TITRATION: STANDARDIZATION OF A BASE AND ANALYSIS OF STOMACH ANTACID TABLETS

PART I: PREPARATION OF SOLUTIONS AND STANDARDIZATION OF A BASE

OBJECTIVE:

The object of this experiment is to become familiar with making solutions and to titrate an acid with a base. One solution will be prepared from a solid and one solution will be prepared by dilution of a concentrated solution.

MATERIALS NEEDED:

hydrochloric acid, HCl, 12 M (concentrated)
sodium hydroxide, NaOH (pellets)
phenolphthalein solution (1% by mass in ethanol)
10 mL graduated cylinder
100 mL graduated cylinder
500 mL volumetric flask with cap or stopper
1000 mL volumetric flask with cap or stopper
2 125-mL Erlenmeyer flasks
2 burets, 25-mL or 50-mL
stirring rod
2 small funnels to fit the burets

SAFETY PRECAUTIONS:

Wear approved eye protection in the laboratory at all times.

Concentrated hydrochloric acid is corrosive. In the event of skin contact, wash well with water. If the skin is blistered or broken, seek professional medical treatment. The dilute hydrochloric acid is less reactive, but one should exercise similar precautions.

Sodium hydroxide is caustic. Do not handle the solid with your hands. In the event of skin contact, wash well with water. If the skin is irritated or broken, seek professional medical treatment. The dilute sodium hydroxide solution is less caustic, but one should exercise similar precautions.

When diluting the hydrochloric acid, remember to add the concentrated acid to water to avoid splattering. Take care in handling the container as the dilution will generate heat.

Dissolving of sodium hydroxide generates heat. Take care in handling the dilution container.

DISPOSAL:

All solutions in this experiment should be disposed of in the proper waste containers as provided in the laboratory.

PREPARING SOLUTIONS:

Prepare 1000 mL of 0.1 M hydrochloric acid solution starting with 12 M HCl (see Diluting Solutions, below). Use distilled or deionized water. The solution will be prepared in a 1000-mL volumetric flask.

To prepare the hydrochloric acid solution:

Determine the amount of 12 M hydrochloric acid needed.
Fill the volumetric flask approximately 75% full with water. Use a funnel.
Add the hydrochloric acid to the volumetric flask.
Carefully, rinse any residual hydrochloric acid from the graduated cylinder and the funnel into the volumetric flask using three 5 mL portions of distilled water from a wash bottle.
Stopper the volumetric flask and gently shake the solution.
Fill the volumetric flask to the 1000-mL mark. Stopper the flask and gently shake the solution.
If necessary, adjust the volume of the solution to 1000 mL using distilled water, and shake again.
Label the volumetric flask.

Prepare 500 mL (0.5 L) of 0.1 M sodium hydroxide solution starting with solid sodium hydroxide (See Solutions from Solid Solutes, below). Use distilled or deionized water. The solution will be prepared in a 500-mL volumetric flask.

To prepare the sodium hydroxide solution:

Determine the mass of sodium hydroxide needed.
Fill the volumetric flask approximately 75% full with water. Use a funnel.
Add the sodium hydroxide to the volumetric flask.
Stopper the volumetric flask and gently shake the solution.
After the sodium hydroxide has dissolved, fill the volumetric flask to the 500-mL mark. Stopper the flask and gently shake the solution.
If necessary, adjust the volume of the solution to 500 mL using distilled water, and shake again.
Label the volumetric flask.

SOLUTIONS PREPARED BY DILUTING A CONCENTRATED SOLUTION:

To dilute a concentrated solution to a lower concentration, the formulas to use are:

$$V_i = \frac{M_f \cdot V_f}{M_i}$$

and

$$V_w = V_f - V_i$$

where M_i = molarity of the initial or concentrated solution
V_i = volume of initial or concentrated solution needed
M_f = molarity of diluted or final solution
V_f = volume of diluted or final solution
V_w = volume of water needed (If a volumetric flask is used, the volume of water does not have to be calculated.)

NOTE: Volume may be in units of mL or L, but the same units must be used for V_i and V_f.

