Name ____________________________ Partner ____________________________
Lab Section M Tu W Th F

Chemistry 130
Experiment 6: Titration and Analysis

Introduction

A neutralization reaction is one in which an acid (proton donor) and a base (proton acceptor) react with each other. The most common type of neutralization occurs between a strong acid [like HCl] and a strong base [like NaOH] to yield a “salt” and water.

$$HCl_{(aq)} \quad + \quad NaOH_{(aq)} \quad ----------> \quad NaCl_{(aq)} \quad + \quad H_2O_{(l)}$$

The total acid (or base) concentration of a solution can be obtained by carrying out a procedure called **titration**. Let us assume, for instance, that we have a HCl solution whose acid concentration we want to find. We begin by measuring out a known volume of the acid solution and add an acid-base indicator. [An acid-base indicator is a substance that changes color depending on the pH of a solution. We will use phenolphthalein, a typical indicator - it is pink-red in basic solution and colorless in acidic solution.] Next we fill a calibrated tube called a *buret* with a NaOH solution of known concentration. We slowly add the NaOH solution until neutralization is complete. When all the moles of acid have been neutralized, any added basic solution will dramatically increase the pH and the color indicator will change from colorless to pink-red. Upon seeing this color change, we stop adding the NaOH solution (since all the acid originally present has been neutralized).

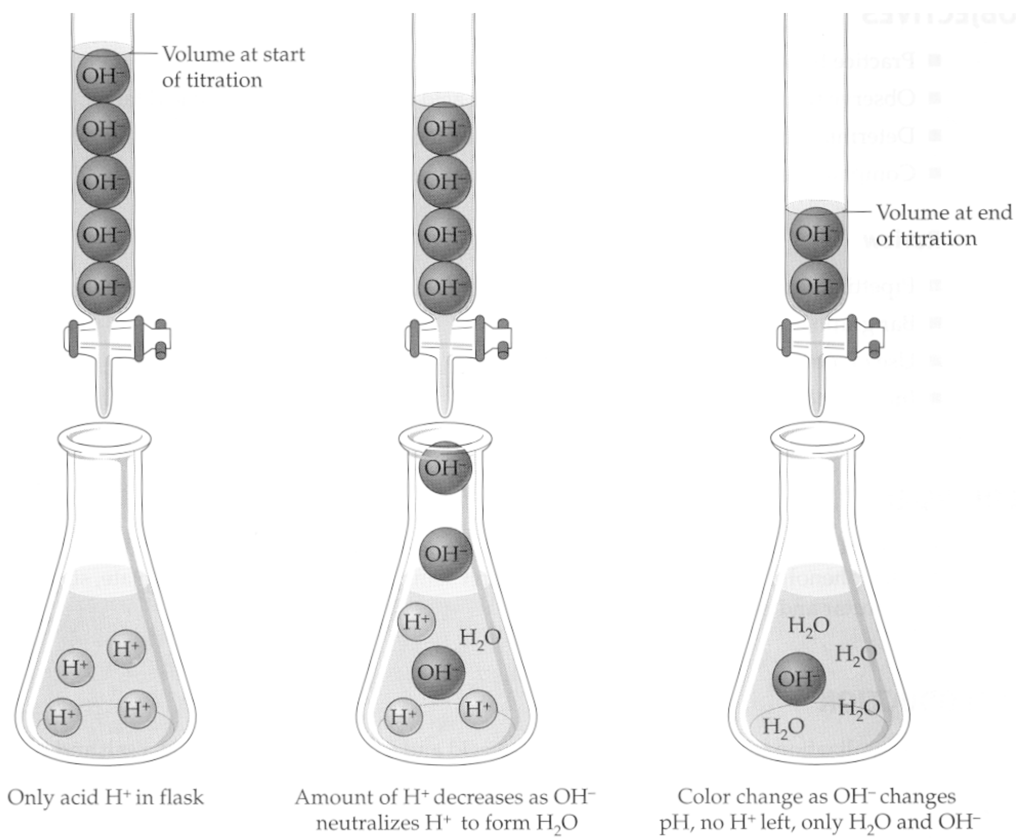


Figure 14.1 Sequence of steps in an acid-base titration.

