SCH3U Quantitative Chemistry	# Limiting Reagent LAB

Objective: This lab allows students, through experimentation, to determine the stiochiometric ratio of reactants that generate a gas.

Equipment and Materials: 60 mL Vinegar, 5g sodium bicarbonate, 6 balloons, 6 test tubes, 10 mL graduated cylinder, test tube rack, ruler, funnel

Safety: Goggles must be worn **&** Hold the balloons on the test tubes tightly while the reaction takes place.

Procedure:

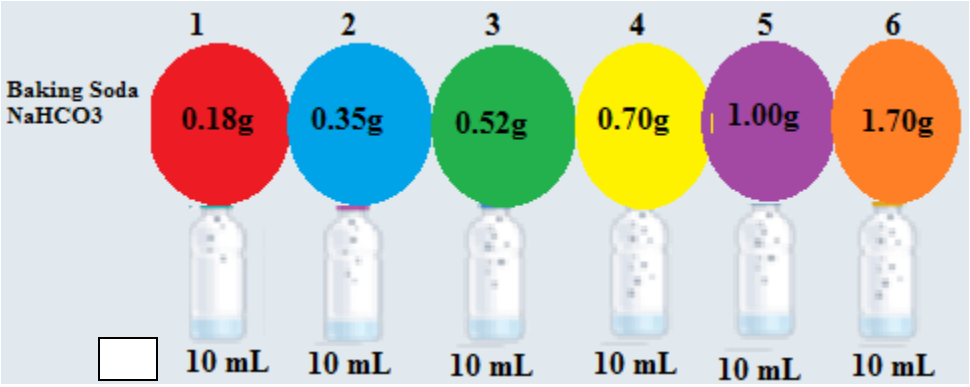
1. You will be working in teams of four – each team member will have specific jobs to do – all members will do the calculations. Decide who will be letters A, B, C, & D. Follow the directions below:

Student A: Weigh the following six amounts of baking soda (sodium bicarbonate, $NaHCO_3$): 0.18 grams, 0.35 grams, 0.52 grams, 0.70 grams, 1.00 grams, and 1.70 grams.

Student B: Label the balloons 1-6. Put the six different masses of baking soda into six balloons using a small plastic funnel. Make sure the baking soda goes to the bottom of the balloon.

Student C: Using the graduated cylinder and pipette, accurately measure and transfer 10.0 mL vinegar (5% acetic acid, $HC_2H_3O_2$) into each of the 6 test tubes. This volume contains **8.3×10^{-3} moles.**

Student D: Attach the filled balloons to the mouth of the test tubes. Make sure that the contents of the balloon and test tube are not mixed.



2. Before mixing the contents of the balloons and test tubes, **make a prediction**

Prediction:_____
_____
_____

3. After the balloons are securely attached to the test tubes, each group member needs to lift a balloon on one of the test tubes so that the contents of the balloon mix with the test tube contents. **Make sure the balloons are held on tightly to the test tube**. **All six test tubes should be reacted simultaneously**.
4. Observe, paying special attention to the size of the balloons after the reactions. You can measure the diameter of each balloon. Hold a ruler horizontally and measure the largest diameter across each balloon, being careful not to change the shape of the balloon
5. Record your observations for each test tube on the table below

Balloon #	**1**	**2**	**3**	**4**	**5**	**6**
Diameter of Balloon (mm)						

Observations

Data Analysis

1. Does each balloon inflate to some degree? Why?
2. Make a graph of the diameter vs. balloon number. Make balloon number the independent variable.
3. Use your observations and the graph to compare the degree to which each balloon inflated.
4. What does the degree of inflation of the balloon tell you about the reactions in the test tube?
5. What is the pattern of inflation in test tubes 1-4?
6. Noting that in these three test tubes the mass of bicarbonate increases, what effect does this have on the reaction?
7. What is the pattern of inflation in test tube 4-6?
8. Noting that in these four test tubes the mass of bicarbonate increases, what effect does this have on the reaction?

Extension Questions:

1. Calculate the number of moles of bicarbonate and acetic acid (vinegar) in each test tube in the inquiry activity. Using the following information. Assume that the density of the vinegar is 1.0 g/mL and that the solution is 5% acetic acid. The molar mass of acetic acid is 60 g/mL and the molar mass of sodium bicarbonate is 84 g/mol.

Test tube	Moles of Acetic Acid	Moles Sodium Bicarbonate
1		
2		
3		
4		
5		
6		

2. What is the mole ratio of Sodium Bicarbonate to acetic acid in test tube #4?
3. Write the balanced equation for the reaction that takes place in each test tube.
4. How does the vinegar-bicarbonate mole ratio in the test tube #4 fit into the equation you wrote?
5. The mass of $NaHCO_3$ increases in each of the test tube. Does this follow the inflation pattern shown in your graph? If not, how do you account for the difference? [Hint; discuss limiting reactants]

Application question:

How do you make a bicycle? Obviously, many specific parts must be assembled. Bike manufacturers must keep careful watch over their inventory during the production process. They must ensure that they have a minimum quantity of each bicycle parts available at all times. If they run out one part the manufacturing process stops. At the same time it is too costly to maintain a large oversupply of parts. Similarity, chemical manufacturers must maintain careful inventory of the reactants used in a chemical process. For example, extracting pure titanium from the ore is complicated and costly. The final step in the process is: $TiCl_4(g) + 2\ Mg_{(l)} \rightarrow Ti_{(s)} + 2\ MgCl_{2(l)}$

If only 0.5 g $TiCl_4$ and 0.5 g Mg are present, what is the mass of the titanium metal produced? In practice, which material limits the amount of titanium metal produced?

<u>Post lab calculations:</u> Answer the following questions and complete the table below. **[7 marks]**

1. **[1 mark]** Write the balanced molecular equation for the reaction that takes place during this lab. Highlight/circle the identity of the gas that inflated the balloons? _____
2. **[3 marks]** Find the number of moles of **baking soda ($NaHCO_3$)** used in each reaction and show your work below.
3. Decide which chemical is the limiting reagent in each test tube reaction and therefore how many moles of carbon dioxide were produced in each flask. Record your data below.
4. **[3 marks]** From the limiting reagent, find the mass of carbon dioxide produced. Show your work below.

Data table:

Test tube #	Mass of sodium bicarbonate	Moles of sodium bicarbonate(baking soda)	Moles of acetic acid	Name of the LR or Excess reagent?	Moles of CO_2 produced?	Grams of CO_2 produced?
1	0.18 g	0.0021 mol	8.3×10^{-3} mol	Baking soda	0.0021 mol	0.924 g
2	0.35 g	0.0042 mol	8.3×10^{-3} mol	Baking soda	0.0042 mol	0.1848 g
3	0.52 g	0.0062 mol	8.3×10^{-3} mol	Baking soda	0.0062 mol	0.2728 g
4	0.70 g	0.00833 mol	8.3×10^{-3} mol	---	0.00833 mol	0.36652 g
5	1.00 g	0.0119 mol	8.3×10^{-3} mol	Acetic acid	0.00833 mol	0.36652 g
6	1.71 g	0.02024 mol	8.3×10^{-3} mol	Acetic acid	0.00833 mol	0.36652 g

Post lab discussion question: