A. Acetic Acid in Vinegar

Materials: Vinegar (white), two beakers (150 and 250 mL), 250-mL Erlenmeyer flask, 10-mL graduated cylinder (or a 5-mL pipet and bulb), phenolphthalein indicator, 50-mL buret (or 25-mL buret), buret clamp, small funnel to fit buret, 0.1 M NaOH (standardized), white paper or paper towel

A.1 Obtain about 20 mL of vinegar in a small beaker. Record the brand of vinegar and the % acetic acid stated on the label. Using a 10-mL graduated cylinder or a 5.0-mL pipet, transfer 5.0 mL of vinegar to a 250-mL Erlenmeyer flask.

Using a pipet: Place the pipet bulb on the end of the pipet and squeeze the bulb to remove air. Place the tip of the pipet in the vinegar in the beaker and allow the bulb to slowly expand. (If the bulb was squeezed too much, the change in pressure will draw liquid up into the bulb.) When the liquid goes above the volume line, but not into the bulb, carefully remove the bulb and quickly place your second finger (index finger) tightly over the end of the stem. By adjusting the pressure of the index finger, lower the liquid to the etched line that marks the 5.0-mL volume and stop. Lift the pipet with its 5.0 mL of vinegar out of the beaker and let it drain into an Erlenmeyer flask. Touch the tip of the pipet to the wall of the flask to remove the rest of the vinegar. A small amount that remains in the tip has been included in the calibration of the pipet. See Figure 1 for use of a pipet. **Caution: If you are using a pipet, use a suction bulb to draw vinegar into a pipet. Do not pipet by mouth!**

Add about 25 mL of distilled water to increase the volume of the solution for titration. This will not affect your results. Add 2–3 drops of the phenolphthalein indicator to the solution in the flask.

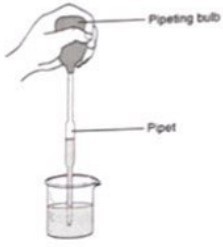

Figure 1 Using a bulb to draw a liquid into a pipet

A.2 Obtain a 50-mL or 25-mL buret and place it in a buret clamp or butterfly clamp as shown in Figure 2. Using a 250-mL beaker, obtain about 100 mL of 0.1 M NaOH solution. (If you are using a 25.0-mL buret, use a 0.2 M NaOH solution.) Record the molarity (M) of the NaOH solution that is stated on the label of the reagent bottle. Rinse the buret with two 5-mL portions of the NaOH solution. Discard the NaOH washings.

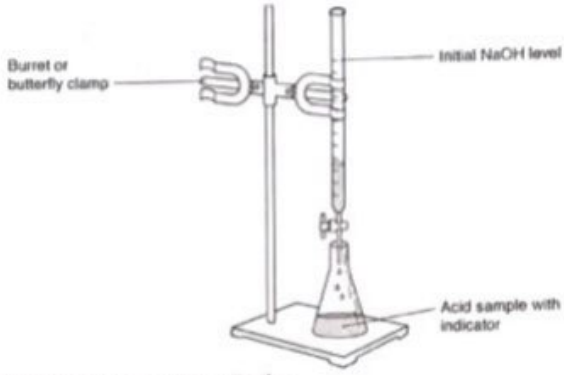

Figure 2 Buret setup for acid–base titration

A.3 Observe the markings on the buret. The top is marked 0.0 mL, and 50.0 mL (or 25.0 mL) is marked at the bottom. Place a small funnel in the top of the buret and carefully pour NaOH into the funnel. Pour slowly as the NaOH fills the buret. Lift the funnel and allow the NaOH to go above the top line (0.0 mL). Slowly open the stopcock and drain NaOH into a waste beaker until the meniscus is at the 0.00 mL line or below. The buret tip should be full of NaOH solution, and free of bubbles. Record the initial buret reading of NaOH.

A.4 Place the flask containing the vinegar solution under the buret on a piece of white paper. (Be sure you added indicator.) Begin to add NaOH to the solution by opening and closing the stopcock with your left hand (if you are right-handed). Swirl the flask with your right hand to mix the acid and the base. At first, the pink color produced by the reaction will disappear quickly. As you near the endpoint, the pink color will be more persistent and disappear slowly. *Slow down* the addition of the NaOH to drops at this time. Soon, one drop of NaOH will give a faint, permanent pink color to the sample. *Stop adding NaOH.* You have reached the endpoint of the titration. See Figure 3.

