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) What is the $H_2 : H_2O$ molar ratio?

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

c) What is the $O_2 : H_2O$ molar ratio?

d) 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

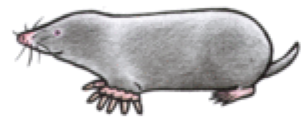
- Set up dimensional analysis conversion factors or write formula
- Write down setup with units and be sure units cancel

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?

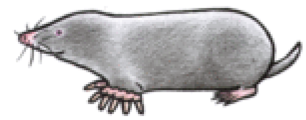
4. ____ $Cu(s)$ + ____ $O_2(g)$ → ____ $Cu_2O(s)$
    a. How many moles of Cu_2O can be made from 25.6 moles of Cu?
    b. How many moles of O_2 does it take to produce 214 moles of Cu_2O?

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 → __ NaBr + __ I_2

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

4. What mass of oxygen will be needed to react with .84mol of C_3H_8:
   __ C_3H_8 + __ O_2 → __ 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?
   __ C + __ ZnO → __ Zn + __ CO_2

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

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

8. 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*.)

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.
   $S_8 + 8\ O_2 \rightarrow 8\ SO_2$

5. 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?
   $2\ C_2H_2 + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O$

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

7. 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

8. How many grams of oxygen will react with 277g of carbon monoxide to produce carbon dioxide?
   __ CO + __ $O_2 \rightarrow$ __ CO_2

9. What mass of hydrogen gas is produced if 225g of iron reacts with hydrochloric acid to produce iron (II) chloride and hydrogen gas? (*Don't forget to write a balanced equation*.)

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:

$$NaHCO_3 + CH_3COOH \rightarrow NaCH_3COO + H_2O + CO_2$$

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:

3) Convert the mass of $NaHCO_3$ to moles of $NaHCO_3$:

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

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

6) Compare the mass of $NaCH_3COO$ actually obtained from the experimental data:

7) Calculate the percent yield:

$$\text{Percent Yield} = \frac{\text{Actual Yield (Step 6)}}{\text{Theoretical Yield (Step 5)}} \times 100$$

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?

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 grams 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?**

7. How many moles 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 moles of magnesium, how many moles of sodium will be produced?

    $Mg + 2\ NaF \rightarrow MgF_2 + 2\ Na$

11. The following reaction occurs when an automobile battery is charged:

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

    a. Balance the equation.
    b. How many grams of sulfuric acid (H_2SO_4) are produce when 68.1g of lead (II) sulfate react?

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

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

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

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

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

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

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

Basic Stoichiometry PhET Lab

Let's make some sandwiches!

Reactants, Products and Leftovers

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

1. 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. **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			
4 slices	3slices			
		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 molecules	0 molecules	0 molecules
9 moles	8 moles			
		4 moles	1 moles	0 moles
4.0 moles	2.5 moles			
1.5 moles		1.5 moles	0 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 is a mole? ___________________

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

7. Balance the 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
1.5 moles	4.0 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: **WATCH FOR FRACTIONS**

mol CH_4	mol O_2	mol CO_2	mol H_2O	Excess mol CH_4	Excess mol O_2
4 mol	4 mol				
3 mol	6 mol				
		2 mol	4 mol		
		3 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)________________

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 $AlBr_3$.

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)________________
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 **<u>LIMITING REACTANT</u> PROBLEMS**

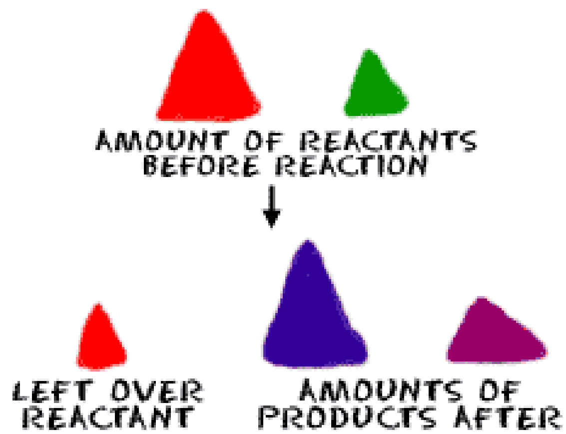
1. Write a **balanced equation** for the reaction
2. Calculate the amount of product formed based on the reactant amounts (**<u>2 stoichiometry problems)</u>**
3. Determine the reactant that produces *less* product (**limiting reactant**)
4. Determine excess reactant (if needed)

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! 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:

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

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, 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?

