Stoichiometry

define "*Stoichiometry*": ____

____

____

<u>**COEFFICIENTS** from a balanced chemical equation are used as **Molar Ratios** to relate substances in a reaction</u>

Given this equation: **$N_2 + 3\ H_2 \rightarrow 2\ NH_3$**, write the following molar ratios:

a) $N_2 : H_2$ b) $N_2 : NH_3$ c) $H_2 : NH_3$

Given this chemical equation: **$8\ H_2 + S_8 \rightarrow 8\ H_2S$**, write the molar ratios:

a) $H_2 : H_2S$ b) $H_2 : S_8$ c) $H_2S : S_8$

Answer the following questions for this equation: **$2\ H_2 + O_2 \rightarrow 2\ H_2O$**

a) Suppose there are 20 moles of H_2 and an excess of O_2, how many moles of H_2O could be produced?

b) Suppose there are 20 moles of O_2 and enough H_2, how many moles of H_2O could be produced?

Use this equation: **$N_2 + 3\ H_2 \rightarrow 2\ NH_3$**, for the following problems:

a) If 1 mole of N_2 is consumed, how many moles of NH_3 could be produced?

b) If 10 moles of NH_3 were produced, how many moles of N_2 would be required?

c) If 3.00 moles of H_2 were used, how many moles of NH_3 would be made?

d) If 0.600 moles of NH_3 were produced, how many moles of H_2 are required?

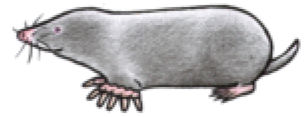
When solving problems in chemistry, the following point system will be used to grade work:

1 Point — **List what you know**
- List the quantities with units in the problem
- Identify what you are solving for
- Calculate the molar masses (as necessary)

2 Point — **Set up the problem**
- Set up dimensional analysis conversion factors or write formula
- Write down setup with units and be sure units cancel

3 Point — **Solve/Calculate**
- Calculate and verify
- Round to appropriate Sig Figs (1/2 point)
- Write answer with the units and the identity of the substance
- Underline or circle the final answer

Mole-to-Mole Stoichiometry



Quantitative Relationships in Chemical Equations

When we balance a chemical equation, we are satisfying the law of conservation of mass; that is, we are making sure that there are the same number of atoms of each element on both sides of the equation. The coefficients we place in front of the substances in an equation are very important because they tell us the mole ratio of the substances in that reaction. For instance, the balanced equation…

hydrogen gas + oxygen gas → liquid water

$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(l)$

can be thought of in terms of ***moles***…

2 **moles** $H_2(g)$ + 1 **mole** $O_2(g)$ → 2 **moles** $H_2O(l)$

1. ____ $Ca(s)$ + ____ $N_2(g)$ → ____ $Ca_3N_2(s)$
   a. How many moles of Ca_3N_2 can be made from 16.8 moles of Ca?
   b. If you need to make 34.4 moles of Ca_3N_2, how many moles of N_2 will you need?

2. ____ $Fe(s)$ + ____ $O_2(g)$ → ____ $Fe_3O_4(s)$
   a. How many moles of O_2 will react with 42.5 moles of Fe?
   b. If you need to make 1.56 moles of Fe_3O_4, how many moles of Fe will you need?

3. ____ $FeCl_2(aq)$ + ____ $KOH(aq)$ → ____ $Fe(OH)_2(s)$ + ____ $KCl(aq)$
   a. How many moles of KOH will react with 86.2 moles of $FeCl_2$?
   b. If you need to make 12.4 moles of KCl, how many moles of $FeCl_2$ will you need?

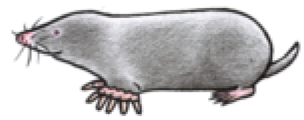
4. ____ $Cu(s)$ + ____ $O_2(g)$ → ____ $Cu_2O(s)$
   a. How many moles of Cu_2O can be made from 25.6 moles of Cu?
   b. How many moles of O_2 does it take to produce 214 moles of Cu_2O?

5. ____ $K(s)$ + ____ $Cl_2(g)$ + ____ $O_2(g)$ → ____ $KClO_3(s)$
   a. How many moles of $KClO_3$ can be made from 89 moles of O_2?
   b. If you have 24.6 moles of Cl_2, how many moles of $KClO_3$ can you produce?

6. ____ $NH_3(g)$ + ____ $H_2S(g)$ → ____ $(NH_4)_2S(s)$
   a. How many moles of $(NH_4)_2S$ can be made from 15.8 moles of NH_3?
   b. If you have 462 moles of NH_3, how many moles of H_2S do you need?

7. ____ $Al_2O_3(s)$ + ____ $H_2SO_4(aq)$ → ____ $Al_2(SO_4)_3(aq)$ + ____ $H_2O(l)$
   a. How many moles of $Al_2(SO_4)_3$ can be made from 6.3 moles of H_2SO_4?
   b. How many moles of Al_2O_3 does it take to make 7.2 moles of H_2O?
   c. If you have 588 moles of Al_2O_3, how many moles of $Al_2(SO_4)_3$ can you produce?

Mass-to-Mole (2-Step) Stoichiometry



1. How many moles of HNO_3 will be produced when 51 g of N_2O_5 reacts:
   $N_2O_5 + H_2O \rightarrow 2\ HNO_3$

2. How many moles of NaBr will be produced when 71 g of bromine reacts:
   __ Br_2 + __ NaI $\rightarrow$ __ NaBr + __ I_2

3. How many grams of HCl are needed to completely react with .36mol of lead?
   __ Pb + __ HCl $\rightarrow$ __ $PbCl_2$ + __ H_2

4. What mass of oxygen will be needed to react with .84mol of C_3H_8:
   __ C_3H_8 + __ O_2 $\rightarrow$ __ CO_2 + __ H_2O

5. Carbon will react with zinc oxide to produce zinc and carbon dioxide. How many moles of carbon dioxide will be produced if 157 g of ZnO is completely reacted? (*Don't forget to write a balanced equation*.)

6. How many moles of water will be consumed if 44g of calcium hydroxide are produced:
   __ CaH_2 + __ H_2O $\rightarrow$ __ $Ca(OH)_2$ + __ H_2

7. Iron will react with oxygen to produce iron (III) oxide. How many grams of Fe_2O_3 will be produced if .18mol of Fe reacts? (*Don't forget to write a balanced equation*.)

8. What mass of benzene (C_6H_6) will be consumed if 2.35mol of oxygen reacts:
   $2\ C_6H_6 + 15\ O_2 \rightarrow 12\ CO_2 + 6\ H_2O$

9. Nitrogen can react with hydrogen in a synthesis reaction to produce ammonia (NH_3). How many moles of nitrogen will be needed to produce 48 g of ammonia (NH_3)? (*Don't forget to write a balanced equation*.)

Mass-to-Mass Stoichiometry

Example: What is the mass of potassium chloride produced from 4.5g of barium chloride?

__ K_2CO_3 + __ $BaCl_2$ → __ KCl + __ $BaCO_3$

Example: What mass of sodium hydroxide is produced when .11g of sodium reacts with water?

