

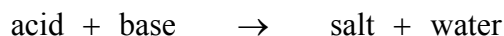
PERCENT ACETIC ACID IN VINEGAR EXPERIMENT 15

PURPOSE

A vinegar solution will be titrated using a standardized NaOH solution to determine the percent acetic acid by mass.

INTRODUCTION

In order to determine the concentration of a solution, there must be something to compare it against (benchmark). This benchmark is referred to as a standard. Sodium hydroxide (basic) is typically used as a standard to determine the concentration of acids. When an acid and base react, they form salt and water (neutral).



A titration measures the volume of a solution added to a reaction using a buret. A buret is a long tube that is typically calibrated in milliliters.

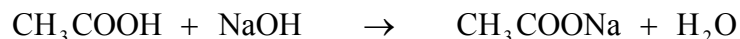
The acid and base are reacted together until one of the two is completely reacted. That point is called the endpoint which is neutral. If any additional acid or base is added, the solution will then become acidic or basic depending on which was added in excess.

To visually determine the endpoint, an indicator is added to the reaction. An indicator is a chemical that changes colors at a particular pH. Since an acid base reaction upon completion is neutral, an indicator is used to visually indicate the point at which just a tiny excess of the acid or base is added beyond the completion of the reaction.

In order to use a standardized solution, the solution must be prepared. After preparation, the exact concentration of the standard solution will be known.

In this experiment, a standardized sodium hydroxide solution (NaOH) will be used.

Using basic stoichiometry, the moles of acetic acid (CH_3COOH) in the vinegar solution can be determined from the moles of NaOH added to the reaction.



Note the molar relationship. For every one mole of acetic acid, it would take one mole of NaOH to completely react it.

For every one mole of NaOH, it takes one mole of acetic acid to react with it.

$$\text{moles of NaOH} = \text{moles of acetic acid}$$

In the titration, the NaOH is added drop-by-drop using the buret. The buret indicated how much NaOH is being added to the vinegar solution. At the point where all the acetic acid in the vinegar solution has been reacted (endpoint) any additional NaOH will turn the solution basic. The indicator, phenolphthalein, in a basic solution turns the solution from clear to pink at this point.

The volume of NaOH added to the vinegar solution is read off the buret in milliliters and converted to liters (liters = ml / 1000)

The moles of the sodium hydroxide used to react with the acetic acid in the vinegar solution can now be determined.

$$\text{moles of NaOH} = (\text{molarity of NaOH}) \times (\text{liters of NaOH})$$

Example:

25 ml of a vinegar solution is titrated with 40 ml of a standardized 0.1 M NaOH solution. How many moles of NaOH were used and how many moles of acetic acid were reacted.

Solution:

$$\text{liters of NaOH} = \frac{\text{ml of NaOH}}{1000} = \frac{40 \text{ ml of NaOH}}{1000} = 0.04 \text{ liters}$$

$$\text{moles of NaOH} = (\text{molarity of NaOH}) \times (\text{liters of NaOH})$$

$$\text{moles of NaOH} = 0.1 \text{ M NaOH} \times 0.04 \text{ liters} = 0.004 \text{ moles}$$

$$\text{moles of NaOH} = \text{moles of acetic acid}$$

Therefore, the moles of acetic acid in the vinegar solution is 0.004 moles.

The mass of the acetic acid in the vinegar solution is determined by using the moles of acetic acid and the molecular mass of acetic acid (58 g/mol).

$$\text{grams of CH}_3\text{COOH} = (\text{molecular mass of CH}_3\text{COOH}) \times (\text{moles of CH}_3\text{COOH})$$

Example:

Calculate the grams of acetic acid in the vinegar solution if the molecular mass of acetic acid is 58 g/mol and there is 0.004 moles of acetic acid.

Solution:

$$\begin{aligned}\text{grams of CH}_3\text{COOH} &= (\text{molecular mass of CH}_3\text{COOH}) \times (\text{moles of CH}_3\text{COOH}) \\ \text{grams of CH}_3\text{COOH} &= 58 \text{ g/mol} \times 0.004 \text{ moles} = 0.236 \text{ grams}\end{aligned}$$

In order to calculate the percent acetic acid in the vinegar solution by mass, we will assume the density of the vinegar solution is the same as water (1.00 g/ml).

$$\text{grams of vinegar solution} = \text{density of vinegar solution} \times \text{volume of vinegar solution}$$

Example:

Calculate the mass of the vinegar solution, if 5 ml of the vinegar solution was used in the titration (assume the density of the vinegar solution is 1.00 g/ml).