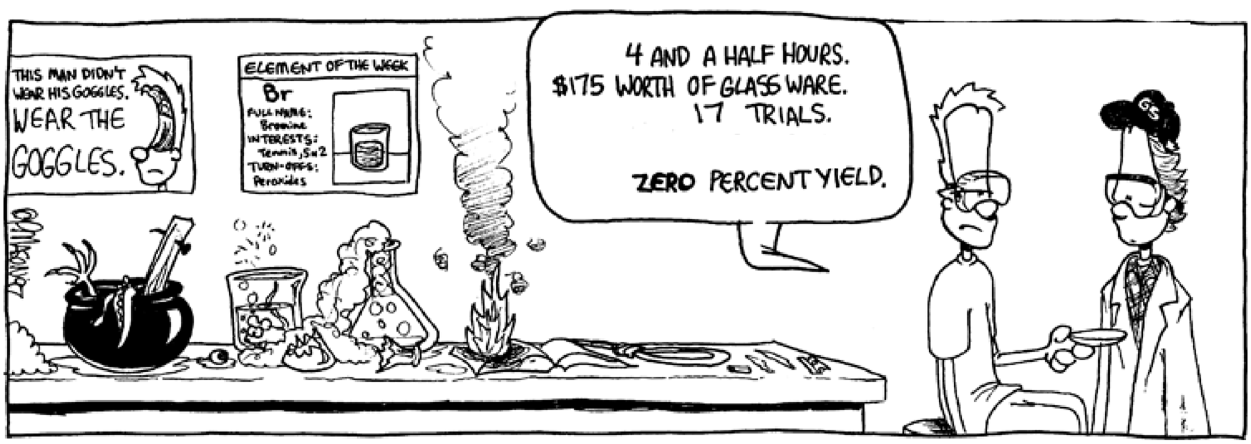
5. In the laboratory, hydrochloric acid and sodium bicarbonate were reacted by mixing the two chemicals together and then evaporating the resulting solution to recover sodium chloride:

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

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?



Percent Yield of Copper Pre Lab

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

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:

Percent Yield of Copper Lab

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

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. Gently decant (remove the liquid) from 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 to dry overnight.
10. After the solid is completely dry, mass of the beaker and the solid copper. Record in your data table.

Data:

Mass of 50-mL beaker	
Mass of 50-mL beaker and iron filings	
Mass of 150-mL beaker	
Mass of 150-mL beaker and $CuSO_4 \cdot 5H_2O$	
Mass of 150-mL beaker and dry Cu product	

Calculations:

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

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:

Academic Chemistry Stoichiometry Review

1. **If 2.47 mol of HCl react, how many moles of water are produced?**

    __ HCl + __ NaOH → __ NaCl + __ H_2O

2. **How many moles of O_2 react if 5.4g of CO_2 is produced?**

    __ CH_4 + __ O_2 → __ CO_2 + __ H_2O

3. **What mass of rust (Fe_2O_3) forms if 8.7mol of iron reacts with oxygen?**

    __ Fe + __ O_2 → __ Fe_2O_3

4. **How many moles of hydrogen gas react with 26.2 mol of oxygen?**

    __ H_2 + __ O_2 → __ H_2O

5. How many grams of $KClO_3$ is produced if 5.0 mol of KCl reacts?

$$2\ KCl_{(s)} + 3\ O_{2(g)}\ \ 2\ KClO_{3(s)}$$

6. Aqueous solutions of silver (I) nitrate reacts with barium chloride react to form silver (I) chloride and barium chloride.

a. Balance the equation: __ $AgNO_3$ + __ $BaCl_2$ → __ $Ba(NO_3)_2$ + __ $AgNO_3$

b. What is the mass of AgCl is produced if 3.45g of $AgNO_3$reacts with 2.14g of $BaCl_2$?

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

7. 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?

