Acid-Base Titration

A titration is a process used to determine the volume of a solution that is needed to react with a given amount of another substance. In this experiment, your goal is to determine the molar concentration of an acid solution by conducting titrations with a base of known concentration. You will be testing a solution and a weak acid, $HC_2H_3O_2$, solution. You will use the sodium hydroxide, NaOH, solution of known concentration. The reaction equation is shown below in net ionic form.

$$HC_2H_3O_2(aq) + OH^-(aq) \rightarrow H_2O(l) + C_2H_3O_2^-(aq)$$

In this experiment, you will use a handheld device 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 acid solutions.

OBJECTIVES

In this experiment, you will

- Accurately conduct acid-base titrations.
- Determine the equivalence point of a weak acid-strong base titration.
- Create a titration curve of a weak acid ($HC_2H_3O_2$) being titrated with a strong base (NaOH).
- Determine the Ka of the weak acid from the titration curve
- Calculate the molar concentrations of two acid solutions.

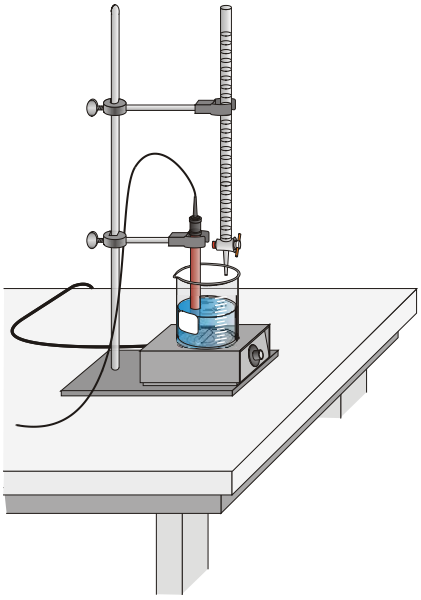

Figure 1

CHOOSING A METHOD

You will conduct the titration in a conventional manner. You will deliver volumes of NaOH titrant from a buret. You will enter the buret readings manually to store and graph each pH-volume data pair.

MATERIALS

Materials for using a buret

LabQuest
LabQuest App
Vernier pH Sensor
0.100 M NaOH solution
0.10 M acetic acid, $HC_2H_3O_2$, solution
50 mL buret
buret clamp
wash bottle
distilled water
ring stand
utility clamp
250 mL Erlenmeyer flask
50 mL graduated cylinder

METHOD 1: Measuring Volume Using a Buret

1. Obtain and wear goggles.
2. Add 50 mL of distilled water to a 250 mL beaker. Add approximately 10 mL of the acid solution into the flask. Record the initial and ending volume exactly. **CAUTION:** *Handle the acid with care. It can cause painful burns if it comes in contact with the skin.*
3. Swirl the flask so that the mixture is stirred.
4. Connect the pH Sensor to LabQuest and choose New from the File menu.
5. Set up a ring stand, buret clamp, and 50.0 mL buret to conduct the titration. Rinse and fill the buret with 0.100 M NaOH solution. **CAUTION:** *Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.*
6. Use a utility clamp to suspend the pH Sensor on the ring stand if available, as shown in Figure 1. Position the pH Sensor so that its tip is immersed in the acid solution but is not struck by the stirring bar. Gently stir the flask of acid solution.
7. On the Meter screen, tap Mode. Change the data-collection mode to Events with Entry. Enter the Name (Volume) and Unit (mL) and select OK.
8. Conduct the titration carefully, as described below.
   a. Start data collection.
   b. Before you have added any NaOH solution, tap Keep and enter **the current buret reading** as the buret volume in mL. Select OK to store the first data pair.
   c. Add the next increment of NaOH titrant (enough to raise the pH about 0.15 units). When the pH stabilizes, tap Keep, and enter the current buret reading as precisely as possible. Select OK to save the second data pair.

d. Continue adding NaOH solution in increments that raise the pH by about 0.15 units and enter the buret reading after each increment. When a pH value of approximately 3.5 is reached, change to a one-drop increment. Enter a new buret reading after each increment.
e. After a pH value of approximately 10 is reached, again add larger increments that raise the pH by about 0.15 pH units, and enter the buret level after each increment.
f. Continue adding NaOH solution until the pH value remains constant.

9. Stop data collection to view a graph of pH *vs.* volume.

10. Dispose of the reaction mixture as directed. Rinse the pH Sensor with distilled water in preparation for the second titration.

11. Examine your titration data to identify the region where the pH made the greatest increase. The equivalence point is in this region.

a. To examine the data pairs on the displayed graph, select any data point.
b. As you move the examine line, the pH and volume values of each data point are displayed to the right of the graph.
c. Identify the equivalence point as precisely as possible and record this information.
d. Store the data from the first run by tapping the File Cabinet icon.

12. (Optional if you wish to try this 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.

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

a. Tap the Table tab and 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.

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

d. Tap Table and choose New Calculated Column from the Table menu.
e. 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.
f. On the displayed plot of d2 *vs.* volume, examine the graph to determine the volume when the 2nd derivative equals approximately zero.

13. Repeat the titration with a second $HC_2H_3O_2$ solution. Analyze the titration results in a manner similar to your first trial and record the equivalence point in your data table.

15. Print a copy of the graph of each titration. Print the graph directly from LabQuest, if possible. Alternately, transfer the data to a computer, using Logger *Pro* software.

DATA TABLE

Create a data table for you data.

Calculations- Based upon the results of your experiment and your graph, determine the equivalence point of the titration of the acetic acid and sodium hydroxide titration. Determine the molarity of the acid solution.

Based on the equivalence point volume, determine the pH of the ½ equivalence point.

Conclusion- Write up a conclusion as we normally do. This lab will not be formally accessed.