Titration of Acetic Acid in Vinegar

Introduction

A titration is a technique often used to find the concentration of a solute in a solution, though it may also be used in other analyses, such as determining the mass of a substance in a mixture of solids. The determination of Vitamin C in food samples and the neutralization capacity of antacids are a couple of other titration experiments that have been performed at this college.

Learner Outcomes

Upon completion of this laboratory activity, the student should be able to

- perform a simple acid-base titration.
- calculate the concentration of an acid in a solution.

Background

The smell of vinegar is attributed to acetic acid. In this experiment, you will determine the molar concentration and the mass percentage of acetic acid in the vinegar. You will be able to compare the mass percentage obtained experimentally with the manufacturer's claim on the label. The concentration of acetic acid will be determined by reacting a known volume of the vinegar with a solution of sodium hydroxide of known concentration. The reaction is as follows:

$$HC_2H_3O_2\ (aq) + NaOH\ (aq) \rightarrow NaC_2H_3O_2\ (aq) + H_2O\ (l)$$

Phenolphthalein, an acid-base indicator, will be used to detect the endpoint of the titration. Phenolphthalein is colorless in acidic and neutral solution, but pink in basic solution. Therefore, you will proceed with the titration until you see a pink color that remains for at least 30 seconds.

Safety

Safety goggles are required at all times. Avoid skin contact with the NaOH solution. If skin contact occurs, wash immediately with large amounts of water. In the event of eye contact, flush eyes thoroughly with water for at least 15 minutes and seek immediate medical attention.

Procedure

Standarizing the NaOH Solution

1. Measure between 0.08-0.1 g of potassium hydrogen phthalate ($KHC_8H_4O_4$), abbreviated as KHP, into a clean 50-mL Erlenmeyer flask. Record the exact mass of KHP used. Add about 10 mL of deionized water, using a wash bottle to rinse down any chemicals that may have splashed onto the walls of the flask. Add 1 drop of phenolphthalein indicator to the flask. Swirl to dissolve the solid.

2. Set up a micro-titration apparatus as described by your instructor. Rinse and fill a clean 2-mL pipet (the microburet) with the NaOH solution. Record the initial microburet reading of the NaOH solution.

3. Slowly add the NaOH solution to the flask containing the KHP, swirling gently during the addition. Continue adding the NaOH until the endpoint is reached, which is the first sign of a pink color that remains after at least 30 seconds of swirling.

4. Record the final microburet reading. Calculate the volume of NaOH solution that was used in your titration.
5. Repeat steps 1-4 **twice** to obtain a total of 3 trials.

6. Calculate the molarity of the NaOH for each of the three trials from the volume of NaOH and mass of KHP used. The balanced chemical equation for the reaction is as follows:

   molecular equation: $KHC_8H_4O_4\ (aq) + NaOH\ (aq) \rightarrow KNaC_8H_4O_4\ (aq) + H_2O\ (l)$

   net ionic equation: $HC_8H_4O_4^-\ (aq) + OH^-\ (aq) \rightarrow C_8H_4O_4^{2-}\ (aq) + H_2O\ (l)$

7. Compute and record the average molarity of the NaOH solution.

Note: If the three trials were not in good agreement, repeat the titration as many times as necessary to obtain three consistent trials.

Titrating the Vinegar

8. Tare a clean 50-mL Erlenmeyer flask on an analytical balance. Using a micropipet, dispense exactly 500 µL (0.500 mL) of vinegar into a clean 50-mL Erlenmeyer flask. Since the liquid may evaporate a fair amount, measure and record the mass of vinegar that was added.

9. Add about 10 mL of deionized water, using a wash bottle to rinse down any chemicals that may have splashed onto the walls of the flask. Add 1 drop of phenolphthalein indicator to the flask. Swirl to mix the solution.

10. Use the NaOH solution you standardized in the first part of the experiment to titrate the vinegar sample to the endpoint. Calculate and record the volume of NaOH used.

11. Repeat steps 8-10 **twice** to obtain a total of 3 trials.

12. Calculate and record the molarity of acetic acid in the vinegar for each of the three trials from the volumes of vinegar and standardized NaOH used and the molarity of the NaOH. Compute the average molarity.

13. Calculate and record the mass percentage of acetic acid in the vinegar for each of the three trials from the mass of vinegar used, the volume of standardized NaOH used and the molarity of the NaOH. Compute the average mass percentage and compare it to the manufacturer's claim on the label. Tell which sample of vinegar was used, by sample number or brand name.

Note: If the three trials were not in good agreement, repeat the titration as many times as necessary to obtain three consistent trials.

Laboratory Report

Complete guidelines for preparing laboratory reports are at http://webs.anokaramsey.edu/chemistry. Click on "Chem 1061," then "Laboratory Reports". The reports will be due at the beginning of the lab period for your next regularly scheduled lab. At your instructor's discretion, you may do a group report or an individual report. If it is an individual report, be sure to indicate this by underlining your name. The report must include the title, experimental details, results, discussion (it will probably be brief), and any references.

Follow your instructor's directions for submitting this lab report. (If you choose to submit on paper, you will need to include a complete set of sample calculations for one trial of the standardization *and* the titration. If you submit electronically, please submit a single Word file that includes all of the lab report components, using the following convention for naming your file: *Lastname1 Lastname2 Titration* and if you email, use a subject line of *Chem 1061: Titration Lab*).