**AP Lab: Identifying a Diprotic Acid**

**Problem:** Can you identify a diprotic acid by determining its molar mass and Ka values from data obtained from titrating it with a standardized solution of NaOH(aq), using a probe unit to help collect and analyze the experimental data?

**Procedure:**

1. Pre-rinse a 50 mL buret and tip with a small amount of NaOH(aq), discard the rinse solution, and then fill it to the 0.0 mL mark with standardized (~ 0.1 M) NaOH(aq) solution. Make sure there are no air bubbles in the tip of the buret.

2. Mass out about 0.20 g of the unknown diprotic acid on a piece of weighing paper. Record the mass to the nearest 0.001 g. Transfer the unknown acid to a 150-mL beaker and dissolve in 50.0 mL of distilled water. Re-mass the paper and determine the exact mass of solid acid used. Place the beaker on a magnetic stirrer and add a stirring bar.

3. Sign out a LabQuest unit with a pH probe. Calibrate the pH probe by using two different buffer solutions with a fairly wide range, such as 4 and 10. (Make sure you rinse the pH probe with distilled water and pat it dry with a paper towel before switching solutions.)

4. Position the pH probe so that it is deep into the acid solution, and so that the NaOH(aq) can be easily added to the beaker.

5. Set up the data-collection mode.

a. On the Meter screen, tap Mode. Change the data-collection mode to Events with Entry.

b. Enter the Name (Volume) and Units (drops). Select OK.

6. You are now ready to perform the titration. This process goes faster if one person adds the NaOH solution while another person enters volumes.

a. Start data collection.

b. Before you have added any of the NaOH solution, tap Keep and enter **0** as the NaOH volume, in milliliters. Select OK to store the first data pair for this experiment.

c. Add ~0.5 mL NaOH. When the pH stabilizes, tap Keep and enter the current buret reading, to the nearest 0.01 mL. Select OK. You have now saved the second data pair for the experiment.

d. Continue this procedure until the pH value becomes pH >10 and then continue for at least 10 more readings. ***Note:*** The equivalence point(s) can be more clearly defined by adding smaller increments of NaOH (~ 0.1 mL) as the pH values undergo rapid increases during the titration.

7. Stop data collection. When all samples have been taken, a graph of the collected data is displayed.

8. Examine the graph and determine the milliliters of NaOH needed to reach the equivalence points. Ideally, the curve should have 8-10 data points before and after the rapid pH change occurs in order to more accurately determine each equivalence point.

9. Examine the data by viewing the data lists directly

10. Sketch the curves on a separate piece of paper. (Your instructor may require a print out of the data tables and or the graphs)

**Results & Calculations:** SHOW ALL WORK USED!

A. Examine the graph of pH vs. mL of NaOH added. Determine the amount of NaOH needed to reach the first and second equivalence points for the diprotic acid and label the points on the curve.



B. **Alternate Equivalence Point Method**

An alternate way of determining the precise equivalence point of the titration is to take the first

and second derivatives of the pH-volume data.

1. Determine the peak value on the first derivative *vs.* volume plot.

a. Tap the Table tab. Choose New Calculated Column from the Table menu.

b. Enter d1 as the Calculated Column Name. Select the equation, 1st derivative (Y,X). Use Volume as the Column for X, and pH as the Column for Y. Select OK.

c. On the displayed plot of d1 *vs.* volume, examine the graph to determine the volume at the peak value of the first derivative.

2. Determine the zero value on the second derivative *vs.* volume plot.

a. Tap the Table tab. Choose New Calculated Column from the Table menu.

b. Enter d2 as the Calculated Column Name. Select the equation, 2nd derivative (Y,X). Use Volume as the Column for X, and pH as the Column for Y. Select OK.

c. On the displayed plot of d2 *vs.* volume, examine the graph to determine the volume when the 2nd derivative equals approximately zero.

C. Calculate the molar mass of the unknown diprotic acid based upon the first ***and*** second equivalence points.

1. Based on the amount of NaOH(aq) needed to reach the half-titration points, calculate the Ka values for losing the first (and second) hydrogen ions.
2. Your unknown acid is one of the following: ascorbic, maleic, malonic, oxalic, or tartaric. Use the CRC Chemistry Handbook, your textbook or some other appropriate source to find the accepted molar mass and Ka values for these diprotic acids, and use them to identify the unknown.

**Conclusions:** Hand in your graph and a work page with all of your calculations. Identify your unknown and justify your answers.