

Plop, Plop, Fizz, Fizz, Limiting Reagent and Determination of NaHCO_3 in Alka Seltzer Tablets

Introduction

The extent of a chemical reaction is determined by the amount of reacting materials, or reactants, present in the reacting system. Reagents are generally not mixed in exact amounts needed for the reaction to take place, there is usually one of the reacting materials added in excess. The excess reagent, usually a non-critical reagent or an inexpensive material, is used to insure that all of the critical reagent is used up so that there will be a maximum amount of product formed. Also, an excess of one reactant can cause the overall reaction to take place at a faster rate. Once the critical reactant is used up, the reaction will stop. That critical reactant is called the *limiting reagent*, that is, it is the reactant in the chemical reaction that is used up first.

Alka Seltzer, and similar over-the-counter combination antacid and pain relief medications, contain aspirin (acetylsalicylic acid), citric acid, and NaHCO_3 as the active ingredients. This medication is designed to be taken by dissolving it in water before ingesting. When the tablet is placed in water, an acid-base reaction involving sodium bicarbonate and the citric acid takes place resulting in the generation of carbon dioxide which is visible by active bubbling of the mixture. The carbon dioxide, from the reaction, escapes into the atmosphere and results in a weight loss from the total mass of the reactants. Using the loss in mass, one can calculate the amount of sodium bicarbonate reacted, and determine the percent by mass of NaHCO_3 contained in Alka Seltzer tablets.

In this experiment, the Alka Seltzer tablets will be reacted with differing amounts of acetic acid, $\text{HC}_2\text{H}_3\text{O}_2$, to produce the carbon dioxide. From the data, and graph of the data, the mass of the sodium bicarbonate in the Alka Seltzer tablets can be calculated, and the identity of the limiting reagent can be determined.

Safety

Goggles or safety glasses must be worn at all times in the laboratory

The chemicals used in this experiment do not pose any hazards. Vinegar, 5% acetic acid, is not harmful, however, in the event of skin contact, wash the affected area with water.

Do not drink any of the Alka Seltzer solutions or use any of the laboratory supplied tablets for medication. Even if the tablets are sealed in foil wrappers, they cannot be assumed free of laboratory chemical contamination.

Disposal

Dispose of all materials in the proper waste containers as provided in the laboratory.

Materials Needed

- 8 tablets, Alka Seltzer Tablets (Bayer Corporation) or generic equivalent
- Acetic acid, 4.5 to 5% (vinegar)
- 2 250 mL beakers

10 mL graduated cylinder
50 mL graduated cylinder
glass stirring rod

PROCEDURE

Measure 35 mL of water into a 250 mL beaker. Weigh the beaker and water and record the mass.

Weigh and record the mass of an Alka Seltzer tablet.

Place the Alka Seltzer tablet into the water in the 250 mL beaker.

When the bubbling has ceased, stir the solution to ensure complete dissolution of the tablet and to remove any visible bubbles of carbon dioxide. Gently tap the stirring rod against the inside of the beaker to remove any drops of liquid before weighing the beaker and its contents.

Weigh the beaker and its contents. Record the mass.

Dispose of the solution in the beaker as instructed. Wash the beaker and rinse it with distilled or deionized water.

Repeat the experiment using 5 mL of acetic acid (vinegar) and 30 mL of water in the 250 mL beaker. NOTE: once the reaction has started, you may use a second 250-mL beaker to run the next trial in the experiment. You can continue to alternate beakers, running the additional experiments in simultaneous, but staggered trials. Be sure to keep track of the mass of each beaker used, as the exact mass of each beaker is different.

Repeat the experiment a third time using 10 mL acetic acid (vinegar) and 25 mL of water in the 250 mL beaker.

Continue to repeat the experiment 5 more times increasing the volume of the acetic acid by 5 mL and decreasing the volume of water by 5 mL for each new trial as indicated in Table 1.

Table 1. Composition of reaction solutions

Exp. No.	Volume of acetic acid, mL	Volume of Water mL
1	0	35
2	5	30
3	10	25
4	15	20
5	20	15
6	25	10
7	30	5
8	35	0

CLEAN UP

Clean up all glassware with soapy water. Rinse well before returning it to your laboratory drawer or locker.

Clean up your work area. Discard all papers and wrappers from the Alka Seltzer in the trash.

CALCULATIONS AND RESULTS

Write the balanced chemical equation for the reaction of NaHCO_3 (Alka Seltzer) and acetic acid.
Calculate the mass of carbon dioxide generated for each of the trials.
Calculate the mass of NaHCO_3 reacted for each of the trials.
Calculate the percent by mass of NaHCO_3 in each tablet of Alka Seltzer.
Calculate the average percent of NaHCO_3 in the Alka Seltzer tablets.
Use *Microsoft Excel*, on a laboratory computer, to plot the percent by mass of the reacted NaHCO_3 in each tablet versus the volume of vinegar used. Print the graph and include it with your laboratory report.

REFERENCE

Chen, Yueh-Huey, and Jing-Fun Young, *Alka Seltzer Fizzing – Determination of Percent by Mass of NaHCO_3 in Alka Seltzer Tablets*, **J. Chem. Educ.**, **79**, (July 2002), 848-850.

REPORT FORM

Plop, Plop, Fizz, Fizz, Limiting Reagent and Determination of NaHCO_3 in Alka Seltzer Tablets

Name _____ Course/Section _____

Partner's Name (if applicable) _____ Date _____

DATA AND RESULTS

Exp. No.	Volume of Acetic acid mL	Volume of Water mL	Mass of beaker and liquid g	Mass of Alka Seltzer tablet g	Total mass of beaker and contents before reaction g	Total mass of beaker and contents after reaction g	Mass of CO_2 (loss of mass) g	Mass of NaHCO_3 in tablet g	% of NaHCO_3 in tablet %
1									
2									
3									
4									
5									
6									
7									
8									

CALCULATIONS

Write the balanced chemical equation for the reaction of NaHCO_3 (Alka Seltzer) and acetic acid.

Show the sample calculations for one trial of the experiment. (One row of the data table on the preceding page.)
Label each step of the calculations clearly.

What is the average percent of NaHCO_3 in Alka Seltzer tablets? _____

%

Show your calculation in the space below.

Use *Microsoft Excel*, on a laboratory computer, to plot the percent by mass of the reacted NaHCO_3 in each tablet versus the volume of vinegar used. Print out the graph and include it with your laboratory report.

QUESTIONS

1. This reaction only requires 35 mL of liquid. Why is the reaction run in a 250 mL beaker?
2. The Alka Seltzer tablet contains citric acid which causes it to react in pure water. Why is acetic acid added to the reaction?
3. Why must the mixture in the beaker be stirred after reaction is completed?
4. Using the graph of reacted NaHCO_3 versus the volume of vinegar, which is the limiting reactant. Explain your answer.
5. Why does the percent of NaHCO_3 vary in the different Alka Seltzer tablets?
6. Carbon dioxide dissolves in water and water evaporates into the atmosphere during the experiment. How do these two factors affect the results of your analysis in this experiment?