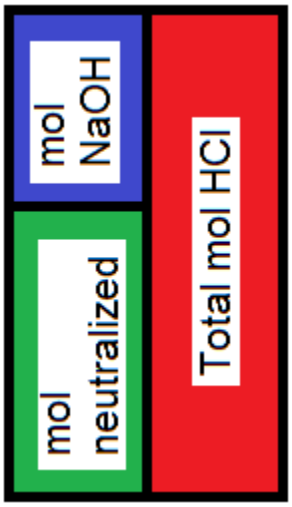
Experiment 5 – Acid Neutralizing Capacity of an Antacid

Background

Stomach acid contains hydrochloric acid. Antacids are taken to reduce the effects caused by excess stomach acid leading to issues such as GERD and acid reflux. Commonly used antacid agents include calcium carbonate, aluminum hydroxide, magnesium hydroxide, and magnesium carbonate. The reactions that are used to neutralize hydrochloric acid using these ages are

$$2\ HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$
$$3\ HCl(aq) + Al(OH)_3(s) \rightarrow AlCl_3(aq) + 3\ H_2O(l)$$
$$2\ HCl(aq) + Mg(OH)_2(s) \rightarrow MgCl_2(aq) + 2\ H_2O(l)$$
$$2\ HCl(aq) + MgCO_3(s) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

In this lab, you will determine the capacity of an antacid table to neutralize hydrochloric acid using a technique called "back titration." In this procedure, you will dissolve some antacid in an excess of hydrochloric acid. Some of the acid will be neutralized, but because there is an excess, not all will be. You will then determine how much HCl was left over by titration with NaOH. Due to the stoichiometry



$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

the number of moles of NaOH used in the titration will be equal to the number of moles of HCl that were left over after the neutralization by the antacid.

For this investigation:

$$mol\ neutralized\ =\ total\ mol\ HCl\ -\ mol\ NaOH$$

$$=\ (Volume_{HCl}\ x\ Molarity_{HCl})\ -\ (Volume_{NaOH}\ x\ Molarity_{NaOH})$$

acid neutralizing capacity per gram of antacid:

$$ANC = \frac{g\ acid\ neutralized}{grams\ of\ antacid}$$

Materials/Equipment

Beakers, 250 mL (2)
Buret (with stand and clamp)
Erlenmeyer flask, 125 mL (2)
Funnel (for filling buret)
Mortar and pestle
Volumetric pipet (20.00 mL)

Reagents

Antacid (ground from tablet form)
Deionized water
Hydrochloric acid (0.10 M HCl, 100 mL)
Sodium hydroxide solution (.1 M NaOH, 100 mL)
Phenolphthalein indicator solution (2 mL)

Procedure

1. Your instructor will assign you an antacid to investigate.
2. Record the name and the names and amounts of the active ingredients each tablet. This information is on the label of the antacid bottle.
3. Measure and record the mass of a single tablet of your assigned antacid.
4. Record the concentration of the NaOH solution being used.
5. Rinse and fill your buret with standardized 0.1 M NaOH. (You only need to rinse the buret before your first run.)
6. Using the table below, determine how much of the ground antacid tablets to use.

Antacid	Mass
A (Tums-like)	0.12 g
B (Gaviscon-like)	0.2 g

7. Measure the mass of crushed antacid actually used and record it in your notebook. (It is a waste of time and makes one look foolish to try to get the above masses exactly. Just get close (within 10% or so) and record the actual mass used.)
8. Transfer the crushed antacid tablet to your Erlenmeyer flask.
9. Record the concentration of the HCl solution being used.
10. Using a volumetric pipet, add 20.00 mL of HCl to the Erlenmeyer flask. Swirl the reaction mixture to ensure complete reaction, being careful to avoid spilling any of the contents.
11. Add three drops of phenolphthalein indicator to the mixture in the Erlenmeyer flask.
12. Record the starting volume on your buret to **two decimal places**, estimating the last decimal to within ± 0.02 mL. (If you do not record the volume on the buret properly, you will lose points on significant digits errors – and who wants to do that?)
13. Carefully titrate the reaction mixture to the endpoint.
14. Record the volume on your buret (again to two decimal places, estimating the last digit to within ± 0.02 mL.
15. Repeat this procedure (steps 5-14) twice. If one of your runs deviates from the others by more than 5%, you can include a fourth run.
16. Based on your data, calculate the ANC for your antacid tablet.
17. Report the average value on the chalk board for the rest of the class. Make sure that you have the data for the entire class before you leave!

Sample Data Table

Molarity of HCl solution _____ **Molarity of NaOH solution _____**

	Run 1	Run 2	Run 3	Run 4 (if needed)
Name of antacid				
Name and mass of active ingredient(s) per tablet				
Mass of one tablet (g)				
Mass of antacid used (g)				
Volume HCl used (mL)				
Initial buret reading for NaOH (mL)				
Final buret reading for NaOH (mL)				

Safety

1. Wear eye protection at all times during this experiment.
2. The ground tablets can create quite a mess – particularly around the balances. Clean up any spills.
3. Do not pipet by mouth!
4. You can collect waste in a large beaker at your work station. Dispose of waste properly at the end of the experiment.

Report Form – Capacity of an Antacid

Name _____ Date _____

Laboratory Partner(s) _____

1.	Antacid used:		_____	
2.	Mass of one tablet		_____ g	
3.	Mass used	_____ g	_____ g	_____ g
4.	Concentration HCl		_____ M	
5.	Volume HCl used	_____ mL	_____ mL	_____ mL
6.	Moles HCl	_____ mol	_____ mol	_____ mol
7.	Initial Volume NaOH	_____ mL	_____ mL	_____ mL
8.	Final Volume NaOH	_____ mL	_____ mL	_____ mL
9.	Volume NaOH delivered	_____ mL	_____ mL	_____ mL
10.	Moles NaOH	_____ mol	_____ mol	_____ mol
11.	Moles HCl neutralized by antacid	_____ mol	_____ mol	_____ mol
12.	Grams HCl neutralized by antacid	_____ g	_____ g	_____ g
13.	ANC: g HCl neutralized per gram antacid	_____	_____	_____
14.	Average ANC		_____	

Discussion Questions:

Was the ANC you found consistent with what was on the label of the tablet you used?

Which antacid had the best ANC according to your class results?

Prelaboratory Assignment – Capacity of an Antacid

Name _____ Section _____

A particular brand of antacid contains 500 mg of $CaCO_3$ per 2.0 g tablet according to the label.

1. How many moles of $CaCO_3$ are in one tablet?

2. The reaction by which the antacid neutralizes HCl is

   $$2\ HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

   How many moles of HCl can be neutralized by one tablet?

3. 50.0 mL of 0.300 M HCl are used to dissolve a 2.00 g tablet. How many moles of acid are used to dissolve the tablet?

4. The excess acid then requires 53.13 mL of 0.100 M NaOH for the back titration. How many moles of excess acid were there in the 50 mL?

5. How many moles of HCl were neutralized by the tablet?

6. How many moles of $CaCO_3$ were in the tablet? How many mg?