Determining the concentration of Citric Acid in 7-Up using Acid/Base Titration

Background

Titration of soda

The acid content of many foods and beverages contributes significantly to their taste. Soft drinks often contain varying quantities of several acids, which give sodas their tart flavor. In cola products, these acids are predominantly carbonic acid (from the carbonated water) and phosphoric acid. In sodas such as Squirt and 7-Up, the acids are carbonic acid and citric acid.

Acids can be classified as monoprotic, diprotic, triprotic, etc.: a monoprotic acid has one proton that can undergo a reaction with a base, a diprotic acid has two such protons, and a triprotic acid has three. Shown below are examples of each type of acid undergoing a reaction with sodium hydroxide.

Monoprotic: $HCl(aq) + NaOH(aq) \rightarrow H_2O(l) + NaOH(aq)$
Diprotic: $H_2SO_4(aq) + 2NaOH(aq) \rightarrow H_2O(l) + Na_2SO_4(aq)$
Triprotic: $H_3PO_4(aq) + 3NaOH(aq) \rightarrow H_2O(l) + Na_3PO_4(aq)$

Any acid that has more than one proton that undergoes a reaction with a base is called a polyprotic acid. Citric acid is a weak, polyprotic acid that undergoes the following reaction.

$$H_3C_6H_5O_7(aq) + 3\ NaOH(aq) \rightarrow 3\ H_2O(l) + Na_3C_6H_5O_7(aq)$$

In this experiment you will be performing a titration to determine the concentration of citric acid in 7-Up. Prior to the titration the majority of the carbonic acid was removed by allowing the 7-Up to go flat so we do not have to take it into consideration.

A burette is used in a titration to dispense measured increments of one solution into a known volume of another solution. Careful technique will allow you to detect the point where the reaction is complete; in this case, when all of the citric acid has been reacted with the base. The technique of titration can be applied to other types of reactions such as oxidation-reduction, precipitation, complexation and other acid-base neutralization reactions.

Indicators

Indicators are used to provide visual information about the amount of acid or base in a solution. You will be using an indicator called phenolphthalein for this experiment.
In a basic solution (a solution that contains more base than acid), phenolphthalein is pink. In solutions that are acidic (a solution that contains more acid than base), phenolphthalein is colorless. During the titration performed in this experiment, the point where the indicator first changes from colorless to pink corresponds to the point where the reaction is complete. This point is called the *endpoint* of the titration.

Preparing a standard base

Prior to performing the titration to determine the amount of acid in a 7-Up sample, you need to know the exact concentration of the base that you will be using. Standardizing the base involves performing a titration with a known amount of a stable acid, which in this case is the monoprotic acid potassium hydrogen phthalate (abbreviated KHP). The reaction of KHP and NaOH is

$$NaOH(aq) + KHC_8H_4O_4(aq) \rightarrow H_2O(l) + KNaC_8H_4O_4(aq)$$

Note that one mole of NaOH reacts with one mole of KHP. **Note that the chemical formula of KHP is not KHP!**

Procedure

Standardization of NaOH

Clean your burette and rinse it with deionized water. Next, rinse your burette twice with 10 mL of the NaOH solution that you will be standardizing. Finally, fill the burette with the NaOH solution.

Accurately weigh, to the nearest thousandth of a gram, approximately 0.05 g KHP and transfer it to one of your 250 mL Erlenmeyer flasks. Add approximately 25 mL of deionized water and 2 to 3 drops of the phenolphthalein indicator. Swirl the flask until all the KHP has dissolved. Read the initial volume of NaOH solution in your burette to the nearest hundredth of a milliliter. Slowly add the NaOH solution to the dissolved KHP until a faint pink color is obtained. Placing a white piece of paper under your Erlenmeyer flask helps you better see this color change. Once a lasting pink color has been reached, read your final volume from your burette. Calculate the molarity of the NaOH solution. Repeat this process two more times and calculate the average molarity of the NaOH solution.

Titration of 7-Up

The citric acid content in Squirt and 7-Up is quite low, so good technique is critical. Obtain 50 mL of 7-Up. The 7-Up in your lab has been opened days in advance to assure it is decarbonated. Pipette 10 mL of the pop into a clean 250 mL Erlenmeyer and add 2 to 3 drops of phenolphthalein. Refill your burette with the standardized NaOH. Again, read the initial volume of NaOH solution in your burette to the nearest hundredth of a milliliter. Slowly add the NaOH solution to the 7-Up until a faint pink color is obtained. Once a lasting pink color has been reached, read your final volume from your burette. Calculate the molarity of the citric acid in 7-Up. Repeat this process two more times and calculate the average molarity. From your average molarity of citric acid, calculate the number of moles of citric acid per can of pop. Finally, calculate the number of grams of citric acid there are in one can of 7-Up.

Standardization of NaOH			
	Trial 1	**Trial 2**	**Trial 3**
Mass of KHP			
Final burette reading, NaOH			
Initial burette reading, NaOH			
Total volume, NaOH			
Molarity of NaOH			
Average molarity of NaOH			

Titration of 7-Up			
	Trial 1	**Trial 2**	**Trial 3**
Volume of 7-Up			
Final burette reading, NaOH			
Initial burette reading, NaOH			
Total volume, NaOH			
Molarity of citric acid			
Average molarity of citric acid			
Average moles citric acid per can			
Average grams citric acid per can			

Calculations Page

In order to receive credit for your answers on the proceeding page, you must show all work for those answers that require calculations.