrogen gas, how many moles of oxygen are required?

## Converting Moles to mass of product produced using Stoichiometry

-Nitrogen gas reacts with oxygen gas to produce dinitrogen monoxide, answer the following questions.
a) Write the balanced chemical equation
b) If 25 moles of nitrogen reacts, how many moles of oxygen is required?
c) What is the mass of oxygen required?
d) What mass of dinitrogen monoxide is produced?

## Converting from Mass of Reactants to Mass of Products and vice versa

-Propane gas, $\mathrm{C}_{3} \mathrm{H}_{8}$ reacts with oxygen in a complete combustion reaction to produce carbon dioxide gas, and water vapour. If 50 g of propane reacts what mass of carbon dioxide gas is produced?


## Summary of Steps to complete Stoichiometry Questions:

## Practice Problems:

1. Use the following balanced equation to answer the questions below;
$2 \mathrm{NH}_{3(\mathrm{~g})}+\mathrm{CO}_{2(\mathrm{~g})} \rightarrow \mathrm{NH}_{2} \mathrm{CONH}_{2(\mathrm{~s})}+\mathrm{H}_{2} \mathrm{O}_{(\mathrm{g})}$
a) What moles of carbon dioxide is required if 50 moles of ammonia reacts? Mole ratio: $\qquad$ Answer: $\qquad$
b) What moles of water is produced if 75 mol of carbon dioxide reacts? Mole ratio: $\qquad$ Answer: $\qquad$
c) What moles of ammonia must have reacted if 300 mols of water is produced? Mole ratio: $\qquad$ Answer: $\qquad$
2. Use the following balanced equation to answer the questions below;
$4 \mathrm{Ag}_{(\mathrm{s})}+2 \mathrm{H}_{2} \mathrm{~S}_{(\mathrm{g})}+\mathrm{O}_{2(\mathrm{~g})} \rightarrow 2 \mathrm{Ag}_{2} \mathrm{~S}_{(\mathrm{s})}+2 \mathrm{H}_{2} \mathrm{O}_{(\mathrm{l})}$
a) How many moles of hydrosulfuric acid is required to react with 18 mol of silver? Mole ratio $\qquad$ Answer: $\qquad$
b) How many moles of oxygen gas is required to reach with 18 mol of silver? Mole ratio: $\qquad$ Answer: $\qquad$
c) How many moles of water is produced if 35 mol of hydrosulfuric acid reacts? Mole ratio: $\qquad$ Answer: $\qquad$
3. If 5 mol of iron (III) oxide reacts with carbon monoxide, what mass of iron will be produced?

$$
\mathrm{Fe}_{2} \mathrm{O}_{3(\mathrm{~s})}+3 \mathrm{CO}_{(\mathrm{g})} \rightarrow 2 \mathrm{Fe}_{(\mathrm{s})}+3 \mathrm{CO}_{2(\mathrm{~g})}
$$

4. If 60 g of carbon dioxide reacts with lithium hydroxide, calculate the mass of lithium hydroxide required. Remember to balance the equation first!

$$
\ldots \mathrm{CO}_{2(\mathrm{~g})}+\ldots \mathrm{LiOH}_{(\mathrm{s})} \rightarrow \ldots \mathrm{Li}_{2} \mathrm{CO}_{3(\mathrm{~s})}+\ldots \mathrm{H}_{2} \mathrm{O}_{(\mathrm{g})}
$$

|  | -the reactant that is completely consumed in a chemical <br> reaction, and therefore controls how much product is <br> produced |
| :--- | :--- |
|  | -the reactant that is present in more than the required <br> amount for a complete reaction to occur |

Key Point: The LIMITING reactant will determine the quantity of your products. Ex Shoe Company:

1 Shoe +1 Lace $\rightarrow 1$ Laced Shoe


Ex. Sweater Factory
1 Sweater +5 Buttons $\rightarrow$ Buttoned Sweater


Let's apply the concepts of limiting reactants to chemistry questions ©

## Practice \#1

If 20 mol of aluminum reacts with 45 mol of oxygen to produce aluminum oxide, determine which reactant is the limiting reactant and which is in excess.

## Practice \#2

If 60 g of aluminum reacts with 100 g of oxygen to produce aluminum oxide, determine which substance is the limiting reactant.

## Practice \#3

A reaction mixture contains 58.5 g of sodium and 125.8 g of chlorine gas, Calculate the mass of sodium chloride that is produced.

## More Practice:

1. If 35 mol of hydrogen gas reacts with 40 mol of oxygen gas to produce water, which substance is the limiting reactant?
2. a) Identifying the limiting reactant and excess reactant when 10.0 g of hydrogen gas and 41.0 g of oxygen gas react to form water as the only product.
b) Determine the mass of water that is obtained from the reaction.
3. Sulfur dioxide gas and oxygen gas react to produce gaseous sulfur trioxide.
a) Identify the limiting reactant and excess reactant when 192.18 g of sulfur dioxide reacts with 45.5 g of oxygen gas.
b) What mass of sulfur trioxide is produced?

|  | -The quantity of product produced in a chemical reaction |
| :--- | :--- |
|  | -The quantity of produce that is actually produced in a chemical reaction <br> -produced in the lab, ie experiment |
|  | -The quantity of product calculated from a balanced chemical equation <br> -determined using stoichiometry |
|  | -Actual vs Theoretical Yield expressed as a percentage of Theoretical <br> yield |

percentage yield $=\frac{\text { actual yield }}{\text { theoretical yield }} \times 100 \%$

## Practice:

-Iron is produced from its ore, hematite, $\mathrm{Fe}_{2} \mathrm{O}_{3(\mathrm{~s})}$, by heating hematite with carbon monoxide in a blast furnace. If 635 g of iron is obtained from 1150 g of $\mathrm{Fe}_{2} \mathrm{O}_{3}$, what is the percentage yield of iron?
$\qquad$ $\mathrm{Fe}_{2} \mathrm{O}_{3}+$ $\qquad$ $\mathrm{CO} \rightarrow$ $\qquad$ Fe + $\qquad$ $\mathrm{CO}_{2}$

## Practice 2

-Aluminum metal reacts with bromine to produce solid aluminum bromide as the only product. If 73.7 g of aluminum reacts with excess bromine, and 55.5 g of aluminum bromide is produced, calculate the percent yield.

## More Practice Questions:

1. Distinguish between actual yield and theoretical yield.
2. If 25 g is obtained of a substance and 32 g was expected, what is the percent yield for this reaction.
3. If the percent yield is $88 \%$ and the theoretical yield is 250 g , what was the actual yield?
4. Zinc reacts with hydrochloric acid, producing zinc chloride and hydrogen gas. Calculate the percentage yield if 25 g of zinc chloride is produced when 18 g of hydrochloric acid reacts with excess of zinc.
$\ldots \mathrm{Zn}_{+} \ldots \mathrm{HCl} \rightarrow \ldots \mathrm{ZnCl}_{2}+\ldots \mathrm{H}_{2}$
5. In an experiment 76.4 g of iron sulphide, FeS , is added to excess oxygen, and 68.5 g of iron (III) oxide is produced, Calculate the percent yield of iron (III) oxide.

$$
4 \mathrm{FeS}+7 \mathrm{O}_{2} \rightarrow 2 \mathrm{Fe}_{2} \mathrm{O}_{3}+4 \mathrm{SO}_{2}
$$

6. In theory can the actual yield ever be greater than the theoretical yield?
