Chemistry Hour\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Dr. Wexler  
Comparison of Citric acid and Vitamin C Content in Fruit Juices (HS-PS1-6)  
Date\_\_\_\_\_

**Background: Neutralization of acids**  
**What is chemical titration?**  
Chemical [titration](http://en.wikipedia.org/wiki/Titration) methods are used for analyzing acids or bases to determine the unknown [concentration](http://en.wikipedia.org/wiki/Concentration). Either a [pH meter](http://en.wikipedia.org/wiki/PH_meter) or a [pH indicator](http://en.wikipedia.org/wiki/PH_indicator) which shows the point of neutralization by a distinct color change can be employed. Simple [stoichiometric](http://en.wikipedia.org/wiki/Stoichiometric" \o "Stoichiometric) calculations with the known volume of the unknown and the known volume and [molarity](http://en.wikipedia.org/wiki/Molarity" \o "Molarity) of the added chemical gives the molarity of the unknown.

**What are applications of acid neutralization?**  
There are many uses of neutralization reactions that are acid-alkali reactions. A very common use is antacid tablets. These are designed to neutralize excess [gastric acid](http://en.wikipedia.org/wiki/Gastric_acid) in the stomach ([HCl](http://en.wikipedia.org/wiki/Hydrochloric_acid" \o "Hydrochloric acid)) that may be causing discomfort in the stomach or lower esophagus. This can also be rememdied by the ingestion of [sodium bicarbonate](http://en.wikipedia.org/wiki/Sodium_bicarbonate) (NaHCO3).

Also in the digestive tract, neutralization reactions are used when food is moved from the stomach to the intestines. In order for the nutrients to be absorbed through the intestinal wall, an alkaline environment is needed, so the pancreas produce an antacid bicarbonate to cause this transformation to occur.

In [wastewater treatment](http://en.wikipedia.org/wiki/Water_treatment), chemical neutralization methods are often applied to reduce the damage that an effluent may cause upon release to the environment. For pH control, popular chemicals include [calcium carbonate](http://en.wikipedia.org/wiki/Calcium_carbonate), [calcium oxide](http://en.wikipedia.org/wiki/Calcium_oxide), [magnesium hydroxide](http://en.wikipedia.org/wiki/Magnesium_hydroxide), and [sodium bicarbonate](http://en.wikipedia.org/wiki/Sodium_bicarbonate). The selection of an appropriate neutralization chemical depends on the particular application.

Another common use, though perhaps not as widely known, is in fertilizers and control of soil pH. Slaked lime (calcium hydroxide) or limestone (calcium carbonate) may be worked into soil that is too acidic for plant growth.[[4]](http://en.wikipedia.org/wiki/Neutralization_(chemistry)#cite_note-3) Fertilizers that improve plant growth are made by neutralizing sulfuric acid (H2SO4) or nitric acid (HNO3) with ammonia gas (NH3), making [ammonium sulfate](http://en.wikipedia.org/wiki/Ammonium_sulfate) or [ammonium nitrate](http://en.wikipedia.org/wiki/Ammonium_nitrate). These are salts utilized in the fertilizer.[[5]](http://en.wikipedia.org/wiki/Neutralization_(chemistry)#cite_note-4)

Industrially, a by-product of the burning of coal, [sulfur dioxide](http://en.wikipedia.org/wiki/Sulfur_dioxide) gas may combine with water vapor in the air to eventually produce sulfuric acid, which falls as acid rain. To prevent the sulfur dioxide from being released, a device known as a scrubber gleans the gas from smoke stacks. This device first blows calcium carbonate into the combustion chamber where it decomposes into calcium oxide (lime) and carbon dioxide. This lime then reacts with the sulfur dioxide produced forming calcium sulfite. A suspension of lime is then injected into the mixture to produce a slurry, which removes the [calcium sulfite](http://en.wikipedia.org/wiki/Calcium_sulfite) and any remaining unreacted sulfur dioxide.[[6]](http://en.wikipedia.org/wiki/Neutralization_(chemistry)#cite_note-5)

**Part A. Citric acid**  
**Background:**   
Citrus fruit juices have a sour taste due to the presence of organic acids. The major acid (~99%) is citric acid. Citric acid has the formula: C3H5O(COOH)3

Citric acid is neutralized by sodium hydroxide (NaOH) according to the following balanced equation:

3NaOH + C3H5O(COOH)3 🡪C3H5O(COO-)3 3- + 3H2O +3Na+

We can determine the concentration of the acid by determined by titrating with a sodium hydroxide solution of known concentration. By measuring the volume of sodium hydroxide needed to completely react with all the acid, it is possible to determine the concentration of the acid. The end point of the titration is determined by adding an indicator to the acid that is being titrated. In this experiment we will use phenolphthalein which is clear in acids and pink in bases (sodium hydroxide is a base). When the solution turns pink, the acid is neutralized.

3NaOH + C3H5O(COOH)3 🡪C3H5O(COO-)3 3- + 3H2O +3Na+

According to the above equation, 3 moles of NaOH will neutralize 1 mole of citric acid. Therefore, if we know how many moles of NaOH were added we can easily calculate the number of moles of citric acid (divide by 3). Then we divide by the volume in liters to determine the molar concentration of the acid.

For example, if 1.5 moles of NaOH neutralized 2 liter of orange juice, then the citric acid concentration of the juice would be 0.25M [(1.5÷3)÷2]

**Objectives:**Compare the molar concentration of citric acid in orange juice, grapefruit juice, and lemon juice.

**Pre-Lab:**1. A solution is created by dissolving 25.0g of NaCl in enough water to form 150mL of solution. Determine the molarity of the solution.