Example: To make 100 mL of a 1.0 M solution of hydrochloric acid from 8.7 M hydrochloric acid

$$V_i = \frac{(1.0\ \text{M}) \times (100\ \text{mL})}{(8.7\ \text{M})} = 11.5\ \text{mL hydrochloric acid solution needed}$$

$$V_w = 100\ \text{mL} - 11.5\ \text{mL} = 88.5\ \text{mL water needed}$$

To make the solution, measure 88.5 mL of water into an appropriate container and add 11.5 mL of the hydrochloric acid solution. **Safety note: Always add acid to water to prevent splattering from occurring.**

SOLUTIONS PREPARED FROM SOLID SOLUTES

To prepare a Molar solution from a solid solute, the formula to use is:

$$g = \frac{M \cdot V \cdot W}{1000}$$

where g = mass of solute needed, in g
M = molarity of the desired solution
V = volume, in mL, of solution to be prepared
W = Molecular mass of the solute
NOTE: The 1000 is a conversion factor from mL to L

Example: To make 100 mL of a 1.0 M solution of sodium hydroxide.

$$g = \frac{(1.0\text{ M}) \times (100\text{ mL}) \times (40.0\text{ g/mol})}{1000} = 4.00\text{ g sodium hydroxide needed}$$

To make the solution, 4.00 g of the solid sodium hydroxide is added to approximately 75 mL of water. After the solid has dissolved, the volume of the solution is adjusted to 100 mL

PROCEDURE FOR STANDARDIZATION OF NaOH:

NOTE: *A sodium hydroxide solution is normally standardized by titrating against a solid acid which can be measured to 0.0001 g. To save time in this experiment, we will assume that the hydrochloric acid solution concentration is 0.10 M and standardize the sodium hydroxide against the hydrochloric acid.*

Rinse a buret with 5 mL of 0.1 M hydrochloric acid solution. Discard the rinse solution. Repeat the rinsing two more times. Fill the buret with 0.1 M HCl solution. Adjust the volume to the zero mark. Use a piece of labeling tape to identify this as the HCl or acid buret.

Rinse a second buret with 5 mL of 0.1 M sodium hydroxide solution. Discard the rinse solution. Repeat the rinsing two more times. Fill the buret with 0.1 M NaOH solution. Adjust the volume to the zero mark. Use a piece of labeling tape to identify this as the NaOH or base buret.

If necessary, clean the 125-mL Erlenmeyer flasks. Rinse well with water. Give the flask a final rinse with distilled or deionized water. The flasks may be left wet for the titrations.

Measure 20 mL of 0.1 M HCl into a 125-mL Erlenmeyer flask. Add 3 to 5 drops of phenolphthalein indicator solution. Record the volume of 0.1 M HCl used.

Titrate the HCl solution with 0.1 M NaOH until the solution just turns pink and the pink color persists for 30 seconds without fading. Record the volume of 0.1 M NaOH used.

Rinse the 125-mL Erlenmeyer flask well with water. Give the flask a final rinse with distilled or deionized water. The flask may be left wet for another titration.

Repeat the titration procedure, above, 2 more times.

Calculate the molarity of the NaOH solution for each of the three titrations. If the values of the molarities do not agree, try another titration.

The neutralized solutions in the 125-mL flasks can be discarded. Save the solutions in the volumetric flasks and in the burets and the burets for Part II of the experiment.

CALCULATIONS:

Assuming the HCl solution is 0.1 M exactly, calculate the concentration of the NaOH solution using the formula:

$$M_{NaOH} = \frac{M_{HCl} \times V_{HCl}}{V_{NaOH}}$$

where M_{NaOH} = molarity of the NaOH solution
V_{NaOH} = volume of the NaOH solution
M_{HCl} = molarity of the HCL solution
V_{HCl} = volume of the HCl solution

Show your calculations on the data page.

PART II: ANALYSIS OF STOMACH ANTACID TABLETS

OBJECTIVE:

The object of this laboratory activity is to become familiar with making solutions and to titrate an acid with a base. One solution will be prepared from a solid and one solution will be prepared by dilution of a concentrated solution.

