



## **ANTACID AND UNCLE HEARTBURN**

Written by Amy Rowley and Jeremy Peacock

### **Annotation:**

Students will design an experiment, using their knowledge of acids and bases, to test the relative effectiveness of over-the-counter antacids.

### **Primary Learning Outcome:**

Students will be able to design and follow a laboratory procedure.

Students will be able to identify common substances as acids or bases.

Students will be able to relate acid-base neutralization to changes in pH.

Students will be able to relate concepts of acids and bases to commonly encountered applications

Students will be able to communicate scientifically the procedures and results of the exercise.

### **Georgia Performance Standards:**

#### *Characteristics of Science*

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

SCSh3. Students will identify and investigate problems scientifically.

SCSh6. Students will communicate scientific investigations and information clearly.

SCSh8. Students will understand important features of the process of scientific inquiry.

#### *Physical Science Content*

SPS6. Students will investigate the properties of solutions.

#### *Chemistry Content*

SC7. Students will characterize the properties that describe solutions and the nature of acids and bases.

### **Duration:**

Preparation: 30 minutes

Introduction: 15 minutes

Laboratory Exercise: 50 minutes

Discussion: 25 minutes

**Total Class Time: 90 minutes**

## **Materials and Equipment:**

### For Teacher Preparation:

1. White vinegar
2. Mylanta® Regular Strength Original Liquid Antacid
3. Generic Regular Strength Original Liquid Antacid
4. Generic Maximum Strength Original Liquid Antacid
5. 5-oz. Plastic cups

### Per Laboratory Group:

1. 5 mL Vinegar
2. 5 mL Mylanta® Regular Strength Original Liquid Antacid
3. 5 mL Generic Regular Strength Original Liquid Antacid
4. 5 mL Generic Maximum Strength Original Liquid Antacid
5. 4 Plastic pipettes
6. pH indicator strips
7. 1 Sheet of wax paper
8. 3 Toothpicks

## **Safety:**

The acids and bases used in this laboratory are common household weak acids and weak bases. Liquids should not be ingested.

## **Technology Connection:**

Not applicable.

## **Procedures:**

### Teacher Preparation:

Label cups as Mylanta®, Generic Regular Strength, Generic Maximum Strength, and Vinegar. Pour approximately 5 mL of each solution into the appropriate cups. Prepare one set of cups per laboratory group. Assemble the remainder of the supplies.

### Introduction:

Hydrochloric acid is essential in the stomach for the proper digestion of foods. Acid hydrolysis is the first step in the chemical breakdown of many foods. However, excess acid may cause discomfort and eventually lead to a break down of the stomach walls and the formation of ulcers. Antacids are bases that may be taken to neutralize stomach acid and reduce the associated discomfort. The most widely used antacids are carbonates and bicarbonates, including magnesium carbonate ( $\text{MgCO}_3$ ), calcium carbonate ( $\text{CaCO}_3$ ), and sodium bicarbonate ( $\text{NaHCO}_3$ ). Of these compounds, sodium bicarbonate, also known as baking soda, is the most popular. Sodium bicarbonate dissolves easily, making it effective in a short amount of time. However, if sodium bicarbonate is consumed in excess, it can pass into the intestine and be absorbed into the bloodstream where it may disturb the body's acid-base equilibrium. Aluminum hydroxide ( $\text{Al}(\text{OH})_3$ ), magnesium hydroxide ( $\text{Mg}(\text{OH})_2$ ), and magnesium oxide ( $\text{MgO}$ ) are other active ingredients found in antacids. Because these compounds, along with magnesium carbonate and calcium carbonate, do not dissolve easily, they are less likely to be absorbed into the bloodstream and are preferable to sodium bicarbonate.

Introduce students to the antacids to be used in the laboratory exercise: Mylanta® regular strength, a generic regular strength, and a generic maximum strength. The active ingredients in these antacids are insoluble metallic hydroxides of aluminum and magnesium.

Explain to students that their assignment will be to determine the relative effectiveness of the three antacids. Review the materials provided. Based on their knowledge of acid-base chemistry, students should use the available materials to develop a procedure that will allow them to determine the relative effectiveness of the three antacids. Stress to students that they should develop a clear plan for their procedure before beginning, because the available materials are limited. Guide students through the development of the procedures, as needed. All procedures should be approved before students begin the exercise.

