Chemistry 213

Titration of a Cola Product

LEARNING OBJECTIVES

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

BACKGROUND

The acid content of many foods and beverages contribute significantly to the taste. Soft drinks often contain varying quantities of several acids. In cola products, these acids are predominantly carbonic acid (from the carbonated water) and phosphoric acid. By decarbonating the cola, you can determine the phosphoric acid concentration via titration. ***The phosphoric acid content is usually quite low, so good technique is critical.***

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

$$H_3PO_4(aq) + OH^-(aq) \Leftrightarrow H_2PO_4^-(aq) + H_2O(l)$$

$$H_2PO_4^-(aq) + OH^-(aq) \Leftrightarrow HPO_4^{2-}(aq) + H_2O(l)$$

$$HPO_4^{2-}(aq) + OH^-(aq) \Leftrightarrow PO_4^{3-}(aq) + H_2O(l)$$

Each of the above reactions has an equivalence point. However, because of the concentration of the base used for the titration, you can only see the first two equivalence points in the titration curve. The curve will look similar to Figure 1.

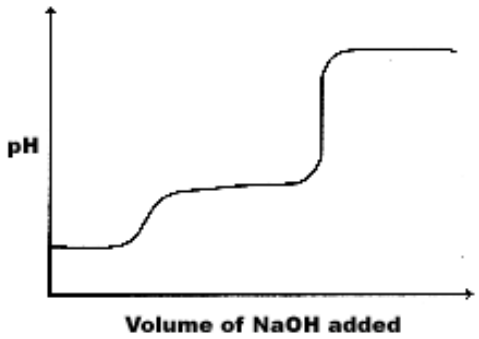

Figure 1. Titration curve for phosphoric acid from cola.

The only equivalence point, which you will be concerned with, is the first one, since it will give you the concentration of H_3PO_4.

It is important to realize that the cola contains two acids, phosphoric and carbonic. Since the objective is to measure the phosphoric acid concentration the carbonic acid must be removed. This can be done by gently boiling the cola to expel the dissolved carbon dioxide.

$$H_2CO_3(aq) \Leftrightarrow CO_2(g) + H_2O(l)$$

Do not forget to reconstitute the cola solution to 100 mL after boiling to compensate for water vapor lost in the process of boiling.

SAFETY PROCEDURES

You must wear lab goggles at all times. If the acid or base solutions get on your skin, rinse them off with plenty of water. All solutions resulting from the titrations may be dumped down the sinks. All remaining base solution should not be placed back into the storage containers; therefore, take only the quantities of solution that you'll need.

EXPERIMENTAL

You are to design your own procedure for this experiment. You will be supplied with the following:

1. Standardized 0.01 M NaOH
2. Cola
3. 100 mL Volumetric Flask
4. 10 mL Pipet
5. pH Meter (with buffers for standardizing)

Hints: The first trial should be used to define the titration curve. Do this carefully as you need to determine the pH at the first equivalence point. Do a minimum of three more trials where the calculated molarity of the phosphoric acid is in agreement. Post the average phosphoric acid concentration (M) on the board.

Chemistry 213 Laboratory

Name(s) _____,_____,_____.

Section_____

Titration of a Cola Product

Turn in report sheets and a full-page copy of the titration curve.

Molarity of NaOH _____(M)

Determination of Phosphoric Acid (H_3PO_4) Concentration in the Cola

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
mL NaOH added					
pH at Equivalence Point					
Calculated H_3PO_4 molarity					

Average H_3PO_4 molarity of Phosphoric Acid in the Cola. _____(M)

Show example calculation:

1. Discuss the precision of the results. Classify random error in this experiment as large or small? Explain.

<u>Write out the procedure developed for the experiment.</u>

Class Results

Group	H_3PO_4 Concentration (M)
1	
2	
3	
4	
5	
6	
7	
8	
9	
Average	
Std. Dev.	

Discuss the precision of the class results. Are there any obvious outliers? If so, how should they be dealt with?

Since there is no known value to compare the experimental values against it is not possible to discuss accuracy, therefore what can be said about systematic error in the experiment?