2019 FREE PASS FOR A LATE LAB

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***Normal Due Date**: Wednesday Nov 6

***Normal Submission time**: 1:00 pm

***Extended Date:** Thursday Nov 7

*New Submission time: 1:00pm

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Signed by Dr. RV:

Rashmi Venkateswaran

(directions for use below)

* Must be filled in!

”Oh How Bitter A Thing It Is” Acid Base Titrations

Written By: Emily Kavanagh, 300138045

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Introduction:

Acids and bases are things that we come into contact with every single day. Both substances are corrosive. Acids tend to have a sour taste while bases tend to be bitter. . When they react with each other, it is known as a neutralization reaction where water and a salt are produced. Acids and bases come in different strengths. Strong acid or base will completely dissociate in water where weak ones do not. When referring to acids and bases, they are mostly referred to with their respective concentrations; a ratio of the acid or base (solute) to their solvent (usually water). The more water you add to a constant amount of acid or base, the less concentrated the solution is. To determine the concentration (M), the number of moles of acid or base can be divided by the volume of the solution (in litres).

A titration is the" counting of the average number of analyte particles in solution through the reaction with a known number of standard particles" (*J. Chem. Educ*). This method is used to determine the concentration of an acid or base. This is done by using a software to monitor the pH at the same time as recording the amount of the unknown concentration acid or base that is added to the solution. This is done with the goal of finding the equivalence point. When you monitor the pH and the amount of substance, you can determine the concentration of the unknown monoprotic (releases one proton) acid by using the equation:

$$C_1V_1=C_2V_2$$

To find the concentration of a diprotic (releases two protons) acid, the following equation is used:

$$C_1V_1=\frac{b}{a}C_2V_2$$

First, you must balance the chemical equation and then use the coefficient of the base for b and use the coefficient of the acid for a. When the amount of acid is present that is the exact amount that is needed to titrate the base, this is known as the equivalence point.

An end point is a value that is close to the equivalence point. This value can be found by using a pH indicator like phenolphthalein. When the solution is acidic, when phenolphthalein is added, the solution will be clear, and when it is basic, it will be pink. In a titration, the point at which the solution changes colour is called the end point.

Procedure:

Refer to lab manual, experiment 4 "OH HOW BITTER A THING IT IS…" ACID BASE TITRATIONS, Dr. Rashmi Venkateswaran, 2019, Exp 4, p. 6-10

Discussion:

The first part of this lab was preparing a dilute NaOH(aq) solution by using a concentrated 6.0M NaOH(aq) solution. This was done by adding enough distilled water to produce a 250mL stock NaOH solution. The initial volume of NaOH that was taken to do this therefore did not have to be exactly accurate, but within an approximate range (our group used 4.10mL of NaOH). After diluting the NaOH solution, it was assumed that the difference in concentrations if 4.00mL of NaOH were used versus our value of 4.10mL, would not be significant enough to cause error within the experiment.

Determining the concentration of NaOH right before it is used is important as it helps improve accuracy. First, you had to standardize the NaOH using an acid with a known Concentration. In this lab, HCl with a 0.1M concentration was used. When the NaOH was first diluted, a calculation was made to estimate the initial concentration of NaOH (see Sample Calculations 1.a)), however this calculation is only an approximation and not accurate enough to for the entire experiment. After standardizing the NaOH, we were able to make calculations for the concentration of NaOH using more accurate values provided by Logger Pro (refer to Sample Calculations- #3), then using the average of those three values (refer to Sample Calculations #3) to be used when trying to find the concentration of the unknown diprotic acid.

Both values calculated for the volumes at the visual endpoint and equivalence were close, but not identical. This is because the visual endpoint and the equivalence point are not directly related. The visual endpoint refers to when the color of the solution changes due to the of the indicator, which in this lab was phenolphthalein. Equivalence point differs as it refers to the equalling of the amounts of acid and base in solution. Since the indicator displays a visual endpoint at approximately the same time that the equivalence point occurs, both the equivalence point and the visual endpoints should be within close proximity of each other. With this being said, relying on the visual endpoint to determine the equivalence point would be inaccurate as the color change is not always instant and visible to the naked eye.