2. What is the molarity if 30.0 mL of 1.25 M acetic acid is diluted to 175mL?

4. How do you know when a titration of an acid solution with a base has reached its endpoint?

5. List the following juices in order from the most sour (most acidic) to the least sour: grapefruit juice, lemon juice, and orange juice. What is the correlation between sourness and acidity?

**Special Materials:**Pipets  
1M NaOH (40.0g/mol)  
Orange juice  
Grapefruit juice  
Lemon juice  
0.33M Citric acid (192.12g/mol)  
Phenophthalein solution

**Part A Procedure:**  
1. Pipette 5.0 mL of juice into an Erlenmeyer flask containing 10mL water. To the flask add three drops of phenolphthalein.

2. Fill a pipette with 10.0ml 1M NaOH and release it to the juice one drop at a time while swirling the flask. As the titration progresses, you will observe a pink coloration where the NaOH solution contacts the juice solution. As you approach the end point of the titration, the pink will momentarily flash throughout the entire sample.

3. The end point is reached when the pink color persists for thirty seconds or more. Record the volume of 1M NaOH added.

4. Thoroughly rinse the flask with distilled water and repeat for the other fruit juices and for the citric acid control.

**Part A Results:**

Your data/calculations table should look like this:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Juice type | Orange juice | Grapefruit juice | Lemon juice | Citric Acid (0.33M) |
| Volume of juice titrated | 5.0mL = 0.05L | 5.0mL = 0.05L | 5.0mL = 0.05L |  |
| Volume of 1.0M NaOH added |  |  |  |  |
| Moles of NaOH added [1.0M x volume (L)] |  |  |  |  |
| Moles of citric acid neutralized  [Moles NaOH added ÷3] |  |  |  |  |
| Molarity of citric acid  [Moles of citric acid ÷ 0.05L] |  |  |  |  |

**Part A Conclusions:**1. Which fruit juice contained the highest concentration of acid?

2. Which fruit juice contained the lowest concentration of acid?

3. Can you conclude that acidity correlates with sourness? Briefly explain.

4. What was the purpose of the citric acid control? Did the result indicate that this procedure was accurate (equal volume of NaOH and citric acid to titrate), or would it be necessary to adjust the fruit juice results if you needed to be quantitative (normalize the data to the control)?

**Part B. Vitamin C**

This method determines the vitamin C concentration in a solution using iodine (I2). Vitamin C, more properly called ascorbic acid, is an essential antioxidant needed by the human body.

Iodine oxidizes (removes electrons from) ascorbic acid (C6H8O6, 176.12 g/mol), converting it to dehydroascorbic acid as according to the reaction:

ascorbic acid + I2 → 2 I− + dehydroascorbic acid

Due to this reaction iodine is immediately reduced to iodide as long as there is any ascorbic acid present. Once all the ascorbic acid has been oxidized, the excess iodine is free to react with the starch indicator, forming the blue-black starch-iodine complex. This is the endpoint of the titration.

The method is suitable for use with Vitamin C tablets, fresh or packaged fruit juices and solid fruits and vegetables.

Note that one mole of iodine will react with one mole of ascorbic acid. Therefore, measuring the number of moles of iodine required to neutralize a given volume of fruit juice allows us to calculate the number of moles of ascorbic acid present (1:1 molar ratio).

The molarity of ascorbic acid is calculated by dividing the moles of ascorbic acid by the volume of juice titrated (L).

**Part B Procedure:**  
1. Pipette 5.0 mL of juice into an Erlenmeyer flask containing 10mL water.

2. Fill a pipette with 5.0ml 0.003M I2 and release it to the juice one drop at a time while swirling the flask. As the titration progresses, you will observe a bluish black coloration where the I2 solution contacts the juice solution. As you approach the end point of the titration, the bluish black will momentarily flash throughout the entire sample.

3. The end point is reached when the bluish black color persists for thirty seconds or more. Record the volume of 0.003M I2 added.

4. Thoroughly rinse the flask with distilled water and repeat for the other fruit juices and for the ascorbic acid control.

**Part B Results:**

Your data/calculations table should look like this:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Juice type | Orange juice | Grapefruit juice | Lemon juice | Apple juice | Ascorbic acid (0.003M) |
| Volume of juice titrated | 5.0mL = 0.05L | 5.0mL = 0.05L | 5.0mL = 0.05L | 5.0mL = 0.05L | 5.0mL = 0.05L |
| Volume of 0.003M I2 added |  |  |  |  |  |
| Moles of I2 added [0.003M x volume (L)] |  |  |  |  |  |
| Moles of ascorbic acid neutralized  [= moles I2 added] |  |  |  |  |  |
| Molarity of ascorbic acid  [= moles of ascorbic acid ÷ 0.05L] |  |  |  |  |  |

**Conclusions:**1. Which fruit juice contained the highest concentration of vitamin C?

2. Which fruit juice contained the lowest concentration of vitamin C?

3. What was the purpose of the ascorbic acid control? Did the result indicate that this procedure was accurate (equal volume of I2 and ascorbic acid to titrate), or would it be necessary to adjust the fruit juice results if you needed to be quantitative (normalize the data to the control)?

4. Compare your results with the published concentrations of vitamin C in the three fruit juices tested.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Experimental (M) | Experimental (g/L)  [M x 176.12g/mol] | Expected (g/L) |
| Orange juice |  |  | 0.52 mg/mL raw |
| Grapefruit juice |  |  | 0.40 mg/mL raw |
| Lemon juice |  |  | 0.26 mg/mL raw |
| Apple juice |  |  | 0.009 mg/mL raw |