__ Na + __ H_2O → __ NaOH + __ H_2

Example: What mass of nitrogen is produced from the decomposition of 145g sodium azide?

__ NaN_3 → __ Na + __ N_2

You Try!: If 16.8g of hydrogen gas react with oxygen, what mass of water vapor is produced?

__ H_2 + __ O_2 → __ H_2O

You Try!: What mass of sulfur dioxide is necessary to react with 11.4g of hydrogen sulfide?

__ SO_2 + __ H_2S → __ S + __ H_2O

Mass-to-Mass (3 Step) Stoichiometry Problem Solving

1. Determine the mass of lithium hydroxide produced when .38g of lithium nitride reacts with water.
   $Li_3N + 3\ H_2O \rightarrow NH_3 + 3\ LiOH$

2. Find the mass of sugar ($C_6H_{12}O_6$) required to produce 1.82g of carbon dioxide gas.
   $C_6H_{12}O_6 \rightarrow 2C_2H_6O + 2CO_2$

3. What mass of oxygen is necessary for the reaction of 425g of sulfur?
   $S + O_2 \rightarrow SO_2$

4. Find the mass of S_8 required to produce 2.47g of sulfur dioxide gas.
   $S_8 + 8\ O_2 \rightarrow 8\ SO_2$

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5. What mass of sodium chloride is produced when chlorine reacts with .29g of sodium iodide?
   __ NaI + __ $Cl_2 \rightarrow$ __ NaCl + __ I_2

6. Find the mass of calcium hydroxide produced when .64g of calcium carbide reacts with water.
   __ CaC_2 + __ $H_2O \rightarrow$ __ $Ca(OH)_2$ + __ C_2H_2

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7. Acetylene (C_2H_2) burns in oxygen to produce carbon dioxide and water. What mass of carbon dioxide is produced when 1.6g of oxygen are consumed?

8. What mass of hydrogen gas is produced if 225g of iron reacts with hydrochloric acid to produce iron (II) chloride and hydrogen gas?

9. How many grams of oxygen are necessary to react with 277g of carbon monoxide to produce carbon dioxide?

Model 2 – Proposed Calculations for Mass of NH_3 to Mass of N_2

Toby's Method

$$\frac{\text{x grams}}{30.0\text{ g}} = \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \rightarrow \text{x} = \_\_\_\_\_\_\text{ g }N_2$$

Rachel's Method

$$30.0\text{ g }NH_3 \times \frac{1\text{ mole }NH_3}{17.0\text{ g }NH_3} = \_\_\_\_\_\_\text{ moles }NH_3$$

$$\frac{\text{x mole }N_2}{\_\_\_\_\_\text{ mole }NH_3} = \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \rightarrow \text{x} = \_\_\_\_\_\_\text{ moles }N_2$$

$$\_\_\_\_\_\_\text{ mole }N_2 \times \frac{28.0\text{ g }N_2}{1\text{ mole }N_2} = \_\_\_\_\_\_\text{ g }N_2$$

Jerry's Method

$$30.0\text{ g }NH_3 \times \frac{1\text{ mole }NH_3}{17.0\text{ g }NH_3} \times \frac{1\text{ mole }N_2}{2\text{ moles }NH_3} \times \frac{28.0\text{ g }N_2}{1\text{ mole }N_2} = \_\_\_\_\_\_\text{ g }N_2$$

11. Model 2 shows three proposed calculations to solve the problem in Question 10. Complete the calculations in Model 2 by filling in the underlined values.
12. Which method does not use the mole ratio in an appropriate manner? Explain.
13. Two of the methods in Model 2 give the same answer. Show that they are mathematically equivalent methods.
14. Use either Rachel or Jerry's method from Model 2 to calculate the mass of hydrogen needed to make 30.0 g of ammonia. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

Stoichiometry: Mixed Problem Solving

$$2\ KClO_3\ (s) \rightarrow 2\ KCl\ (s) + 3\ O_2\ (g)$$

1. **How many moles of O_2 is produced if 2.50 mol of $KClO_3$ completely decomposes?**

2. **How many grams of KCl is produced if 2.50 g of $KClO_3$ is decomposed?**

3. **How many moles of $KClO_3$ is used to produce 10 moles of O_2?**

4. **How many moles of KCl is produced if 15 g of $KClO_3$ is used?**

5. **How many molecules of O_2 are produced if 5 moles of $KClO_3$ is used?**

6. **How many moles of O_2 is produced if 10 g of KClO3 s used?**

more Mixed Problem Solving

7) How many molecules of water will be produced if 10.0g of lithium hydroxide react?
$LiOH + HBr \rightarrow LiBr + H_2O$

8) If 45 grams of ethylene react, what mass of carbon dioxide gas will be produced?
$C_2H_4 + 3\ O_2 \rightarrow 2\ CO_2 + 2\ H_2O$

9) What mass of hydrogen gas is produced if .50 moles of acid react?
$Mg + 2\ HCl \rightarrow H_2 + MgCl_2$

10) If you start with 5.5 x 10^{23} atoms of magnesium, how many grams of sodium will be produced?
$Mg + 2\ NaF \rightarrow MgF_2 + 2\ Na$

The following reaction occurs when an automobile battery is charged.

$$PbSO_4(s) + H_2O(l) \longrightarrow PbO_2(s) + Pb(s) + H_2SO_4(aq)$$

a. Balance the equation.

b. How many grams of sulfuric acid are produced when 68.1 g of lead(II) sulfate react?

Liquid sulfur difluoride reacts with fluorine gas to form gaseous sulfur hexafluoride.

a. Write the balanced equation for the reaction.

b. How many fluorine molecules are required to react with 5.00 mg of sulfur difluoride?

Lithium nitride reacts with water to form ammonia and aqueous lithium hydroxide.

$$Li_3N(s) + 3H_2O(l) \longrightarrow NH_3(g) + 3LiOH(aq)$$

a. What mass of water is needed to react with 32.9 g Li_3N?

b. When the above reaction takes place, how many molecules of NH_3 are produced?

Hydrogen gas can be made by reacting methane (CH_4) with high-temperature steam:

$$CH_4(g) + H_2O(g) \longrightarrow CO(g) + 3H_2(g)$$

How many hydrogen molecules are produced when 158 g of methane reacts with steam?

Stoichiometry Stumper: Zoom Zoom

You are a NASCAR pit crew member. On race day Darrell is leading the race with 20 laps to go. Yeeeee haaaa!! He just finished a pit stop which included refueling to fill up his tank. You know that 25 gallons of fuel (3.5 kg) are in the tank.

On the way out of the pits, Darrell radios back to you and asks, “Am I going to have enough fuel to finish the last 20 laps of the race or am I going to have to make another pit stop?” Jeff Gordon, who is in second place also just finished a pit stop...so the race is close. You radio back saying, “Hang on! Let me make a few calculations and get back to you!”

