Titration of Vinegar

This lab requires you to keep a notebook and write a formal report. Read the guidelines and the rubric carefully.

Goal

To determine the mass percent of acetic acid in a solution via titration.

Introduction

Vinegar is a common household item that is found in a number of products from salad dressing to cleaners. Vinegar is a solution of acetic acid (CH_3COOH or $HC_2H_3O_2$) in water. The amount of acetic acid is usually 5% by mass in the vinegar solution. In this experiment, you will determine the mass percent of acetic acid in two different vinegars by titration.

Titration is a common method used by chemists to find the concentration of a substance in a solution. Titration involves two key components: the titrant and the analyte. The titrant is a solution of known concentration which is used to find the concentration of the analyte, a solution of unknown concentration. Acid-base titrations are the most common type of titration. If the analyte is an acid, then the titrant is a base. The titrant would be added to the analyte until all of the acid is neutralized -- this is known as the equivalence point or end-point. At the equivalence point, the number of moles of acid (H^+) is equal to the number of moles of the base (OH^-)(based on stoichiometry). By carefully measuring the amount of titrant used, you can determine the number of moles of acid present.

The easiest way to determine the equivalence point of the reaction taking place is to use a visual indicator. Visual indicators change color at different pH. For this titration the indicator is phenolphthalein, which changes from colorless (pH < 8) to pink (pH > 8). The analyte for this experiment is the acetic acid in vinegar with pH less than 7. Our titrant will be sodium hydroxide, a base. When enough titrant, NaOH, is added to neutralize the acetic acid, the solution will change from colorless to just barely pink in color.

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

In titrations, it is important that you measure all volumes precisely. You must know the exact amount (to 0.01 mL) of NaOH(aq) required to react with the $HC_2H_3O_2$ as well as the amount of $HC_2H_3O_2$ you began with.

The reaction of NaOH with $HC_2H_3O_2$ is 1:1 stoichiometrically. Since you will measure the volume of NaOH(aq) added and be given the molar concentration of the NaOH, you can find the moles of NaOH. The moles of NaOH will be equal to the moles of $HC_2H_3O_2$ in the solution. To get percent by mass of $HC_2H_3O_2$ in vinegar, you will need to know the molar mass of the $HC_2H_3O_2$ and the mass of the vinegar sample.

This lab requires you to keep a notebook and write a report. Read the guidelines for these and the rubric carefully.

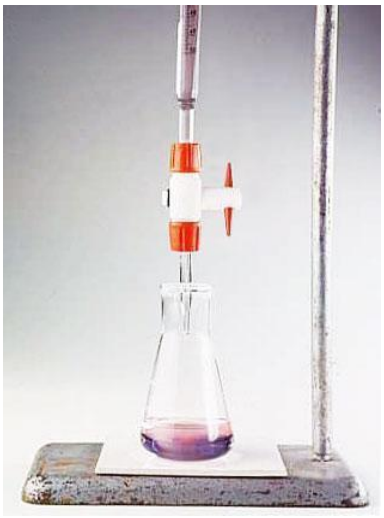
Laboratory Activity

Materials:

2 x 125 mL Erlenmeyer flasks	vinegars	deionized water
50 mL buret	200 or 250 mL beaker	phenolphthalein
buret stand and holder	funnel	standardized sodium hydroxide (NaOH) (aq)

Procedure

1. This lab will be performed individually by all students. Each student will use their own buret.
2. Rinse a 50 mL buret two or three times with deionized water. Be sure to let the water run out of the tip.
3. Remove traces of water from the buret by rinsing with NaOH(aq): add two pipettes' worth (approximately 2 mL) of NaOH(aq) to the buret. Drain some NaOH(aq) out of tip then pour the rest out of the top into the sink, rotating as you pour to coat the sides with the solution. Repeat with another 2 mL portion of NaOH(aq).
4. Fill the buret with NaOH solution until the volume reads a little above the 0.00 mL line. Drain the buret into a waste beaker until the buret reads 0.00 mL. The tip of the buret should be completely filled with solution – any air bubbles present will interfere with your measurements. If there is an air bubble in the tip, continue draining until the bubble comes out then refill the buret to 0.00 mL.
5. Record the molarity of standardized NaOH as written on the bottle (not 0.1M! This is the approximate value, you need more significant figures)
6. Obtain an Erlenmeyer flask and rinse it well with deionized water (you do not need to dry it). Carefully measure 2.00 mL of white vinegar in a **10 mL graduated cylinder** and add it to one flask. Then add about 25 mL of deionized water and one drop (**only 1 drop**) of phenolphthalein to the flask.



7. Titrate the vinegar solution by carefully adding NaOH(aq) from the buret into the Erlenmeyer flask containing the vinegar. Gently swirl the flask constantly to mix. Stop the titration when a ***faint*** pink color appears and persists for 30 seconds. Record the volume added to 0.01 mL. This is the equivalence point.
8. Repeat steps 6 & 7 one more time for white vinegar.
9. Choose a different vinegar (cider, malt, wine). Refill your buret to the 0.00mL mark. Repeat steps 6 & 7 two more times substituting the other vinegar for white vinegar. (Use the same type for both runs).
10. Pour unused sodium hydroxide from your buret into the recovery bottle. Rinse the buret several times (including the tip!) with deionized water before putting it back.