Solution:

$$\begin{aligned}\text{grams of vinegar solution} &= \text{density of vinegar solution} \times \text{volume of vinegar solution} \\ \text{grams of vinegar solution} &= 1.00 \text{ g/ml} \times 5 \text{ ml} = 5 \text{ grams}\end{aligned}$$

To calculate the % acetic acid by mass in the vinegar solution:

$$\% \text{ acetic acid in vinegar solution} = \frac{\text{grams of acetic acid}}{\text{grams of vinegar solution}} \times 100$$

Example:

Calculate the % acetic acid by mass in the vinegar solution if the mass of the vinegar solution was determined to be 5 grams and the mass of the acetic acid was found to be 0.236 grams.

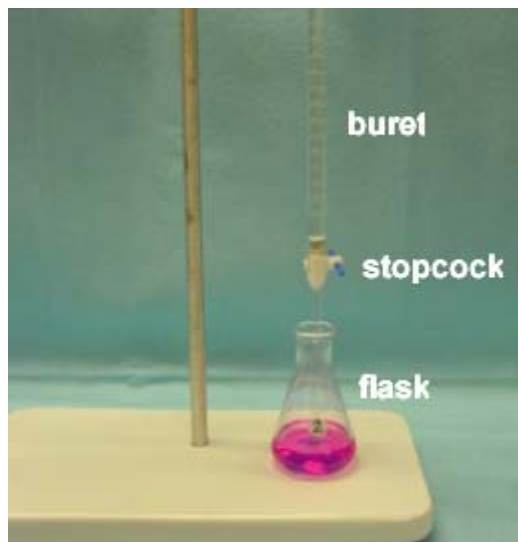
$$\% \text{ acetic acid in vinegar solution} = \frac{\text{grams of acetic acid}}{\text{grams of vinegar solution}} \times 100$$

$$\% \text{ acetic acid in vinegar solution} = \frac{0.236 \text{ grams of acetic acid}}{5 \text{ grams of vinegar solution}} \times 100 = 4.72 \% \text{ acetic acid}$$

PROCEDURES

PREPARATION OF BURET

1. Clean a 50 ml buret and rinse with DI water. A clean buret will have no droplets clinging to the inside of the glass.
2. Rinse the buret with two 5 ml portions of the your standardized NaOH solution. Make sure you drain the NaOH solution through the tip of the buret.
3. Using a funnel, fill the buret with the standardized NaOH solution. Make sure that the tip is also filled and there are no air bubbles in the tip.
4. Slowly drain the NaOH out of the buret until the buret reads 0.0 ml. Read from the bottom of the meniscus. It is sometimes helpful to hold a piece of paper with a black line behind the buret and line it up with the meniscus.



PREPARATION OF THE VINEGAR SOLUTION

5. Pipet 5 ml of the vinegar solution into a clean 250 ml flask.
6. Add 50 ml of DI water to the flask.
7. Add two drops of phenolphthalein indicator.

DETERMINATION OF % ACETIC ACID IN A VINEGAR SOLUTION

8. Place a white background underneath the flask with the vinegar solution.
9. Slowly add with constant swirling the NaOH drop-wise to the vinegar solution.
10. Continue adding drop wise to the vinegar solution until the vinegar solution turns a faint shade of pink that remains for 30 seconds. This is called your endpoint.
11. Calculate the % by mass of acetic acid in the vinegar solution.



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NAME _____
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**DETERMINATION OF % ACETIC ACID IN A VINEGAR SOLUTION
 REPORT SHEET
 EXPERIMENT 15**

Titration of Vinegar Solution	Trial 1	Trial 2	Trial 3
Final buret reading in ml			
Initial buret reading in ml			
Volume of NaOH added (final – initial) in ml			
Volume of NaOH added in liters (ml / 1000)			
Molarity of Standardized NaOH			
Moles of NaOH (molarity NaOH x liters NaOH)			
Moles of Acetic Acid			
Molecular Mass of Acetic Acid (g/mole = amu)	58 g/mole	58 g/mole	58 g/mole
Grams of Acetic Acid (moles acetic acid x 58 amu)			
Density of Vinegar Solution	1.00 g/ml	1.00 g/ml	1.00 g/ml
Volume of Vinegar Solution Titrated	5 ml	5 ml	5 ml
Grams of Vinegar Solution (density of vinegar solution x volume of Vinegar Solution)			
% Acetic Acid in Vinegar Solution			
Average % Acetic Acid in Vinegar Solution			