Antacid Analysis
Neutralizing Stomach Acid

OBJECTIVE

Students will determine which brand of antacid neutralizes stomach acid the most effectively and is the most cost-efficient.

LEVEL

Middle Grades: Life Science

NATIONAL STANDARDS

UCP.1, UCP.2, UCP.3, C.5

CONNECTIONS TO AP

Biology:
- III. Organisms and populations
  - B. Structure and function of plants and animals
    - 2. Structural, physiological, and behavioral adaptations

Chemistry:
- III. Reactions
  - A. Reaction types
    - 1. Acid-base reactions; concepts of Arrhenius, Brönsted-Lowry, and Lewis; coordination complexes; amphoterism

TIME FRAME

45 minutes

MATERIALS

(For a class of 28 working in pairs)

0.01 *M* NaOH solution in 14 dropper bottles
phenolphthalein indicator solution in 14 dropper bottles
0.1 *M* HCl solution, 1.5 L
distilled water
various brands of antacids
42 coffee filters
28 beakers, 50 mL
28 thin-stem pipettes
14 graduated cylinders, 50 mL
14 glass stirring rods
14 microplates, 12-well
7 mortar and pestle sets (one for each group of four) or waxed paper and a rolling pin or hammer
test tube brush

TEACHER NOTES

The setup for this activity is based on 28 students working in pairs with four students at each table. Each pair of students will test three different brands of antacids.

If dropper bottles are not available for the indicator solution, you can substitute test tubes and thin-stem pipettes. When the solutions are not in use, cover them with plastic wrap or Parafilm or a cork so evaporation does not occur. If 28 beakers of the same size are not available, smaller or larger ones can be used. If beakers are not available at all, polystyrene or plastic cups may be substituted.

Students will need the following information from the antacid boxes: tablets per dose, cost of package, names of active ingredients, and amount of active ingredient. Include this information on the board or overhead if antacid boxes are not available.

You might need to take the opportunity to explain what the "*M*" represents in the materials and introduction section of the lab. The students do not need to know how to calculate it but they do need to understand that the "*M*" represents *molarity*, which is a measure of the concentration of the acid. The higher the "*M*," the more concentrated the solution.

Preparation of Solutions

- 0.1 *M* HCl acid (1.0 L): Fill a liter container (the most accurate you have available, graduated cylinder, volumetric flask) with about 500 mL of distilled water, then add 8.3 mL of concentrated (12.0 *M*) HCl. Bring the solution to a total volume of 1.0 L. Alternately, 0.1 *M* HCl acid can be purchased from a laboratory supply company if you choose not to buy concentrated HCl.
- 0.01 *M* NaOH solution (500 mL): Measure out 0.2 g of solid NaOH, place in a 500 mL volumetric flask, and add distilled water to the 500 mL mark.

Taking It Further

Students can display their antacid data on poster board and present their findings to the class. As each group discusses their data, the students in class can copy the data into a class table to better analyze the information. Once all of the data has been shared, students can return to their groups and discuss which antacid is the best at neutralizing acid and which is the most cost-effective.

You may want to prepare an acid/base solution that has been neutralized so that students can see the color of pink you wish their solutions to reach. They will need to know that when the solution turns a slight pink and remains that way, the solution has been neutralized.

PRELAB QUESTIONS

1. What is the active ingredient in your antacid? Give the chemical name and chemical formula.
   - The most common substances found in antacids are hydroxides—such as magnesium hydroxide, $Mg(OH)_2$ or aluminum hydroxide, $Al(OH)_3$—calcium carbonate, $CaCO_3$, and sodium bicarbonate, $NaHCO_3$.

2. What is the job of an antacid?
   - Antacids are used to neutralize the excess acid in the stomach.

3. Which type of acid is predominantly found in your stomach?
   - Hydrochloric acid, HCl

4. What is the approximate pH of the acid in your stomach?
   - pH = 1

5. What is the job of the acid found in your stomach?
   - The job of stomach acid is to digest food and provide the proper pH for enzyme function.

6. What is the role of an indicator solution?
   - An indicator solution is used to determine when a change in pH has taken place. Phenolphthalein is often used in acid-base titrations because it turns from colorless in acid solution to pink in basic solution. This allows you to visually determine when neutralization has occurred.