Reading the buret gives the volume of the NaOH solution that was added. Since we have *both* the volume and the initial concentration for the NaOH solution, we can calculate the moles of NaOH that were added and consumed by the acid in the neutralization reaction.

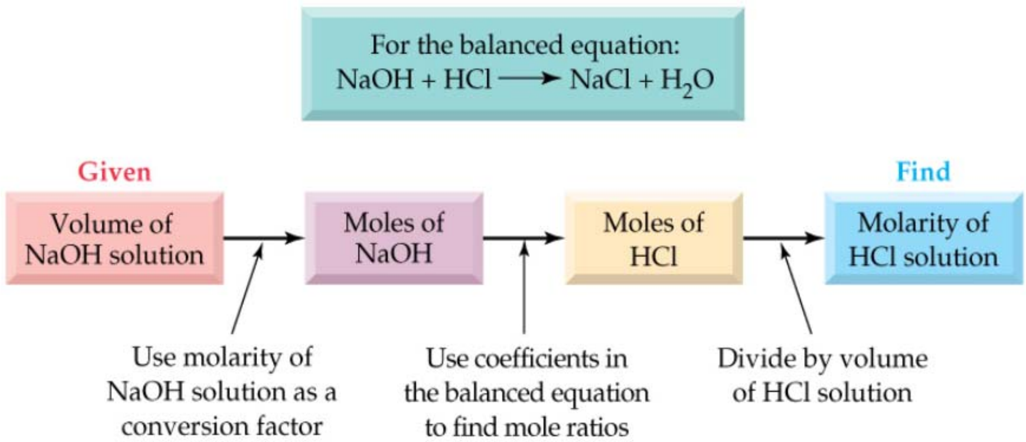
Volume of base (in Liters) X Molarity (Moles / Liter) = Moles base used

The balanced equation shows that one mole of NaOH will react with one mole of HCl **,** so this means that we originally had the exact same number of moles of acid.

Moles base used = Moles acid originally present

And, since we know the volume of the original acid solution that we used, we can calculate the unknown concentration of the HCl solution.

Moles acid originally present / Original volume of acid (in Liters) = Molarity of acid



Our experiment will consist of two parts: Part I will be an example of the titration described above, actually using $HCl_{(aq)}$ and $NaOH_{(aq)}$. The procedure in Part II is known as a "back titration."

Part I: Titration Procedure

1. Clean, rinse, and fill a buret with NaOH solution. Record the initial NaOH volume reading from the buret (+0.02 mL). Do not try to get the reading to be 0.00 mL - just some reading between 0.00 and 2.00 mL!

Initial buret reading ________________ mL

2. Transfer 10.00 mL of the HCl solution to an Erlenmeyer flask. Add about 10 mL of water to this flask and swirl the contents to make a homogeneous solution.

3. Add 3 - 4 drops of phenolphthalein indicator to the flask and gently swirl the flask. You **MUST** add this color indicator! This color indicator is colorless in acidic solution but pink in basic solution.

4. Titrate the acid solution with the NaOH solution by adding NaOH solution *dropwise* until the color change occurs (called the phenolphthalein endpoint). As you add the NaOH solution, *swirl* the flask to promote mixing of the reagents. When you see a permanent color change in the combined solution, STOP adding the NaOH solution. Record the final NaOH volume (+0.02 mL).

Final buret reading ______________________ mL

5. What is the total volume of NaOH solution added (difference between final and initial volumes) ____________________________________ mL

Molarity of NaOH solution (see label) _________________ M.

6. How many moles of NaOH were added in your titration?

7. How many moles of HCl were in the original acid solution?

8. You had 10.00 mL of the original HCl solution. What is the concentration of the original HCl solution?

9. Compare your calculated molarity with the actual molarity listed on the bottle of $HCl_{(aq)}$.

Molarity of HCl solution (see label) _________________ M. **Comments?**

Part II: Analysis of Commercial Antacid Tablets

Hydrochloric acid (HCl) is one of the substances found in gastric juices secreted by the lining of the stomach. HCl is needed by the enzyme pepsin to catalyze the digestion of proteins in the food we eat. Heartburn is a symptom that results when the stomach produces too much acid .

