Carbonated Soda Stoichiometry

INTRODUCTION

Fizzies are instant sparkling drink tablets that were popular in the 1950's and 1960's. When placed in water, these tablets bubble and fizz, forming an instant carbonated beverage. The chemical reaction occurs in Alka-Seltzer antacid tablets, effervescent denture cleaners and Kool-Aid Slushies. Fizzies contain citric acid ($H_3C_6H_5O_7$) and baking soda ($NaHCO_3$). When water is added they react, forming sodium citrate, carbon dioxide and water in the following ***unbalanced*** reaction:

$$H_3C_6H_5O_7 + NaHCO_3 \rightarrow Na_3C_6H_5O_7 + CO_2 + H_2O$$

Objective: In this lab you will make your own carbonated beverage and attempt to calculate the correct ratio of citric acid to baking soda to perfect your drink

Materials:

1. 5 clean, 10 oz beverage cups
2. 4 paper muffin cups
3. Plastic spoon
4. Marker
5. Balance
6. Cup measure
7. Sugar
8. Powdered drink mix
9. Citric acid
10. Baking soda
11. Cold water

Procedure:

1. Read the instructions on a package of unsweetened powdered drink mix. **Determine the mass of drink mix and the volumes of sugar and water for a single 8oz serving.**
   Drink mix: ____________g ~~Sugar: ____________ml~~ **Water:**____________**cups**
2. Label 3 paper muffin cups as follows: ***'drink mix'***, ~~*'sugar'*~~, ***'citric acid'***, ***'baking soda'***
3. Label 5 plastic cups ***A thru E***
4. Place the muffin cup labeled **'drink mix'** on the balance and zero it. Weigh the quantity of drink mix for a **single serving** and transfer it to the cup **labeled A.**

5. **Repeat step 4 for the other 4 cups , B thru E**
6. ~~Add the amount of sugar for a single serving to *each of the 5 plastic cups* using the balance and the muffin cup labeled 'sweetener'~~
7. Add the quantity of cold water for a single serving to the cup labeled 'A'. Stir until all solid has dissolved. Taste and record your observations in the table below. Set aside. This is your CONTROL cup!!
8. Using the muffin cup labeled 'citric acid' and the balance, add (1.0grams) of citric acid to the cup labeled B. Add the quantity of cold water for a single serving, stir, taste a small amount, record and discard.
9. Using the muffin cup labeled 'baking soda' , measure out 1.0grams of baking soda and add to cup C. Add the cold water for a single serving, stir taste, record and discard.
10. Using the appropriate muffing cups and the balance, measure 1.0 grams each of baking soda and citric acid and add to plastic cup D. Add the cold water, stir, taste, record and discard.

11. Balance the chemical equation for this reaction of citric acid and baking soda.

$$H_3C_6H_5O_7 \ + \ NaHCO_3 \ \rightarrow \ NaC_6H_5O_7 \ + \ CO_2 \ + H_2O$$

12. Using stoichiometry, determine the mass in grams of citric acid required to react completely with 1.00g of baking soda. Have your work checked before proceeding. **(SEE ANALYSIS SECTION BELOW for calculation!!)**
13. Weigh out 1.0g of bakiing soda and the correct amount of citric acid calculated in **step 12** and add these to the cup labeled E. Add the correct amount of water, stir, taste and compare to cup A.

DATA & Observations

	Cup A **Control**	Cup B	Cup C	Cup D	Cup E
DRINK MIX (g)					
Sugar(g)					
Water (c)					
Citric acid (g)					
Baking soda (g)					
Visual observations					
taste					

Analysis and Interpretation:

1. Calculate the correct mass of citric acid needed to react with 1.0 g of baking soda:
   - From the balanced equation, what is the RATIO of MOLES of citric acid needed to react with MOLES of baking soda? ____________________
   - What is the molar mass of baking soda ($NaHCO_3$)? ________________g/mol
   - What is the molar mass of citric acid ($H_3C_6H_5O_7$)? ________________g/mol
   - Convert from grams of baking soda used, to grams of citric acid needed using the following picket fence method:

Moles of NaHCO3 | mole Ratio citric acid to Baking soda | grams of citric acid per mole

1.0g NaHCO3

2. Why do citric acid and baking soda not react until water is added? ______________________

____

____

3. How will the drink taste if too much citric acid is added? How will it taste if too much baking soda is added? ____

____

____

____

4. Why is fizzing observed in cup C? ____

____

____

5. What are some other practical uses of stoichiometry? __________________________

____

____

H_2 and O_2 Rockets: Small Scale

Hydrogen is a colorless gas which is said to be "combustible" - meaning that it can burn quite readily. Oxygen is also a colorless gas that is said to "support combustion"—meaning that it must be present for combustible materials to burn. In this lab you will generate small amounts of hydrogen and oxygen gases separately and test them with a flame. Then you will mix small amounts of hydrogen and oxygen and test them with a flame. Finally, you will attempt the find the optimal ratio of hydrogen to oxygen for complete combustion.

The hydrogen will be generated by reacting zinc with hydrochloric acid. Oxygen will be generated by the decomposition of hydrogen peroxide, H_2O_2 using a catalyst.

Objectives:

1. Safely generate small amounts of hydrogen and oxygen gas.
2. Test the behavior of hydrogen and oxygen gases with a flame.
3. Determine the optimal ratio in a mixture of hydrogen and oxygen.