Figure 3 During a titration, the solution in the flask is swirled as NaOH is added to the acid sample.

At the endpoint, record the final buret reading of the NaOH. Fill the buret again. Repeat the titration with new samples of the same brand of vinegar. *Be sure to add water and indicator to each new sample of vinegar.*

Calculating the molarity of acetic acid

Using the average measured volume of the NaOH, and its molarity (on the label), the moles of NaOH used can be calculated.

$$\text{Moles NaOH used} = \text{L NaOH used} \times \frac{\text{moles NaOH}}{\text{L NaOH}}$$

When an acid is completely neutralized, the moles of NaOH are equal to the moles of acetic acid ($HC_2H_3O_2$) present in the sample. This occurs because there are the same number of H^+ and OH^- ions in the reactants:

$$\text{Moles } HC_2H_3O_2 = \text{moles NaOH}$$

Using the moles of acid, the molarity of acetic acid in the 5.0-mL sample of vinegar is calculated.

$$\text{Molarity (M) } HC_2H_3O_2 = \frac{\text{moles } HC_2H_3O_2}{0.0050 \text{ L vinegar}}$$

Calculating the percent (mass/volume) of acetic acid

To calculate the percent (m/v) of $HC_2H_3O_2$ in vinegar, we convert the moles of acetic acid to grams using the molar mass of acetic acid, 60.0 g/mole.

$$\text{g } HC_2H_3O_2 = \text{moles } HC_2H_3O_2 \times \frac{60.0 \text{ g } HC_2H_3O_2}{1 \text{ mole } HC_2H_3O_2}$$

$$\text{Percent (m/v)} = \frac{\text{g } HC_2H_3O_2}{5.0 \text{ mL}} \times 100$$

B. Titration of an Antacid

Stomach acid is primarily hydrochloric acid (HCl), which has a concentration of about 0.1 M. Sometimes when a person is under stress, excess HCl may be produced, causing discomfort. An agent called an antacid is used to neutralize some of the excess stomach acid. In this experiment, the volume (mL) of 0.1 M HCl that can be absorbed by some common antacids will be determined.

Milk of magnesia, Di-Gel $\quad Mg(OH)_2 + 2HCl \longrightarrow MgCl_2 + 2H_2O$

Tums $\quad CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

Lab Information

Time: 2 hr

Comments: Tear out the Lab report sheets and place them next to the matching procedures.
Practice observing the color change for the indicators before you do the titrations.
Carefully read the markings on the buret.
Students may bring their own antacid samples to test.

Related topics: Acid, base, neutralization, titration, percent concentration, molarity

Goals

- Prepare a sample for titration with a base.
- Set up a buret and use proper titration technique in reaching an endpoint.
- Calculate the molar concentration and percentage of acetic acid in vinegar.
- Determine the acid-absorbing capacity of a commercial antacid.

Discussion

In a neutralization reaction, the protons (H^+) from the acid combine with hydroxide ions (OH^-) from the base to produce water (H_2O). The remaining substance is a salt, which is composed of ions from the acid and base. For example, the neutralization of HCl by NaOH is written as

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

If we write the ionic substances in the equation as ions, we see that the H^+ and the OH^- form water.

$$H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O$$

$$H^+ + OH^- \longrightarrow H_2O$$

In a complete neutralization, the amount of H^+ will be equal to the amount of OH^-.

A. Acetic Acid in Vinegar

Vinegar is an aqueous solution of acetic acid, $HC_2H_3O_2$ or CH_3COOH. The amount of acetic acid in a vinegar solution can be determined by neutralizing the acid with a base, in this case NaOH. As shown in the following equation, one mole of acetic acid is neutralized by one mole of NaOH.

$$\underset{\textit{Acetic acid}}{HC_2H_3O_2} + \underset{\textit{Base}}{NaOH} \longrightarrow \underset{\textit{Salt}}{C_2H_3O_2^-\,Na^+} + H_2O$$

A *titration* involves the addition of a specific amount of base required to neutralize an acid in a sample. When all the H^+ (or H_3O^+) from the acid has been neutralized, an indicator in the sample will change color. This change in the indicator color determines the *endpoint*, which signals that the addition of the base should be stopped. The volume of base used to neutralize the acid is then determined. In this experiment, phenolphthalein is the indicator; it changes from colorless in acid to a faint but permanent pink color in base.