Titration of a Cola Product

INSTRUCTOR RESOURCES

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.

PROCEDURE OVERVIEW

- the pH electrode is calibrated with buffers of 4, 7, and 10 pH
- the instructor will designate what type of titration, e.g., timed, drop count or buret volume by keyboard input, will be performed and refer the students to the **Measurement Manual** for the specific instructions.
- at least three titrations of a decarbonated cola product are accomplished with standardized 0.01 M NaOH.
- the exact volume for the first equivalence point is determined for each titration.
- The molarity value for each titration is determined from equivalence point volume, and the average and standard deviation are obtained.

NAME: _____ SECTION:_____ DATE: _____

TITRATION OF A COLA PRODUCT

REPORT SHEETS:

Calibration: 1st _____ 2nd _____ (drops/5 ml)

TITRATION DATA:(Modify as needed if you do not use first or second derivatives.)

Trial #	1st der. vol.	2nd der. high vol.	2nd der. low vol.	2nd der. interp. vol.	2nd der. mmol NaOH	H_3PO_4 conc.
1						
2						
3						
4						
Ave. 1-4						
Std Dev.						
% error						

QUESTIONS FOR YOUR CONSIDERATION:

1. **Using the *MicroLAB* Hand Enter**, set up a **Spreadsheet** similar to the one above (modified as per your instructor) and calculate the exact concentration of each of your H_3PO_4 solutions Show a sample calculation below.

2. **Using the Column Statistics** function by right clicking on the **Concentration** column, determine the **Mean** (average) and standard deviation of all the titrations and add to the above table, then express your final average concentration as "Ave. value ± Std. Dev." in the space below.

3. Why must one never pipet a liquid by sucking on the pipet by mouth?

NAME: _____ SECTION:_____ DATE: _____

TITRATION OF A COLA PRODUCT

REPORT SHEETS (page 2)

4. Why is it necessary to rinse the buret or pipette with three rinses of the solution to be placed in it?

5. By discussing in detail what is happening to the pH near the equivalence point versus volume of titrant added, explain why it is necessary to take as small of volume increments as possible near the equivalence point.

K_{a1} OF PHOSPHORIC ACID BY TITRATION

Tips and Traps

1. During the calibration of the pH probes, students may compare millivolt readings and become concerned that they may differ widely from system to system. Assure them that this is natural and is a function of differences in the nature of the pH electrodes. The values should be around 0 ±100 millivolts if the pH probe is good.

2. You may find a wide variation in the quality of electrodes depending upon the manufacturer and/or age of the electrode. Some electrodes will reach equilibrium quite rapidly, while others may take a while. All electrodes should be checked out in advance to determine if they obtain equilibration within about 5 to 10 seconds. If not, the electrodes should be treated with an enzymatic cleaner, then soaked in an electrode conditioning solution, both of which can be obtained from Markson.

3. It is not necessary in this experiment to know absolute pH, only relative pH, since we are only looking at changes in pH to determine the general shape of the titration curve. Therefore, as in item 2 above, allow a reasonable time for equilibration during the calibration procedure, and then use that same time interval for each measurement during the titration.

4. There is a tendency for students to leave the pH probe hanging out in the air between titrations. If the time between titrations is small, this probably won't matter much, but it is better to teach them good practice, and that is to store the probe in their buffer in a beaker placed at the back of the bench between titrations. There is less chance of breakage this way, and the probe is equilibrating at or near the equivalence point pH.

5. In between uses, all electrodes should be kept in a sealed container with the bulbs covered with the conditioning solution mentioned above.