Materials:

- one beaker, 250-mL
- two one-hole stopper delivery tops
- one 10-mL graduated cylinder
- 3M HCl, 50 mL
- zinc metal
- copper wire
- permanent marking pen
- two 13 × 100 mm test tubes
- one cut off Beral pipet bulb
- Bunsen burner
- 3% hydrogen peroxide
- manganese metal
- Tesla coil

Safety:

Hydrochloric acid and hydrogen peroxide are corrosive to skin and eyes. Wear safety goggles. Do not shoot rockets at anyone.

Prelab:

1. Read the introduction and procedure before you begin.
2. Answer the prelab questions on the Report Sheet
3. Before you begin the activity, construct a data and observation table on the Report Sheet for your measurements and observations.

Procedure:

1. **Water Supply:** Fill a beaker 3/4 full with tap water. Use this as a source of water for the rest of the experiment.
2. **Collection bulb calibration:** Using the graduated cylinder and permanent marking pen, mark a cut off Beral pipet bulb into six equal volume intervals. This bulb will be called the "collection bulb."
3. **Hydrogen generator:** Add several pieces of zinc metal to the test tube. Add enough HCl until the level is about 2 cm below the mouth of the test tube. Insert a one-hole stopper delivery assembly, label, and set the generator in the beaker of water.
4. **Collect hydrogen:** Fill the collection bulb completely with water from the beaker. Insert the stem of the one hole stopper delivery assembly into the mouth of the collection bulb and collect the hydrogen in the collection bulb.

Mike Roadruck

5. **Test the hydrogen:** Once you have filled the collection bulb with hydrogen, hold it horizontally about 1 cm from the lower portion of a Bunsen burner flame. Squeeze the bulb blowing the hydrogen into the flame. Observe and note the results. Squeeze the bulbs contents into the flame several times and note the results. Fill the collection bulb with hydrogen. After holding it uncovered with the opening up for a minute try the flame test.

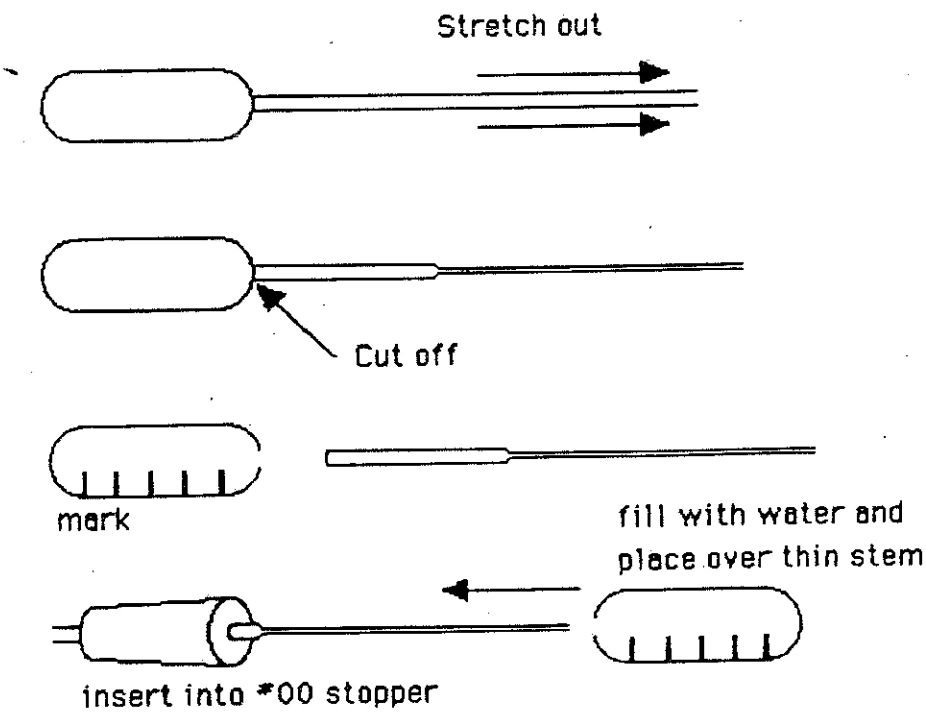
6. **Oxygen generator:** Leave the hydrogen generator going and proceed to make an oxygen generator. Add a spatula of manganese metal to the second small test tube. Label it oxygen generator. Add enough H_2O_2 until the level is about 2 cm below the mouth of the test tube. Insert a one-hole stopper delivery assembly, and set the generator in the beaker of water. Manganese metal has a thin coating of manganese dioxide on its surface. This manganese rust acts as a catalyst decomposing the H_2O_2.

7. **Collect oxygen:** Fill the collection bulb completely with water from the beaker. Insert the stem of the one hole stopper delivery assembly into the mouth of the collection bulb and collect the oxygen in the collection bulb.

8. **Test the oxygen:** Once you have filled the collection bulb with oxygen, hold it horizontally about 1 cm from the lower portion of a Bunsen burner flame. Squeeze the bulb blowing the oxygen into the flame. Observe and note the results. Squeeze again and note the results. Light a wooden splint and then blow it out leaving the wood glowing. Squeeze oxygen gas onto the glowing splint. Fill the collection bulb with oxygen. After holding it uncovered with the opening up for a minute try the flame test.