There were many sources of error present in this lab. One possible error would be contaminated equipment. In this lab, the same beaker was used many times throughout the lab. Although it was washed off in between uses, there is still the possibility of there being trace amounts of the acid or base still in the beaker which would have affected the rate at which the solution reaches its equivalence point in the next trial. Additionally, there could have been errors with the drop counter. The size of drops was constant throughout the entire experiment but it is hard to tell if each drop was actually counted. Lastly, in the first titration, our group did not turn the spin plate on. This would have affected the ability of the substances to react with one another which would affect the equivalence point.

When 0mL of base is added, no reaction is occuring. This means the beaker should contain H_2O, H_3O^+, and H_2A (the unknown acid).

1 proton is donated midway to the equivalence point. This means there should be a ratio of 1 H_2O: 1 H_3O^+: 1 H_2A: 1 H_3A. Some Na^+ ions may also be present.

At the first equivalence point, the only species in the beaker should be H_2O and salt, with a ratio of 2 H_2O : 1 Na_2A. This can be assumed based on the previously balanced chemical equation of

$$2NaOH + H_2A \rightarrow 2\,H_2O + Na_2A$$

Midway to the second equivalence point would be expected to have a ratio of $1H_2O : 1OH^- : 1HA^- : 1H_2A$.

At the second equivalence point, just like the first, it is expected to only have water and salt with the ratio of 2 H_2O : 1 Na_2A

Conclusion:

This experiment was successful in determining the concentration of a dilute stock solution of NaOH to be 0.1029M as well as finding the concentration of unknown diprotic acid to be 0.06457M.

Reference(s):

J. Chem. Educ. 2012, 89, 6, 767-770
Publication Date:March 28, 2012

OH HOW BITTER A THING IT IS…" ACID BASE TITRATIONS, Dr. Rashmi Venkateswaran, 2019, Exp 4, p. 6-10

Appendix:

Raw Data

Experiment 4- "OH HOW BITTER, A THING IT IS..."
ACID BASE TITRATION

Part 1 - Preparing Sol'n of NaOH by Dilution

6 mol/L NaOH - ~~0.~~ 4.10mL

Distilled Water ≃ 247mL

Part 2 - Calibrating Drop Counter

~38 ~~40~~mL in Plastic Buret

2.15mL in Graduated cylinder (44 drops)

Step 19 Concentration of Dilute NaOH solution = $6M \times \left(\frac{4.10mL}{247+4.10mL}\right)$

~~C_{dil} / C_{conc}~~ ~~$\frac{4.10}{247}$~~

$C_{dil} = 6M \times \left(\frac{4.10mL}{251.1}\right)$

$C_{dil} = 0.09797$

Step 20 1mL = 20drop

0.05mL/drop

2.15mL = 44 drops
= 0.04886mL/drop ∴ OK
= 0.05mL/drop

Part 3

Step 22 HCl → 35.0mL

1st titration

Step 24 Initial Buret Reading - ~~24.90mL~~ ~~0.0~~ 0.1

Final Buret Reading - 15.9mL

Exact V of acid transferred = initial Buret Reading - Final Buret Reading
= 0.1mL ~~24.90mL~~ - 15.90mL
= ~~10.00mL~~ 15.8mL

