Lab Activity H12
The Baking Soda Volcano Reaction

OUTCOMES

After completing this lab activity, the student should be able to:
- find the actual, theoretical, and percentage yields for a given reaction.
- explain the concept of limiting reactant.

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DISCUSSION

Many of you have likely seen or performed a reaction between baking soda and vinegar before. Frequently referred to as a volcano reaction, since large amounts of gas are produced when the two materials are quickly mixed together in large proportions, the chemical reaction between baking soda and vinegar is the reaction many kids first see or remember in their elementary school science experience.

Sodium bicarbonate, the chemical name for baking soda, is used as a leavening agent in many recipes. A leavening agent is a substance that causes a dough or batter to rise, giving it more volume and a lighter or fluffier texture. Baking soda does this by releasing bubbles of carbon dioxide gas that get trapped in the dough or batter caused simply by heating in an oven or deep fryer, and often enhanced by adding a slightly acidic ingredient (such as vinegar or buttermilk) that reacts with the baking soda to produce the bubbles.

Baking soda is a very environmentally friendly chemical that has many other uses. While an internet search will undoubtedly turn up many other uses for baking soda, here are some of the other ways the author has used baking soda:

- Scrubbing toilets, bathtubs, and showers, especially to remove soap scum.
- Placing an open box in the refrigerator to remove odors.
- Filling and emptying stinky shoes to freshen them up.
- Adding to loads of laundry to remove musty smells from towels or other items.
- Removing corrosion from car battery terminals by dipping a damp toothbrush into baking soda and scrubbing.
- Throwing a box into a wood stove to extinguish a chimney fire, since heating baking soda releases carbon dioxide – found in many fire extinguishers.
- Removing baked on grease and splatters that form around stove top burners. When heated, baking soda becomes more basic making it effective for this purpose.
- Consuming a small amount dissolved in a glass of water – see baking soda box for directions – though one must remain upright to burp out the carbon dioxide gas generated when ingested to avoid a large buildup of gas in the stomach.

Acetic acid (IUPAC name – ethanoic acid) is the acid found in vinegar. Acetic acid may be produced through the oxidation of ethanol found in wine, beer, or fermented fruit juice. For this reason, limiting the exposure of wine to air prevents it from taking on the taste of vinegar.

Vinegar is also an environmentally friendly chemical with many uses. Uses by the author include lowering the pH of soil for various growing applications, cleaning lime deposits around faucets and shower heads, cleaning toilets, soaking glassware to remove dull film and restore luster, and running through an empty dishwasher to remove caked on soap and scraps of food. Once again, an internet search will turn up many other uses.

The balanced chemical equation for the reaction between baking soda and vinegar is:

$$NaHCO_3 \ (s) + HC_2H_3O_2 \ (aq) \longrightarrow NaC_2H_3O_2 \ (aq) + H_2O \ (l) + CO_2 \ (g)$$

In this lab, the combined mass of baking soda and vinegar will be measured before and after reacting them together. The difference in the two masses will yield the mass of carbon dioxide produced in the reaction. The actual mass of carbon dioxide measured in this experiment should be less than the theoretical mass of carbon dioxide calculated, due to the solubility of carbon dioxide in water (1.8 g/L at 20°C).

MATERIALS (Provided By Student)
Baking **Soda** (**not** baking powder)
Spoon
White Vinegar (5%) - 1000 mL (1 L needed)

MATERIALS (From Kit)
Beral pipet
Electronic Balance
Graduated cylinder - 100 mL
Plastic cup
Portion cup, translucent
Safety Goggles/Safety Glasses

REQUIRED PHOTO: Includes your <u>face</u> and/or clearly shows a <u>Picture I.D.</u> (with name), with all of the materials used in this lab visible.

PROCEDURE

1. Turn on and tare the electronic balance. Place an empty plastic cup onto the electronic balance. Measure and record the mass into **column (A)** of the data table.

2. To avoid damaging the balance, remove the cup from the balance. Use a graduated cylinder to add 75 mL of vinegar to the plastic cup. Place the cup back onto the balance. Use a dropper to add or remove vinegar to bring the mass of vinegar in the cup to exactly 75.0 g, taking into consideration the mass of the cup. Record the combined mass of the cup and vinegar into **column (C)** of the data table.

> **Example:** If the cup has a mass of 6.8 g, then exactly 75.0 g of vinegar added to the cup would bring the combined mass of the cup and vinegar to 81.8 g.

3. Remove the cup containing the vinegar and place a portion cup onto the balance. Measure and record the mass of the portion cup into **column (D)** of the data table.

4. Using a spoon, add the exact mass of baking soda shown in **column (E)** of the data table to the portion cup for the respective trial, remembering to take into consideration the mass of the cup. Record the combined mass of the portion cup and baking soda into **column (F)** of the data table.

5. Sum together the masses found in **columns (C)** and **(F)** to find the combined mass of both cups and both reactants before the chemical reaction. Record the sum into **column (G)** of the data table.

6. Remove the portion cup from the balance. Without spilling, slowly pour the baking soda into the cup containing the vinegar in small portions. As the baking soda is added, gas bubbles will form and the mixture will begin to foam up. Do not allow the foam to rise higher than ½ to ¾ the height of the cup to prevent loss of any liquid.

> Before adding additional portions of baking soda, it is best to allow the foam to settle and disappear. Otherwise, the baking soda may rest on the surface of the foam and fall into the vinegar at once causing the mixture to foam over.