K_{a1} OF PHOSPHORIC ACID BY TITRATION

Suggested Answers

NAME: _____ SECTION:_____ DATE: _____

Calibration: 1st _____ 2nd _____(drops/5 ml)

TITRATION DATA:

Trial #	1st der. vol. (ml)	2nd der. high vol. (ml)	2nd der. low vol. (ml0	2nd der. interp. vol. (ml)	2nd der. mmol NaOH	H_3PO_4 conc. M
1	9.45	9.40	9.45	9.450	0.9436	0.0944
2	9.80	9.82	9.80	9.806	0.9806	0.0981
3	9.30	9.30	9.25	9.247	0.9247	0.0925
4	9.65	9.65	9.654	9.654	0.9650	0.0965
Ave. 1-4	9.55			9.539	0.953	0.0954
Std Dev.	0.22			0.24	0.02	0.002
% error	2.3			2.6	2.6	2.6

QUESTIONS FOR YOUR CONSIDERATION: (The data for these calculations was acquired using a volumetric buret, but the principles are the same.)

1. **Using the *MicroLAB* Hand Enter**, set up a **Spreadsheet** similar to the one above (modified as per your instructor) and calculate the exact concentration of each of your H_3PO_4 solutions Show a sample calculation below.

$$\frac{(9.436\ ml\ OH^-)(0.1\ mmol\ OH^-)(1\ mmol\ H^+)}{(1\ ml\ OH^-)(1\ mmol\ OH)(10\ ml\ H^+)} \cdot \frac{1}{} = 0.0944\ M$$

2. **Using the Column Statistics** function by right clicking on the **Concentration** column, determine the **Mean** (average) and standard deviation of all the titrations and add to the above table, then express your final average concentration as "Ave. value ± Std. Dev." in the space below.

   0.0954 ±0.002

3. Why must one never pipet a liquid by sucking on the pipet by mouth?

   Sucking on a pipet by mouth can cause the ingestion of chemicals into the mouth and or stomach, which can be very corrosive or toxic.

4. Why is it necessary to rinse the buret or pipette with three rinses of the solution to be placed in it?

   The buret has been stored filled with water. If the titrant is added directly to the buret without rinsing several times first, the concentration of the titrant will be diluted and you will not obtain the correct results for the titration.

5. By discussing in detail what is happening to the pH near the equivalence point versus volume of titrant added, explain why it is necessary to take as small of volume increments as possible near the equivalence point, or if doing drop titrations, to slow the drop rate down significantly in the equivalence point region.

   The pH changes very slowly during the titration until the titration approaches the equivalence point region. In this region, the [H^+] concentration begins to be very small by orders of magnitude, so that a small drop of titrant will cause a significant change in the [H^+], consequently the need for very small drops within the equivalence point region of the titration.

   In doing a drop titration, the drop rate should be significantly slowed in the equivalence point region due to the rapid change of pH in that region. Since the pH electrode has a response time on the order of ten or more seconds, there needs to be time for the electrode to approximate equilibration before the next drop is added in order to get good pH readings.