→ Turned purple when base was added →

2nd titration

Initial Buret Reading - 15.90

Final Buret Reading - 5.10

Exact V of Acid transferred 15.9 - 5.1 = 1080 mL

3rd

Init. Buret Reading - 12.10mL

Final Buret Reading - 22.10 mL

Exact V of Acid transferred 12.10 - 22.10 = 10.00mL

Step 4

1st trial Initial Buret Reading : ~~25~~ 0.00

Final Buret Reading : ~~11.90~~ 10.15

Exact amt. of Acid transfered 10.15mL

2nd trial Initial Buret Reading - 10.15

Final Buret Reading - 20.20

Exact amt. of Acid transferred 10.05

3rd Trial Initial Buret Reading - 12.45

Final Buret Reading - 22.35

Exact amt of Acid transferred 9.90 mL

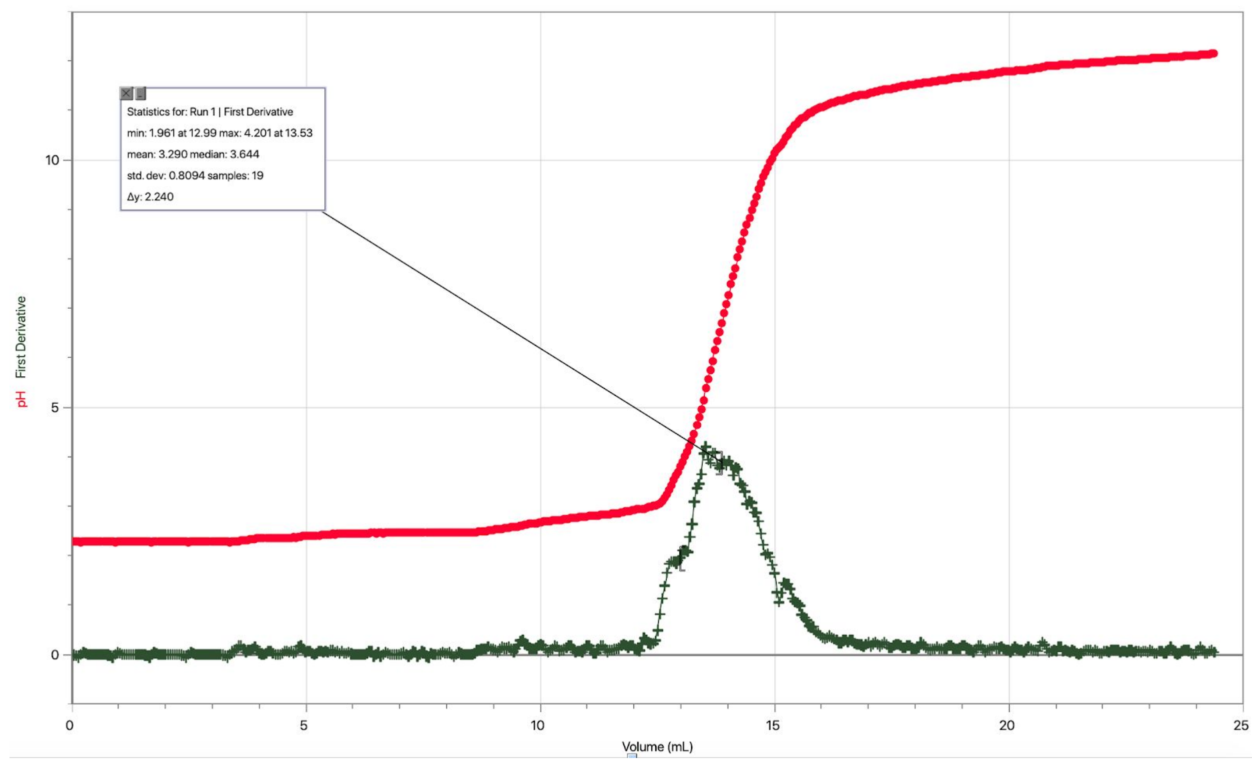
Additional Data

Table 4.0: Partial Results From the Titration of the NaOh Solution and a standardized solution of 0.1M HCL

