Determining the Phosphoric Acid Content in Soft Drinks

Phosphoric acid is one of several weak acids that exist in carbonated beverages. It is a component of all cola soft drinks. Phosphoric acid has a much higher concentration than other acids in a container of soft drink, so its concentration can be determined by a simple acid-base titration.

In this experiment, you will titrate a sample of a cola soft drink with sodium hydroxide solution and determine the concentration of phosphoric acid, H_3PO_4. Hydrogen ions from the first dissociation of phosphoric acid react with hydroxide ions from the NaOH in a one-to-one ratio in the overall reaction:

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

In this experiment, you will use a pH Sensor to monitor pH as you titrate. The region of most rapid pH change will then be used to determine the equivalence point. The volume of NaOH titrant used at the equivalence point will be used to determine the molarity of the H_3PO_4.

OBJECTIVES

In this experiment, you will

- Use a pH Sensor to monitor pH during the titration of phosphoric acid in a cola soft drink.
- Using the titration equivalence point, determine the molarity of H_3PO_4.

MATERIALS

computer	0.050 M NaOH
Vernier computer interface	various cola soft drinks, decarbonated
Logger *Pro*	distilled water
Vernier pH Sensor	ring stand
50 mL buret	utility clamp
100 mL graduated cylinder	magnetic stirrer (if available)
250 mL beaker	stirring bar

PROCEDURE

1. Obtain and wear goggles.
2. Use a graduated cylinder to measure out 40 mL of a decarbonated cola beverage and 60 mL of distilled water into a 250 mL beaker. **CAUTION:** *Do not eat or drink in the laboratory.*
3. Place the beaker on a magnetic stirrer and add a stirring bar. If no magnetic stirrer is available, you need to stir with a stirring rod during the titration.
4. Connect the pH Sensor to the computer interface. Prepare the computer for data collection by opening the file "35 Phosphoric Acid" from the *Chemistry with Vernier* folder of Logger *Pro*.

5. Use a utility clamp to suspend a pH Sensor on a ring stand as shown in Figure 1. Position the pH Sensor in the HCl solution and adjust its position so that it is not struck by the stirring bar.

6. Obtain a 50 mL buret and rinse the buret with a few mL of the 0.050 M NaOH solution. **CAUTION:** *Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.* Dispose of the rinse solution as directed by your teacher. Use a utility clamp to attach the buret to the ring stand as shown in Figure 1. Fill the buret a little above the 0.00 mL level of the buret with 0.050 M NaOH solution. Drain a small amount of NaOH solution so it fills the buret tip *and* leaves the NaOH at the 0.00 mL level of the buret. Record the precise concentration of the NaOH solution in your data table.

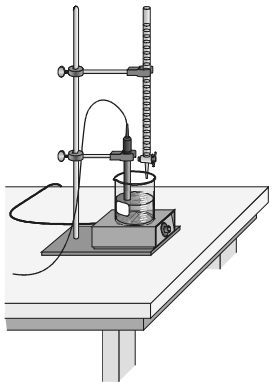

Figure 1

7. You are now ready to perform the titration. This process goes faster if one person manipulates and reads the buret while another person operates the handheld and enters volumes.
   a. Start data collection.
   b. Before you have added any NaOH solution, click Keep and enter **0** as the buret volume in mL. Click OK to store the first data pair for this experiment.
   c. Add 0.5 mL of NaOH solution. When the pH stabilizes, click Keep and enter the current buret reading in mL. Click OK.You have now saved the second data pair for the experiment.
   d. Continue to add 0.5 mL increments, entering the buret level after each increment. When the pH has leveled off (near pH 10), click Stop to end data collection.

8. Examine the data on the graph of pH *vs.* volume to find the *equivalence point*—that is, the 0.5 mL volume increment that resulted in the largest increase in pH. As you move the examine line, the pH and volume values of each data point are displayed to the right of the graph. Go to the region of the graph with the large increase in pH. Find the NaOH volume (in mL) just *before* this jump. Record this value in the data table. Then record the NaOH volume *after* the 0.5 mL addition producing the largest pH increase.

9. Print a copy of the graph of pH *vs*. volume. Then print a copy of the NaOH volume data and the pH data for the titration.

10. Dispose of the beaker contents as directed by your teacher. Rinse the pH Sensor and return it to the storage solution.

PROCESSING THE DATA

1. Use your printed graph and data table to confirm the volume of NaOH titrant you recorded *before* and *after* the largest increase in pH values upon the addition of 0.5 mL of NaOH solution.

2. Determine the volume of NaOH added at the first equivalence point. To do this, add the two NaOH values determined above and divide by two.

3. Calculate the number of moles of NaOH used.

4. See the equation for the neutralization reaction given in the introduction. Determine the number of moles of H_3PO_4 reacted.

5. Recall that you pipeted out 40.0 mL of the beverage for the titration. Calculate the H_3PO_4 concentration.

DATA TABLE

Concentration of NaOH	M
NaOH volume added *before* the largest pH increase	mL
NaOH volume added *after* the largest pH increase	mL

Volume of NaOH added at equivalence point	mL
Moles NaOH	mol
Moles H_3PO_4	mol
Concentration of H_3PO_4	mol/L

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Chemistry with Vernier* lab manual includes 36 labs and essential teacher information. The full lab book is available for purchase at:
http://www.vernier.com/cmat/cwv.html

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