9. **Testing different mixtures:** With both generators going, collect and test as you did above, the different possible mixtures of the gases, using the marked collection bulb increments. Note and record the results.

10. **Rockets:** Once you have tested all the mixtures and found an optimal mixture, place the collection bulb filled with the optimal mixture of hydrogen and oxygen on the launch pad and have the teacher ignite the mixture with a spark from the Tesla coil or gas grill igniter.



Make the one-hole generator stopper and collection bulb as shown above. Stretch out a plastic pipet's stem. Cut it off at the bulb. Graduate the bulb into sixths with a permanent marker. Insert the thicker section of the stem into a one-hole stopper with the thinner end extending out the top. Insert the assembly onto a test tube with Zn & acid or Mn and H_2O_2. Fill the bulb with water and place it onto the thin stem to collect the gas by displacement.

Name ______________________________

Report Sheet

H_2 and O_2 Rockets: Small Scale

Prelab Questions:

1. Write in your own words the purpose of this activity.

2. Write and balance the equations for generating the two gases used in this experiment.

3. Write and balance the equation for the reaction of the hydrogen and oxygen.

4. What is the role of a catalyst? What catalyst was is used in this experiment?

H_2 and O_2 Rockets: Small Scale

Data and Observations

H_2 and O_2 Rockets: Small Scale

Analysis and Conclusions

1. Explain the behavior of the hydrogen filled bulb on successive squeezings.

2. What evidence does this experiment provide about the solubility of these two gases in water?

3. What is the ratio of hydrogen to oxygen that gave the loudest pop in the experiment and how does that compare to the ratio of hydrogen to oxygen in the balanced equation of #3 of the prelab questions?

4. Why does the water stay in the collection bulb and not drip out until the gas bubbles into the bulb?

5. What are some chemical and physical properties of hydrogen and oxygen demonstrated in this experiment?

H_2 and O_2 Rockets: Small Scale
Synthesis

1. If a student got confused and accidentally added the acid to the oxygen generator tube instead of the hydrogen peroxide, what would be the result?

2. Hydrogen peroxide can be decomposed rapidly using a solution of potassium iodide. What is a possible reason the oxide coating on manganese metal was used instead?

3. It is said that "Oxygen supports combustion, but is not flammable." What does this mean?

4. The rockets in this experiment used gaseous oxidizer and fuel. What disadvantages would gaseous oxidizer and fuel have for use on NASA's rockets?

5. What actually caused the "rocket" to fly?

Extensions:

1. Would any other gases behave as these two did?
2. Describe the experiments of Cavendish and Lavoisier with these two gases.

Relating Moles to Coefficients of a Chemical Reaction

Purpose: Find the ratio of moles of a reactant to moles of a product of a chemical reaction. Relate this ratio to the coefficients of these substances in the balanced equation for the reaction. This experiment should aid in the understanding of balanced equations. It should also exemplify a common type of single replacement reaction.

Chemicals needed: copper (II) sulfate crystals, iron filings

Apparatus needed:

Balance	hot plate (or ring stand and ring)
Burner	stirring rod
Beaker, 100 mL	safety glasses
Beaker, 250 mL	
Graduated cylinder	

Safety precautions: Students should wear safety glasses and protective clothing. Safety precautions for working around heated substances should be followed.

Disposal methods: Follow the directions of the teacher.

Procedure:

1. Find the mass of a clean, dry 100 mL beaker. Record.
2. Measure out 8.0 g of $CuSO_4$ and add to beaker.
3. Measure 50.0 mL of water in a graduated cylinder and add it to the beaker.
4. Heat the mixture in the beaker to just below boiling. Do not allow the liquid to boil.
5. Continue heating and stirring the mixture until the crystals are completely dissolved. Turn off the heat source.
6. Using the balance, measure precisely 2.24 g of iron filings. Record.
7. Add the filings, small amounts at a time, to the hot copper sulfate solution. Stir continuously. After all the iron has been added and the mixture stirred, allow the beaker to sit for 10 minutes while the reaction proceeds.
8. Decant the liquid into a 250-mL beaker. Do not disturb the solid at the bottom of the beaker.
9. Add about 10 mL of water to the solid in the 100 mL beaker. Stir vigorously in order to wash off the solid. Let the solid settle and decant the liquid. Repeat the washing.
10. Spread the solid out on the bottom of the beaker and place the beaker in a drawer or oven to dry. Complete step 11 and the rest of the experiment at the beginning of the next lab period.
11. Find the mass of the beaker and the dry copper metal. Record.

Copper and Iron
A Mole Lab That Really Works !!!

I. Purpose: You will perform a single displacement reaction in order to gain a better understanding of the mole concept as related to a balanced equation.

II. Materials:

12.5 g of $CuSO_4$
2.24 g of Fe
deionized water
beaker, 100 ml
beaker, 250 ml
50 ml graduated cylinder
stirring rod
hot plate
balance
oven

III. Procedure:

1. Mass a clean, dry 100 ml beaker. Record the mass in the data table.

2. Add 12.5 g of $CuSO_4$ in the previously masses 100 ml beaker.

3. Using the graduated cylinder, measure 50 ml of deionized water. Add this water to the 100 ml beaker with the $CuSO_4$.