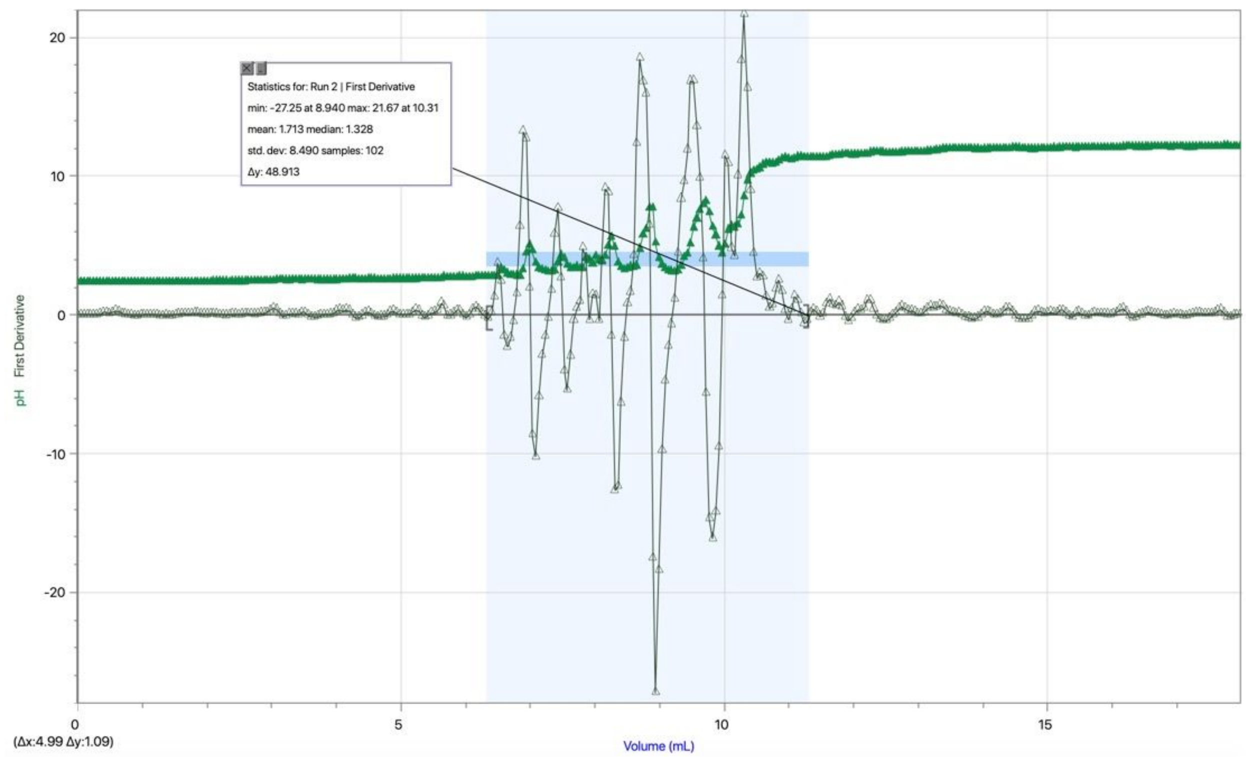
	Run 1			Run 2			Run 3			Run 4			Run 5			Run 6		
	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD
1	0.000	2.28	0.000	0.000	2.29	0.000	0.000	2.40	-0.012	0.000	2.64	-0.115	0.000	2.75	-0.158	0.000	2.73	-0.011
2	0.049	2.28	-0.009	0.049	2.29	0.000	0.049	2.40	-0.024	0.049	2.63	-0.032	0.049	2.74	-0.088	0.049	2.73	-0.032
3	0.098	2.28	-0.018	0.098	2.29	0.000	0.098	2.40	-0.069	0.098	2.64	-0.031	0.098	2.74	-0.026	0.098	2.73	-0.069
4	0.147	2.28	-0.055	0.147	2.29	0.000	0.147	2.39	-0.042	0.147	2.63	-0.082	0.147	2.74	-0.006	0.147	2.72	-0.046
5	0.195	2.27	0.000	0.195	2.29	0.000	0.195	2.40	-0.076	0.195	2.63	-0.085	0.195	2.74	0.000	0.195	2.72	0.093
6	0.244	2.28	0.055	0.244	2.29	0.000	0.244	2.38	-0.067	0.244	2.62	-0.049	0.244	2.74	0.000	0.244	2.73	0.238
7	0.293	2.28	0.018	0.293	2.29	0.012	0.293	2.39	0.010	0.293	2.62	0.082	0.293	2.74	0.000	0.293	2.74	0.424
8	0.342	2.28	0.006	0.342	2.29	0.047	0.342	2.39	-0.063	0.342	2.64	0.000	0.342	2.74	0.000	0.342	2.77	0.553
9	0.391	2.28	0.000	0.391	2.29	0.154	0.391	2.38	-0.063	0.391	2.62	-0.082	0.391	2.74	0.000	0.391	2.81	0.327
10	0.440	2.28	0.000	0.440	2.31	0.160	0.440	2.38	0.000	0.440	2.62	0.044	0.440	2.74	0.000	0.440	2.81	-0.071
11	0.489	2.28	0.000	0.489	2.31	0.088	0.489	2.38	0.069	0.489	2.63	0.067	0.489	2.74	0.000	0.489	2.79	-0.234
12	0.537	2.28	0.000	0.537	2.31	0.157	0.537	2.39	0.075	0.537	2.63	0.030	0.537	2.74	0.000	0.537	2.78	-0.233
13	0.586	2.28	0.000	0.586	2.32	0.303	0.586	2.39	0.023	0.586	2.63	0.029	0.586	2.74	0.000	0.586	2.77	-0.230
14	0.635	2.28	0.000	0.635	2.35	0.251	0.635	2.39	0.000	0.635	2.63	0.069	0.635	2.74	0.000	0.635	2.76	-0.243
15	0.684	2.28	0.000	0.684	2.35	0.076	0.684	2.39	-0.017	0.684	2.64	0.052	0.684	2.74	0.006	0.684	2.74	-0.129
16	0.733	2.28	0.000	0.733	2.35	0.018	0.733	2.39	-0.052	0.733	2.64	-0.052	0.733	2.74	0.024	0.733	2.75	-0.053