MATERIALS NEEDED:

stomach antacid tablets
sodium bicarbonate (baking soda)
hydrochloric acid, HCl, 0.1 M (previously prepared)
sodium hydroxide, NaOH (previously prepared and standardized)
bromphenol blue solution
100 mL graduated cylinder
2 250-mL Erlenmeyer flasks
mortar and pestle
2 burets, 25 or 50 mL (previously rinsed and filled with HCl and NaOH in Part I of this experiment)
2 small funnels to fit the burets

SAFETY PRECAUTIONS:

Wear approved eye protection in the laboratory at all times.

Hydrochloric acid is corrosive. In the event of skin contact, wash well with water. If the skin is blistered or broken, seek professional medical treatment.

Sodium hydroxide is caustic. In the event of skin contact, wash well with water. If the skin is irritated or broken, seek professional medical treatment.

Stomach antacid tablets used in this experiment have been stored under laboratory conditions and may be contaminated. Do not taste any materials used in this experiment.

DISPOSAL:

All solutions in this experiment should be disposed in the proper containers provided in the laboratory. Solid waste can be disposed of in the trash.

INTRODUCTION:

A television commercial claims that "Rolaids consumes 47 times its own weight in excess stomach acid" while another commercial claims that "for fast relief of acid indigestion and heartburn due to stomach acidity... take Tums for the tummy".

Claims such as these raise questions such as: What is stomach acid? What is excess stomach acid? What does the word "consume" mean with respect to the action of an antacid tablet?

Warner-Lambert Pharmaceutical Company, producer of Rolaids, says that stomach acid is approximately 0.1 M hydrochloric acid. Excess stomach acid is a term used to describe the situation where the pH of the stomach contents falls below 3.0 and the symptoms which are commonly called heartburn and indigestion occur. Consumes, says Warner-Lambert, means that in a test tube a Rolaids tablet maintains the pH above 3.0 as acid is added. Test have been made with both human gastric juice and 0.1 M hydrochloric acid where acid is added to a crushed Rolaids tablet at constant temperature with controlled agitation until the pH is reduced to 3.0. These test are said to justify the manufacturer's claims.

An opposing view to the use of antacid tablets is presented by the Consumers Union, publishers of *Consumer Reports*. They do not give much credit to the claims made for the various antacids and they claim that the old home remedy, sodium bicarbonate, is safe and effective as an antacid if not used is excess.[2]

This experiment will attempt to evaluate the effectiveness of various antacids with respect to sodium bicarbonate and endeavor to support or disprove the advertising claims made by the various antacid manufacturers.

PROCEDURE:

Crush one antacid tablet using a mortar and pestle. Weigh the crushed tablet to the nearest 0.001 g (or the precision of your balance) and transfer it to a 250-mL Erlenmeyer flask. Add exactly 100 mL of 0.10 M HCl to the flask (you may use a graduated cylinder to measure the HCl solution) and gently swirl the flask to dissolve the crushed tablet as completely as possible. Add 2-5 drops of bromphenol blue indicator solution to the flask. At this point the solution should be yellow, if it is blue, add additional 0.1 M HCl in 10 mL increments until the solution is yellow.

Titrate the solution with your standardized NaOH until the indicator just turns blue (this color change is not distinct). Record the volume of NaOH solution required to neutralize the excess acid.

Repeat this procedure two more times using the same brand of antacid tablet.

Repeat the above procedure three more times using a different brand of antacid tablet or using 0.70 gram portions of sodium bicarbonate (baking soda) in place of the antacid tablet. (Note: If sodium bicarbonate is used, add the acid to the sodium bicarbonate very slowly to prevent excess frothing.)

At the conclusion of the experiment, empty the burets and rinse them three times with distilled or deionized water.

CALCULATIONS:

The moles of 0.1 M HCl consumed by the antacid tablet (or by the sodium bicarbonate) is given by the formula:

$$\text{moles}_{HCl} = (V_{HCl} \times M_{HCl}) - (V_{NaOH} \times M_{NaOH})$$

where: M_{NaOH} = concentration of your standardized NaOH
V_{NaOH} = volume of NaOH used in L
M_{HCl} = concentration of HCl
V_{HCl} = volume of HCl used in L

The moles of HCl consumed by 1.0 gram of antacid tablet (or by the sodium carbonate) is given by the formula:

$$\text{moles}_{HCl}/\text{g antacid} = \frac{\text{moles}_{HCl}}{\text{mass antacid used}}$$

Show your calculations on the data page.