4. Using a hot plate, heat the beaker of $CuSO_4$ and water. Do not boil the solution.

5. To help dissolve the $CuSO_4$ crystals, stir with a glass stirring rod.

6. When all the crystals have dissolved, stop heating the solution.

7. While stirring, carefully add exactly 2.24 g of Fe to the hot $CuSO_4$ solution. When all the Fe has been added, let the solution sit for 10 minutes to allow it to completely react. Stir it occasionally and record any observations.

8. When the 10 minute reaction time is up, decant the liquid into a 250 ml beaker. Be careful to pour off only the liquid **without pouring away the solid.**

9. To wash the solid, add about 10 ml of deionized water to the solid remaining in the bottom of the 100 ml beaker. Stir vigorously, then let the solid settle to the bottom. Decant the liquid into the 250 ml beaker. Repeat the washing and decanting 2 more times.

10. Spread the solid out in the bottom of the 100 ml beaker and let it dry overnight. An oven will be used to speed the drying process.

11. Weigh the beaker and dry copper. Record the mass in the data table.

12. Complete the calculations and questions that follow.

Data:

A) mass of empty 100 ml beaker ____________________

B) mass of Fe ____________________ 2.24 g

C) mass of beaker and dry copper ____________________

Observations:

Questions/Calculations:

1. A single displacement reaction occurred when you combined Fe with $CuSO_4$. Write a balanced equation for this reaction. (Fe will have a +2 charge when it forms a compound.)

2. Find the mass of the copper metal produced in the reaction.

3. Calculate the number of moles of copper produced.

4. Calculate the number of iron moles reacted.

5. Calculate the whole number ratio of moles of iron reacted to moles of copper produced.

6. How does the mole ratio calculated in #5 compare to the theoretical mole ratio?

7. Calculate the % yield of copper for this experiment.

8. Calculate your percent error for this experiment.

9. Describe at least 3 factors that could have caused your % yield to be too low (and your % error to be too high!!).

10. What did you observe in this reaction that helped you to see that a single displacement reaction occurred?

“Mole”arity: The Concentration of Solutions

by Lee Marek

Purpose:

The demonstration is hopefully an amusing attempt to help students learn the concept of molarity. In addition, it helps students visualize the direct and indirect relationship between moles and volume respectively on molarity.

Materials:

A variety of different size beakers, “moles”

Chemicals:

None

Safety Precautions:

Students will think you are a bit eccentric, but who cares!

Procedure:

On the board, prepare a three column chart (1st “moles”, second “volume (L),” third “Molarity (mol/L).” Fill in the chart as the demonstration proceeds. Begin by placing one “mole” into the liter beaker. Vary the number of “moles”, including tearing the “mole” into fractions. Note the direct relationship between the number of moles and the molarity. Continue the demonstration by varying the volume. Place one “mole” into beakers of various volumes, 50 mL, 100 mL, 250 mL, etc. note the indirect relationship between volume and molarity.

Demonstration Notes:

The demonstration can be expanded to include the relationship between mass of solute and molarity by assigning an arbitrary molar mass to the “mole.” Volumetric flasks can also be shown to emphasize the importance of the total volume of the solution to the concept of molarity. Using equal amounts of sand (or Wamoís Magic Sand), two “solutions” can be prepared. The first “solution” is prepared by adding the sand to some water, and then bringing the total volume to one liter. The second “solution” is prepared by the first filling the flask to volume, then adding the sand. The more water that spills over the better.

When the back half of the “mole” is put into the beaker, allow the students time to calculate the molarity. Tell the students that their calculations are close. Give the correct answer, “mole-asses.”

References:

The ideas and jokes come from Weird Science.

This was written up by Sandy Sherwin of Glenbard North High School for the Illinois State University Demonstration book.

Name ________________
Date ________________
Period ________________

Moles Samples and Molar Mass

Part A:

1. Molar samples of different elements have been prepared at each station.
2. There is a card at each station stating how many moles of the unknown substance are present.
3. Using the balance, measure the total mass of each sample bag.
4. Subtract the mass of the bag that is indicated on it from the total mass.
5. Using a periodic table, identify which element is contained in the bag at each station.

Unknown	# of Moles (decimal)	Mass of Substance (g)	Molar Mass Calculated	Identity of Substance
#1				
#2				
#3				
#4				
#5				
#6				
#7				
#8				

Name ________________
Date ________________
Period ________________

Part B:

1. At each station, there is a Ziploc bag containing an unknown compound marked with a letter.
2. On an index card at each station, the number of moles of the substance is indicated. The mass of the bag itself is also indicated.
3. Determine the molar mass of the substance using the information given.
4. From the list given below, determine which substance is contained in the bag.
5. Do not open the bag to identify the compounds.

Calcium oxide
Sodium acetate
Calcium acetate
Potassium sulfate

Sodium chloride
Sodium carbonate
Zinc oxide
Magnesium oxide

Potassium chloride
Sodium sulfate
Iron oxide
Calcium Carbonate

Unknown	Number of moles	Mass (g)	Molar Mass	Identity of the substance
A				
B				
C				
D				
E				
F				
G				

Name ______________________
Date ______________________
Period ______________________

The Bean Lab

Introduction

There are many situations in which items are bought and sold in groups: eggs come in dozens, as do doughnuts; paper is sold in reams; tennis balls and golf balls come in boxes or cans of three. The purpose of this short experiment is to help you get a feel for the basic counting unit of chemistry, the mole. To accomplish this goal, we will use a model to simulate the real thing. Beans of different kinds will substitute for atoms of different elements, with each bean having its own symbol, just as each element has its own symbol. In addition we will establish a temporary counting unit for our beans, which we will call the **pot**. A pot of beans will be analogous to a **mole** of atoms.