K_{a1} OF PHOSPHORIC ACID BY TITRATION

Sample Data

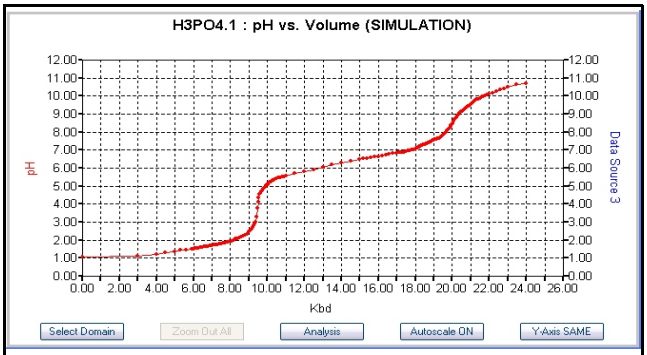

Figure 1. H_3PO_4 Titration curve

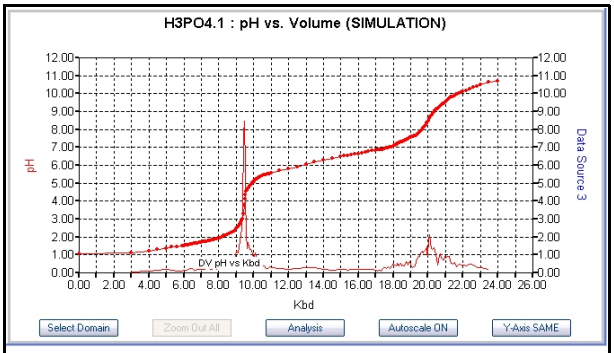

Figure 2. H_3PO_4 Titration curve with first derivative

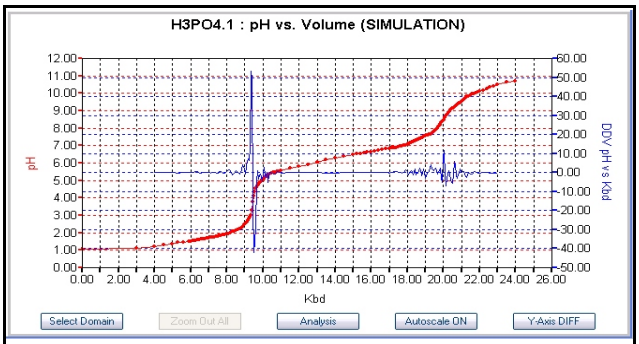

Figure 3. H_3PO_4 Titration curve with second derivative

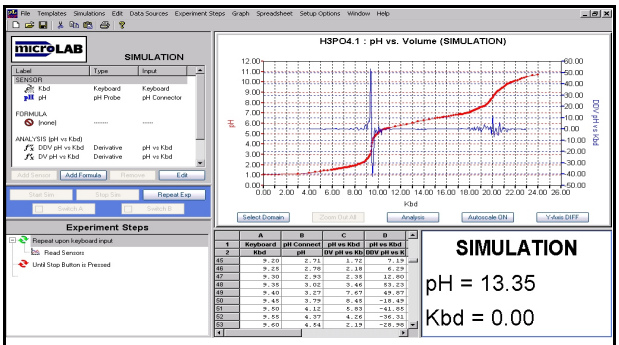

Figure 4. H_3PO_4 Titration curve main screen

The other three titration curves should be analogous to these.

K_{a1} OF PHOSPHORIC ACID BY TITRATION

Laboratory Preparation (per student station)

EQUIPMENT:
You will need to have the following equipment available per pair of students before beginning this experiment.

1 - Dropping buret system
1 - 5 ml pipet
3 - 10 ml beakers
1 - magnetic stirrer with stirring bar
1 *MicroLAB* drop counter
1 - pH probe with a BNC connector
1 utility clamp for the dropping buret
1 - pipetting bulb
4 - 250 ml beakers
1 - ring stand
1 - clamp for the drop counter
1 - *MicroLAB* interface and two *MicroLAB* programs (*Drop Counter Calibration* and one of the titration programs under the **Titration** tab) to do the titration.

CHEMICALS:

The following chemicals will be provided for you in the laboratory. Please take no more than the recommended amounts.

- 150 ml of 0.100 M NaOH solution
- 30 ml of 0.100 M H_3PO_4 solution
- 15 ml of pH 4, 7 and 10 buffer solutions per pair of students in a 25 ml beaker.

CAUTIONS OF CHEMICAL HAZARDS:

- H_3PO_4 solution: Severely corrosive to eyes, skin and other tissue. Toxic, strong skin irritant.

- NaOH solution: Corrosive liquid, skin burns are possible, very dangerous to eyes.

The other chemicals are innocuous, however you should keep all chemicals away from eyes and mouth, wash hands after use and before leaving the laboratory, and use prudent laboratory practices at all times.

DISPOSAL OF SOLUTIONS: ADD ANY LEFT OVER ACID TO THE LEFT OVER BASE, NEUTRALIZE, AND DISCARD THEM DOWN THE SINK WITH LOTS OF WATER TO DILUTE THEM.