17	0.782	2.28	-0.006	0.782	2.35	-0.006	0.782	2.38	0.000	0.782	2.63	-0.063	0.782	2.74	0.085	0.782	2.74	-0.067
18	0.830	2.28	-0.018	0.830	2.35	-0.023	0.830	2.39	0.046	0.830	2.63	-0.006	0.830	2.75	0.108	0.830	2.74	-0.018
19	0.879	2.28	-0.055	0.879	2.35	-0.075	0.879	2.39	-0.006	0.879	2.63	0.046	0.879	2.75	0.123	0.879	2.74	-0.012
20	0.928	2.27	0.000	0.928	2.34	-0.075	0.928	2.39	-0.069	0.928	2.64	0.006	0.928	2.76	0.166	0.928	2.74	-0.023
21	0.977	2.28	0.055	0.977	2.34	-0.023	0.977	2.38	-0.075	0.977	2.63	-0.029	0.977	2.77	0.119	0.977	2.74	-0.075
22	1.026	2.28	0.018	1.026	2.34	-0.006	1.026	2.38	-0.023	1.026	2.63	0.057	1.026	2.77	0.082	1.026	2.73	-0.069
23	1.075	2.28	0.006	1.075	2.34	0.000	1.075	2.38	-0.006	1.075	2.64	0.069	1.075	2.78	0.006	1.075	2.73	-0.006
24	1.124	2.28	0.000	1.124	2.34	0.000	1.124	2.38	0.000	1.124	2.64	0.029	1.124	2.77	-0.052	1.124	2.73	0.046
25	1.172	2.28	0.000	1.172	2.34	-0.006	1.172	2.38	0.000	1.172	2.64	0.030	1.172	2.77	-0.017	1.172	2.74	0.000
26	1.221	2.28	0.000	1.221	2.34	-0.024	1.221	2.38	0.006	1.221	2.64	0.085	1.221	2.77	-0.006	1.221	2.73	-0.052
27	1.270	2.28	0.000	1.270	2.34	-0.079	1.270	2.38	0.029	1.270	2.65	0.102	1.270	2.77	0.000	1.270	2.73	-0.017
28	1.319	2.28	0.000	1.319	2.33	-0.085	1.319	2.38	0.099	1.319	2.65	0.105	1.319	2.77	0.006	1.319	2.73	-0.006
29	1.368	2.28	0.000	1.368	2.33	-0.047	1.368	2.39	0.154	1.368	2.66	0.104	1.368	2.77	0.017	1.368	2.73	0.006
30	1.417	2.28	0.000	1.417	2.33	-0.081	1.417	2.40	0.096	1.417	2.66	0.098	1.417	2.77	0.052	1.417	2.73	0.023
31	1.466	2.28	0.000	1.466	2.32	-0.075	1.466	2.40	0.012	1.466	2.67	0.080	1.466	2.78	0.000	1.466	2.73	0.075
32	1.514	2.28	0.000	1.514	2.32	-0.017	1.514	2.40	-0.049	1.514	2.67	0.017	1.514	2.77	-0.052	1.514	2.74	0.075
33	1.563	2.28	-0.006	1.563	2.32	0.017	1.563	2.39	0.000	1.563	2.67	-0.011	1.563	2.77	-0.017	1.563	2.74	0.023
34	1.612	2.28	-0.018	1.612	2.32	0.075	1.612	2.40	0.055	1.612	2.67	-0.057	1.612	2.77	-0.006	1.612	2.74	0.006