Antacids are bases used to neutralize the acid that causes heartburn. Despite the many commercial brands, almost all antacids act on excess stomach acid by neutralizing it with weak bases. The most common of these bases are hydroxides, carbonates, or bicarbonates. The following table contains a list of the active ingredients found in several common commercial antacids, and the reactions by which these antacids neutralize the HCl in stomach acid.

Compound	Formula	Chemical Reaction
Aluminum hydroxide	$Al(OH)_3$	$Al(OH)_3$ (s) + 3 HCl(aq) -----> $AlCl_3$(aq) + 3 H_2O(l)
Calcium carbonate	$CaCO_3$	$CaCO_3$ (s) + 2 HCl(aq) -----> $CaCl_2$(aq) + H_2O(l) + CO_2(g)
Magnesium carbonate	$MgCO_3$	$MgCO_3$ (s) + 2 HCl(aq) -----> $MgCl_2$(aq) + H_2O(l) + CO_2(g)
Magnesium hydroxide	$Mg(OH)_2$	$Mg(OH)_2$ (s) + 2 HCl(aq) -----> $MgCl_2$(aq) + 2 H_2O(l)
Sodium bicarbonate	$NaHCO_3$	$NaHCO_3$ (aq) + HCl(aq) -----> NaCl(aq) + H_2O(l) + CO_2 (g)

In this experiment, several brands of antacids will be analyzed to determine how much acid is neutralized per tablet and the cost analysis of each tablet. The analytical procedure used is known as **back titration**. In this procedure, a known amount of HCl, which is in excess, will be reacted with a weighed portion of a ground-up antacid tablet. The HCl remaining after the antacid has been neutralized will be determined by titration with NaOH until all the acid is neutralized. We will again use phenolphthalein as the indicator. How much HCl is neutralized by the antacid ($HCl_{neutralized}$) is the difference between the amount of HCl initially present in excess ($HCl_{initial}$) and the amount of HCl titrated by the NaOH ($HCl_{titrated}$).