Procedure

Part 1

1. Draw a data table with the following columns and rows for four types of bean:

Type of bean	Symbol	Mass of 50 beans (g)	Average mass of one bean (g)	Relative mass	Number of beans per pot

2. Weigh an empty cup (or other container) to ±0.01 g.
3. Place exactly fifty beans of one kind in the container. Discard any beans that are not "typical."
4. Reweigh the cup with the fifty beans. Calculate the mass of fifty beans and record it in the data table. (For each type of calculation you do, you should show a sample calculation.)
5. Repeat the process for each of the remaining types of beans. Record the masses.
6. Calculate the average mass of each type of bean. Record your results in the data table.
7. Calculate the relative mass for each type of bean. (Divide the average mass for each type of bean by the average mass of the lightest type of bean.) Record your results in the data table.

Part 2

8. For each type of bean, weigh out a mass in grams numerically equal to the relative mass which you calculated for that type of bean. Record the number in the data table. You may not be able to hit some of the masses exactly, so use the whole number of beans that comes closest to the relative mass that you calculated in part 1.

Clean up

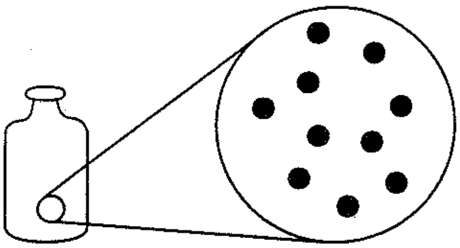
Put all supplies and materials back where they were at the beginning of the lab. Clean the lab table and wash your hands before leaving the lab.

Name ___________________________
Date ___________________________
Period __________________________

Questions and Calculations

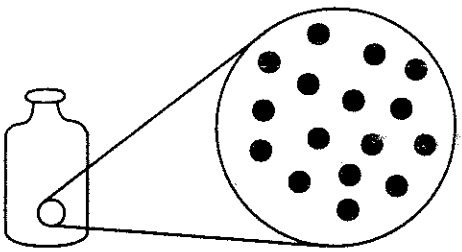
1. How does the number of beans in a pot compare from one type of bean to the next? Allowing for experimental errors and the fact that only whole numbers of beans could be used, were the results fairly consistent from type to type?
2. Calculate for each type of bean:
    a. the number of beans in 250 grams
    b. the number of pots in 250 grams
    c. the number of pots in 250 beans
    d. the number of beans in 3.17 pots
    e. the number of grams in 3.17 pots
3. Of the five values calculated in #3, only two are about the same for all types of beans. Which are they? What do these quantities have in common that distinguishes them from the others?
4. Explain in a single, well-developed paragraph how this experiment provides data for the beans that is similar to the relative atomic weights shown on the periodic table.

Conceptual Understanding of Moles



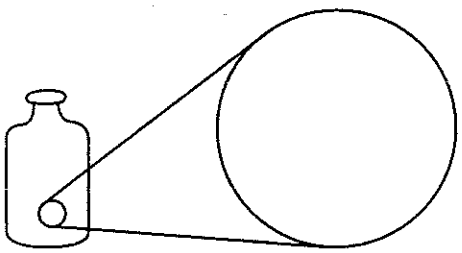
The illustration at the left shows a bottle which contains 1.00 mole of argon gas. The mass of the gas in the bottle is 40.0 g.

Base your answers to the next four questions on this information.



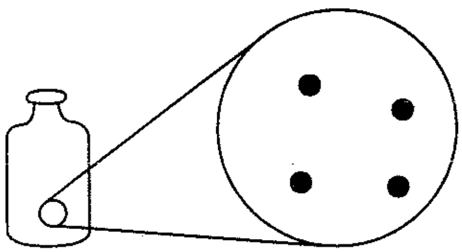
How many moles of Ar are illustrated in this bottle? __________

What is the mass of the gas in this bottle? __________



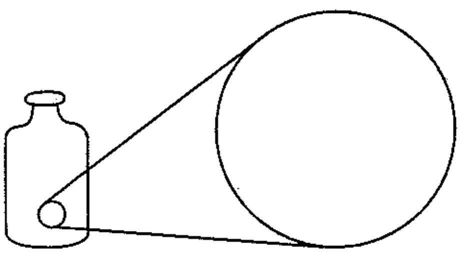
The bottle on the left contains 0.50 mol of argon gas. Put the appropriate number of particles in the circle.

What is the mass of the gas in this bottle? __________



How many moles of Ar are illustrated in this bottle? __________

What is the mass of the gas in this bottle? __________



The bottle at the left contains 60.0 grams of argon gas. Put the appropriate number of dots in the circle.

