Honors Chemistry Lab 23: 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.

ASK: How can I determine the molarity of phosphoric acid in cola by titrating the cola to the equivalence point?

MATERIALS

LabQuest
LabQuest App
Vernier pH Sensor
50 mL buret
100 mL graduated cylinder
250 mL beaker
0.025 M NaOH (~55 mL)
various cola soft drinks, decarbonated
distilled water
ring stand
utility clamp
magnetic stirrer (if available)
stirring bar

RESEARCH:

1. Obtain and wear goggles.
2. Use a graduated cylinder to measure out 20 mL of a decarbonated cola beverage and 30 mL of water and combine both the cola and water into an appropriately sized beaker.
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 LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
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 soda and adjust its position so it is not struck by the stirring bar.
6. Obtain a 50 mL buret and fill the buret a little above the 0.00 mL level of the buret with 0.025 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.

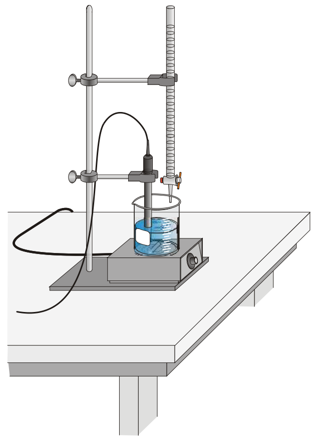


Figure 1

7. Set up the data-collection mode.
   a. On the Meter screen (icon looks like a speedometer) tap the Mode bottom. Change the data-collection mode to Events with Entry.
   b. Enter the Name (Volume) and Units (mL). Select OK.

8. You are now ready to perform the titration. This process goes faster if one person manipulates and reads the buret while another person enters volumes.
   a. Start data collection by pressing the green arrow in the lower left corner.
   b. Before you have added any NaOH solution, tap Keep and enter **0** as the buret volume in mL. Select OK to store the first data pair for this experiment.
   c. Add 0.5 mL of NaOH solution. When the pH stabilizes, tap Keep and enter the current buret reading. Select OK.
   d. Continue to add 0.5 mL increments, entering the buret level after each increment. When the pH has leveled off (near pH 10), stop data collection.

9. 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 tap each data point (or use the ► or ◄ keys on LabQuest), the pH and volume values are displayed. 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.

10. Sketch a copy of the graph of pH *vs*. volume. Then record the NaOH volume data and the pH data for the titration.

11. Dispose of the beaker contents down the drain with copious water. Rinse the pH Sensor, shake off excess water, and return it to the storage solution.

PROCESSING THE DATA

1. Use your 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. Show all calculations record in data table.

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 20.0 mL of the actual cola 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	
Moles NaOH	
Moles H_3PO_4	
Concentration of H_3PO_4	

MAKE your claim to address the question and include the answers to Q1-5 in your STEM journals.

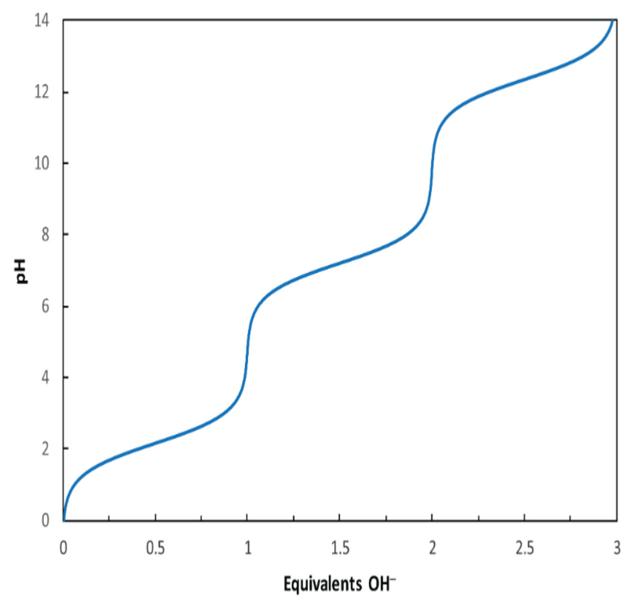
Q1. Explain how to prepare 200 mL of a 0.025 M solution of sodium hydroxide. You will be preparing the solution using pellet stock sodium hydroxide.

Q2. What is the difference between the equivalence point and the end point of a titration? Do you believe these could both be the same?

Q3. In processing the data section, step 2, what is meant by the "first equivalence point"?

Q4. On the graph to the right sketch and label all three equivalence points for the complete titration and deprotonation of phosphoric acid.

Q5. Using the dissociation equation in the introduction section as a reference. Write the next two dissociation equations that would occur in the complete titration and deprotonation of phosphoric acid.



Summarize and reflect to complete the lab write-up.