Additional Graphs

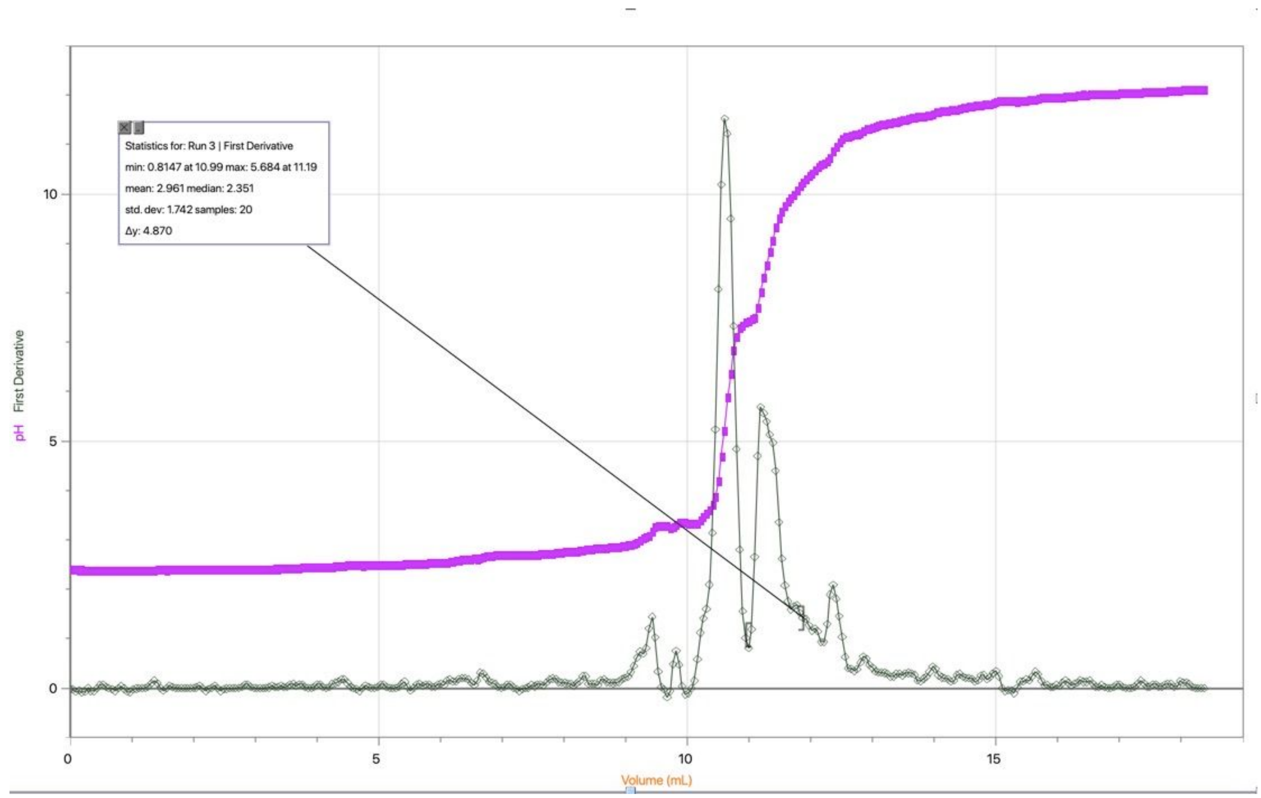
Graph 1.0- Plot of pH as a Function of Volume for the Determination of the Concentration of NaOH, including derivative - Trial 1