7. Define *endpoint*.
   - An endpoint is the point at which the neutralized solution begins to just turn pink.

8. Define *neutralization reaction*. In this definition, include the two types of compounds produced.
   - A neutralization reaction is a reaction between an acid and a base to produce water and a salt.

9. What is an ionic compound?
   - An ionic compound is one involving a positive and negative ion or a metal and a nonmetal.

CONCLUSION QUESTIONS

1. Which brand of antacid was the most effective at neutralizing the stomach acid? Explain your answer.
   - Answers will vary based on the types of antacids selected.
   - The explanation should include the most effective antacid was the one whose solution required the least additional drops of base (NaOH).

2. Which brand of antacid was the least effective at neutralizing the stomach acid? Explain your answer.
   - Answers will vary based on the types of antacids selected.
   - The explanation should include the least effective antacid was the one whose solution required the most additional drops of base (NaOH).

3. List two possible sources of error in your lab and explain how these sources of error would specifically alter your results.
   - Answers will vary but may include:
     - Inaccurate counting of drops. If the numbers of drops are not recorded accurately, the most effective or least effective antacid reported could also change.
     - Size of the drops used was not consistent. Again, this might have changed the most effective or least effective antacid.
     - Failure to pulverize the antacid tablets or allow them to dissolve as completely as possible. If the tablets are not pulverized, all of the active ingredient may not be released to neutralize the acid. It may be discarded upon filtration.

CONCLUSION QUESTIONS (CONTINUED)

4. Cindy was an assistant for you and your partner in the laboratory. You asked her to help with some of the antacid testing to speed up the collection of data. Everything was going great until she noticed that on her last set of tests she had accidentally placed 3 drops of indicator solution into the acid instead of 1 drop. Would this affect the results? Explain your answer.

   - Adding additional indicator solution will not affect the final results. Indicator is simply a solution used to determine when the neutralization reaction has been achieved; it is not part of the reaction.

5. Based on the results of your three antacids, which antacid should be the most cost-effective? You will need to analyze the cost per dose and effectiveness per dose, and determine which is the best brand to buy based on how well it works and how much it cost. Show all calculations below.

   - The students will need to analyze the cost, how much active ingredient per dose, and how well the antacid worked and create their own method for determining cost effectiveness.

Antacid Analysis
Neutralizing Stomach Acid

The human stomach regularly secretes acid to help digest food. Hydrochloric acid of 0.1 *M* is involved in this important process. Although acid plays an important role in our digestive system, it is also a corrosive substance. For this reason, your stomach has a mucosal lining that keeps the acid from coming into direct contact with the sensitive stomach tissue.

Sometimes excess acid builds up in the stomach or esophagus and causes painful indigestion or heartburn. If the acid gets too excessive, it can lead to a stomach ulcer or a hole in the stomach lining. However, current research indicates that many ulcers are caused by bacterial infections, not acid build-up. Between 10% and 20% of Americans suffer from ulcers at some point in their lives.

For those who suffer from acid build-up, antacids are available. These medicines contain bases, which remove excess acid through a neutralization reaction. A **neutralization reaction** is the reaction between an acid and a base to produce water and an ionic compound, also known as a **salt**.

$$HCl + NaOH \rightarrow H_2O + NaCl$$

PURPOSE

You and your partner have been hired by the Food and Drug Administration to test various antacids and determine which is the best at neutralizing stomach acid and which is the most cost effective. To accomplish this task, you will need to determine how much antacid (base) is needed to neutralize 0.1 *M* hydrochloric (HCl) acid.

As a knowledgeable biologist, you know that an indicator must be used to determine when neutralization has occurred. The indicator you have chosen is phenolphthalein because it turns pink when neutralization has taken place. The point at which the solution turns pink is known as the *end point*.

MATERIALS

0.1 *M* HCl solution
dropper bottle of NaOH
dropper bottle of phenolphthalein indicator solution
distilled water
various brands of antacids
mortar and pestle set or waxed paper and rolling pin or hammer
3 coffee filters
2 beakers, 50 mL
graduated cylinder, 100 mL
thin-stem pipette
glass stirring rod
microplate, 12-well

Safety Alert!