You whip out your calculator and begin your calculations based on your knowledge of stoichiometry. Other information from your records on the driver and car:

- The formula for the fuel is C_5H_{12} and it undergoes a combustion reaction in the engine of the car.
- The car uses an average of 300 grams of oxygen for each lap.

When you radio Darrell back, what are you going to tell him? “Go for it!” or “You’ll need to come into the pits one more time…”

1) Write a balanced equation for the combustion reaction of pentane, C_5H_{12}:

2) How much fuel is required for the final 20 laps?

3) Will Darrell be able to finish the race without another pit stop?

Stoichiometry Stumper 1:

Space Exploration

In space shuttles, the CO_2 that the crew exhales is removed from the air by a reaction within canisters of lithium hydroxide. These LiOH canisters can play a vital role in the survival of the astronauts who depend on them. As any astronaut can tell you, if the carbon dioxide concentration in the air increases beyond 8%, you will suffer certain death. On average, each astronaut exhales about 20.0 mol of CO_2 daily.

Problem:

You have been given the job of stocking WASA's next shuttle mission with enough Lithium Hydroxide canisters to sustain the crew for the entire duration of their mission. The "A'mole'o 13" mission is a seven-day mission in space carrying a crew of three astronauts and one 'happy' chimpanzee. Assume each passenger (include the chimp) expels the average 20mol of CO_2 per day. You will need to determine how much LiOH is required to provide the astronauts with enough breathable air for a safe return home.

Notes:

- Be sure to plan for a delay in travel, you wouldn't want to be stuck in space with insufficient LiOH (plan for at least 10 days)!
- The lithium hydroxide scrubbers are only 85% efficient.

Before you equip the shuttle with the LiOH scrubbers, you must first propose your calculations to the boss. **Your team will create a visual using the Educreations app with the following information/calculations:**

1. Write a balanced chemical equation for the reaction of lithium hydroxide and carbon dioxide to produce lithium carbonate and water.

2. How many total moles of CO_2 will be produced during the length of the mission (plan for 10 days for 4 astronauts)?

3. Using stoichiometry, how many grams of LiOH are needed to support the CO_2 demands?

4. What amount of LiOH is needed, taking into account that the scrubbers only operate at 85% efficiency.

Stoichiometry Stumper 2:

"We Bought a Farm"

Farming is a big business in the United States, with profits for the lucky, and possible bankruptcy for the less fortunate. Farmers should not be ignorant of the chemistry involved. For instance, to be profitable, a farmer must know when to plant harvest, and sell his/her crops to maximize profit. In order to get the greatest yield farmers often add fertilizers to the soil to replenish vital nutrients removed from the previous seasons crops. Corn is one product that removes tremendous amount of phosphorous from the soil. For this reason, farmers will rotate crops and/or add fertilizer to the ground before planting crops the following year. On average, an acre of corn will remove 6 kilograms of phosphorous from the ground.

Problem:

Assume that you inherit a farm and now have to purchase fertilizer for the farm. The farm is 340 acres and also had corn planted the previous year. You must add fertilizer to the soil before you plant this year's crop. You go to the local fertilizer store and find **SuperPhosphate**™ brand fertilizer. You read the fertilizer bag and can recognize from your high school chemistry class a molecular formula $Ca_3P_2H_{14}S_2O_{21}$ (*you don't understand anything else written on the bag because it is imported fertilizer from Japan*). You must decide how much fertilizer to buy for application to your cornfields. If each bag costs $54.73; how many bags of fertilizer do you need to purchase and how much will it cost you to add the necessary fertilizer to your fields?

Notes:

- You will need to determine the percent composition of Phosphorous before you can calculate the amount (in grams) of phosphorous in each bag of fertilizer
- 1 bag of fertilizer weighs 10,000 g
- 1 acre of corn = 6 kilograms of phosphorous (Hint: use this conversion factor to determine how much actual fertilizer is needed)

Before you make the mistake of purchasing the wrong amount of fertilizer, you must first draw up your plans for calculating how much fertilizer you would need.

The following information/ calculations should be included in the Educreations visual:

1. How much total phosphorus is removed from the 340 acre farm?

2. What is the molar mass of Super Phosphate ™ fertilizer?

3. Using percent composition, how much phosphorus is in Super Phosphate™ fertilizer?

4. Using stoichiometry, determine the amount of fertilizer needed to replenish the phosphorus.

5. How many bags of fertilizer will need to be purchased?

6. What is the dollar amount that this project will cost?

Stoichiometry Stumper 3:

Air Bags Save Lives!

Automobile airbags are the result of some incredible engineering. In a high-speed crash, the occupants of the car can be hurled into the side, dash, or windshield. But in an airbag-equipped car, in the instant after a crash is detected, the onboard electronics detonate a small explosive charge that inflates the airbag, providing enough cushioning to protect the occupant from impact with something less yielding than the inflated bag. Fatality and serious injury rates have plummeted since the widespread installation of airbags in cars.

However, an airbag has a challenging job to do. It must fully inflate in a few milliseconds and be firm enough to stop a rapidly-accelerating body, but must do so while still providing cushioning. Hitting a brick-hard rigidly-inflated airbag could do as much damage as no airbag at all, and airbags must work for a wide range of body sizes, from children to large adults, over a wide range of automobile speeds and varying impact angles. Automotive designers must find one airbag design that works for a wide range of conditions. This all means that airbag design is quite a precise science.

<u>Problem:</u>
You are the head engineer in charge of airbag construction for a large manufacturing company. It is your job to instruct new engineers on how to properly calculate the correct amount of chemicals to incorporate into the airbag's explosive device. You must teach the new engineers exactly how an airbag works and then show them how to calculate the amount of NaN_3 that is needed each time a new airbag is manufactured. The slightest miscalculation could cost someone their life!!

Notes:

- Assume that 65.1 L of N_2 gas are needed to inflate a standard airbag to the proper size.
- The density of N_2 gas at this temperature is about 0.916 g/L

In order to prepare your new engineers for their weeks ahead on the job, you must prepare a teaching visual using the Educreations app that includes the following information:

1. Research and write the balanced chemical equations that regulate air bag deployment.

2. Convert liters of N_2 needed to inflate a standard air bag to grams of N_2 using density as a conversion.

3. How many grams of NaN_3 will be needed for each airbag?

Stoichiometry Stumper 4:

Water from a Camel

Camels are well known for their humps, however, they do not store water in them as is commonly believed; their humps are used as a reservoir of fat. This stored up fat can be converted into immediate energy and allow the camel to go for long periods of time (up to two weeks) without food or water. So, how does this process work?

When the fat tissue from the camel's hump is metabolized, it becomes a vital source of energy. More importantly, it can also yield more than 1 g of water for each 1 g of fat converted through a reaction with oxygen in the air. This process of fat metabolization generates a net loss of water through the respiration of oxygen.

It is important to mention that although camels produce water through metabolic processes, they can also drink and store up to 20 gallons of water in their bloodstream. Both of these adaptations happen to be very useful for camels that happen to live in desert habitats, where food and water are scarce.

