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:

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

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.

MATERIALS

- LabPro or CBL 2 interface
- TI Graphing Calculator
- DataMate program
- pH Sensor
- various cola soft drinks, decarbonated
- 0.050 M NaOH
- distilled water
- 50-mL buret
- 100-mL graduated cylinder
- 250-mL beaker
- ring stand
- utility clamp
- magnetic stirrer (if available)
- 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. Plug the pH Sensor into Channel 1 of the LabPro or CBL 2 interface. Use the link cable to connect the TI Graphing Calculator to the interface. Firmly press in the cable ends.
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.

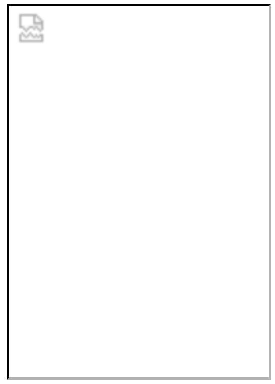

Figure 1

7. Turn on the calculator and start the DATAMATE program. Press to reset the program.

8. Set up the calculator and interface for the pH Sensor.
   a. Select SETUP from the main screen.
   b. If CH 1 displays PH, proceed directly to Step 9. If it does not, continue with this step to set up your sensor manually.
   c. Press to select CH 1.
   d. Select PH from the SELECT SENSOR menu.

9. Set up the data-collection mode.
   a. To select MODE, press once and press .
   b. Select EVENTS WITH ENTRY from the SELECT MODE menu.
   c. Select OK to return to the main screen.

10. 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 calculator and enters volumes.
    a. Select START to begin data collection.
    b. Before you have added any NaOH solution, press and type in "0" as the buret volume, in mL. Press to save the first data pair for this experiment.
    c. Add 0.5 mL of NaOH solution. When the pH stabilizes, press and enter the current buret reading. 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), press to end data collection.

11. Examine the data on the displayed graph 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 cursor right or left on the displayed graph, the volume (X) and pH (Y) values of each data point are displayed below 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.

12. 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.

13. 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