1. Wear safety goggles and aprons throughout the entire lab.
2. 0.1 *M* HCl is slightly toxic by ingestion. It is also corrosive, so avoid tissue contact. If contact does occur, wash thoroughly and inform your teacher.
3. Phenolphthalein is a tissue irritant. Wash thoroughly if contact occurs.
4. 0.01 *M* NaOH is slightly toxic by ingestion and skin absorption. It is a skin irritant and causes eye burns. If contact does occur, was thoroughly and inform the teacher.

PROCEDURE

1. Use the antacid box, online resources, or other reference material to answer the Pre-Lab questions on your student answer page.

2. Obtain three different brands of antacids from the supply table.

3. Based on any experiences you have had with antacids, hypothesize which antacid you believe will be the best at neutralizing stomach acid. Record your hypothesis in the space provided on your student answer page.

4. Use the graduated cylinder to measure 25.0 mL of the 0.1 *M* HCl. Pour the acid into a 50-mL beaker. Be sure to read the volume from the bottom of the meniscus.

5. Pulverize 1 dose of an antacid sample. Make sure you read the antacid box to determine the number of tablets in one dose. Record the brand name of the antacid, dose amount, and cost in the data table. Pour the antacid into the beaker with the acid and stir thoroughly using a glass stirring rod.

   The antacid will neutralize only a portion of the acid; you will add NaOH to neutralize any remaining acid. The antacid that requires the least amount of NaOH neutralizes best.

6. Rinse the graduated cylinder two times with distilled water. Measure 10.0 mL of distilled water and pour it into the beaker with the acid and antacid. Use a stirring rod to mix the solution.

7. Place a coffee filter over the top of another beaker and secure it with your hand. Have your partner slowly pour the antacid solution through the coffee filter, making sure not to spill any of the solution on your hand. If this does occur, wash your hands immediately. Dispose of the filter as directed by your teacher.

8. Add one drop of indicator solution to the filtered solution.

PROCEDURE (CONTINUED)

9. Using a thin-stem pipette, add 10 drops of the acid solution to one of the wells on your microplate.

10. Using the dropper bottle labeled "NaOH" (sodium hydroxide), add one drop at a time to the acid solution in the microplate until the endpoint is reached. You will know when you have reached the endpoint because the solution will remain pink. You may need to gently swirl the solution in the microplate to determine if the pink color remains.

11. Record the number of NaOH drops needed to neutralize the acid solution in the data table.

12. Repeat Steps 9–11 two more times in separate microplate wells.

13. Average the number of drops needed for the three trials. Record the average to two significant figures.

14. Repeat Steps 4–13 with the other two antacids.

15. Once you have completed the lab, dispose of the materials as directed by your teacher. Make sure to clean the microplate with a test tube brush to rid the container of any solution residue.

HYPOTHESIS

PRE-LAB QUESTIONS

1. What is the active ingredient in your antacid? Give the chemical name and formula.

2. What is the job of an antacid?

3. Which type of acid is predominantly found in your stomach?

4. What is the approximate pH of the acid in your stomach?

5. What is the job of the acid found in your stomach?

6. What is the role of an indicator solution?

7. Define *endpoint*.

8. Define *neutralization reaction*. In this definition, include the two types of compounds produced.

9. What is an ionic compound?

DATA AND OBSERVATIONS

Antacid Brand	Drops of NaOH	Drops of NaOH (avg)	Tablets/Dose	Cost/Dose	Active Ingredients

CONCLUSION QUESTIONS

1. Which brand of antacid was the most effective at neutralizing the stomach acid? Explain your answer.

2. Which brand of antacid was the least effective at neutralizing the stomach acid? Explain your answer.

3. List two possible sources of error in your lab and explain how these sources of error would specifically alter your results.

   a.

   b.

CONCLUSION QUESTIONS (CONTINUED)

4. Cindy was an assistant for you and your partner in the laboratory. You asked her to help with some of the antacid testing to speed up the collection of data. Everything was going great until she noticed that on her last set of tests she had accidentally placed 3 drops of indicator solution into the acid instead of 1 drop. Would this affect the results? Explain your answer.

5. Based on the results of your three antacids, which antacid should be the most cost-effective? You will need to analyze the cost per dose and effectiveness per dose, and determine which is the best brand to buy based on how well it works and how much it costs. Show all calculations.