How many moles of argon are in this bottle? __________

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Title of Worksheet	**Brief description of Worksheet**	**pdf format**	**MS Word**
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Balancing Equations Race	Teach the kids how to balance equations in a fun and chellenging way.	Click here!	*N/A*
Writing Complete Equations	Practice writing, balancing, and writing all of the correct symbols for chemical equations.	Click here!	Click here!
Six types of reaction	Practice with determining the differences between the six types of chemical reaction. I've also snuck some equation balancing in here, too!.	Click here!	Click here!
Double displacement reactions	Do your students have a hard time predicting which product of a double displacement reaction will precipitate? With this worksheet and a table of solubility product constant values, they'll understand in no time!	Click here!	Click here!
Chemical equation review	Practice problems involving all aspects of chemical equations	Click here!	Click here!
Balancing chemical equations	Simple equation balancing problems	Click here!	Click here!
Writing word equations	Given the written names of reagents and products, balance the equations	Click here!	Click here!
Stoichiometry practice problems	Practice problems involving stoichiometry	Click here!	Click here!
Limiting Reagent Worksheet	Practice limiting reagent problems	Click here!	Click here!
A very long equations worksheet	A very long equations worksheet	Click here!	Click here!
Predicting reaction products	Predict the products of various chemical reactions	Click here!	Click here!
Percent, actual and theoretical yields	A practice worksheet containing various yield-related problems	Click here!	Click here!

Questions? Comments? Email them to me at misterguch@chemfiesta.com

Stoichiometry Lab
Vinegar and Baking Soda

Purpose: 1) To determine the mass of carbon dioxide produced when vinegar (acetic acid) and baking soda (sodium hydrogen carbonate) react. 2) To calculate the theoretical yield of carbon dioxide produced and analyze for reasons for error.

Materials:

Acetic acid
Sodium hydrogen carbonate
Balance
250mL beaker
100mL graduated cylinder
stirring rod

Procedure:

1. Determine the mass of a clean dry graduated cylinder. Record.
2. Measure 100mL of acetic acid in the graduated cylinder. Determine the mass of the cylinder and acetic acid and record.
3. Measure the mass of a clean, dry beaker. Add approximately 2 grams of sodium hydrogen carbonate. Determine the mass of the beaker and sodium hydrogen carbonate and record.
4. Slowly add acetic acid to the sodium hydrogen carbonate. (Do not overflow.)
5. When the reaction is complete, determine the mass of the graduated cylinder and unused acetic acid. Record.
6. Then determine the mass of the beaker and reaction products. Record.

Data:

Mass of grad. Cylinder (empty)	
Mass of GC and acetic acid	
Mass of beaker (empty)	
Mass of beaker and sodium hydrogen carbonate	
Mass of GC and unused acetic acid	
Mass of beaker and reaction products	

Calculations: Show all work on the back of this paper.

1. Write a balanced equation for the chemical reaction that occurred.
2. Calculate the mass of sodium hydrogen carbonate used.
3. Using this mass, calculate the theoretical mass of carbon dioxide produced.
4. Calculate the actual mass of carbon dioxide produced.
5. Determine the percent yield of carbon dioxide.
6. Determine two reasons for error and their effects on the percent yield.

from Debbie Brock

Name: ______________________ Period: __________

Stoichiometry: You Want S'more?

Objective: To construct as many mini-S'mores as possible with the provided ingredients.

Introduction:

Two atoms or molecules must come together in just the right way in order for them to react. As a result, it is virtually impossible to obtain 100% of the products expected in a chemical reaction even when the reactants are combined in the exact proportions called for by the chemical equation. In order to increase the odds that at least one reactant will react completely, we often add more than is needed of another reactant. This reactant is said to be in **excess**. The reactant that is used up first in the reaction is called the **limiting reactant** because once it runs out, it limits the amount of product formed.

In this activity, you will use a recipe for S'mores as an analogy for a chemical equation in which reactants and products are in set proportions to each other. You will be given varying amounts of each reactant. One of these reactants will limit the number of S'mores you can produce. The other reactants will be in excess. After working with this culinary "reaction," you will identify the limiting and excess reactants in *chemical* reactions and perform stoichiometry calculations based on the amount of the limiting reactant present.

Safety:

- Do not eat any of the S'mores until the end of the lab.
- Do not allow any of the S'mores to come in contact with the lab benches, keep all ingredients on the piece of wax paper at all times
- Use only the provided materials to prepare S'mores.

Materials:

- S'mores ingredient bag - Wax paper

Procedure:

1. Obtain a plastic bag of S'mores ingredients.
2. Record the quantity of each ingredient in your bag.
3. Use the following recipe to construct as many S'mores as possible using your ingredients.
   - 2 Teddy Grahams: (chemical symbol Tg)
   - 1 mini marshmallow (chemical symbol Mm)
   - 3 Chocolate Chips (chemical symbol Cc)
4. When done, record the number of S'mores you are able to construct along with the quantities of any remaining ingredients
5. Following your instructors directions, you may cook and consume your S'mores along with any remaining ingredients.
6. Clean up your lab station and return all remaining materials.

Analysis Questions: On your own paper

1. Write a reaction for the formation of S'mores. What type of reaction is this?
2. Which reactant(s) limited the number of S'mores you could produce? Which reactant(s) did you have in excess?

Conclusion Questions:

3. Write a definition of a limiting reactant that would explain to a non-chemistry student doing this lab what a limiting reactant is.
4. Write a definition of an excess reactant that would explain to a non-chemistry student doing this lab what an excess reactant is.