#### Laboratory Exercise:

Students should obtain the provided materials. Students should use any available equipment to develop and perform a procedure to determine whether there is a difference in the effectiveness of the three antacids. Students should complete a laboratory report in their laboratory notebooks following the outline provided in the attached rubric. Student procedures may vary, but it is anticipated that the basic steps will involve placing several drops of vinegar on the wax paper at three locations. Each of the antacids can then be added, drop-wise, to the vinegar. After addition of each drop, the solutions can be stirred with a toothpick and the pH of the mixture checked with an indicator strip. In this simple titration setup, the antacid that is able to neutralize the vinegar with the fewest drops is the most effective.

#### Discussion:

Have each group present to the class their procedures and results. As a class, discuss the methods chosen, the reason each was selected, and the results obtained. During the discussion, review the definitions of acids, bases, pH, neutralization, and titration. *Note: This activity may serve as an introduction to titrations and acid-base neutralization and may provide a foundation for further experiments.*

#### **Assessment:**

Assessment should be based on the attached rubric as well as on completion of the post-laboratory and discussion questions.

#### Post-Laboratory Questions:

Students should answer the following questions based on the data collected during the exercise:

- Identify all acids and bases used in this experiment.
  - What is the definition of an acid?
  - What is the definition of a base?
- Using the pH values observed during this experiment, provide an explanation of neutralization.
  - What are the reactants of a neutralization reaction?
  - What product is formed in all neutralization reactions?
- Identify sources of uncertainty in this experiment.

b. What procedures and/or materials might you change to improve the experiment?

Discussion Questions:

- Magnesium hydroxide,  $\text{Mg}(\text{OH})_2$  is the active ingredient of some antacids. Hydrochloric acid,  $\text{HCl}$ , is the acid found within the stomach. How does  $\text{Mg}(\text{OH})_2$  work to relieve the pain caused by excess stomach acid?
  - Write the equation for the neutralization reaction of this acid/base pair.
- Provide a possible explanation as to why one antacid may be more effective than another.

**ANTACID AND UNCLE HEARTBURN** *Scoring Rubric*

| <b>CRITERIA</b>                   | <b>4</b>   | <b>3</b>   | <b>2</b>   | <b>1</b>   | <b>SCORE</b>       |
|-----------------------------------|--|--|--|--|--------------------|
| <b>Introduction</b>               | Introduction is a clear, concise, and thoughtful explanation of the claim to be tested and any needed background information. The purpose of the experiment or the question to be answered during the experiment is clearly identified and stated. | Introduction is a brief explanation of the claim to be tested and any needed background information. The purpose of the experiment or the question to be answered during the experiment is identified, but is stated in a somewhat unclear manner. | Introduction is too brief, unrelated to the experiment, or provides little or no background information. The purpose of the experiment or the question to be answered during the experiment is partially identified, and is stated in a somewhat unclear manner. | Introduction is missing or shows little effort. The purpose of the experiment or the question to be answered during the experiment is erroneous or irrelevant. | _____<br>Comments: |
| <b>Materials &amp; Procedures</b> | All materials and equipment used in the experiment are clearly and accurately described. Procedures are listed in clear steps. Each step is numbered and is a complete sentence.   | Almost all materials and equipment used in the experiment are clearly and accurately described. Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.   | Most of the materials and equipment used in the experiment are accurately described. Procedures are listed but are not in a logical order or are difficult to follow.  | Many materials are described inaccurately OR are not described at all. Procedures do not accurately list the steps of the experiment.                          | _____<br>Comments: |
| <b>Experimental Design</b>        | Experimental design is a well-constructed test of the stated hypothesis.   | Experimental design is adequate to test the hypothesis, but leaves some unanswered questions.  | Experimental design is relevant to the hypothesis, but is not a complete test.   | Experimental design is not relevant to the hypothesis.   | _____<br>Comments: |
| <b>Replicability</b>              | Procedures appear to be replicable. Steps are outlined sequentially and are adequately detailed.   | Procedures appear to be replicable. Steps are outlined and are adequately detailed.  | All steps are outlined, but there is not enough detail to replicate procedures.  | Several steps are not outlined AND there is not enough detail to replicate procedures.   | _____<br>Comments: |