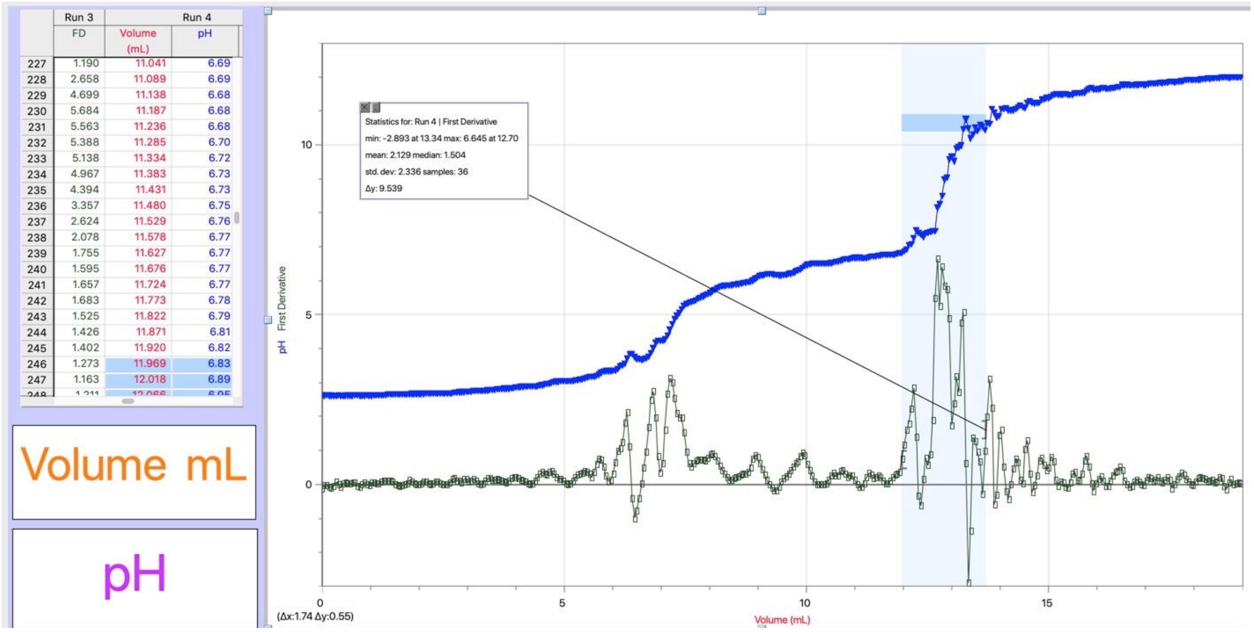
Graph 2.0- Plot of pH as a Function of Volume for the Determination of the Concentration of NaOH - Trial 2



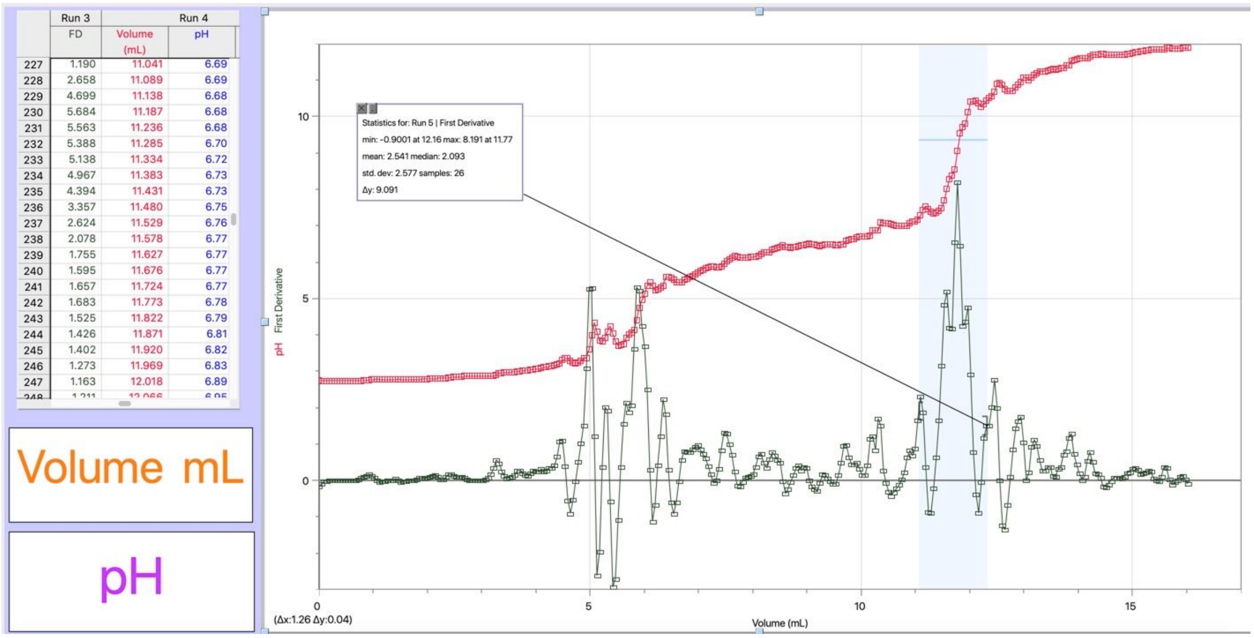
Graph 3.0- Plot of pH as a Function of Volume for the Determination of the Concentration of NaOH, including derivative - Trial 3



