Name: _____ Date: _____

Back-Titration of an Antacid

Objective: In this experiment, you will standardize a solution of base using the analytical technique known as titration. Using this standardized solution, you will determine the acid neutralizing power of a commercially available antacid tablet.

Abstract:

An understanding of the properties of acids and bases is an essential part of understanding chemical reactions. In aqueous solutions, a compound that produces H^+ ions upon dissolution is termed an acid. A compound that produces OH^- ions when dissolved in water is called a base. The reaction of an acid and base is a neutralization reaction, the products of which are a salt and water. In an aqueous solution, virtually all of the OH^- ions present will react with all of the H^+ ions which are present:

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)} \quad (1)$$

Because this reaction is quantitative, it is possible to determine the concentration of an acid or base in an aqueous solution with high accuracy.

When a solution of hydrochloric acid, HCl, is exactly neutralized with a solution of sodium hydroxide, NaOH, the number of moles of NaOH used will equal the number of moles of HCl originally present. The following relationship then holds true:

$$\text{moles}_{NaOH} = \text{moles}_{HCl} \quad (2)$$

$$(M_{NaOH})(V_{NaOH}) = (M_{HCl})(V_{HCl}) \quad (3)$$

In order to determine when a solution has been exactly neutralized, an acid-base indicator is used which changes color in a certain pH range. This color change is termed the endpoint of the titration. Because the pH of a neutral solution is 7, an indicator that changes color near this pH should be used for an acid-base titration. Phenolphthalein indicator changes color in the range pH = 8.3 – 10.0 and can be used to determine when the correct amount of base has been added to an acidic solution to exactly neutralize it.

Standardization of a Sodium Hydroxide Solution

In order to determine the concentration of an acidic or basic solution, it is necessary to know the number of moles of acid or base which are required to neutralize it. This quantity can be calculated by accurately weighing a solid sample of an acid or a base, dissolving it in water and titrating this solution; that is, adding the solution of unknown concentration to it until the endpoint has been reached.

It is difficult to accurately mass sodium hydroxide since it is hygroscopic. A solution of NaOH is usually standardized using an acid known as a primary standard. A primary standard must satisfy the four following criteria:

1. Solid compound that is not hygroscopic and can be easily handled
2. Is available in very pure form
3. Stable
4. Has a medium to high molecular mass

For this experiment, a solution of NaOH, which has an approximate concentration of 0.1 M, will be standardized using potassium hydrogen phthalate, KHPh. The molecular mass of KHPh is 204.23 g/mole, and it has one acidic proton which will react with OH^-:

$$OH^-_{(aq)} + KHPh_{(aq)} \rightarrow H_2O_{(\ell)} + KPh^-_{(aq)} \quad (4)$$

For the highest accuracy, a sample size is chosen such that it will consume as large a volume of the base as possible without exceeding the capacity of the buret. If a 50 mL buret is used, the amount of KHPh is chosen such that it will require approximately 20 mL of 0.1 M NaOH solution to reach the endpoint. Thus, about 0.002 moles, or 0.4 g, of KHPh is needed.

At the endpoint, the number of moles of NaOH equals the number of moles of KHPh used:

$$M = \frac{n_{KHPh}}{V_{NaOH}} = \frac{\frac{mass_{KHPh}}{204.23\ g}}{V_{NaOH}} \quad (5)$$

Once the NaOH solution has been standardized, it can be used to determine the acid neutralizing capacity of an antacid tablet.

Determination of the Acid Neutralizing Capacity of an Antacid Tablet

The stomach has an acidic interior generated by dilute HCl, "stomach acid", which insures proper digestion. When the acidity of the stomach becomes high enough to cause discomfort, brought about by the ingestion of certain types of food, an antacid tablet can be taken to neutralize the excess stomach acid. The active ingredient in every antacid is a base, the most common being metal hydroxides, metal carbonates or a mixture of the two.

