Titration of Citric Acid in Apple Juice

# Introduction

The sweet, tangy taste of fruit juices is caused by natural chemicals. The sweet is caused by various sugars and the tangy is caused by acids, which taste sour. Fruit juices contain several different types of acid, including citric acid, C3H5O(COOH)3, malic acid, C2H4O(COOH)2, acetic acid, CH3COOH, and others. In this experiment, we will make the calculations easier by assuming that citric acid is the only acid present. All *acids* can react by losing H+ ions and all *bases* can react by gaining H+ ions. Citric acid is a *triprotic* acid, which means it can lose up to three H+ ions. When an acid and a base react, it is called a *neutralization* reaction. Here is the neutralization reaction of citric acid with the base sodium hydroxide.

C3H5O(COOH)3 + 3 NaOH → Na3C3H5O(COO)3 + 3 H2O

In a titration, the concentration of one solution to calculate the concentration of the other. Because precise volumes for both solutions can be measured, the art of a titration is adding *just barely enough* of a solution to react with the other. In this experiment, the mass of citric acid in apple juice is found by titrating with sodium hydroxide. The indicator phenolphthalein changes color when just enough sodium hydroxide is added to neutralize the acids.

The first step is to accurately determine the concentration of the sodium hydroxide solution by titrating it with a known acetic acid solution, which is *standardizing* the NaOH solution.:

CH3COOH + NaOH → NaCH3COO + H2O

Two different units are used in this experiment to describe the concentrations of solutions. The most common is molarity, mol/L or *M*. Molarity is defined as moles of solute per liter of solution.



The concentration of citric acid in apple juice will be described in units of grams per liter, g/L which is calculated by dividing the grams of citric acid by the liters of apple juice.

# Materials and Methods

Buret, buret stand, and funnel

Erlenmeyer flask and waste beaker

Acetic acid solution

Sodium hydroxide solution - Corrosive, Mutagenic, Toxic

Apple juice

Phenolphthalien solution

# Procedure

## Part 1: Buret Preparation

1. Add around 90 mL of distilled water to a clean 150 mL beaker. Use a graduated cylinder to measure about 10 mL of 1.0 M NaOH to the beaker. Swirl the beaker to mix the solution and label it “NaOH”. Label the largest beaker “Waste”.
2. Fill the buret with the NaOH solution, making sure there is no bubble in the buret tip.

## Standardizing the NaOH solution

* 1. Rinse a clean 250 mL Erlenmeyer flask with about 10-20 mL of distilled water and discard the rinse.
  2. Use a 10-mL volumetric pipet to pipet 10.00 mL of standard acetic acid solution into your Erlenmeyer flask. Record the exact concentration of the acetic acid solution.
  3. Add three drops of phenolphthalein solution and about 100 mL of distilled water to the acetic acid solution.
  4. Record the initial volume of the NaOH solution in the buret. Estimate and record the volume to the nearest 0.01 mL.
  5. Add NaOH solution to the acetic acid solution gradually with stirring until the solution turns faint pink and stays pink for at least 30 seconds. This is the endpoint, at which you have added *just* enough NaOH to neutralize the acid.
  6. Record the final volume as carefully as you did the initial volume. Subtract the initial volume from the final volume to get the volume of NaOH used and then calculate the molarity of your NaOH solution. Pour the mixture from the Erlenmeyer flask into your waste beaker.

## Citric acid determination

1. Rinse the Erlenmeyer flask with about 10-20 mL of distilled water and discard the rinse.

2. Use a 10-mL volumetric pipet to pipet 10.00 mL of apple juice into the flask.

3. Add three drops of phenolphthalein solution and about 100 mL of distilled water to the apple juice.

4. Record the initial volume of the NaOH solution in the buret. Estimate and record the volume to the nearest 0.01 mL.

5. Add NaOH solution to the apple juice solution gradually with stirring until the solution turns faint pink and stays pink for at least 30 seconds. This is the endpoint, at which you have added *just* enough NaOH to neutralize the acid.

6. Record the final volume as carefully as you did the initial volume and calculate the concentration of citric acid in your apple juice.

## Neutralization

1. Pour the mixture from the Erlenmeyer flask into your waste beaker. Drain the NaOH solution from your buret into your waste beaker.
2. If the solution in your waste beaker is pink, skip this step and go to the next step. Add three drops of phenolphthalein to your waste beaker. If the solution in the waste beaker is still colorless, add 1 M NaOH gradually with stirring until the solution turns pink.
3. Add 6 M hydrochloric acid, HCl (Caution: Caustic), dropwise with stirring until the solution turns colorless. It is OK to add a few drops extra but don’t add a large excess of 6 M HCl.[[1]](#footnote-1)
4. Rinse the neutralized waste solution down the drain with plenty of tap water.

# Data and Results

* 1. Calculate the molarity of the sodium hydroxide concentration to three significant figures by multiplying the concentration of acetic acid by its volume (10.00 mL) and dividing by the volume of NaOH solution added to neutralize it.
  2. Calculate the moles of acid in solution by multiplying the molarity of NaOH by its volume (in liters).
  3. Calculate the moles of acid in the sample by dividing the moles of sodium hydroxide found in the last stem by 3 (since citric acid is triprotic.
  4. Determine the concentration of citric acid in apple juice, in g/L, by multiplying the moles of citric acid by its molar mass (192.1 g/mol) and dividing by the sample size of apple juice (in liters).

1. If you add just a little too much HCl, the solution will be *buffered* by the weak acids present in the apple juice which keeps it from becoming too acidic. Buffers are covered in CHEM 1212K, Principles of Chemistry II. [↑](#footnote-ref-1)