

Expt 8 Virtual Lab: Acid/Base Titration Part 1:

Standardization of NaOH

In this experiment, you will be determining the concentration of a solution of NaOH by titrating a solution of potassium hydrogen phthalate, abbreviated as KHP. The indicator we'll use is phenolphthalein, which turns pink in the presence of excess hydroxide ion.

To access the lab, go to <http://chemcollective.org/vlab/101>.

I. Setting up for the titration

Load the following items onto your Workbench:

~1M NaOH solution
0.500 M KHP solution 50
mL buret
Phenolphthalein

Make sure that you leave space on the Workbench at the top for your glassware. If you receive a message that your Workbench is full, then move some of the glassware away from the top to make space.

Fill the buret to the 0.0 mL mark by adding 52.00 mL of the NaOH solution by moving the beaker of NaOH over the buret. The extra 2.00 mL fills the buret tip and region between the 50.00 mL mark and the buret tip.

Add 1 mL of phenolphthalein to the flask of the KHP by moving the phenolphthalein over the flask of the KHP.

II. Titration

For the titration, you are going to keep track of your additions of NaOH so that you can make a titration curve. You can do this either by using an Excel or Google sheet spreadsheet or on paper. Eventually, you will need to enter all the values into a spreadsheet (directions for making the graph will come later).

While going through the titration process, keep an eye on your KHP flask for when it turns pink. That will tell you when you've reached the endpoint of the titration.

Because there is no undo button, if you miss a point or add too much, you will need to start the titration over (this is just like in lab!), so take your time as you go through the process.

- A. Record the pH of the initial KHP solution and a volume of 0.00 mL.
- B. Add 1.00 mL of NaOH from the buret to the KHP solution by moving the buret over the flask of KHP. You will notice the temperature changes each time you add NaOH, so you need to wait a little for the temperature to return to 25.0 °C before

recording your pH. Record the volume added and the pH of the solution in your table.

- C. Add another 1.00 mL of NaOH from the buret to the KHP solution, wait for the temperature to stabilize, and record the pH. Continue this process until you complete 12.00 mL of NaOH added.
- D. After you've added 12.00 mL of NaOH, you will change your volume increments to 0.05 mL so that you can catch the equivalence point of the titration. Since the actual concentration of NaOH is unknown, keep a close eye on your KHP flask to note when the color change takes place. Make a note of what volume of NaOH you've added to get the color change.
- E. Continue adding 0.05 mL increments until your pH reaches about 10.5.
- F. Switch back to 1.00 mL increments of NaOH and continue until you have added a total volume of around 25.00 mL.
- G. Once you've finished your titration, you will be ready to start your calculations and are done and can close your Workbench.

III. Analysis

- A. Open an Excel file or Google sheet.
- B. Label a column "mL of NaOH" and enter your volumes of NaOH added.
- C. Label a column "pH" and enter your pH values.
- D. To create a graph, highlight the two columns. For Excel, select the "Insert" tab on the top and from "Charts" select "Scatter." For Google sheets, select "Insert" and "Chart" (this will automatically create a Scatter plot).
- E. Save this file as "Expt 8_xx" where "xx" are your initials. You will upload this file as part of your lab. You will use this same file for both Part 1 and Part 2 of the lab.
- F. In Data Table Part 1, enter the volume of NaOH used to reach the endpoint of the titration.
- G. Using the concentration of the KHP and its volume, determine the moles of KHP you used. Record this value in Data Table Part 1.
- H. The chemical formula of KHP is $\text{HC}_8\text{H}_4\text{KO}_4$. In Data Table Part 1, write the reaction for KHP and NaOH using the actual chemical formulas. Label the weak acid, strong base, and conjugate weak base.

- I. Identify the pH at the endpoint. Briefly explain why the pH of the solution was not 7.00 at the endpoint, when all the acid was neutralized in Data Table Part 1. (Hint: look at the equation you just wrote.)
- J. Since the reaction is 1:1 between NaOH and KHP, the moles of KHP and moles of NaOH at the endpoint are the same. Use this to determine the concentration of the original NaOH solution. Record your answer in Data Table Part 1.
- K. The halfway point of a titration is when half of the volume of NaOH to reach the endpoint has been used. Determine the volume of NaOH at the halfway point. Record this volume and the pH at this volume (from your spreadsheet) in Data Table Part 1. You may have to estimate the pH as you may not have the exact volume at the halfway point in your spreadsheet table.
- L. The pK_a of a weak acid is equal to the pH at the halfway point. Using the relationship $K_a = 10^{-pK_a}$, determine the K_a for KHP from your experiment. Show your calculation and record the value in Data Table Part 1.
- M. The actual value of the K_a for KHP is 3.9×10^{-6} . How close is your experimental value to this? Record your answer in Data Table Part 1.

Part 2: Titration of an Unknown Acid

In this experiment, you will be determining the identity of an unknown acid. The process will be much the same as for your standardization of NaOH, however, this time, you don't know the acid.

To access the lab go to <http://chemcollective.org/vlab/103>.

I. Setting up for the titration

Load the following items onto your Workbench:

0.100 M NaOH solution
0.1 L Unknown Acid
250 mL Erlenmeyer flask 50
mL buret Phenolphthalein

Make sure that you leave space on the Workbench at the top for your glassware. If you receive a message that your Workbench is full, the move some of the glassware away from the top to make space.

