TITRATION OF A COLA PRODUCT (#11.9)

The CCLI Initiative
Computers in Chemistry Laboratory Instruction

Learning Objectives

The objective of this laboratory experiment is to determine the molar concentration of phosphoric acid in a cola product.

Background

Titration is an analytical technique used to find the concentration of a known volume of unknown substance by adding a known concentration of a known substance. As the unknown and known substance react, we look for a "tell-tale" indication that the reaction is complete, which allows us to determine the concentration of the unknown. For our purposes, the **equivalence point** is the most crucial point in the titration. It is the point during the titration where the moles of base added will equal the moles of acid in the unknown solution (or *vice versa*). Since the volume of base added can be read from the buret at this point and the concentration of the base and the volume of the acid are also known, the concentration of the unknown acid solution can be determined. There follows a discussion of equivalence point and several ways to determine such.

The acid content of many foods and beverages contribute significantly to the taste. Cola drinks often contain varying quantities of carbonic acid (from the carbonated water) and phosphoric acid. By de-carbonating the cola, you can determine the phosphoric acid concentration via titration. The phosphoric acid content is usually quite low, so good technique is critical.

Important Reactions Phosphoric acid is a weak polyprotic acid, which means it will liberate more than one proton (H^+) in solution. Phosphoric acid will react with NaOH in the following manner:

$$H_3PO_{4(aq)} + OH^-_{(aq)} \Longrightarrow H_2PO_4^-{}_{(aq)} + H_2O_{(l)} \quad (1)$$

$$H_2PO_4^-{}_{(aq)} + OH^-_{(aq)} \Longrightarrow HPO_4^{2-}{}_{(aq)} + H_2O_{(l)} \quad (2)$$

$$HPO_4^{2-}{}_{(aq)} + OH^-_{(aq)} \Longrightarrow PO_4^{3-}{}_{(aq)} + H_2O_{(l)} \quad (3)$$

Each of the above reactions will have its own equivalence point. However, because of the concentration of the base used for the titration and th small value of K_{a3}, you can only observe the equivalence points for reactions (1) and (2). The overall titration curve will look similar to Figure 1.

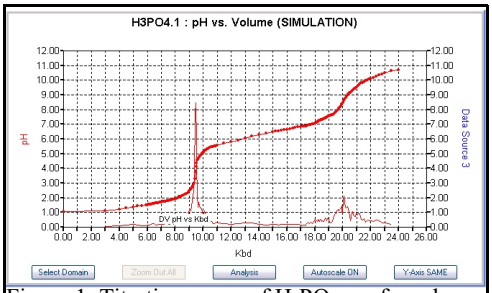

Figure 1. Titration curve of $H_3PO_{4(aq)}$ of a cola drink with the 1st derivative plot.

Experimental Procedures

- *Drop Counter Calibration*
- Students will obtain temperature and/or pH, and volume data for at least 5 mL beyond the equivalence point for at least three titrations.
- The solution should be stirred with a magnetic stirrer.

Data Analysis

Guidance is given in calibrating the drop counter, calculating the necessary parameters to determine the concentration of $H_3PO_{4(aq)}$ in the cola and calculating the average and standard deviation of the results.

Instructor Resources Provided

- Sample Report Sheets providing the format to organize the data collection with sample data.
- Questions to consider, answer and turn-in with suggested answers.
- Tips and Traps section to assist the instructor with potential problems and solutions.
- Sample ***MicroLAB*** screen shots and graphs.
- Laboratory preparation per student station.

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