

Name:

Period:

Seat#:

Required Sections: (Refer to R-15 for guidelines and requirements. Make note of any specific changes given by your teacher in class.)

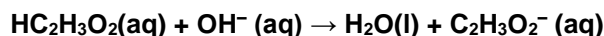
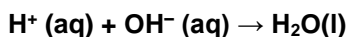
Prelab: Purpose, Materials, Reagent Table, Procedures, and set up Data Tables before you get to class.

During Lab: Data section – Fill out your data table that is already set up from the prelab.

Post-lab: Calculation section, Post-Lab Questions, Post-Lab Two Pager done on separate Worksheet.

Background

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 two acid solutions by conducting titrations with a base of known concentration. You will be testing a strong acid, HCl, solution and a weak acid, HC₂H₃O₂, solution. You will use the sodium hydroxide, NaOH, solution that you standardized in Lab 6 as your base of known concentration. The reaction equations are shown below in net ionic form.



The stoichiometry of the two reactions is identical; thus, your calculations will be straightforward. However, you will observe a significant difference in how the two acid solutions react with NaOH.

In this experiment, you will 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 HCl solution.

You will deliver volumes of NaOH titrant from a burette. You will enter the burette readings manually to store and graph each pH-volume data pair.

Objectives

In this experiment, you will

- Accurately conduct acid-base titrations.
- Determine the equivalence point of a strong acid-strong base titration, and of a weak acid-strong base titration.
- Calculate the molar concentrations of two acid solutions.

Materials

Chemicals

- 0.100* M sodium hydroxide, NaOH (*approximate)
- Unknown molarity of hydrochloric acid, HCl
- Unknown molarity of acetic acid, HC₂H₃O₂

Equipment

- Chromebook, Graphical Analysis
- Vernier wireless pH sensor
- Stir station and magnetic stir bar
- Electrode support

- 250mL beaker
- 25mL grad. cylinder
- 50mL burette w/clamp
- Disposable pipettes
- Distilled H₂O

Procedure

- 1) Obtain and wear goggles.
- 2) Add 100mL of distilled water to a 250mL beaker.
- 3) Using a graduated cylinder, obtain 10 mL of a hydrochloric acid solution of unknown concentration. Add it to the 250 mL beaker.
- 4) Place the beaker on a Stir Station and add a stirring bar.
- 5) Set up a Stir Station, burette clamp, and 50.0 mL burette to conduct the titration (see Figure 1). Rinse and fill the burette with 0.100 M NaOH solution (your teacher may have done this for you already). Use the other small beaker to help with this step. **Note:** Record the actual concentration of the NaOH solution in your data table.
- 6) Use an Electrode Support to suspend the pH Sensor on the Stir Station, as shown in Figure 1. Position the Sensor so its tip is immersed in the HCl solution but is not struck by the stirring bar. **YOUR TEACHER MUST CHECK YOUR SET UP BEFORE YOU TURN ON THE STIR PLATE!** Turn the stir bar to its lowest setting. Use a nickel inside the lid of the pH sensor vial so the buffer inside does not spill during the lab.

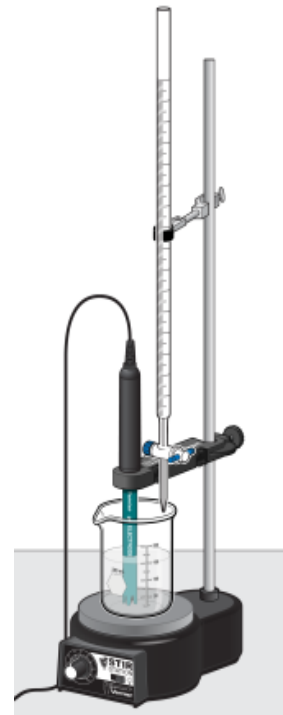


Figure 1

- 7) Connect a pH Sensor to your Chromebook by opening Graphical Analysis and clicking Sensor Collection. Select the wireless probe that matches the number on the back of your probe. In the bottom left corner click where it says "Time Based." Change it to "Event Based." Name the event "Volume" and the units are "mL."
- 8) You are now ready to begin the titration.
- Before adding NaOH titrant, click . Once the displayed pH reading has stabilized, click . In the edit box, type 0 (for 0 mL added). Click to continue.
 - Add the next increment of NaOH (go slowly! Add enough to raise the pH about 0.15 units). When the pH stabilizes, again click . In the edit box, type the current burette reading as accurately as possible. Click to continue.
 - Continue adding NaOH solution in increments that raise the pH by about 0.15 units and enter the total running amount of NaOH that has been added each time. Make sure to be observing the shape of your curve. When you see the pH start to increase more quickly, slow down! Start adding even more slowly, even one drop at a time.
 - Continue adding NaOH solution until the pH value remains relatively constant, when you have a nice plateau at the top.
- 9) When you have finished collecting data, click . Dispose of the reaction mixture as directed. Rinse the pH Sensor with distilled water in preparation for the second titration.
- 10) Follow the steps below to find the *equivalence point*, which is the largest increase in pH upon the addition of a very small amount of NaOH solution. A good method of determining the precise equivalence point of the titration is to take the second derivative of the pH-volume data, a plot of $\Delta^2\text{pH}/\Delta\text{Vol}^2$.
- Click the 3 dots next to the pH column. Click "add calculated column" then click "insert expression" and select "Second Derivative."
 - Analyze the second derivative plot and find where the large spike crosses the x-axis and record the volume of NaOH at that point, which will be the equivalence point.
- 11) Go back to the original titration graph. Conduct a second trial if directed by your instructor. If you wish to save the results of the titration, choose Store Latest Run from the Experiment menu.
- 12) Rinse your glassware, use a new disposable pipette, and repeat the necessary steps to test the acetic acid solution. Conduct a second trial of the acetic acid solution if directed by your instructor. Analyze, print, and save the titration data for your acetic acid solution trial(s).
- 13) YOUR INSTRUCTOR MUST PUT THE pH PROBE BACK IN THE VIAL! BRING THE VIAL AND THE PROBE TO YOUR INSTRUCTOR WHEN YOU ARE DONE AND HAVE RINSED IT THOROUGHLY WITH DI WATER.**

Data Table

- Make your own data table! Remember, you need to make sure your data table has all required elements!

HCl trial	Volume HCl (mL)	[NaOH] (M)	Equivalence point (mL)	HC ₂ H ₃ O ₂ trial	Volume HC ₂ H ₃ O ₂ (mL)	[NaOH] (M)	Equivalence point (mL)
1				1			
2				2			

- Glue in a copy of your Logger Pro graph below your data table.

Calculations - Record any, and all, manipulation of numbers in your calculation section.

- Calculate the molar amounts of NaOH used in the reaction with the HCl solution and with the HC₂H₃O₂ solution.
- Calculate the molar concentration (molarity) of the HCl solution and the HC₂H₃O₂ solution.

Post-Lab Discussion Questions

- Compare the actual molarity of your two acid solutions with your calculated molarities. Were the calculated molarities within a reasonable range (about 5%) of the actual values? If not, suggest reasons for the inaccuracy.
- The equivalence points of the two titration curves were not in the same pH range. Explain.