Disposal

- unused NaOH(aq) in the buret – **pour back into the recovery bottle**.
- all other solutions–down the sink drain

Calculations

The percent by mass of acetic acid in the vinegar solution is:

$$\frac{grams\ HC_2H_3O_2}{grams\ vinegar}\ \text{x } 100$$

Because the ratio of NaOH to $HC_2H_3O_2$ is 1:1, the moles of NaOH = ($V_{\text{in liters}}$) x (Molarity NaOH) = moles of $HC_2H_3O_2$.

Grams of $HC_2H_3O_2$ = moles of $HC_2H_3O_2$ x Molar Mass of $HC_2H_3O_2$.

The grams of vinegar can be calculated from the volume of vinegar titrated x density vinegar. (assume density of all vinegars = 1.005 g/mL)

For percent error, use the actual value for white vinegar of 5.0% by mass.

$$Percent\ error\ = \left(\frac{|\ actual\ value\ -\ your\ experimental\ value\ |}{actual\ value}\right) x\ 100$$

Notebook Work
● You may write your work on loose paper, in a notebook, or in a file ● All work should be *in your own words*. Plagiarized notebooks will earn a zero. ● Bring your notebook work with you to lab.
Before Lab Write the following and upload either a picture of your handwritten work or a file of typewritten work to Canvas. ● Title of the lab ● Write the procedure in your own words with enough detail that you could perform the lab without the manual. ● Summarize the safety hazards for NaOH and phenolphthalein. See Section 2 of the SDS.
During the Lab Record the following and show it to your instructor before you leave lab ● Record the molarity of standardized NaOH on **your** bottle. Record all digits! ● Record any deviations from your written procedure ● For each of four titration runs record: ○ type of vinegar ○ initial volume of buret ○ final volume of buret ○ color of end point

Lab Report

- The report should be in your own words. Plagiarized reports will earn a zero. Review what constitutes plagiarism here if needed. Use of paraphrase generators is plagiarism.
- Follow the guidelines carefully. Your report should have the sections below, in the same order.

Title
Lab title, name, course section and semester/year included at top of report

Purpose:
State the goal of the lab in 1-2 sentences. This is an experimental goal, not a learning goal.

Procedure

- Summarize procedure and type in paragraph form.
- Write what you did, not what was supposed to happen if it differs.
- Write in past tense. You do not have to use passive voice and use of "I" is fine. (I added one drop.)
- Include details of your experiment - specify molarity of NaOH, specify vinegars used.

Data

- include a table of the four runs which lists: run #, type of vinegar, initial volume, final volume, volume added, color of end point, mass % (from calculation section below)

Calculations

- Show calculations clearly and completely with units and proper sig figs for each run.
- Written by hand and embed a picture in the report or typed. Either way it should be your own work.
- Include calculations for all runs
    - mol NaOH added
    - mass of acetic acid in sample
    - mass of vinegar sample (calculate once - it is same for each run)
    - mass percent acetic acid in vinegar
    - average mass percent of white vinegar based on two runs
        - percent error (actual mass % = 5.0%)
    - average mass percent of your other vinegar based on two runs

Discussion

- Compare the average mass percent of the two vinegars. Were they the same? different?
- Discuss your percent error for white vinegar. How did your experiment go?
- Propose one thing you could have done differently that would have improved your results.
- Discuss if a dark pink endpoint would lead to an over or underestimated mass percent and explain why.

Conclusion: In 1-2 sentences summarize your results. Should answer the purpose section of the lab.

CHM111 Lab – Vinegar Titration – Grading Rubric

Criteria	Points possible	Points earned
Notebook		
Submitted through Canvas before lab: procedure written in your own words with enough detail that you could perform lab without the manual. Summary of safety hazards for all chemicals used.	4	
Written during lab: observations including end point color, any deviation from written procedure, data table, work for standardization. Shown to instructor before leaving. Lab work performed correctly. Proper safety procedures followed and waste disposed of correctly. Work space and glassware cleaned up. Participated actively in the experiment.	3	
Lab Performance		
Formal Lab Report. Use the data collected and your calculations to complete the formal lab report		
Title: Lab title, name, course section and semester/year included at top of report	1	
Purpose: Goal of lab clearly stated in 1-2 sentences.	1	
Procedure: Summarized in past tense paragraph form. Includes specifics of your reaction, written in own words, not copy-pasted from manual.	4	
Data: include a table listing: run #, type of vinegar, initial volume, final volume, volume added, color of end point, mass %	4	
Calculations: Calculations shown clearly and completely with units and proper sig figs for each run. Includes: mol NaOH added, mass of acetic acid in sample, mass of vinegar sample, mass percent acetic acid in vinegar, avg mass % white vinegar and % error, avg mass % other vinegar.	15	
Discussion Compare the average mass percent of the two vinegars. Were they the same? different? Discuss your percent error for white vinegar. How did your experiment go? Propose one thing you could have done differently that would have improved your results. Discuss if a dark pink endpoint would lead to an over or underestimated mass percent and explain why.	6	
Conclusion: In 1-2 sentences summarize your results.	2	
Total	40	

Subject to additional penalties at the discretion of the instructor.