Problem:

After volunteering all year long at the Best in the West Animal Clinic, you have just arrived at your summer destination point…North Africa. You have been given the opportunity to embark on an epic journey across the Sahara Desert with a group of photographers. You have been assigned the job of taking care of the camels during this 3 month long trip. As your tour group makes preparations for the long trek ahead, you are asked to complete a last minute check on the camels. You notice that one of the camels has a sinking hump. This is not a good sign. It is malnourished and possibly dehydrated. It needs nourishment in order to restore its hump to a healthy shape. Luckily you packed a 1.5-pound bag of oat hay in case of an emergency.

Notes:

- Oat Hay is roughly equivalent to 872 calories per pound and there are about 9 calories per gram of fat.

Before you leave on your trip you need to calculate the odds of your camel making it to its next meal. You will need to draw up your calculations as a journal entry using the Educreations app.

1. Write and balance the chemical equation for the metabolization of fat in a camels hump. Camels store the fat tristearin ($C_{57}H_{110}O_6$) in the hump which reacts with oxygen gas via respiration to produce carbon dioxide and water as the products.

2. How much fat (in grams) did you feed the camel?

3. Using stoichiometry, how much water is produced as a result of the amount of food given to the camel?

Stoichiometry Stumper 5:

"Acid Rain"

Coal, which is mostly carbon, is burned in power plants in the Midwestern United States. Most coal contains some sulfur (S_8) which, which is ultimately responsible for some acid rain in the eastern United States. The sulfur undergoes a series of reactions with oxygen and water in the air to eventually form sulfuric acid (H_2SO_4).

- Sulfur burns in the presence of oxygen to create sulfur dioxide gas.
- Sulfur dioxide gas combines with oxygen gas and is converted into sulfur trioxide gas in a reaction known as a photooxidation (powered by the rays of the good old sun).
- Sulfur trioxide reacts with water vapor in the atmosphere to create sulfuric acid, which subsequently becomes aqueous with the moisture in the air falls to the Earth as rain water.

Problem:

You are an environmental consultant and must examine the concerns of acid rain. If 0.0037% by mass of all of the coal ore burned in the Midwest is actually sulfur, how many *kilograms* of coal ore have to burn to generate 1 kilogram of acid?

Your task is to prepare a visual using the Educreations app which includes the following information:

1. Write out the balanced equations for the 3 steps of reactions in forming acid rain.

2. Using stoichiometry, calculate the amount of coal burned in generating 1 kg of acid.

3. Research the concerns of acid rain deteriorating limestone and marble statues and write a balanced chemical equation.

More Stoichiometry Stumpers…

1. You are a forensic scientist. You are investigating a murder involving poison. The victim was poisoned with a compound called di-chloro benzene whose formula is $C_6H_4Cl_2$. Autopsy results show that the victim's body contained about 31 g of the poison, but the actual amount could have been slightly higher due to tissue absorption. The main suspect is his wife, Suzanne, who works as a chemistry professor at the local university. Records show that she purchased 15 g of benzene (C_6H_6) two days before the murder. Benzene is one of the compounds used to make the poison, but she claims she was using it to make ethyl benzene ($C_6H_5CH_3$), an innocuous compound, for use in her lab. She shows you the bottle of ethyl benzene she claims to have made. It contains 25 grams of ethyl benzene.

   Is she telling the truth or did she have more nefarious motives? If you can show that it is possible to produce 25 g of ethyl benzene from 15 grams of benzene, then she was telling the truth. Otherwise, you will have caught her in a lie, which makes it likely she killed her husband with the poison. After extensive research in the literature, you find the two reactions related to this case.

   To produce di-chloro benzene, the reaction is: $Cl_2 + C_6H_6 \rightarrow C_6H_4Cl_2 + H_2$

   To produce ethyl benzene, the reaction is: $CH_4 + C_6H_6 \rightarrow C_6H_5CH_3 + H_2$

   After balancing reactions, use stoichiometry to solve this case. Be sure to show all your work and explain whether the results show the wife to be innocent or a murder.

2. You are a NASA engineer. You are the chief engineer for the Apollo 13 mission to the moon. The astronauts are running out of oxygen and need to get rid of the excess carbon dioxide. You know that sodium hydroxide has been suggested as a means of removing carbon dioxide from the spacecraft cabin. The filter which they had been using is fully saturated and no longer works. You remember that the astronauts have a 5 kg container of sodium hydroxide on the ship. You also know that sodium hydroxide can be used to remove carbon dioxide according to the following reaction:

   $$NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$$

   The astronauts have 2 days left before they land on earth. You know that there are three astronauts, and each astronaut emits roughly 500 g of carbon dioxide each day. Is there enough sodium hydroxide in the cabin to cleanse the cabin air of the carbon dioxide, or are the astronauts doomed? Again be sure to show all your work!

	Exemplary 4	Proficient 3	Developing 2	Needs Improvement 1
Stoichiometry	All stoichiometric calculations are accurate and all work is shown with units and proper sig figs. Students are able to problem solve as a group with limited teacher clarifications.	Most stoichiometric calculations are accurate and all work is shown with units. Students are able to problem solve with some teacher guidance.	Stoichiometric calculations are completed with significant teacher support.	Students have limited progress in demonstrating an understanding of solving stoichiometry problems.
Educreations Poster	The poster is extremely neat and organized and the problem solving process is explained through notes or thought bubbles so that other groups can easily see the thought process and learn from the poster.	The poster is organized and there is some insight into the thought process so that other groups increase their understanding.	The poster displays all information in the scenario, but there is limited insight as to how students solved the problem.	The poster is unorganized which distracts from other groups ability to learn from the information presented.
Collaboration	All group members equally collaborate in discussing and solving the problem. All group members are able to explain the problem solving process and answer questions.	Most group members collaborate in discussing and solving the problem and all group members are then able to explain how to solve the problem and answer questions.	Some group members collaborate in discussing and solving the problem and are able to answer questions.	There is limited collaboration among group members.

Basic Stoichiometry PhET Lab

Let's make some sandwiches!

Introduction:

When we bake/cook something, we use a specific amount of each ingredient. Imagine if you made a batch of cookies and used way too many eggs, or not enough sugar. YUCK! In chemistry, reactions proceed with very specific ratios. The study of these ratios is *stoichiometry*.

Procedure: *PhET Simulations → Play with the Sims → Chemistry → Reactants, Products, and Leftovers* Run Now!

If a yellow bar drops down in your browser, click on it and select "Allow Blocked Content"

Part 1: Making Sandviches: Sandwich Shop

The Cheese Sandwich is a simulation of a two-reactant *synthesis* reaction. In this case, one reactant will be *limiting*, while the other will be in excess.

1. Take some time and familiarize yourself with the simulation.
2. Set the reaction to a simple mole ratio of 2:1:1

3. Complete the table below while making tasty cheese sandwiches:

Bread Used	Cheese Used	Sandwiches Made	Excess Bread	Excess Cheese
5 slices	5 slices			
		2 sandwiches	1 slice	0 slices
6 slices		3 sandwiches		4 slices

Part 2: Real Chemical Reactions: Real Reaction

Now let's work with real chemical reaction, one that creates a very entertaining BOOM!