Bonus Problems: On your own paper

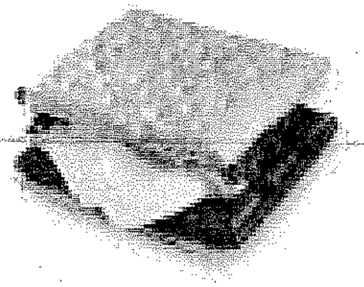
1. Suppose you were given unlimited amounts of Tg and Mm, but only 3 Cc:
   a. How many S'mores could you make?
   b. How many Tg would you need?
   c. How many Mm would you need?
2. Suppose you wanted to make 24 S'mores to share with friends:
   a. How many Tg would you need?
   b. How many Mm would you need?
   c. How many Cc would you need?
3. Suppose you were given 43 Mm, 285 Cc, and 76 Tg:
   a. Which ingredient limits the number of S'mores you could make?
   b. How many S'mores could you make?
   c. Which ingredients are in excess?
   d. How much of each excess reactant would you have left over?
4. Now tie the idea to chemistry. The synthesis reaction between hydrogen and oxygen shown below is a little bit like "synthesizing" S'mores from Teddy Grahams, chocolate chips and mini marshmallows.

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

   a. What is the ratio of hydrogen to oxygen needed to produce 2 moles of water in this reaction?
   b. The chart below shows three experiments, each with different amounts of reactants. Identify the limiting reactant in each experiment. Then determine the number of moles of water that will be produced when the limiting reactant is used up.

	Starting amount of H_2	**Starting amount of O_2**	**Amount of water predicted**
Experiment 1	8 moles	12 moles	
Experiment 2	6 moles	6 moles	
Experiment 3	12 moles	8 moles	

S'more Stoichiometry



Contributed by Carole Henry
San Antonio, TX

Definitions: 'Stoichio' means element and 'metry' means the process of measuring. The mass and quantity relationships among reactants and products in a reaction are found using the process of stoichiometry.

Problem:

1) If you are given one bag of large marshmallows, what is the maximum number of S'mores that can be made?
2) How many boxes of graham crackers and how many chocolate bars are needed to make this many S'mores?

Solutions:

1st Step: Write a chemical equation using the following symbols:

Substance	Symbol	Unit Mass
Graham Cracker	S	7.00 g
Marshmallow	Mm	7.10 g
Chocolate Pieces	Or	3.30 g
S'more	S_2MmOr_3	________ g

Calculate the unit mass of the S'more (S_2MmOr_3)below:

2nd Step: Balance the equation: What does the equation tell us? What do the coefficients represent?

They represent the ratio of the __________ or the ____________.

3rd Step: Calculating the number of units (or moles) given:

Determine the number of unit marshmallows that are available in the bag. If there are 454 g marshmallows in one bag, how many marshmallows do you have?

4th Step: Finding the units of other substances in the reaction:

Now, determine how many units of graham crackers and chocolate segments are needed to make the maximum number of s'mores available.

5th Step: Convert your number of graham crackers and chocolate segments into mass (gram) values:

When you go to the store, you cannot quickly determine the exact number of graham crackers or chocolate segments there are in a box or bar. The mass is easy to read, however. Using mass values, you can quickly determine how much you need to buy.

6th Step: Finally-convert the masses into your needed units.

In this case, if a box of graham crackers has a mass of 254 g, how many boxes do you need? Also, if one chocolate bar has a mass of 49.5 g, how many bars do I need?

Now we will transfer this process into the language of chemical reactions. When you complete this problem, get it checked by your teacher and you will be rewarded with the necessary items to make your S'more!

If we were to add a piece of solid Cu to an aqueous solution of silver nitrate, the Silver would be replaced in a single replacement reaction forming aqueous copper (II) nitrate and solid silver. How much silver is produced is 15.00 grams of Cu is added to the solution of excess silver nitrate? Show all work and don't forget to use significant figures.

Steps 1 and 2: Write and balance the chemical equation:

Step 3: Convert g Cu to moles Cu:

Step 4: Convert moles of Cu to moles of Ag produced:

Step 5: Convert moles Ag to grams of Ag produced:

Step 6: If silver metal sells for %4.50/ounce, could you get rich from this lab? (How much would it be worth?) Conversion factor: (1 gram = 0.0353 oz)

Extra: Try writing this entire stoichiometric process on one line. Remember to cancel out all necessary units!

Introduction to Stoichiometry
HASTI 2003

Objectives:
This lesson will serve as an introduction to reaction stoichiometry. The student will be able to predict the quantities of substances needed or produced in a chemical reaction by using stoichiometric relationships.

Prior Skills to Review:
- Writing chemical formulas
- Writing and balancing chemical equations
- Mole/Mass conversions
- Molar Mass determination
- Molar ratios in a chemical reaction

Lesson Extensions
- Calculate quantity of a substance produced or needed in a reaction given a balanced equation and a certain quantity of another substance in a reaction.
- Perform a chemical reaction in lab between a known amount of sodium bicarbonate and excess acetic acid. Determine theoretical yield, actual yield, and percent yield of the sodium chloride produced. Report data and calculations on a lab report and be able to make the same calculations on a new data set.

Connections:

The Nature of Chemical Change

C.1.9 Describe chemical reactions with balanced chemical equations.

C.1.12 Demonstrate the principle of conservation of mass through laboratory investigations.

C.1.12 Use the principle of conservation of mass to make calculations related to chemical reactions. Calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.

