16C-ANTACIDS: AN INQUIRY STUDY

INQUIRY
How do antacids work to settle an upset stomach?

MATERIALS
- Device with SPARKvue software
- pH sensor
- 2-3 brands of antacid tablets
- 0.1 M HCl, 50 mL
- 0.1 M NaOH, 100 mL
- Phenolphthalein indicator solution
- Graduated cylinder, 50-mL
- Beaker, 150-mL
- Pipet, with 1 mL graduations
- Heater stirrer*

* Your instructor may not require a heater stirrer

MATERIALS
- Burette
- Magnetic stirrer with magnet
- Electrode support
- Wash bottle filled with distilled water
- Stirring rod
- Mortar and pestle
- Burette clamp
- Ring stand
- Funnel
- pH 4 and pH 10 buffer solutions

BACKGROUND
Antacids are a class of drugs that work to neutralize stomach acid. Stomach acid consists of hydrochloric acid (HCl) which our body uses to break down food for digestion and to protect us from harmful bacteria. Depending on our dietary choices and/or infections in the stomach, our body can produce too much hydrochloric acid. This results in the feeling of an upset stomach.

You will investigate how antacid tablets work and determine how much of the active ingredient is found in one tablet using a back titration method.

SAFETY
Follow these important safety precautions in addition to your regular classroom procedures.
- Wear safety goggles at all times.
- Clean up acid spills with sodium bicarbonate solution.
- Clean up base spills with dilute acetic acid solution.
**Antacids - An Inquiry Study**

**PROCEDURE**

1. Open SPARKvue.

2. Open the 16C Antacids An Inquiry Study lab file in SPARKvue.

3. Use the Bluetooth icon to connect the pH sensor. Calibrate the sensor with pH 4 and 10 buffer solutions.

4. Use the mortar and pestle to crush an antacid tablet into a fine powder.

5. Measure between 0.10 to 0.20 g of the powdered antacid tablet. Record the powdered antacid mass in the table. Dispose of the unused powder according to your teacher's directions and clean the mortar and pestle.

6. Add 25.0 mL of 0.10 M HCl to the 150-mL beaker. Use the stirring rod to dissolve the measured antacid powder in the solution.

   *Note: If your antacid contains carbonate or bicarbonate you may see bubbling as carbon dioxide is produced. To drive off carbon dioxide and help dissolve the antacid, heat the mixture in the beaker to approximately 70°C for a few minutes. Then allow the mixture to cool before moving to the next step.*

7. Rinse along the inside of the beaker with distilled water. Continue adding distilled water to the 150-mL beaker until the total volume is about 70 mL.

8. Add a magnetic stir bar to the beaker and place it on the magnetic stirrer.

9. Use the ring stand and electrode support to suspend the pH sensor into the solution. Make sure the glass bulb of the pH sensor is covered by the solution. Position the sensor near the edge of the beaker to keep it safely away from the magnetic stir bar.

10. Add 2-3 drops of phenolphthalein indicator.

11. For this experiment, you need to make sure that all the antacid has reacted and that there is excess acid in the beaker. If your solution is pink, it is basic. Fill the graduated cylinder with 50.0 mL of 0.1 M HCl. Use the pipet to transfer HCl from the graduated cylinder to the beaker until the solution is acidic and colorless. Add the amount of extra HCl added by pipette to the initial 25 mL of HCl to get the total volume of acid added to the beaker. Record the total volume of acid that you added to the beaker in Table 1.

12. Rinse the burette with 0.1 M NaOH. Close the burette and use the funnel to help you fill the burette with 0.1 M NaOH. Remove bubbles from the burette tip by gently tapping the tip while the burette is open. Fill the burette with 0.1 M NaOH solution up to the 0.00 mL mark.
13. Use the burette clamp on the ring stand to position the burette to drain into the beaker when opened.

14. Start collecting data. Use the check mark in SPARKvue to record the initial pH of the solution with 0.0 mL of NaOH added.

15. Add about 0.5 mL of NaOH solution into the beaker. Record the pH and the exact volume of NaOH added in SPARKvue.

16. With constant stirring, continue adding NaOH into the beaker in 0.5 mL increments. Continue recording the pH and volume.

   *Note: If the addition of NaOH causes a change of pH that is greater than 0.5 pH units, slow down the addition of NaOH to 0.1 mL or drop increments.*

17. Continue adding the 0.10 M NaOH until a faint pink color just begins to persist for 30 seconds. Record the volume of NaOH added to reach this point in Table 2.

18. Continue collecting data until the readings level off and are similar for 5 data points. Stop collecting data and sketch the graph of pH vs volume of titrant added in Graph 1.

19. Dispose of the solution in the beaker according to your teacher's instructions. Rinse and thoroughly dry the beaker and the magnetic stir bar. Refill the burette to the 0.00 mL mark with NaOH.

20. Return to Step 4 to repeat the titration process for each brand of antacid.

### Table 1 - Antacid data for back titration

<table>
<thead>
<tr>
<th>Antacid name</th>
<th>Active ingredient(s)</th>
<th>Mass of antacid (g)</th>
<th>Total volume of HCl added (ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Graph 1 - Antacid back titration

[Graph showing pH vs volume for titration]
Antacids - An Inquiry Study

ANALYSIS

Table 2 - Titration data

<table>
<thead>
<tr>
<th>Antacid name</th>
<th>Total moles of HCl (mol)</th>
<th>Total volume of 0.1 M NaOH added (ml)</th>
<th>Moles of HCl neutralized by the NaOH (mol)</th>
<th>Moles of HCl neutralized by the antacid (mol)</th>
<th>Effectiveness (mol HCl/g antacid)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Using the total volume of 0.10 M HCl added from Table 1, determine the total moles of HCl that was added to the beaker. Record this value in Table 2.

2. Record the total volume of 0.10 M NaOH added to reach equivalence (faint pink color) in Table 2.

3. Determine the number of moles of 0.10 M NaOH added to reach equivalence and record the value in Table 2.

4. Based on the mole-to-mole ratio, determine the number of moles of HCl that were neutralized by the 0.10 NaOH for each trial. Record this value in Table 2.

5. Looking at the total moles of HCl, and the moles of HCl neutralized by NaOH, how many moles of HCl were neutralized by the antacid? Record the value in Table 2.

6. Determine the effectiveness of the antacid. For consistent comparison, use the moles of acid neutralized per gram of antacid basis (mol HCl / g antacid). Record this value in Table 2.

QUESTIONS

1. Study the ingredients list of at least two brands of antacid tablets. Which ingredients do they have in common? Which ingredients are different?

2. Antacids work to neutralize stomach acid. Which ingredient(s) do you believe is the active ingredient in this neutralization process? Be sure to list the active ingredient(s) for each brand.

3. What was the purpose of adding the HCl solution to the antacid tablet?

4. Compare the effectiveness of each antacid. How are they similar and/or different from each other?

5. What happens to the pH of your stomach when you consume an antacid tablet?
6. A patient enters the doctor's office complaining of indigestion. If you were the doctor, which brand of antacid would you recommend to the patient? Justify your choice with data from this investigation.

7. The same patient returns the following day with new symptoms. S/he is now constipated and has a lot of gas. They tell the doctor they took twice the recommended amount of antacid. What caused the new set of symptoms?

8. Antacids are specifically designed as buffers. What is a buffer? What are the key qualities of a buffer? Which of these qualities are shared by the antacid?