|                   |   |   |  |  |                    |
|-------------------|---|---|--|--|--------------------|
| <b>Safety</b>     | Experiment is carried out with full attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual.          | Experiment is carried out with attention to relevant safety procedures. The experiment posed no safety threat to any individual, but one safety procedure needs to be reviewed.   | Experiment is carried out with some attention to relevant safety procedures. The experiment posed no safety threat to any individual, but several safety procedures need to be reviewed. | Safety procedures were ignored and/or some aspect of the experiment posed a threat to the safety of the student or others. | _____<br>Comments: |
| <b>Data</b>       | Professional looking and accurate representation of the data in tables and/or graphs. Graphs and tables are accurately labeled and titled.                            | Accurate representation of the data in tables and/or graphs. Graphs and tables are accurately labeled and titled.   | Accurate representation of the data in written form, but no graphs or tables are presented.  | Data are not shown OR are inaccurate.  | _____<br>Comments: |
| <b>Analysis</b>   | Answers to analysis questions are clear and accurate. Student demonstrates a thorough understanding of the concepts addressed.  | Answers to analysis questions are clear and accurate. Student demonstrates an understanding of most of the concepts addressed.  | Answers to analysis questions are present. Student demonstrates a limited understanding of the concepts addressed.   | Answers to analysis questions are incomplete or missing.   | _____<br>Comments: |
| <b>Discussion</b> | Answers to discussion questions are clear and accurate. Student demonstrates an accurate and thorough understanding of scientific concepts underlying the experiment. | Answers to discussion questions are clear and accurate. Student demonstrates an accurate and thorough understanding of most of the scientific concepts underlying the experiment. | Answers to discussion questions are present. Student demonstrates a limited understanding of the concepts addressed.   | Answers to discussion questions are incomplete or missing.   | _____<br>Comments: |



|                                 |   |  |  |   |                    |
|---------------------------------|---|--|--|---|--------------------|
| <b>Written Communication</b>    | Lab report follows assigned outline and is written in paragraph form. Writing is clear and free of grammar, spelling, and typographical errors. | Lab report follows assigned outline and is written in paragraph form. Writing is clear and contains no more than 5 grammar, spelling, or typographical errors. | Lab report follows assigned outline and is written in paragraph form. Writing is unclear and/or contains 5 or more grammar, spelling, or typographical errors. | Lab report does not follow assigned outline or is not written in paragraph form. Writing is unclear and contains many grammar, spelling, or typographical errors. | _____<br>Comments: |
| <b>Participation</b>            | Used time well in lab and focused attention on the experiment.  | Used time pretty well. Stayed focused on the experiment most of the time.  | Did the lab but did not appear very interested. Focus was lost on several occasions.   | Participation was minimal OR student was hostile about participating.   | _____<br>Comments: |
| <b>Total Score (out of 40):</b> |   |  |  |   | _____              |

**Additional Teacher Comments:**

## ANTACID AND UNCLE HEARTBURN *Student Handout*

### Introduction

Have you ever had acid indigestion or heartburn? If so, you may have used an over-the-counter antacid to relieve your symptoms. Antacids are bases that may be taken to neutralize stomach acid, primarily hydrochloric acid (HCl), and reduce the associated discomfort.

### Purpose

To determine the relative effectiveness of the three antacids.

### Materials

1. 5 mL Vinegar
2. 5 mL Mylanta® Regular Strength Original Liquid Antacid
3. 5 mL Generic Regular Strength Original Liquid Antacid
4. 5 mL Generic Maximum Strength Original Liquid Antacid
5. 4 Plastic pipettes
6. pH indicator strips
7. 1 Sheet of wax paper
8. 3 Toothpicks

### Procedure

Based on your knowledge of acid-base chemistry, you should use the available materials to develop a procedure that will allow you to determine the relative effectiveness of the three antacids. You will be limited to only the materials provided; therefore, you should develop a clear plan for your procedures before beginning the experiment.

### Data

Record data in a table that allows for comparison of the three antacids. Provide any additional tables and/or graphs you deem necessary.

### Analysis Questions

1. a. Identify all acids and bases used in this experiment.  
b. What is the definition of an acid?  
c. What is the definition of a base?
2. a. Using the pH values observed during this experiment, provide an explanation of neutralization.  
b. What are the reactants of a neutralization reaction?  
c. What product is formed in all neutralization reactions?

### Discussion Questions

- Magnesium hydroxide,  $\text{Mg}(\text{OH})_2$  is the active ingredient of some antacids. Hydrochloric acid,  $\text{HCl}$ , is the acid found within the stomach. How does  $\text{Mg}(\text{OH})_2$  work to relieve the pain caused by excess stomach acid?
  - Write the equation for the neutralization reaction of this acid/base pair.
- Provide a possible explanation as to why one antacid may be more effective than another.
- Identify sources of uncertainty in this experiment.
  - What procedures and/or materials might you change to improve the experiment?