Determining the Amount of Acetic Acid in Vinegar

Introduction

Vinegar is a dilute solution of acetic acid, CH_3COOH, that, according to the Food and Drug Administration, should contain at least 4.0 g of acetic acid per 100 mL of solution. Because acetic acid is a weak acid, its concentration in any solution, including vinegar, is easy to determine by titrating a sample of known volume using a strong base such as NaOH.

$$CH_3COOH(aq) + OH^-(aq) \longrightarrow H_2O(l) + CH_3COO^-(aq)$$

Because the reaction's stoichiometry is 1:1, the moles of NaOH used is equivalent to the moles of acetic acid in the sample of vinegar. The concentration of acetic acid in vinegar is then easily calculated.

Skills Emphasized In This Lab

By completing this lab you will become more comfortable with:

- calibrating and using a pH electrode
- performing an automated titration using a drop counter
- standardizing a solution by an acid-base titration
- learning to find a titration curve's equivalence point
- writing a succinct procedure that provides an experienced scientist with enough information to duplicate your work

Preparing for Lab

Before coming to lab, review the essays on "Titrimetry" and "Potentiometry," and complete the appropriate sections of your electronic notebook.

Procedure

Begin by preparing approximately 300 mL of nominally 0.1 M NaOH by transferring an appropriate amount of NaOH into a beaker and dissolving it in 300 mL of deionized water. Because NaOH is not available in a pure form, we cannot calculate the exact concentration of this solution from the mass of NaOH taken and the volume of solution used. Instead, you will determine the solution's concentration by titrating it against the weak acid potassium hydrogen phthalate, $C_8H_5O_4K$, also known as KHP, which is available in a pure form. This process is called a standardization, the reaction for which is

$$OH^-(aq) + C_8H_5O_4^-(aq) \longrightarrow H_2O(l) + C_8H_4O_4^{2-}(aq)$$

To complete the titration, set up and calibrate the drop counter. Fill the reservoir with your solution of nominally 0.1 M NaOH. Transfer an approximately 0.3 g portion of KHP into a small beaker and dissolve it in approximately 50 mL of deionized water (you may gently heat the solution if the KHP is difficult to dissolve, but you must allow this solution to cool to room temperature before continuing). Although you must know the exact mass of KHP, the volume of water is not critical, provided that it is sufficient to cover the tip of the pH probe. Calibrate your pH electrode and suspend it in the solution of KHP. Add a small stir bar and gently stir the solution. Begin the titration and continue until you obtain a complete titration curve. Locate the equivalence point and calculate the molarity of your NaOH solution.

To analyze vinegar for its concentration of acetic acid, pipet 2.00 mL of vinegar into a small beaker and add enough deionized water to cover the pH electrode's sensing bulb when it is suspended in the beaker. Gently stir the solution and titrate the sample with your NaOH until you obtain a complete titration curve. Locate the equivalence point and calculate the %w/v acetic acid in the vinegar.

To ensure you have sufficient data for both the standardization of NaOH and the analysis of vinegar, alternate between these two titrations. Gather as much data as you can by the end of the lab period.

Caution

There are no cautions for this lab other than the normal respect for chemicals.

Waste Disposal

All solutions may be disposed of down the drain with copious amounts of water.

Lab Report

For this report, focus your draft on the ***procedure section only***, limiting yourself to a single double-spaced page of text (if you find yourself needing more space then this, then you are including too much detail!). Be sure to review the guidelines for preparing reports and the sample report, both available on the course's website. You may find it useful to make a list of everything you did and every measurement you recorded in your notebook and then divide these items into two groups: those that you would include in your results and conclusions section (if you were writing this section) and those that you will include in your procedure.

Working together, prepare a draft of your report and then, after receiving feedback on this draft, prepare a final report. Deadlines are listed on the course's website. When you submit your final report, please include a one-page summary of your results in the form of two well-constructed tables: one reporting results for the standardization of your NaOH solution and one reporting results for your analysis for the %w/v of acetic acid in vinegar.