REFERENCES:

1. James M. Miller and Don V. Zahniser, "Antacid Analysis", *Chemistry*, **44**, (no. 7) July-August 1971, page 28.

2. The Editors of Consumer Reports, *The Medicine Show*, Revised Edition, Consumers Union, Mount Vernon, N.Y., 1963, pages 38-40.

TITRATION: STANDARDIZATION OF A BASE AND ANALYSIS OF STOMACH ANTACID TABLETS

DATA AND RESULTS

Name ____ Date ________________

PART I: STANDARDIZATION OF A BASE

Preparing Solutions:
Calculate the quantity of 12 M HCl needed to prepare 1000 mL of a 0.10 M solution. Show your calculations below:

Calculate the quantity of NaOH needed to prepare 500 mL of a 0.10 M solution. Show your calculations below:

Standardization of NaOH:

	Trial 1	Trial 2	Trial 3
Initial reading, HCl buret	____________ mL	____________ mL	____________ mL
Final reading, HCl buret	____________ mL	____________ mL	____________ mL
Volume HCl used	____________ mL	____________ mL	____________ mL
Initial reading, NaOH buret	____________ mL	____________ mL	____________ mL
Final reading, NaOH buret	____________ mL	____________ mL	____________ mL
Volume NaOH used	____________ mL	____________ mL	____________ mL
Molarity of NaOH	____________ M	____________ M	____________ M

Show a sample calculation for the Molarity of NaOH below:

Average Molarity of NaOH ____________M

PART II: ANALYSIS OF STOMACH ANTACID TABLETS

Antacid Tablet Analysis 1:

Brand of antacid used __________________________

	Trial 1	Trial 2	Trial 3
Mass of crushed antacid tablet	____________ g	____________ g	____________ g
Volume of HCl used	____________ mL	____________ mL	____________ mL
Initial reading, NaOH buret	____________ mL	____________ mL	____________ mL
Final reading, NaOH buret	____________ mL	____________ mL	____________ mL
Volume NaOH used	____________ mL	____________ mL	____________ mL
Moles of HCl consumed by antacid	____________ mol	____________ mol	____________ mol
Moles of HCl consumed by 1.0 gram of antacid	____________ mol/g	____________ mol/g	____________ mol/g

Show a sample calculation of the moles of HCl consumed by the antacid tablet and the moles of HCl per gram of antacid tablet below:

Average moles of HCl consumed by 1.0 g of antacid tablet ____________ mol/g

Antacid Tablet Analysis 2:

Brand of antacid used ___________________________

	Trial 1	Trial 2	Trial 3
Mass of crushed antacid tablet	____________ g	____________ g	____________ g
Volume of HCl used	____________ mL	____________ mL	____________ mL
Initial reading, NaOH buret	____________ mL	____________ mL	____________ mL
Final reading, NaOH buret	____________ mL	____________ mL	____________ mL
Volume NaOH used	____________ mL	____________ mL	____________ mL
Moles of HCl consumed by antacid	____________ mol	____________ mol	____________ mol
Moles of HCl consumed by 1.0 gram of antacid	____________ mol/g	____________ mol/g	____________ mol/g

Show a sample calculation of the moles of HCl consumed by the antacid tablet and the moles of HCl per gram of antacid tablet below:

Average moles of HCl consumed by 1.0 g of antacid tablet ____________ mol/g

QUESTIONS:

1. It was assumed that the concentration of the HCl solution was exactly 0.1 M in this experiment. How exact do you think the concentration of the HCl solution is when prepared by diluting concentrated HCl? Explain.

2. How exact do you think the concentration of the NaOH solution is? Explain.

3. Why is it okay to leave the flasks wet with rinse water for the titrations?

4. What is the chemical composition of the antacid tablet(s) that you used? (If the exact composition is not given on the label, list the active ingredients.)

5. If the antacid tablet did not dissolve completely in the 0.1 M HCl solution, how can you explain this?

6. If there were variations in the weight of acid consumed for the same brand of antacid tablet, how can you explain this?

7. Which one of the antacid that you tested appeared to be the most effective? Can you explain the difference between them?

8. Do you think that the antacids that you tested live up to the claims of their manufacturers?