$$HCl_{initial} - HCl_{titrated} = HCl_{neutralized}$$

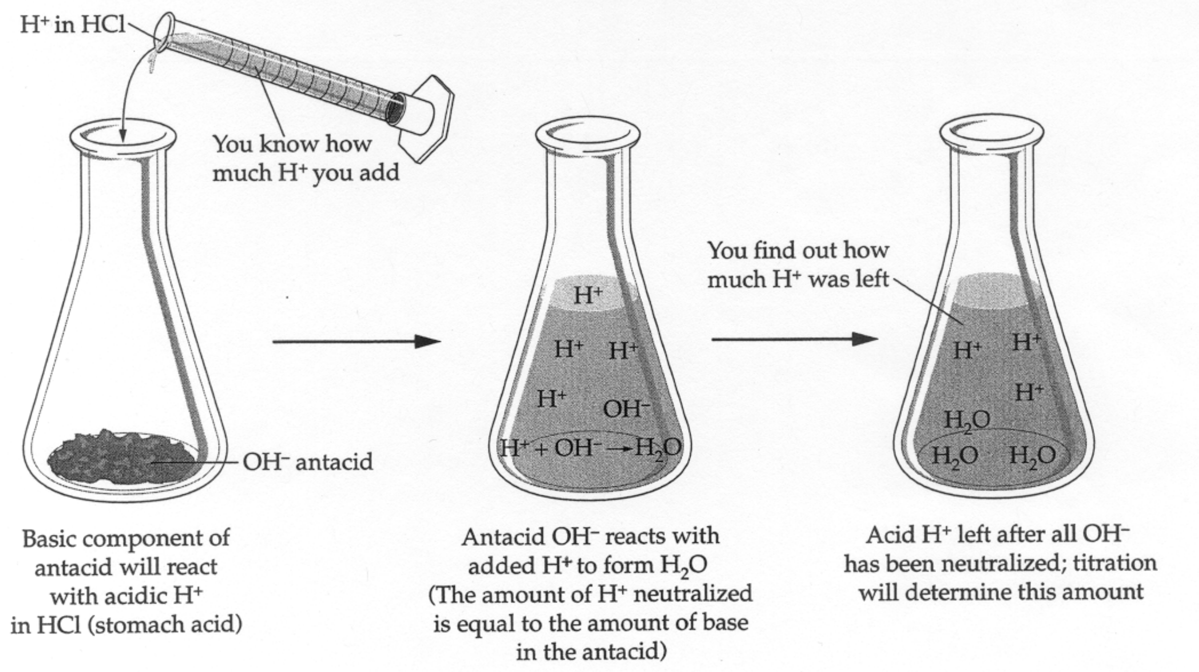


Figure 14.2 Sequence of steps involved in the neutralization of stomach acid (HCl) by the base in an antacid.

Back Titration Procedure:

1. Fill a buret with NaOH solution. Record the initial NaOH volume reading from the buret (+0.02 mL). Do not try to get the reading to be 0.00 mL - just some reading between 0.00 and 2.00 mL!

Initial buret reading ________________ mL

2. Weigh an antacid table in a weighing boat. Transfer the tablet to a clean mortar and crush the tablet into a fine powder using the pestle.

Antacid Brand __________________

Weight of antacid tablet _______________ g

3. Weigh about 0.2 grams (+0.01 g) of the ground up tablet powder and transfer it to a clean 125 mL Erlenmeyer flask.

Weight of powder ___________________ g

4. Transfer 20 mL of the HCl solution to the flask which contains your antacid.

Molarity of HCl solution (see label) _________________ M.

5. Swirl the flask to help dissolve the antacid. Since the antacid tablet may contain inert ingredients, much of the tablet may not dissolve and the liquid may be cloudy. The active antacid ingredient will dissolve however and react with the acid very quickly while the liquid will remain cloudy.

6. Add 3 - 4 drops of phenolphthalein indicator to the flask and gently swirl the flask. You MUST add this color indicator! This color indicator is colorless in acidic solution but pink in basic solution.

7. Titrate the acid solution with the NaOH solution by adding NaOH solution *dropwise* until the color change occurs (called the phenolphthalein endpoint). Since the liquid is cloudy, the color change at the endpoint may be hard to detect, so watch very closely. As you add the NaOH solution, *swirl* the flask to promote mixing of the reagents. When you see a permanent color change in the combined solution, STOP adding the NaOH solution. Record the final NaOH volume (+0.02 mL).

Final buret reading ______________________ mL

8. What is the total volume of NaOH solution added (difference between final and initial volumes)

____________________________________ mL

Molarity of NaOH solution (see label) _________________ M.

CALCULATIONS:

Brand of Antacid: ___________________

1. How many moles of HCl were added to the antacid powder? [our $HCl_{initial}$]

2. How many moles of NaOH were added in the titration?

3. How many moles of “excess” HCl were neutralized by the NaOH in the titration?

4. How many moles of HCl were neutralized by the antacid powder?
   [NOTE: moles neutralized = moles initial - moles titrated]

5. How many moles of HCl does one antacid pill neutralize? Remember that you only used 0.2 g of the powder - and not all of the pill.

6. The recommended dosage for each of these antacids is two tablets. Find the data (from number 5 above) from other groups in the lab who used the different antacid brands, and contemplate which is the most cost effective antacid.

The price for each type of antacid is: Tums - $4.29 for 72 tablets
Rolaids - $4.49 for 100 tablets
Alka-Seltzer - $4.79 for 36 tablets

Which of these antacids would you recommend as the better buy?

Figures 14.1 and 14.2 are from: W. Gloffke, “Introductory Chemistry Laboratory Manual,” Benjamin/Cummings, 2000, pp. 88-89.