1. How Much Acetic Acid Is in Vinegar?

Introduction

Quantitative analysis determines the amount of a particular substance in a sample. Often, this determination is accomplished through a *titration* (Ebbing/Gammon, Section 4.10) of the sample with a solution of another substance whose concentration is known. These substances must react with each other, of course.

Some physical or chemical response must be coupled to the titration to signal the exact completion of the reaction. An *indicator* can sometimes be used. The indicator chosen will have one color before the reaction is complete and another color when completion occurs. After the indicator is added to the sample solution, the solution of known concentration is delivered carefully from a buret until the indicator changes color. The Introduction to this manual describes the proper use of a buret.

Purpose

You will determine the amount of acetic acid in white vinegar by titration with a solution of sodium hydroxide whose concentration is known. The indicator will be phenolphthalein.

Concept of the experiment

The object of this experiment is to determine the molar concentration (Ebbing/Gammon, Section 4.7) of acetic acid ($HC_2H_3O_2$) in vinegar. You will accomplish this through the titration of a sample of vinegar with a solution of sodium hydroxide (NaOH). These substances react readily.

$$HC_2H_3O_2 + NaOH \rightarrow NaC_2H_3O_2 + H_2O$$

Phenolphthalein will be used as the indicator. It will be colorless before the completion of this reaction but pink after the completion. You must be prepared to search carefully for a point in the titration at which 1 drop of the NaOH solution causes the solution being titrated to turn from colorless to a barely discernible pink color. This point is called the *endpoint*. You will do a trial titration to find the approximate endpoint before you do a pair of exact titrations. These titrations, the molarity of the solution of sodium hydroxide and the balanced equation, will provide all that you need to determine the molarity of the acetic acid.

Procedure

Getting started

1. Obtain a 10-mL transfer pipet and a 50-mL buret.
2. Next obtain about 30 mL of white 5% vinegar and about 85 mL of the solution of NaOH. The vinegar may be kept in a clean, dry beaker.

However, the NaOH solution must be kept in a clean, dry Erlenmeyer flask that is closed with a rubber stopper. This solution must be protected when it is not in use because NaOH will react with carbon dioxide (CO_2) in the air. The molarity of this solution will lie between 0.2 *M* and 0.3 *M*; the exact concentration will be given on the label of the bottle.

Cleaning and filling your buret

1. The Introduction to this manual gives instructions for using a buret. Clean your buret and fill it with the NaOH solution after you have read those procedures carefully.

Doing the trial titration

1. Pipet 10.0 mL of vinegar into a clean 125-mL Erlenmeyer flask. Add about 20 mL of distilled water from a clean graduated cylinder. Add 2 drops of phenolphthalein solution.

   CAUTION: Never use your mouth to draw liquid into the pipet. Use a rubber suction bulb or some other suction device.

2. Record the molarity of the NaOH solution and the initial buret reading.
3. Place the flask under the buret with the capillary tip inside the mouth of the flask. Place a piece of white paper under the flask.
4. Add the NaOH solution to the flask in increments of about 1 mL while swirling. Note the color of the solution after each addition.
5. This trial titration is complete when an addition of about 1 mL causes the color to change from colorless to any shade of pink.
6. Record the buret reading. Subtract the initial reading from this reading to obtain the volume required for the approximate endpoint.

Doing the exact titrations

1. Repeat Steps 1, 2, and 3 of the procedure used for the trial titration.
2. Subtract 1 mL from the volume found in the trial titration. *Rapidly* add the resulting volume to the flask from the buret.
3. Rinse the walls of the flask with distilled water from a plastic wash bottle.
4. Continue the titration on a *drop-by-drop* basis. Swirl the flask rapidly after each drop. The endpoint is the first permanent, *barely visible* pink color. Finding the true endpoint requires patience and skill. Absolutely no skill is required to miss the endpoint and achieve a very deep pink color. If you are unsure about the endpoint, record the buret reading before you add the next drop.
5. Repeat the procedure with a second sample of vinegar.
6. If the volumes at the endpoints of these two exact titrations differ by more than 0.15 mL (about 3 drops), repeat the titrations with additional samples of vinegar until two consecutive results have this precision.
7. Calculate and record the molarity of the vinegar from each of the two titrations. Does each molarity have the correct number of significant figures? Obtain the mean molarity.

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Prelaboratory assignment

1. a. What is the purpose of the trial titration?

   b. Describe the endpoint for the titration in some detail.

   c. Explain why the walls of the flask are washed with distilled water during the titration. How will this affect the outcome of the titration?

2. A 10.0-mL sample of aqueous HCl requires 24.32 mL of 0.134 *M* NaOH to reach the endpoint. What is the molar concentration of HCl? The equation for the reaction is

$$NaOH + HCl \rightarrow NaCl + H_2O$$

3. What safety rule must be observed during this experiment?

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Results

Molarity of the NaOH solution: .....

1. *Trial titration*

   Final buret reading (mL): .....

   Initial buret reading (mL): .....

   Volume of NaOH solution (mL): .....

2. *Exact titrations*

Sample No.	**1**	**2**	**3**	**4**
Final buret reading (mL)	.....	.....	.....	.....
Initial buret reading (mL)	.....	.....	.....	.....
Volume of NaOH solution (mL)	.....	.....	.....	.....
Concentration of $HC_2H_3O_2$ (M)	.....	.....	.....	.....
Mean concentration (M)	.....			

Calculations:

Questions

1. The manufacturer of the vinegar used in this experiment claims that the vinegar contains 5% acetic acid by weight. Use your results and a density of 1.0 g/mL to investigate this claim.

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2. Redo the numerical problem in the Prelaboratory Assignment, substituting H_2SO_4 for HCl.