PURDUE UNIVERISTY INSTRUMENT VAN PROJECT

Determining the Effectiveness of an Antacid Using a pH Meter
(Chemistry II Version)
(Revised 5/14/96)

Introduction

As you may recall, the stomach contains hydrochloric acid. Upset stomach, indigestion, and the much publicized "acid reflux" all occur when the body produces an excess of this acid which travels to more delicate tissues, causing a burning, painful sensation. An antacid is taken to neutralize this excess acid.

Antacids can contain any one or a combination of the following ingredients: aluminum hydroxide, calcium carbonate (commonly known as chalk), various magnesium compounds and sodium bicarbonate. Although these substances are effective, each one has certain disadvantages. For example, sodium bicarbonate loses its effectiveness quickly, and many people must limit their intake of sodium. Magnesium compounds can cause constipation, aluminum hydroxide can act as a laxative, and calcium carbonate has an unpleasant taste.

There are two other important considerations. First, the rate at which the neutralization reaction occurs is very important. It should be relatively fast. The second consideration is the fact that some of these antacids produce carbon dioxide gas as one of the products of the neutralization reaction. In this case, the reaction must occur quickly enough to relieve pain, but slowly enough to allow the gas to dissipate and not build up in one's system.

The neutralization of an antacid by HCl involves some complex chemistry. In fact, in many cases, buffers actually control part of the reaction. For example, sodium bicarbonate is an amphoteric substance, which makes it an important part of a good buffer system in aqueous solution. In this case, the buffer system is the same as that found in human blood, *i.e.* the HCO_3^-/CO_3^{2-} buffer system. In the blood, the following equilibria are involved:

$$CO_3^{-2}{}_{(aq)} + H^+{}_{(aq)} \Leftrightarrow HCO_3^-{}_{(aq)}$$

$$HCO_3^-{}_{(aq)} + H^+{}_{(aq)} \Leftrightarrow H_2CO_3{}_{(aq)} \Leftrightarrow H_2O{}_{(aq)} + CO_2{}_{(g)}$$

In this experiment, part of this system is simulated by adding HCl to the antacid:

$$CO_3^{-2}{}_{(aq)} + 2HCl{}_{(aq)} \Leftrightarrow H{}_{(aq)} + CO_2{}_{(g)}$$

The problem, however, is that excess HCl will be added. Since we need to know precisely how much HCl is neutralized by the antacid, the excess HCl will be reacted (*i.e.*, titrated) with a base, and the neutralization (of the excess HCl) will then be monitored.

This set of reactions forms a buffer system, and as a result, the endpoint of the titration is not especially sharp. Since a sharp endpoint is desirable, an experimental method must be

developed to improve the sharpness of the endpoint. The equilibrium must be shifted.

In order to measure the "effectiveness" of an antacid, we need to consider the amount of "binding" of the antacid. For example, the greater the binding of an antacid the better it is said to work. To do this, we will use the following expression:

$$\text{Volume HCl bound by the antacid} = \text{Total HCl added} - (\text{mL NaOH} \times 20)$$

Note that this experiment requires a 5 mL aliquot of the antacid mixture, not the entire sample, and this is the reason for the factor of 20 in the above expression.

Purpose

In this experiment, you will be using a pH meter to help you determine which brand of antacid is the best at combating indigestion.

Materials

3 - 50 mL beakers	1 - 250 mL beaker
1 - 30 mL beaker	stirring rod
4 different brands of antacids	10 mL graduated cylinder
stirring plate and magnetic stir bar	100 mL graduated cylinder
DI water	50 mL buret
mortar and pestle	safety goggles
10 mL 1 M HCl	10 mL 1 M NaOH
100 mL 0.1 M HCl	100 mL 0.1 M NaOH

Procedure

Part A- Determination of pH of an antacid dose

1) Grind one dose of an antacid of your choice (use one tablet) using a mortar and pestle.

2) Place this dose in a 50 mL beaker. Repeat this process for two more tablets so that you have three 50 mL beakers each containing a single dose.

3) Add 10 mL of distilled water to beaker #1. Add 10 mL of 1 M HCl to beaker #2, and add 10 mL of 1 M NaOH to beaker #3.

4) Draw or describe what you see occurring in each beaker on your data sheet.

5) After the reactions have ceased, check the pH of each solution using a pH meter. Be sure to rinse the electrode with deionized water and blot it dry before transferring the probe to the next beaker.

6) Record your data on your data sheet and answer Question #1.

Part B- "Cent" and "Scent" analysis

1) Record the posted data regarding the cost of various bottles of antacids, and the number of doses contained in each bottle in the Data Table. Calculate the cost per dose for each antacid.

2) Record the scents of each brand, noting which is most appealing to you.

3) Finally, record the active ingredients for each brand of antacid.

Part C- Determination of the neutralization power of antacids

1) Crush the recommended dose (use 2 tablets) of your antacid using a mortar and pestle. Make the powder as fine as possible, so that it resembles flour.

2) Transfer the powder to a 250 mL beaker. Measure 100 mL of 0.1 M HCl and use some of it to rinse the mortar. Pour this into the beaker, along with the remaining HCl.

3) Use a stirring plate to stir the mixture thoroughly until the powder is completely dissolved.

4) Describe what happens on your observation sheet.

5) Test the pH of the solution using a pH meter and record this value as your initial pH.

6) Transfer 5 mL of this solution to a 100 mL beaker.

7) Fill a buret with 0.1 M NaOH and record the initial volume of the solution. (Remember -- estimate to two decimal places!)

8) Place the electrode into the beaker and press the "auto" key to obtain a constant reading of the pH.

9) Add one mL of the NaOH solution at a time, recording the pH after each addition. Be sure to swirl the beaker carefully after each addition to provide good mixing.

10) When the pH reaches 10.00 and remains at or above this level for 30 seconds, stop adding the NaOH solution. You have finished collecting the necessary data points.

11) Record the final volume of the NaOH solution on your data sheet.

12) Compare your results with those of the other groups and complete your data table.

Questions (to be submitted with your Data Table)

1) Which solution from Part A most closely resembles the contents of the stomach?

2) What is the relationship between the amount of NaOH added and the ability of the antacid to neutralize HCl?

3) Propose an experimental method that would produce a sharp endpoint in the titration. Remember to think in terms of shifting the equilibrium.

Conclusion

In addition to submitting your Data Sheet, you are to use your data to analyze which antacid product is the best and most effective. Use the following factors in your analysis: cost per dose, effectiveness (binding), scent and active ingredients. Write this as an article that the general public (parents or other relatives) would be able to understand and use. Be sure to back up your claims with your data! The article does not need to be long, just report your findings and explain. For a more complete article, make a graph of your data by plotting pH vs. mL NaOH added.

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Name: _____

Hour: _____

Antacid Determination Experiment

Data: Part A

Antacid Brand Name: _____

Beaker #	Observations	pH of solution
1		
2		
3		

Question 1:

Data: Part B

Antacid Brand	Bottle Cost	# Doses	Cost per Dose	Scent	Active Ingredients
1.					
2.					
3.					
4.					
5.					

Question 2:

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Data: Part C

Antacid Brand	mL of NaOH to reach pH 7.00	mL of NaOH to reach pH 10.00	mL HCl used by antacid
1.			
2.			
3.			
4.			
5.			

Antacid Brand: _____

mL NaOH	pH (nearest 0.00)

mL NaOH(cont')	pH (cont')