Fill the buret to the 0.0 mL mark by adding 52.00 mL of the NaOH solution by moving the beaker of NaOH over the buret. The extra 2.00 mL fills the buret tip and region between the 50.00 mL mark and the buret tip.

Transfer 25.00 mL of the unknown acid to the 250 mL Erlenmeyer flask. Add 1 mL of phenolphthalein to the flask containing the unknown acid by moving the phenolphthalein over the flask.

II. Titration

For the titration, you are going to keep track of your additions of NaOH so that you can make a titration curve just like you did in Part 1. You can do this either by using an Excel or Google sheet spreadsheet or on paper. Eventually, you will need to enter all the values into a spreadsheet (directions for making the graph will come later).

While going through the titration process, keep an eye on your acid flask for when it turns pink. That will tell you when you've reached the endpoint of the titration.

Because there is no undo button, if you miss a point or add too much, you will need to start the titration over (this is just like in lab!), so take your time as you go through the process.

- A. Record the pH of the initial acid solution and a volume of 0.00 mL.
- B. Add 0.50 mL of NaOH from the buret to the acid solution by moving the buret over the flask of acid. You will notice the temperature changes each time you add NaOH, so you need to wait a little for the temperature to return to 25.0 °C before recording your pH. Record the volume added and the pH of the solution in your table.
- C. Add another 0.50 mL of NaOH from the buret to the acid solution, wait for the temperature to stabilize, and record the pH. Continue this process until you complete 10.00 mL of NaOH added.
- D. After you've added 10.00 mL of NaOH, you will change your volume increments to 0.02 mL so that you can catch the equivalence point of the titration. Since the actual concentration of the weak acid is unknown, keep a close eye on your acid flask to note when the color change takes place. Make a note of what volume of NaOH you've added to get the color change.
- E. Continue adding 0.02 mL increments until your pH reaches about 10.5.
- F. Switch back to 0.50 mL increments of NaOH and continue until you have added a total volume of around 25.00 mL.
- G. Once you've finished your titration, you will be ready to start your calculations and are done and can close your Workbench.

III. Analysis

- A. Open your Excel file or Google sheet.
- B. Label a column "mL of NaOH" and enter your volumes of NaOH added.
- C. Label a column "pH" and enter your pH values.
- D. To create a graph, highlight the two columns. For Excel, select the "Insert" tab on the top and from "Charts" select "Scatter." For Google sheets, select "Insert" and "Chart" (this will automatically create a Scatter plot).
- E. In Data Table Part 2, enter the volume of NaOH used to reach the endpoint of the titration.
- F. Using the concentration of the NaOH and its volume, determine the moles of the unknown weak acid you used. Record this value in Data Table Part 2.
- G. Since the reaction is 1:1 between NaOH and the unknown acid, the moles of weak acid and moles of NaOH at the endpoint are the same. Use this to determine the concentration of the original weak acid solution. Record your answer in Data Table Part 2.
- H. The halfway point of a titration is when half of the volume of NaOH to reach the endpoint has been used. Determine the volume of NaOH at the halfway point. Record this volume and the pH at this volume (from your spreadsheet) in Data Table Part 2. You may have to estimate the pH as you may not have the exact volume at the halfway point in your spreadsheet table.
- I. The pK_a of a weak acid is equal to the pH at the halfway point. Using the relationship $K_a = 10^{-pK_a}$, determine the K_a for the weak acid from your experiment. Show your calculation and record the value in Data Table Part 1.
- J. Using the table of weak acids from your workbook, identify a weak acid that has a similar K_a value.
- K. Write the equation for the reaction of NaOH with the weak acid you have identified in Data Table Part 2. Label the weak acid, strong base, and conjugate weak base.

Submit your Data Table pages and your spreadsheet for Lab 8 on Canvas.

Data Table Part 1

Volume NaOH to reach endpoint	13.2mL
Moles of KHP (25.00 mL, 0.500 M)	0.0125moles
Concentration of NaOH solution	$1000 \times 0.0125 / 13.2 = 0.94697$ 0.94697M
Volume of NaOH to reach the halfway point	6.6mL
pH at halfway point	5.20

Write the reaction and label the acid, base, and conjugate weak base.	$\text{NaOH(aq)} + \text{KHC}_8\text{H}_4\text{O}_4\text{(aq)} \rightarrow \text{KNaHC}_8\text{H}_4\text{O}_4\text{(aq)} + \text{H}_2\text{O(l)}$
What is the pH at the endpoint? Why is the pH not 7.00?	7.8. It is due to the production of conjugate base during the titration. The resulting solution is slightly basic
Determine K_a of KHP	$K_a = 10^{-5.20}$ $K_a = 0.00000630957$ $K_a = 6.30957\text{E-}06$
Compare experimental K_a to theoretical K_a	Percentage error = $((6.31 - 3.9) / 3.9) \times 100\% = 61.8\%$

Data Table Part 2

Volume NaOH to reach endpoint	10.52mL
Moles of NaOH (0.100 M)	0.001052
Concentration of weak acid solution	0.04208M
Volume of NaOH to reach the halfway point	5.26mL
pH at halfway point	5.20

Determine K_a of unknown weak acid	$K_a=10^{-5.20}$ $K_a=0.00000630957$ $K_a=6.30957E-06$
Identity of weak acid	
Write the reaction and label the acid, base, and conjugate weak base.	