The most fun part of this lesson is when the students get to turn in their problem and then receive the material to make their own s'mores. You may wish to let them make the s'more then place it in the microwave for 15-20 seconds. Be careful of it tipping over. This is a really boring way to do it, however, compared to letting them roast their marshmallows over a Bunsen burner. This is an activity your students will talk about when they see you years down the road. Why not let one of their fondest chemistry memories be about "S'more Stoichiometry"?

THE STOICHIOMETRY OF S'MORES

Written by Amy Rowley and Jeremy Peacock

Annotation

In this activity, students will explore the principles of stoichiometry by building S'mores, the delicious, chocolate, marshmallow, and graham cracker treats.

Primary Learning Outcome:

Students will be able to identify and demonstrate the Law of Conservation of Matter.

Students will be able to write and balance a chemical equation for a synthesis reaction.

Students will be able to define and identify the limiting reactant of a reaction.

Students will be able to solve stoichiometry problems relating mass to moles and mass to mass.

Assessed GPS:

SPS2. Students will explore the nature of matter, its classifications, and its system for naming types of matter.

d. Demonstrate the Law of Conservation of Matter in a chemical reaction.

e. Apply the Law of Conservation of Matter by balancing the following types of chemical equations:

• Synthesis

SC2. Students will relate how the Law of Conservation of Matter is used to determine chemical composition in compounds and chemical reactions.

a. Identify and balance the following types of chemical equations:
  • Synthesis

d. Identify and solve different types of stoichiometry problems, specifically relating mass to moles and mass to mass.

e. Demonstrate the conceptual principle of limiting reactants.

Duration:

Preparation: 15 minutes
Pre-Lab: 10 minutes
Laboratory Assignment: 30 minutes
Post-Lab: 10 minutes
Total Class Time: 50 minutes

Materials and Equipment:

For Teacher Preparation:

1. Hershey's Chocolate bars
2. Marshmallows (large)
3. Graham crackers

4. Paper plates

Per Class:

1. Electronic balance(s)

Per Group:

1. 1 Paper plate containing 1 Hershey's Chocolate bar, 6 marshmallows, and 5 graham crackers
2. Napkins

Safety:

Because students will be allowed to eat their S'mores at the end of the activity, precautions should be taken to prevent materials from coming into contact with lab equipment or surfaces. Materials should remain on paper plates or on clean napkins at all times. Napkins can be used as weighing paper while weighing materials on the balance.

Technology Connection:

Not applicable.

Procedures:

Teacher Preparation:

For each group, prepare a plate containing 1 Hershey's Chocolate bar, 5 marshmallows, and 4 graham crackers.

Estimated Time:

15 minutes

Pre-Lab:

Provide students with the *Stoichiometry of S'mores* student handout. Introduce them to the lab activity by reviewing the student handout, as well as the basic concepts of stoichiometry and limiting reactants. Explain to students that in this activity each of the S'mores ingredients, chocolate square (C), marshmallow (M), and graham cracker (G), represent an element on the periodic table. Graham cracker represents a diatomic element, always found in pairs, and should therefore be represented as G_2. Explain to students that they are to write and balance a synthesis reaction for the formation of a S'more, in which they can choose any size of each of the ingredients to use when making the S'mores. Therefore, it is likely that students will have different molecular formulas for their S'more. Further, explain to students that they must determine the limiting reactant in their S'mores reaction.

Estimated Time: 10 minutes

Laboratory Assignment:

Students should follow procedures outlined in the attached *Stoichiometry of S'mores* student handout.

Estimated Time:
30 minutes

Post-Lab:
Perform with students a sample calculation, if needed. Collect handouts and review answers to post-lab and extension questions. Answer any student questions pertaining to lab activity. Once the laboratory activity is complete, students may eat their S'mores and remaining ingredients.

Estimated Time:
10 minutes

Assessment:
Assessment should be based on completion of the *Stoichiometry of S'mores* student handout.

Name:

Date:

Class Period:

THE STOICHIOMETRY OF S'MORES
Student Handout

Introduction:
In this laboratory experiment, you will explore the principles of stoichiometry by building S'mores, the delicious, chocolate, marshmallow, and graham cracker treats.

Purpose:
To determine the limiting reactant in the synthesis of S'mores.

Materials:
Per Group:
1. 1 Chocolate bar
2. 6 Marshmallows
3. 5 Graham crackers
4. Paper plate
5. Napkins
6. Electronic balance

Procedures / Data:
The following symbols will be used for each reactant.

C = chocolate square
M = marshmallow
G = graham cracker

1. Mass and record one of each reactant.

   Chocolate square (the size you wish to use on each S'more): ________ g

   Marshmallow: ________ g

   Graham cracker (the size you wish to use on each S'more): ________ g

2. Perform a **synthesis reaction**, thus forming a S'more. Write the balanced equation for the reaction below.

3. Cause the reaction to go to completion by forming as many of the products as you possibly can. Mass and record **ONE** of the representative products.

S'more: ________ g

4. Count and record the number of products you were able to form. ________

Post-Lab Questions:

1. Is there a relationship between the mass of a S'more and the masses of the reactants used to make it? If so, what is the relationship? What law have you studied in this course that might define this relationship?

2. A limiting reactant is the material responsible for a reaction reaching completion. In the reaction, what was the limiting reactant?

3. What reactants, if any, were in excess? Mass and record the total of each excess reactant.

Extension Questions:

1. How many S'mores could you make if you had started with 100g of each reactant?

2. What would be the limiting reactant?

3. How much of each excess reactant would result?