7. Once the reaction is complete, allow a few minutes for most of the bubbling to cease. Without emptying the contents of the cup holding the reaction mixture, **place <u>both</u> of the cups onto the balance**. If necessary, the portion cup may rest on its edge or be lowered into the larger plastic cup. Record the combined mass of the cups and contents into **column (H)**.

   REQUIRED PHOTO: Includes the <u>date</u> clearly shown on a calendar, newspaper, cell phone, or written on a sheet of paper, with both cups on the balance and the mass displayed on the balance visible in the photo.

8. Calculate the mass of carbon dioxide produced by subtracting the total mass of the cups and reactants **after** the reaction from the total mass of the cups and reactants **before** the reaction. That is, subtract **column (H)** from **column (G)**. Record the mass of carbon dioxide produced into **column (I)** of the data table.

9. Empty the reaction mixture down the drain and rinse the cup with water. Dry the cup with a paper towel. Also, use a dry paper towel to wipe the inside of the portion cup clean and dry.

10. Repeat steps 1-9, increasing the mass of baking soda used in each subsequent trial as shown in **column (E)** of the data table, until all ten trials have been completed.

11. Repeat any suspect trials or trials in which any of the reaction mixtures were spilled or foamed over.

Name_____   Lab Section_____

1. What is the chemical name for baking soda? What is its chemical formula?

2. What are two different names for the acid found in vinegar? What is the chemical formula
    for the acid?

3. Which gas is produced in the reaction between baking soda and vinegar? How should the
    total mass of baking soda and vinegar compare AFTER they are mixed to their total mass
    BEFORE the two are mixed?

4. Thinking beyond this lab activity, what is a limiting reactant, in your own words?

5. Given the balanced equation for the reaction between baking soda and vinegar,

- What mass of carbon dioxide is expected when 3.0 g of baking soda reacts with an excess of acetic acid?

- What mass of carbon dioxide is expected when 4.0 g of baking soda reacts with an excess of acetic acid?

- Show the work/setup used to calculate the answers.

6. Which safety precautions, if any, must be observed during this lab activity?

PHOTOS - Please compress photos and save your file **before** uploading to the dropbox. Photos should come close to filling the boxes below and all required items should be **clearly visible**.

Required Photo 1:

Required Photo 2:

Name_____   Lab Section_____

DATA

Trial	(A) Mass of Plastic Cup (g)	(B) Mass Vinegar (g)	(C) Mass of Vinegar and Plastic Cup (g)	(D) Mass of Portion Cup (g)	(E) Mass of Baking Soda (g)	(F) Mass of Baking Soda and Portion Cup (g)	(G) Total Mass BEFORE the reaction (g)	(H) Total Mass AFTER the reaction (g)	(I) Mass of CO_2 produced (g)
1		75.0			1.0				
2		75.0			2.0				
3		75.0			3.0				
4		75.0			4.0				
5		75.0			5.0				
6		75.0			6.0				
7		75.0			7.0				
8		75.0			8.0				
9		75.0			9.0				
10		75.0			10.0				

POSTLAB QUESTIONS

1. Using the graph paper supplied on page H12.12, Microsoft *Excel*, or Vernier *LoggerPro*, prepare a graph in which the mass of CO_2 produced for each trial (column I) is plotted against the mass of baking soda used (column E) in that trial. Label the axes and draw a **best-fit line**, **best-fit curve**, or combination of **best-fit lines/curves**. This graph **may** require two best-fit lines. Using the graphing fundamentals learned in an earlier lab (**no bar graphs**), place the variables on the correct axis and have the values increase in the proper direction.

2. If your data is correct, the effect of limiting reactants on the shape of the graph should easily be noticed.

   a) Circle or color code the portion of the graph in which sodium bicarbonate is the limiting reactant. Label this portion of the graph with the letter **A**.

   b) Circle or color code the portion of the graph in which acetic acid is the limiting reactant. Label this portion of the graph with the letter **B**.

   c) Explain your answers to parts (a) and (b).

3. a) What were the actual masses of carbon dioxide produced in this experiment when 3.0 g of baking soda were reacted with vinegar and when 4.0 g were reacted?

   b) Using the answers from (a) and the theoretical yields calculated in PreLab Question #5, what was the percentage yield when 3.0 g of baking soda were reacted with vinegar and when 4.0 g of baking soda were reacted? Show the work/setups used to calculate each answer.

4. Assuming that the vinegar used in this lab was 5% acidity, 75 g of vinegar contains 75 g × 0.05 = 3.8 g acetic acid (or 4 g with one significant figure).

   a) Using the balanced chemical equation given in the discussion, what mass of baking soda would completely react with 3.8 g acetic acid? Show the work/setup used to calculate the answer.

   b) How does this answer help explain the shape of your graph?

Lab Report Submission Checklist

Complete the appropriate checklist and **submit this page** along with your lab activity.

Lab Activity Submitted Via the D2L Dropbox

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos of the procedure included.	
	At least one photo shows face or photo I.D. At least one photo clearly shows the date.	
	Document filename in format of **Lastname Firstname HX**.	
	File size is no larger than 10 MB.	
	Only one document submitted for this lab activity.	
	Lab submitted on time.	
		If late, this is your first extension.

Lab Activity Submitted Via the US Postal Service or In Person

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos (at least one showing face or photo I.D.; at least one shows the date) of the procedure or a tangible artifact or product from the lab activity is included.	
	If return is desired, a self-addressed stamped envelope **with sufficient postage** is included*.	
	Lab submitted on time (postmarked by due date if sent via USPS).	
		If late, this is your first extension.

*You may find a postage calculator at http://postcalc.usps.gov. Use the balance in your kit to find the weight.

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