4. Balance the equation for the reaction of hydrogen and oxygen to produce water?

$$\_\_H_2 + \_\_O_2 \rightarrow \_\_H_2O$$

5. Complete the table below while making water H_2O from hydrogen H_2 and oxygen O_2:

Hydrogen Molecules H_2	Oxygen Molecules O_2	Water Molecules H_2O	Excess H_2	Excess O_2
4 molecules	4 molecules			
7 molecules	6 molecules			
4 moles	3 moles			
		4 moles	1 moles	0 moles

6. Notice that the labels changed from ***molecules*** to **moles**. This does not change the mole ratio, as a mole is simply a large number of molecules. How many molecules are in 1mole? ________________

Now try producing **ammonia**, a very important chemical in industry and farming.

7. Balance the chemical equation for the production of ammonia? $\_\_N_2 + \_\_H_2 \rightarrow \_\_NH_3$
8. Complete the table below:

Moles N_2	Moles H_2	Moles NH_3	Excess N_2	Excess H_2
3 moles	6 moles			
6 moles	3 moles			
		4 moles	2 moles	0 moles

Combustion of **hydrocarbons** like methane CH_4 produces two products, water and carbon dioxide CO_2.

9. Balance the equation for the combustion of methane? $\_\_CH_4 + \_\_O_2 \rightarrow \_\_CO_2 + \_\_H_2O$
10. Complete the table below:

mol CH_4	mol O_2	mol CO_2	mol H_2O	Excess mol CH_4	Excess mol O_2
4 mol	4 mol				
		2 mol	4 mol		

Basic Stoichiometry

11. Load the "*Reactants, Products, and Leftovers*" simulation and work through each of the levels of the **Game!**
12. For the reaction $P_4 + 6Cl_2 \rightarrow 4PCl_3$, determine how many moles of chlorine Cl_2 would be needed to react with 3 moles of phosphorus P_4 to entirely use up all the phosphorus. ________________
13. If 5 moles of P_4 reacted with 22 moles Cl_2 according to the above reaction, determine:
    a. How many moles PCl_3 are produced a)________________
    b. How many moles of P_4 are left in excess after the reaction (if any) b)________________
    c. How many moles of Cl_2 are left in excess after the reaction (if any) c)________________

In reality, reactants don't have to react in perfect whole-numbers of moles. Usually **one reactant gets entirely used up (and determines how much product is made)**. For instance, when solid, metallic aluminum Al and red, liquid bromine Br_2 are brought together, they make a white solid according to the reaction $2Al + 3Br_2 \rightarrow 2AlBr_3$. If 5.0 moles of aluminum Al was reacted with 10 moles bromine Br_2, all five moles of aluminum would react, with only 7.5 moles bromine. (2:3 mole ratio) This would produce only 5.0 moles of $AlBr_3$, leaving 2.5 moles of excess Br_2 behind.

14. Now assume 3 moles Al and 4 moles Br_2 react
    a. Which chemical is the "*limiting reactant*"? a)________________
    b. Which chemical must be the "*excess reactant*"? b)________________
    c. How many moles of $AlBr_3$ can be produced? c)________________
    d. If all the limiting reactant gets used up, how much of the excess reactant is left? d)________________
15. What is the maximum amount (in moles) of NaCl that can be produced from 4.5 moles of Na and 3.5 moles of Cl_2 according to the reaction $\_\_Na + \_\_Cl_2 \rightarrow \_\_NaCl$ (you need to balance the equation)?

____

Limiting Reactants

define **Limiting Reactant**:

Reasons why a reactant would be "limited":

define **Excess Reactant**:

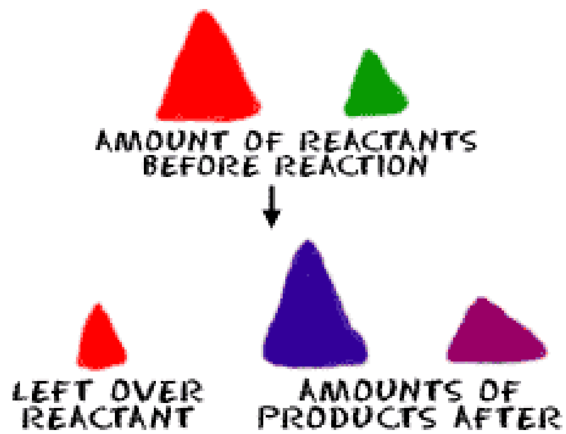
Reasons why a reactant would be "in excess":

SOLVING **LIMITING REACTANT PROBLEMS**

1. Write a **balanced equation** for the reaction
2. Calculate the amount of product formed based on the reactant amounts (**2 stoichiometry problems)**
3. Determine the reactant that produces *less* product (**limiting reactant**)
4. Determine excess reactant (if needed)

Example: 90.0g of $FeCl_3$ reacts with 52.0g H_2S. What is the limiting reactant? What is the mass of HCl produced?

(FW $FeCl_3$ = 162.00g/mol, FW H_2S = 34.10g/mol, FW HCl = 36.50g/mol)



$2\ FeCl_{3(aq)} + 3\ H_2S_{(aq)} \rightarrow 6\ HCl_{(aq)} + Fe_2S_{3(s)}$

Solve for the limiting reactant:

Example 2: A solution containing 3.50g Na_3PO_4 is mixed with a solution of 6.40g $Ba(NO_3)_2$. How many grams of $Ba_3(PO_4)_2$ are formed?

(FW Na_3PO_4 = 163.94g/mol, FW $Ba(NO_3)_2$ = 261.34g/mol, FW $Ba_3(PO_4)_2$ = 601.93g/mol)

$2\ Na_3PO_{4(aq)} + 3\ Ba(NO_3)_{2(aq)} \rightarrow 6\ NaNO_{3(aq)} + Ba_3(PO_4)_{2(s)}$

Solve for the limiting reactant to determine the mass of product (grams $Ba_3(PO_4)_2$) formed:

You Try! Example 3: A 2.00g sample of ammonia (NH_3) is mixed with 4.00g oxygen (O_2). What is the limiting reactant? How many grams of NO are produced?

(FW NH_3 = 17.0g/mol, FW O_2 = 32.00g/mol, FW NO = 30.0g/mol)

$4\ NH_{3(g)} + 5\ O_2 \rightarrow 4\ NO_{(g)} + 6\ H_2O_{(g)}$

Limiting Reactant Problem Solving

1. Identify the limiting reactant if 1.22g of O_2 reacts with 1.05g of H_2 to produce water.

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

2. Identify the limiting reactant if 4.68g of Fe reacts with 2.88g of S to produce FeS.

   $Fe + S \rightarrow FeS$

3. If 4.1g of Cr is heated with 9.3g of Cl_2, what mass of $CrCl_3$ will be produced?

   $2\ Cr + 3\ Cl_2 \rightarrow 2\ CrCl_3$

Theoretical Yield:

Actual Yield:

Percent Yield = $\frac{\textbf{actual yield}}{\textbf{theoretical yield}} \times 100\%$

List some reasons why actual yield is lower than the theoretical yield:

1. Determine the percent yield for the reaction between 3.74g of Na and excess oxygen if 5.34g of Na_2O_2 is recovered.

   THEORETICAL YIELD:

   PERCENT YIELD:

2. What is the percent yield if 6.92g of potassium reacts with 4.28g of oxygen, and 7.36g of potassium oxide is actually produced.

   THEORETICAL YIELD:

   PERCENT YIELD:

3. Determine the percent yield if 45.9g of NaBr reacts with excess chlorine gas to produce 12.8g of NaCl and an unknown quantity of bromine gas.

4. In a synthesis reaction between 82.4g of rubidium and 11.6g of oxygen, 39.7g of rubidium oxide is produced. What is the percent yield? (*Don't forget to write a balanced equation*!)

5. In another synthesis reaction, 2.00g of hydrogen reacts with 4.00g of nitrogen to produce ammonia (NH_3). If only 1.00g of ammonia is actually collected, what is the percent yield?

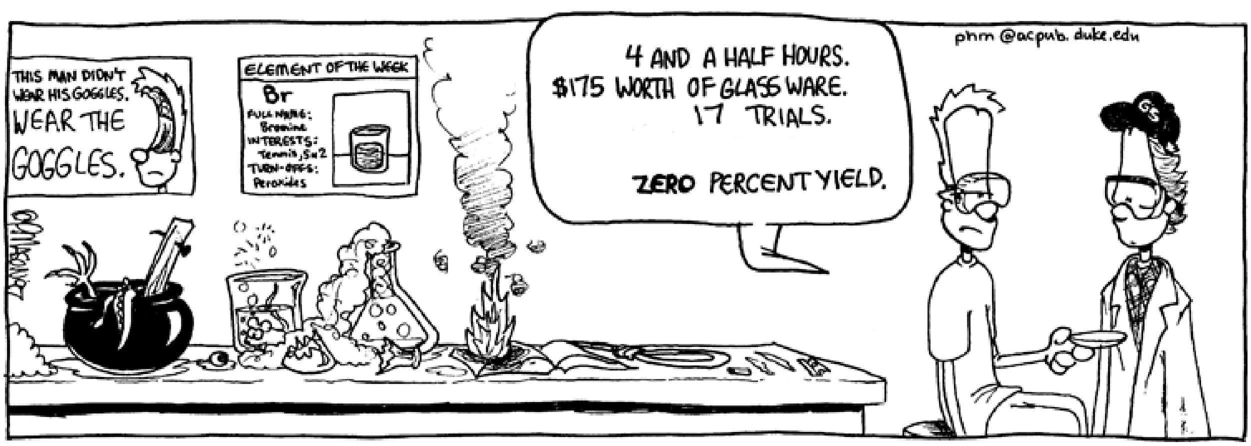
6. In the laboratory, hydrochloric acid and sodium bicarbonate were reacted by mixing the two chemicals together and then evaporating the resulting solution to recover sodium chloride:

$$NaHCO_{3(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$$

The following data was recorded:

Mass of empty beaker	93.650g
Mass of beaker and $NaHCO_3$	95.151g
Mass of $NaHCO_3$	
Mass of beaker and NaCl	94.691g
Mass of NaCl	

What is the percent yield of sodium chloride for this experiment?



Stoichiometry of Reactions Lab: $NaHCO_3$ + CH_3COOH

Learning Target:

- I can experimentally determine the quantity (moles) of reactants and products in a reaction.
- I can analyze experimental data to determine the theoretical and percent yield of products.

Procedure:

See textbook pages 750-753.

Data:

Material	Mass (g)
Empty evaporating dish and watch glass	
Evaporating dish, watch glass, and $NaHCO_3$	
Heating 1: Evaporating dish, watch glass, and $NaCH_3COO$	
Heating 2: Evaporating dish, watch glass, and $NaCH_3COO$	

Data Analysis:

$$\mathbf{NaHCO_3 + CH_3COOH \rightarrow NaCH_3COO + H_2O + CO_2}$$

1) Calculate the molar mass of $NaHCO_3$ and $NaCH_3COO$:

   $NaHCO_3$: _____________ g/mol

   $NaCH_3COO$: _____________ g/mol

2) Calculate the mass of $NaHCO_3$ from the experimental data and convert the mass of $NaHCO_3$ to moles of $NaHCO_3$:

3) Use the molar ratios to convert between the moles of $NaHCO_3$ (Step 2) to moles of $NaCH_3COO$:

4) Convert moles of $NaCH_3COO$ (Step 3) to calculate the **theoretical mass** of $NaCH_3COO$ produced:

5) Calculate the **actual yield**: Calculate the of $NaCH_3COO$ actually obtained from the experimental data:

6) Calculate the **percent yield**:

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

Stoichiometry Lab: $SrCl_2$ and Na_2CO_3

Learning Targets

- I can write a chemical equation for the precipitation reaction of strontium chloride and sodium carbonate.
- I can apply gravimetric methods to calculate the mass of Na_2CO_3 in a solution of unknown concentration.

Procedure:

Read the background information and procedure on **page 744-747**

Data:

Volume of Na_2CO_3 solution added	
Volume of $SrCl_2$ solution added	
Mass of dry filter paper	
Mass of beaker with paper towel	
Mass of beaker with paper towel, filter paper, and precipitate	

Data Analysis and Interpretation:

1) Predict the products and write a balanced chemical equation for the precipitation reaction of strontium chloride and sodium carbonate. Be sure to add states of matter (s, l, g, aq) to indicate which product is the precipitate.

2) Calculate the mass of the dry precipitate from the lab data:

3) Calculate the number of moles of precipitate:

4) Using stoichiometry, calculate how many moles of Na_2CO_3 were present in the 15mL sample:

5) There are .30mol of $SrCl_2$ in every 1000mL of solution. Calculate the number of moles of $SrCl_2$ added based on the volume of $SrCl_2$ added.

6) How would the calculated results vary if the precipitate was not completely dry?

7) How many grams of Na_2CO_3 were present in the 15mL sample?

Percent Yield of Copper Lab

Problem: What is the percent yield of copper metal in the reaction between copper (II) sulfate and iron?

