OBJECTIVE:

To determine the percentage by mass of acetic acid in vinegar.

LEARNING OUTCOMES

After conducting this experiment, you should be able to:
1. Calculate the concentration of acetic acid in vinegar
2. Determine the percent by mass of acetic acid in vinegar

INTRODUCTION:

Acetic acid is the chemical compound responsible for the characteristic odor and sour taste of vinegar. Household vinegar is a 4 – 5 % (by mass) acetic acid, CH_3COOH, solution (4% is the minimum federal standard). Generally, caramel flavoring and coloring are also added to make the product aesthetically more appealing. In this experiment you are going to analyze a sample of vinegar to find the percent-by-mass of acetic acid in the vinegar.

Volumetric analysis is a technique that employs the measurement of volumes to determine quantitatively the amount of a substance in solution. In any reaction between two or more species, the reaction equation will show the stoichiometric ratio of reacting species. In a volumetric analysis, if one of these species is present in known molar concentration, then by taking a fixed volume of one solution and progressively adding the other solution, it is possible to find a point at which complete reaction of the substances has occurred. This is called the *equivalence point*. The incremental process is called *titration* and enables the concentration of a solution to be determined from the ratio of reacting volumes, the stoichiometric equation and the one known concentration.

The titration techniques is the method used for determine of the percent by mass of acetic acid in vinegar. A measured mass of vinegar is titrated to the phenolphthalein or thymol blue endpoint with a measured volume of a standardized sodium hydroxide solution. As the volume and molar concentration of the standardized NaOH solution are known, the moles of NaOH used for the analysis are also known.

The moles of CH_3COOH are calculated from the balanced equation:

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \rightarrow NaCH_3CO_{2(aq)} + H_2O_{(l)} \qquad (4.1)$$

The mass of CH_3COOH in the vinegar is calculated from the measured moles of CH_3COOH neutralized in the reaction and its molar mass, 60.05 g/mol:

$$Mass\ (g)\ of\ CH_3COOH = mol\ CH_3COOH \times 60.05\ g/mol\ CH_3COOH \qquad (4.2)$$

Finally, the percent by mass of CH_3COOH in vinegar is calculated:

$$\%by\ mass\ \ of\ CH_3COOH = \frac{mass\ (g)\ of\ CH_3COOH}{mass\ (g)\ of\ vinegar} \times 100\% \qquad (4.3)$$

LAB EQUIPMENT

Volumetric flask 100 mL,
Pipette 20 mL,
Burette 50 mL,
Conical flask 125 or 250 mL

CHEMICALS AND MATERIALS

Standardized NaOH solution,
Sample of vinegar
Thymol blue indicator

EXPERIMENTAL PROCEDURE:

1. Clean 100 mL volumetric flask, and measure its mass.
2. Add the 10 mL of the vinegar to a volumetric flask with previously measured mass.
3. Measure the combined mass of the volumetric flask and sample of vinegar.
4. Dilute a concentrated solution with fill the volumetric flask to the 100 mL mark using distilled water, gently shake the solution.
5. In 125 or 250 mL Erlenmeyer flask, pipette 20 mL of the diluted acid solution (from volumetric flask). Add 5 drop of thymol blue indicator solution.
6. Rinse a clean 50 mL burette with the standardized NaOH solution; fill the burette with NaOH solution. Adjust the volume to the zero mark and record the initial volume.
7. Titrate the sample solution with NaOH solution until the solution just turns blue and the blue color persists for 30 seconds. Read and record the final volume of NaOH titrant in the burette.
8. Repeat the titration procedure above (step 5 to 7), 2 more times.