Week 6: Neutralizing Power of Antacids

Objectives: In this experiment you will study the neutralizing power of several commercial antacid tablets.

Antacid tablets contain a material that will neutralize stomach acid (about 0.01 M HCl in normal stomachs, but higher after periods of stress and exciting weekends). Most brands use calcium carbonate as the active ingredient. The tablet could be directly titrated with 1.0 M HCl; unfortunately the end point would be very difficult to determine because of the slow dissolution of the tablet. A more efficient determination is to add an excess of HCl (more than enough to react completely with the CaCO₃ and dissolve the tablet) and then titrate the leftover (unreacted) HCl with 1.0 M NaOH. This procedure is known as back-titration of the sample. The reactions are

\[
\text{CaCO}_3(s) + 2 \text{HCl(aq)} \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O(l)} + \text{CO}_2(\text{g}) \quad (1)
\]

followed by (back titration with NaOH)

\[
\text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{H}_2\text{O(l)} + \text{NaCl(aq)} \quad (2)
\]

Prelab assignment: (Answer these questions in your notebook under a section titled Prelab Questions.)

1. a. For the first reaction between the calcium carbonate and the hydrochloric acid, which reactant will be the limiting reagent?
   b. How do you know this?
   c. How could you test this experimentally?

2. Write the net ionic equations for the two reactions (1 & 2) given above.

Prepare for lab by writing up your procedure section and making up any data tables you will need. Leave room for making corrections or updates.

In Class

You will work in groups of two. Your group will be given a sample of approximately 1.0 M NaOH that has been standardized (make note of the concentration!) and approximately 1.0 M HCl. You must use the NaOH solution to standardize the HCl solution. For your procedure, think about what volume of HCl would be the best to use in the standardization titration. Discuss this with your lab partner. Use the Drop Counter and pH meter for your titrations in the same
manner as last week. Before you begin titrating, there are several aspects about your equipment you should double-check: the drop-counter and pH sensor should be calibrated; a few drops of phenolphthalein should be in solution; the tip of the pH meter should be fully submerged; the stir bar should be agitating the solution. **Make sure you press the data collection button before beginning your titration.** If you have questions about your equipment, refer to last week’s procedure or ask your instructor. You can use the graphs you make to determine the solution’s equivalence volume, and further, the molarity of the HCl solution. Do your calculations in your lab notebook.

Once your group has standardized the acid and base solutions, you will begin the reaction with the antacid tablet. Each group of students will study a different brand of antacid, and each student will analyze one antacid tablet. Begin by grinding a tablet into a powder with the mortar and pestle. Transfer as much of the powder as you can into a weigh boat, and **measure its mass.** In a 100 or 150 mL beaker, prepare a solution containing the ground-up tablet and 25 mL of HCl. **What glassware is appropriate for this?**

Once the tablet has been dissolved, your solution may still look cloudy because of other components of the pill that do not dissolve in HCl. Titrate the remaining acid in each solution with your standardized NaOH using a phenolphthalein indicator. **Make sure you press the data collection button before beginning your titration.** In your notebook, record the approximate volume at which the solution’s color change takes place.

**Calculations** (Be sure to show all of your work in your notebook!)

You need to first determine the concentrations (molarity) of the NaOH and HCl solutions to 4 sig. figs. from your standardization data. Ultimately, you will need to find the grams of acid (HCl) neutralized per gram of antacid, and the grams of CaCO₃ in each tablet.

First, determine the moles of HCl that reacted with the antacid tablet. Remember: this is the moles of HCl that was used up in the first reaction, not the moles of HCl that remained at the end of the reaction!

Once you have determined the moles of HCl that reacted with the antacid tablet, you can then calculate the grams of HCl reacted per gram of the tablet. This would represent the neutralizing power of each tablet.

You will also use the moles of HCl that reacted with the antacid tablet to find the grams of CaCO₃ in each tablet. You will need to take into consideration the stoichiometry of the balanced reaction shown in the introduction of this experiment.

Record your average results and standard deviation for your group in your notebook for the grams of acid (HCl) neutralized per gram of tablet and the grams of CaCO₃ in each tablet. You should also post these values on the class database. Compare the grams of CaCO₃ to the value given on the product label and calculate the % error. As a class, you will discuss any differences between the various brands of antacids.
Outline of the Experiment

I. Titrate HCl with NaOH and calculate molarity of HCl (to 4 sig. figs.)
II. Determine neutralizing power of antacid
   A. Mass antacid tablet powder, and record value in notebook
   B. Dissolve powder in an excess of standardized HCl
   C. Titrate excess HCl with the standardized NaOH
   D. Determine moles of HCl that reacted with the antacid
   E. Calculate the grams of HCl that reacted with each gram of tablet (neutralizing power)
   F. Calculate grams of CaCO3 in each tablet and percent error based on label value

Laboratory notebook outline:

Heading: Title, Date, Lab partners

Prelab questions: Answer the questions in complete sentences.

Procedure: Write out a detailed stepwise procedure for your measurements. Be sure to include the specific glassware and measuring devices you will use and the amount of reagents.

Data: Make sure that you write down the concentrations of your reagents and the masses of antacid powder. You will also need to record any important information from the package label.

Calculations and Results: Show all calculations. Be sure to give any formulas you used and clearly define variables. All calculations should include proper units and your final values circled. Summarize the final results for your group with the average values and standard deviations for the grams of acid (HCl) neutralized per gram of antacid, and the grams of CaCO3 in each tablet. Compare your results to the values given on the package label and calculate % error. Also, make up a table of the class results for the various brands studied.

Conclusions:

1. How does the acid neutralizing power of the different antacids differ between different brands?

2. Explain the possible sources of these differences.