Percent Yield of Copper Pre-Lab:

The following data was collected in lab:

Mass of 50-mL beaker	26.292g
Mass of 50-mL beaker and iron filings	26.603g
Mass of 150-mL beaker	98.325g
Mass of 150-mL beaker and $CuSO_4 \cdot 5H_2O$	101.367g
Mass of 150-mL beaker and dry Cu product	98.673g

$$Fe + CuSO_4 \cdot 5H_2O \rightarrow FeSO_4 + Cu + 5\ H_2O$$

1. Determine the limiting reactant (Fe or $CuSO_4 \cdot 5H_2O$):

2. What is the theoretical yield of copper metal?

3. From the sample data, what is the actual yield of copper?

4. Determine the percent yield:

Materials:

copper (II) sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$)
iron filings
balance
beakers (100mL, 250 mL)
graduated cylinder (10 mL)
glass stirring rod
hot plate

Procedure:

1. Determine the mass of a clean, dry 100 ml beaker. Record the mass in a neatly labeled data table.
2. Measure 12.5 grams of copper (II) sulfate pentahydrate – record the exact mass in your data table. Add the copper (II) sulfate pentahydrate to the beaker.
3. Measure 50 ml of water and add the water to the crystals in the beaker.
4. Place the beaker on the hot plate. Carefully heat the mixture, but do not allow it to boil.
5. Continue heating and stirring the mixture with the stirring rod until the crystals are completely dissolved. Use beaker tongs to remove the beaker from the hotplate.
6. Measure 2.24 grams of iron filings. Record the exact mass in your data table. Add the filings a little at a time to the hot copper (II) sulfate solution, stirring continuously. After you have finished adding the iron filings, allow the beaker to cool for 10 minutes.
7. Decant the liquid into a 250 ml beaker by gently pouring the liquid down the stirring rod into the beaker. Do not disturb the solid at the bottom of the beaker.
8. Add about 10 ml of water to the solid in the 100 ml beaker, stirring vigorously. Allow the solid to settle and decant again.
9. Spread the solid over the bottom of the beaker and place the beaker on top of a paper towel with your name on it. Ask you teacher where you should set the beaker/paper towel set-up.
10. After the solid is completely dry, find the mass of the beaker and the solid copper. Record this mass in your data table.

Calculations:

1. How much copper should be produced if all of the copper (II) sulfate reacts?
2. How much copper should be produced if all the iron filings react?
3. What is the limiting reactant for this lab?
4. What is the theoretical yield?
5. Calculate the actual yield of copper?
6. Determine the percent yield for this experiment.
7. Suggest two specific sources of error as to why the yield is not perfectly 100%?
8. Suggest some possible improvements to increase percent yield for this lab:

The Stoichiometry Challenge

Learning Targets:

- I can predict the amount of product that will be produced when sodium bicarbonate is decomposed.
- I can analyze the accuracy of the results by calculating percent yield and evaluating sources of error and suggesting experimental improvements to increase percent yield.

Your challenge in this experiment includes two parts:
(1) you will apply stoichiometric calculations to predict the amount of solid product that will be left in a test tube after sodium bicarbonate undergoes a decomposition reaction
(2) you will test your prediction by performing the experiment: your grade on this lab will be determined based on the accuracy of your prediction – so be careful and watch your lab technique!

Safety Precautions
Before you begin, inspect the test tube for chips and cracks. When using the Bunsen burner, tie back long hair and do not wear loose clothing. Never leave lit burners unattended.

Procedure
1. Obtain a large borosilicate test tube and weigh it on one of the balances. *Record* this mass in the Data Table.
Note: Borosilicate is a type of glass that can be subjected to very high (and low) temperatures without shattering.

2. Weight 1-2 scoops (about 5g) of sodium bicarbonate directly in the test tube and *record* this mass in the Data Table.

3. Calculate the mass of the sodium bicarbonate in the test tube and record the amount in the Data Table.

4. Holding the test tube nearly horizontally shake the baking soda gently so that it spreads out.

5. Tighten the test tube in a test clamp on a ring stand.

6. Light a burner and adjust the flame so that the outer flame is hitting the bottom half of the test tube.

7. Record the time you started heating. __________.

   Note: This heat will initiate a chemical change (a decomposition reaction) that breaks the $NaHCO_3$ down, not into its elements but into three separate compounds.

8. Carefully observe the test tube.

9. Move the burner occasionally to ensure a thorough heating of the entire bottom half of the test tube.

10. Observe the substance that is left in the test tube. It may look just like the sodium bicarbonate you started with, but it has actually been converted into something else: sodium carbonate. <u>Answer question 1-4 now</u>.

11. After heating the test tube for 10–12 minutes, turn off the burner and let the test tube cool for 7–8 minutes.

12. While waiting for the test tube to cool, <u>answer Questions 5–7</u>.

14. If your test tube has been cooling for 7–8 minutes, it should be ready for the official weigh-in! Bring the test tube, along with this sheet containing your prediction from Question 7, to the teacher who will weigh it on the same scale you used before. Your grade will be based on how closely your prediction came to the actual mass (see the Scoring Table).

15. After you have finished all of the above, rinse out the test tube in the sink and place back at your lab table.

16. Answer the *Post-Lab Questions*.

Data Collection

Mass of Test Tube (g)	
Mass of Test Tube + Sodium Bicarbonate (g)	
Mass of Sodium Bicarbonate (g)	

Observation Questions

1. What common substance appears to be one of the three products in this reaction?

2. Another product is a gas. What test could you perform to confirm the identity of this gas? Explain.

3. The third product of the reaction is sodium carbonate. What is the correct formula for sodium carbonate?

4. Write a complete balanced chemical equation (with phases) for the decomposition reaction of $NaHCO_3$.

5. **PREDICT THE AMOUNT OF EACH PRODUCT**: Apply stoichiometry to calculate the theoretical mass of water, carbon dioxide, and sodium carbonate that should be produced in the reaction. Show all work.

7. Assuming all the baking soda reacted and has been converted into sodium carbonate (with the product gases driven off), what should be the mass of sodium carbonate with the test tube?

	Predicted Amount (g)	Actual Amount (g)	Difference	Score
Sodium Carbonate				
Carbon Dioxide		X	X	X
Water		X	X	X

Scoring Table

If you are within…	Your grade will be…
0.03 g	10/10
0.10 g	9/10
0.20 g	8/10
0.50 g	7/10
1.00 g	6/10
5.00 g	5/10
<5.00g You Tried	4/10

Post Lab Questions

8. Suppose you only heated the test tube for 5 minutes – how would this alter your results and prediction?

9. Use data to demonstrate and defend how this reaction follows the Law of Conservation of Mass:

10. Calculate the percent yield of your experiment – showing all your work. If it is not 100%, describe at least three errors that could have contributed to a loss in yield. Classify errors as random or systematic error.

11. Suppose you were an engineer employed by a company to produce sodium carbonate on a large scale. How could you improve the yield of this reaction? List at least three suggestions.

HONORS Stoichiometry Review

Solve the following stoichiometry problems. Show ALL work.

- **2 points** writing and balancing the chemical equation (if needed)
- **2 points** list information from the problem
- **2 points** set up the conversions with UNITS
- **2 points** calculate answer, round to Sig Figs, label with units and substance identity

1. Determine the number of moles of lithium hydroxide produced when 0.38 moles of lithium nitride reacts with water according to the following equation:

$$Li_3N + 3H_2O \rightarrow NH_3 + 3LiOH$$

2. Hydrochloric acid and sodium hydroxide react in a double replacement reaction.
   a) Write a balanced chemical equation:

   b) If 2.47mol of HCl react, how many grams of water are produced?