The acid neutralizing capacity of a tablet is the amount of hydrochloric acid that it can neutralize. It is the quantity which is referred to in some advertisements when it is stated that the tablet "neutralizes x times its mass in stomach acid". This capacity can be determined by a technique called back-titration. A known amount of antacid is dissolved in an excess of HCl, and then the excess acid is back-titrated with standardized NaOH solution. When the endpoint is reached, the number of moles of acid which was added to the antacid sample is equal to the number of moles of base present, NaOH plus the antacid. Therefore, the number of moles of HCl which was neutralized by the antacid is equal to the total number of moles of HCl added minus the number of moles which were neutralized by the NaOH:

moles acid neutralized = (moles of HCl added) – (moles of NaOH required for back-titration)

$$= (M_{HCl} \times V_{HCl}) - (M_{NaOH} \times V_{NaOH}) \quad (6)$$

Procedure:

A few milliliters of NaOH solution should be used to thoroughly rinse down the sides of the buret. The buret is filled to a point above the "0" mL mark with NaOH solution. In order to fill the tip of the buret with liquid, the solution is drained out of the bottom until the meniscus lies between the "0" and "1" mL marks. The initial buret reading can now be recorded to the nearest 0.01 mL.

Standardization of NaOH solution

Accurately mass out a sample of approximately 0.3-0.4 g of primary standard potassium hydrogen phthalate, KHP, which has been previously dried at 120°C. Do not use more than 0.4 g. Place an Erlenmeyer flask on a balance, tare it, and add the approximate amount of solid needed.

Dissolve the KHP sample in about 20 mL of distilled water and add 2-3 drops of phenolphthalein. Place the flask on the hot/stir plate add a magnet and begin adding the approximately 0.1 M sodium hydroxide solution from the buret. Do not open the stopcock completely. When the color persists for 30 seconds after swirling, the endpoint has been reached. The color will fade after some time due to absorption of CO_2 from the air. If a deep pink color results, the endpoint has been overrun. Just prior to the endpoint, the flask walls should be rinsed down with a stream of distilled water from your wash bottle. It is possible to add "half-drops" of solution from the buret. Open the stopcock until a drop just forms at the tip of the buret. Touch the drop to the side of the flask and wash it down with distilled water.

When the endpoint is reached, record the final buret reading to the nearest 0.01 mL. Refill the buret so that you do not run out of NaOH solution in the middle of the next titration.

Back-titration of an antacid

Choose a brand and obtain an antacid tablet. Avoid touching it with your fingers as much as possible. Record the brand name in your lab book. Obtain a tablet and crush it with a mortar and pestle. Transfer the crushed tablet to an Erlenmeyer flask and mass to the nearest 0.01 g.

Obtain a second buret, rinse it with HCl, and fill it to just below the 0 mark. Record the initial volume of the acid. Add approximately 12 mL of standardized HCl to the flask containing the antacid tablet. Record precisely how much acid was added using the initial and final readings of the buret. Also, be sure to record the exact molarity of the HCl solution.

Rinse down the inner walls of the flask with 40-50 mL of distilled water, and swirl the flask. The tablet may contain an insoluble binder and filler which will not dissolve; however, be certain that no large chunks or chips of the tablet remain.

Carbonate ions in the sample will react with the HCl and produce CO_2. The CO_2 can be driven off by heating the contents of the flask just to boiling:

$$2\ H^+_{(aq)} + CO_3^{2-}{}_{(aq)} \rightleftharpoons H_2CO_3{}_{(aq)} \xrightarrow{\Delta} CO_2{}_{(g)} + H_2O_{(\ell)}$$

Adjust the hot plate to maintain a gentle boil for 10 minutes. Remove from the heat and allow the flask to cool until it is comfortable to hold.

Add 8 drops of phenolphthalein to the flask and swirl to mix; then rinse down the sides of the flask with your wash bottle. If the solution is pink at this point, more acid must be added from the buret, 1 mL at a time, until the color disappears. After it is clear, titrate the solution, as in the first part of the experiment, to the pale pink endpoint using the standardized NaOH solution.

Calculations:

Consult the proper equations in the abstract for assistance:

1. From the class set of data, determine the molarity of sodium hydroxide in the standardization. Perform a Q-Test on these molarities, and average all the remaining values.
2. From the class set of data, determine the moles of HCl neutralized in each trial.
3. From the class set of data, find a ratio of moles of HCl neutralized to mass of tablet. Perform a Q-Test on these ratios, and average all the remaining values.