

An Analysis of a Household Acid: Titrating Vinegar

Purpose

To determine the concentration of a common acid by acid-base titration.

Introduction

Analytical chemistry is a branch of chemistry concerned with sample analysis – *what* is present and *how much* is present. Research in this field focuses on both developing new analysis methods, as well as regenerating older methods for new applications. More recently, applications in this field have focused on *in situ* methods, in which analysis is performed on molecules present in a system that is as near to reality as possible. Instrumentation also plays an important role in this field by reducing the time required for analysis as well as improving the quality.

Before an analysis can be performed, chemical properties of the sample must be known in order to choose the proper method (although with modern developments there are some exceptions). Simple chemical tests can be performed to determine the “nature” of a substance. Some of the most widely used methods in analytical chemistry are “wet-chemical” methods, which involve solutions and known chemical properties, e.g. if the substance is an acid or base. Titration of an acid or base was first introduced by Guy-Lussac, who invented “Gay-Lussac’s tower”, which is referred to as a buret in these modern times, as well as other volumetric glassware. Because acids and bases encompass a wide variety of both inorganic and organic compounds, they are found in a wide variety of commercial products. For quality-control purposes, acid-base titrations are still in wide use.

Acid-base titrations rely upon the neutralization reaction – just enough base is added to a sample of acid for a complete reaction. Typically one solution is of known concentration (standard solution or titrant) while the other is of an unknown concentration. The equivalence point of the titration is the point at which just enough standard has been added to completely react the unknown. At this point, the number of moles of standard has been added in the exact stoichiometric ratio to the number of moles of unknown present. This point is detected by using an acid-base indicator, which is a dye molecule that emits a different color in acidic and basic solutions.

In order to determine the concentration as accurately as possible, carefully measure the amounts of unknown and standard solution. Special glassware has been designed for just this purpose, burets, transfer pipettes and volumetric flasks. It is also important to perform multiple titrations to attempt to eliminate any user errors that may occur.

In this experiment the concentration of acetic acid ($\text{HC}_2\text{H}_3\text{O}_2$) in vinegar will be determined by acid-base titration. The vinegar concentration determined by titration will be compared to the listed value on the vinegar container.

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Procedure

1. Obtain and clean a 10 mL volumetric pipette, a 50 mL buret, two small beakers and three 250 mL Erlenmeyer flasks with stoppers.
2. Label one of the small beakers Vinegar, and place about 50 mL of commercial vinegar in it. Make sure to record the brand of vinegar and its listed concentration on the data sheets.
3. Label the other small beaker NaOH, and add about 60 mL of standard base solution. Make sure to record the concentration of the standard base from its container on your data sheets.
4. Rinse the buret two times with small portions (5 – 10 mL) of the NaOH solution, allowing the entire portion to drain after each rinse. Fill the buret up to near the 0.00 mL mark. Open the stopcock to allow the base to fill the tip of the buret. Record the initial volume of base (which may or may not be 0.00 mL) to the nearest 0.01 mL on your data sheets.
5. Use a pipette bulb to draw some vinegar into the volumetric pipette. Rinse the inside of the pipette with this solution. Drain this solution into the sink.
6. Weigh a 250 mL Erlenmeyer flask, recording this mass on the data sheets. Transfer 10 mL of vinegar into this flask using a volumetric pipette and weigh it again. (This mass and the delivered volume will be used to determine the density of the vinegar solution).
7. Add about 50 mL of deionized water and a few (2 – 5) drops of phenolphthalein indicator to the vinegar sample; swirl to mix.
8. Titrate this solution, continuing to swirl, until a faint pink color persists for ~ 20 seconds. It may be helpful to place a piece of white paper under the flask to see the endpoint. The color **should not** be deep pink – this means too much base was added. Record the new volume of base remaining in the buret to the nearest 0.01 mL on your data sheets.
9. Repeat the titration (steps 6 – 7) two additional times. Be sure to record the mass of your samples each time.

Calculations:

1. Determine the moles of base delivered for each trial.
2. Use stoichiometry to relate the moles of base to moles of acid present in the vinegar sample for each trial.
3. Use the mass of acid present and the mass of the solution before titrating to determine the %(w/w) concentration.

Waste Disposal

Pour all solutions down the sink with an excess of water.

Clean-Up

Wash all glassware with soap then rinse 3 times with tap water, and once with deionized water.

An Analysis of a Household Acid: Titrating Vinegar**Data Sheet***Show all work for calculations on a separate piece of paper.*

Name: _____

Lab Partner: _____

Identity of vinegar sample: _____

Write the balanced chemical reaction occurring in the titration:

	Trial 1	Trial 2	Trial 3
1. Volume of vinegar transferred (mL)			
2. Mass of empty flask and stopper (g)			
3. Mass of stopper, flask, and vinegar sample (g)			
4. Mass of vinegar transferred (g)			
5. Density of vinegar (g/mL)			
6. Concentration of NaOH standard solution (mol/L)			
7. Initial buret reading (mL)			
8. Final buret reading (mL)			
9. Volume of NaOH transferred (mL)			
10. Number of moles of NaOH used			
11. Number of moles of HC ₂ H ₃ O ₂ in sample			
12. Mass of HC ₂ H ₃ O ₂ in sample			
13. Molar concentration of HC ₂ H ₃ O ₂ in sample (mol/L)			
14. Percent by weight concentration [% (w/w)] of HC ₂ H ₃ O ₂ in vinegar sample			
15. Average % (w/w) Concentration of HC ₂ H ₃ O ₂ in vinegar sample			

Listed Concentration of HC₂H₃O₂ in vinegar (% w/w): _____

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Post-Lab Questions

Name: _____

1. Explain why adding distilled water to the vinegar sample prior to titration does not affect the concentration determination.
2. Why is it important not to add so much NaOH that the vinegar solution becomes bright pink (or magenta)?
3. Considering the reported concentration, calculate a percent error in your determination.
4. How well does your experimental value for the concentration of acetic acid in vinegar match that on the label? List some possible sources of error.
5. How many mL of 0.101 M HCl are needed to neutralize 1.00 gram of potassium hydroxide?