3. Iron and oxygen react to form rust (iron (III) oxide).
   a) Write a balanced chemical equation:

   b) What mass of rust (Fe_2O_3) forms if 870g of iron reacts with oxygen?

4. The decomposition reaction of magnesium oxide forms magnesium metal and oxygen gas.
   a) Write a balanced chemical equation for the decomposition of magnesium oxide:

   b) How many grams of magnesium are produced from 30.0 mol of magnesium oxide?

5. Aqueous solutions of silver (I) nitrate reacts with barium chloride react to form a precipitate.
   a) Write a balanced chemical equation:

   b) What is the mass of silver chloride produced if 3.45g of silver nitrate reacts with 2.14g of barium chloride?

   c) If only .95g of silver chloride is actually produced, what is the percent yield?

6. Potassium chloride and oxygen react in a synthesis reaction to produce potassium chlorate.
   a) Write a balanced chemical equation:

   b) Determine the limiting reactant if 500g KCl and 820g O_2 react.

   c) In the lab, 640g of $KClO_3$ are actually recovered. What is the percent yield?

7. **Lab Application: Critical Thinking**

In a lab, magnesium metal reacts with hydrochloric acid and bubbles vigorously, producing hydrogen gas and magnesium chloride.

$$Mg + 2\ HCl \rightarrow MgCl_2 + H_2$$

During lab, the following data was recorded:

Mass of test tube	2.51 g
Mass of test tube and magnesium	3.56 g

a. What is the mass of the magnesium?

b. What mass of hydrogen is produced?

Long Term Learning Target: I can relate chemical quantities of reactants and products in real world and laboratory applications of stoichiometry.

<table>
<tr><th rowspan="2">Date</th><th rowspan="2">Learning Target</th><th colspan="2">Learning Activities
Self-reflect and evaluate yourself as
Beginning, Developing, Accomplished, or Exemplary
and complete the corresponding target practice</th><th rowspan="2">Progress Reflection
What evidence supports that I am <u>meeting</u> the target and am ready to quiz/ test?</th></tr>
<tr><th>*Beginning/ Developing*</th><th>*Accomplished/ Exemplary*</th></tr>
<tr><td rowspan="2">**2/23, 2/24**</td><td rowspan="2">I can define and describe practical applications of stoichiometry.
I can analyze molar ratios in a chemical reaction to determine the number of moles of reactants and products in a balanced chemical reaction.</td><td colspan="2">**Introduction to Stoichiometry**
Mole-to-Mole Stoichiometry
Lab: Synthesis of Aspirin (*lab report <u>due</u> 3/9, 3/10*)</td><td rowspan="2"></td></tr>
<tr><td>solve *all* on pg 2</td><td>solve any 2 on pg 2
Research and print a picture with a brief description of a practical application of stoichiometry</td></tr>
<tr><td rowspan="2">**2/25**</td><td rowspan="2">I can apply stoichiometry to convert between moles and mass of substances in a balanced chemical reaction.</td><td colspan="2">**Mole-to-Mass Problem Solving**</td><td rowspan="2"></td></tr>
<tr><td>solve *all* on pg 3</td><td>solve any 3 on pg 3
Lab: $NaHCO_3$ and CH_3COOH (pg 23)</td></tr>
<tr><td rowspan="2">**2/26**</td><td rowspan="2">I can apply stoichiometry to convert between mass of two different substances in a chemical reaction.</td><td colspan="2">**Mass-to-Mass Problem Solving**</td><td rowspan="2"></td></tr>
<tr><td>solve *all* on pg 5</td><td>solve any 4 on pg 5
Lab: $NaHCO_3$ and CH_3COOH data analysis (pg 23)</td></tr>
<tr><td rowspan="2">**2/27**</td><td rowspan="2">I can differentiate when to solve for moles/ mass of substances in a chemical reaction.</td><td colspan="2">**Mixed Mole-Mass Problem Solving**</td><td rowspan="2"></td></tr>
<tr><td>solve *all* on pg 7-8</td><td>solve any 4 on pg 7-8
Lab: $SrCl_2$ and Na_2CO_3 (pg 24)
Quiz #1 (if ready)</td></tr>
<tr><td rowspan="2">**3/2, 3/3**</td><td rowspan="2">I can apply stoichiometry to experimentally prepare 2.00 grams of a precipitate in a double replacement reaction.</td><td colspan="2">**Lab: 2.00 grams of a Compound**
(lab calculations <u>due</u> before starting lab today)</td><td rowspan="2"></td></tr>
<tr><td>Quiz #1</td><td>Quiz #1 (if not done yet)
finish $SrCl_2$ and Na_2CO_3 Lab, data analysis (pg 24)</td></tr>
<tr><td colspan="5">**Quiz #1: Stoichiometry Problem Solving** (completed <u>before</u> 3/4)</td></tr>
</table>

Date	Learning Target	Learning Activities **Self-reflect** and evaluate yourself as *Beginning, Developing, Accomplished, or Exemplary* and complete the corresponding target practice ***Beginning/ Developing***	 ***Accomplished/ Exemplary***	Progress Reflection What evidence supports that I am meeting the target and am ready to quiz/ test?
3/4 **Quiz #1**	I can problem solve real world examples of stoichiometry.	**Stoichiometry Stumpers**		
		solve 8 practical apps of stoichiometry solve 2 additional stoichiometry stumpers for homework (using tutorial videos for support) Quiz #1 (if not done yet)	solve and create an Educreations tutorial video for 1 stoichiometry stumper	
3/5	I can calculate the theoretical yields of products by analyzing the limiting reactant.	**Limiting Reactant Problem Solving**		
		Limiting Reactant PhET (pg 17-18) solve *all* on pg 20	solve any 2 on pg 20 Lab: Percent Yield of Copper (pg 25-26)	
3/6	I can experimentally analyze the theoretical and percent yield of a chemical reaction.	**Percent Yield Problem Solving**		
		solve *all* on pg 21-22 data analysis (given sample data) of Percent Yield of Copper Lab (page 25-26)	solve any 3 on pg 21-22 Quiz #2 (if ready) finish Percent Yield of Copper Lab, data analysis (pg 25-26)	
3/9, 3/10 **Aspirin Lab Report due** **Quiz #2**	I can experimentally analyze the theoretical and percent yield of a chemical reaction.	**Stoichiometry Challenge Lab**		
		Quiz #2 Review (pg 30-31)	Quiz #2 (if not done yet) Review (pg 30-31)	
Quiz #2: Limiting Reactants, Percent Yield (completed before 3/11)				
3/11	I can relate chemical quantities of reactants and products in real world and laboratory applications of stoichiometry.	**Stoichiometry Stumpers**		
		Review (pg 30-31)	Review Game (practical applications of stoich)	
3/12	**Test** **Test Retakes: The review must be completed and turned in for credit prior to taking the test.**			

Beginning = I need more help on this - I don't really understand it at all!
Developing =I kind of understand, but I need to spend more time reviewing/practicing.
Accomplished = I understand! I'm confident and can explain what I've learned on a test.
Exemplary = I could teach someone who knows nothing about this target everything they need to know.