8. Lab Application: Critical Thinking

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

$$\mathbf{Mg + 2\ HCl \rightarrow MgCl_2 + H_2}$$

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 *only* the magnesium?

b. How many moles of hydrogen gas are produced?

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

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?
Mon, Tues 2/23, 2/24	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.	**Introduction to Stoichiometry** **Mole-to-Mole Stoichiometry** solve *all* on pg 2 POGIL Model 1 (#1-7)	solve any 3 on pg 2 Research and design a poster with an illustration and brief description of a practical application of stoichiometry	
Weds 2/25	I can apply stoichiometry to convert between moles and mass of substances in a chemical reaction.	**Mole-to-Mass Problem Solving** solve *all* on pg 3	solve any 4 problems (including #8, 9) on pg 3 POGIL Model 1 (#8)	
Thurs 2/26	I can apply stoichiometry to convert between mass of two different substances in a chemical reaction.	**Mass-to-Mass Problem Solving** solve any 8 on pg 5	solve any 4 on pg 5 (including #9) POGIL Model 2	
Fri 2/27	I can apply stoichiometry to convert between mass of two different substances in a chemical reaction.	**Mass-to-Mass Problem Solving** continue Problem Solving	Lab: $NaHCO_3$ and CH_3COOH (pg 6)	
Mon, Tues 3/2, 3/3	I can relate chemical quantities of reactants and products in laboratory applications of stoichiometry.	**Stoichiometry Lab** Lab: $NaHCO_3$ and CH_3COOH (pg 6)	Lab: $SrCl_2$ and Na_2CO_3 (pg 7)	
Weds 3/4	I can differentiate when to solve for moles/ mass of substances in a balanced chemical reaction.	**Mixed Stoichiometry** solve all on pg 8-9	solve any 5 on pg 8-9 solve and create an Educreations tutorial for 1 stoichiometry stumper	

<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">**Thurs 3/5**
Quiz Today</td><td rowspan="2">I can differentiate when to solve for moles/ mass of substances in a balanced chemical reaction.</td><td colspan="2">**Introduction to Limiting Reactants**</td><td rowspan="2"></td></tr>
<tr><td colspan="2">**<u>Quiz</u> on Stoichiometry** (1, 2, 3 steps)
Limiting Reactant PhET (pg 10-11)</td></tr>
<tr><td rowspan="2">**Fri 3/5**</td><td rowspan="2">I can calculate the theoretical yields of products by analyzing the limiting reactant.</td><td colspan="2">**Limiting Reactants**</td><td rowspan="2"></td></tr>
<tr><td>solve *all* on pg 13</td><td>solve any 2 on pg 13
Lab: Limiting Reactant Balloons</td></tr>
<tr><td rowspan="2">**Mon, Tues 3/9, 3/10**</td><td rowspan="2">I can experimentally analyze the theoretical and percent yield of a chemical reaction.</td><td colspan="2">**Percent Yield Lab**</td><td rowspan="2"></td></tr>
<tr><td colspan="2">Lab: Percent Yield (pg 16-18)
Percent Yield Lab data analysis (#1-4 on pg 18)
solve *all* on pg 14-15</td></tr>
<tr><td rowspan="2">**Weds 3/11**</td><td rowspan="2">I can relate chemical quantities of reactants and products in real world and laboratory applications of stoichiometry.</td><td colspan="2">**Stoichiometry Practical Applications**</td><td rowspan="2"></td></tr>
<tr><td>finalize data analysis for Lab (#5-8 on pg 18)
see point system for practical applications of stoichiometry</td><td>finalize data analysis for Lab (#5-8 on pg 18)
solve and create an Educreations tutorial for 1 stoichiometry stumper</td></tr>
<tr><td rowspan="2">**Thurs 3/12**</td><td rowspan="2">I can relate chemical quantities of reactants and products in real world and laboratory applications of stoichiometry.</td><td colspan="2">**Review**</td><td rowspan="2"></td></tr>
<tr><td colspan="2">Review (pg 19-20)</td></tr>
<tr><td>**Fri 3/13**</td><td colspan="4">**Test**
Test Retakes: The review must be completed and turned in for credit <u>prior</u> to taking the test.</td></tr>
</table>

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.