

## Determination of Acetic Acid Content of Vinegar

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**Introduction**—Vinegar or French for sour wine is formed by aerobic bacteria oxidizing grain alcohol to acetic acid and water. More generally, vinegar can be defined as a solution composed of acetic acid ( $\text{HC}_2\text{H}_3\text{O}_2$ ), water, and, perhaps, other substances. To be sold in stores as vinegar, this solution must contain at least four grams of acetic acid per 100 ml of solution. The objective of this experiment is to measure the total acid concentration in a specific brand of vinegar and to determine if the vinegar meets the minimum acetic acid content specified by commercial law. Also the percent acetic acid will be calculated to test the authenticity of the total acidity declared on the vinegar's label.

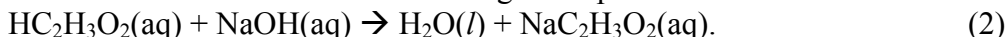
The method used to measure the total acidity of the vinegar being studied is an analytical chemistry technique called an acid-base titration. A titration mixes two solutions which contain reactants for a known chemical reaction under conditions such that:

- a) the point at which both reactants have been completely consumed by the known reaction can be detected (end point)
- b) the amount of one reactant can be calculated from the known concentration of reactant in a standard solution, the volume of standard solution used, and the balanced known chemical equation.

For an acid-base titration, the known chemical reaction in general is:



and for the titration of the vinegar in this experiment the following specific reaction will be used to calculate the acetic acid content of the vinegar sample:



Sodium hydroxide will be the standard reactant solution for this titration, and acetic acid the calculated unknown reactant.

The end point in this experiment will be detected with an acid/base indicator. An acid/base indicator is a colored substance with two or more different colors depending on the value of the pH of the solution. Indicators are also very weak acids or bases and react with added acid or base if no other base or acid is present in a solution. Phenolphthalein is the indicator used in this experiment, and phenolphthalein is colorless in acid and neutral solutions but is red in basic solutions. The phenolphthalein will change color with the addition of a single drop of sodium hydroxide if no other acid (acetic acid for this experiment) is present in the phenolphthalein-sodium hydroxide solution.

Another important concept in this experiment is concentration. Concentration refers to the composition of a solution and may be expressed as either the ratio of solute/solvent or solute/solution. Two units of concentration expressing the latter ratio are:

$$\text{Molarity}(\text{M}) = \text{moles of solute/liters of solution} \quad (3)$$

and

$$\% \text{ by mass} = (\text{mass of solute/mass of solution}) \times 100\%. \quad (4)$$

Molarity is a convenient laboratory unit that delivers for a measured the volume of solution a known number of solute molecules (i.e. moles of solute). Percent is a familiar concept to most

people and for this reason percent by mass is used on many labels. Both of these units will be used in this experiment.

### **Procedure**

Your instructor will demonstrate the proper way of filling a buret and controlling the flow of liquid so that you can, if necessary, allow the liquid to run out one drop at a time. Also, your instructor will show you how to read the liquid level in the buret with the aid of a buret card.

Using a double buret-clamp on a ring stand, attach one 50 ml buret loaded with standard NaOH solution. Measure into a clean, 250 ml Erlenmeyer flask 5ml of vinegar or 50ml of white wine (noting the brand), and place the flask on a circle of white filter paper beneath the buret set-up. Now add one dropper full of phenolphthalein indicator to the solution in the flask and mix its contents by gentle swirling. Carefully open the buret stop-cock and allow the NaOH solution to drain into the flask slowly while swirling it to insure continuous mixing.

As more NaOH is added, the red color, which forms on the point of contact, becomes progressively harder to bleach by swirling. The base should be added till one drop turns the solution faint pink, and then stopped. The faint pink color at the end-point should persist for at least 30 seconds of swirling to be accepted as genuine.

Weigh a clean dry 50 ml beaker, 150 ml beaker, or a 10 ml graduated cylinder and record mass. Pipette 5ml of vinegar into the beaker or add 5 ml of vinegar to the graduated cylinder. Weigh the vinegar and beaker or vinegar and graduated cylinder and record mass.

## Report Sheet for Assay of Acetic Acid Content of Vinegar

### Data

Concentration of sodium hydroxide \_\_\_\_\_ M

Brand of Vinegar \_\_\_\_\_ Declared acidity \_\_\_\_\_

Volume of vinegar sample \_\_\_\_\_ ml

Mass of vinegar sample and beaker or vinegar sample and graduated cylinder \_\_\_\_\_ g

Mass of beaker or graduated cylinder \_\_\_\_\_ g

Mass of vinegar sample \_\_\_\_\_ g

	Run 1	Run2	Run 3	Run 4
Final buret reading				
Initial buret reading				
Volume of sodium hydroxide needed to reach end point				

### Data Processing

- 1) Calculate average volume of sodium hydroxide needed to reach the end point.
- 2) Convert average volume from step 1 from ml to liters.
- 3) Using the definition of Molarity (equation 3), calculate moles of NaOH at end point using answer to step 2 and concentration of NaOH solution.

4) Using the chemical equation relating moles of acetic acid and moles of sodium hydroxide, calculate moles of acetic acid at end point. The answer to this step is the number of moles of acetic acid in the vinegar sample.

5) Using the chemical formula of acetic acid, calculate the molar mass (sum of atomic masses for all atoms composing one acetic acid molecule)

6) Avogadro's law states that one mole of compound equals the molar mass of compound in grams. Using Avogadro's law and the molar mass of acetic, calculate the mass of acetic acid in the vinegar sample.

7) Using the answer to step 6 and the volume of the vinegar sample, calculate the mass of acetic acid per ml of vinegar.

8) Using the answer to step 6, the definition of percent mass, and the mass of the vinegar sample, calculate the percent mass of acetic acid in the vinegar.

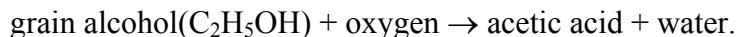
### **Conclusions**

Does the vinegar studied meet the commercial law specification of a minimum of 4 g of acetic acid/100 ml of vinegar? Support your answer with data.

Has the vinegar supplier truthfully reported the percent acidity? Support your answer with data.

## Questions

1. A word equation summarizing the souring of wine is:



Please convert this word equation to a balanced chemical equation.

2. The chemical equations in question 1 summarize aerobic bacterial oxidation of grain alcohol. Use this information to explain why it is possible to prevent wine in a corked bottle from turning to vinegar by:

a) keeping the bottle on its side

b) adding brandy to the wine?

3. Different vinegars may have different percentages of acetic acid. Is vinegar a mixture, compound, or an element?

4. If you had titrated standard NaOH, in the flask, against vinegar, in the buret, instead of the way you actually performed the titration, how would you have recognized the end-point with phenolphthalein indicator? Would carrying out the titration in this manner change your calculated results or conclusions?

5. Why is it a good idea to rinse the buret with the NaOH solution, instead of with water, before filling it at the start of the titration?