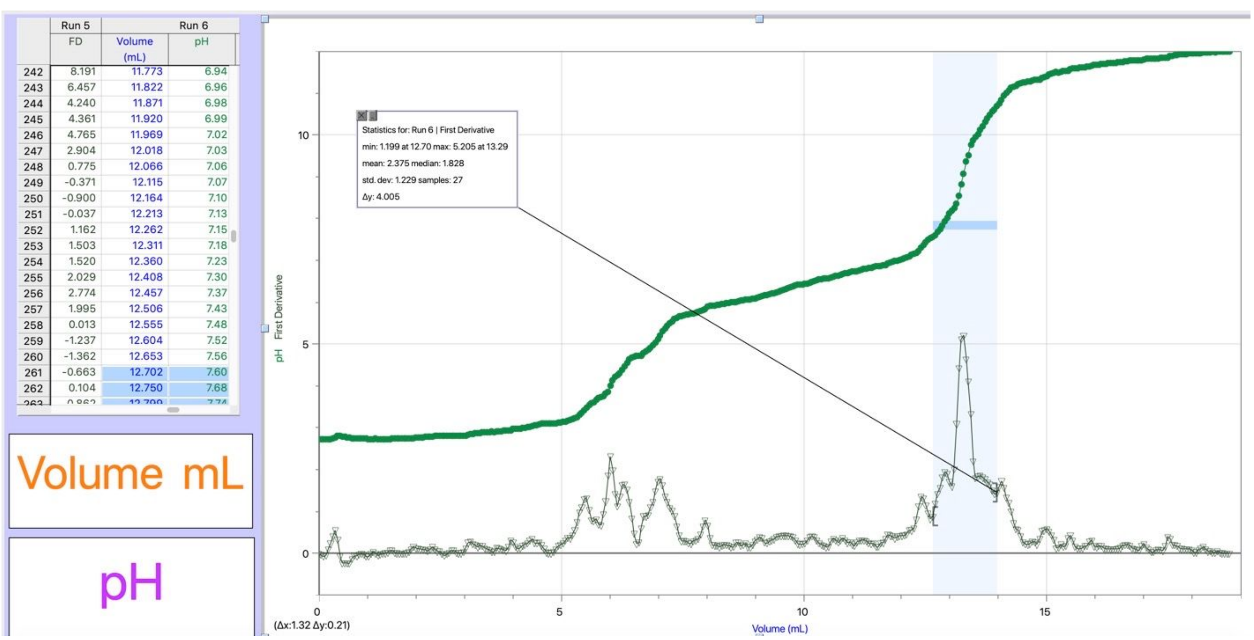
Graph 4.0- Plot of pH as a Function of Volume for the Determination of the Concentration of unknown diprotic acid, including derivative - Trial



Graph 5.0- Plot of pH as a Function of Volume for the Determination of the Concentration of unknown diprotic acid, including derivative - Trial 2



Graph 6.0- Plot of pH as a Function of Volume for the Determination of the Concentration of unknown diprotic acid, including derivative - Trial 3



Sample Calculations

1.

1. Determining approximate concentration of NaOH solution
   C_{1NaOH}= 6.0M
   V_{1NaOH}= 4.10mL
   $C_{2\ NaOH\ final}$ = ?
   $V_{2\ total}$ = 251.10mL

$C_1V_1=C_2V_2$

$C_2 = \frac{C1V1}{V1}$

$C_2 = \frac{(6\ mol/L\ x\ 0.0041L)}{0.2511L}$

C_2=0.0980 M

2. Exact concentration of $NaOH_{(aq)}$using values in Logger Pro- example

a) Trial 1

Givens:

Exact concentration of $NaOH_{(aq)}$ (C_1)= ?

Initial volume of $NaOH_{(aq)}$ (V_1)= 13.53mL/0.01353L *found using Logger Pro, refer to Graph 1.0

Concentration of $HCl_{(aq)}$(C_2)= 0.100M

Volume of $HCl_{(aq)}$(V_2) = 15.80 mL/0.01580L

Calculation

$C_1V_1 = C_2V_2$

C_1 = [(0.100mol/L)(0.01580L)] / 0.01353L

= 0.1168 M

C_1

-Trial 2: 0.1048 M

C_1

-Trial 3: 0.08937M

Average concentration of NaOH(aq):

Average concentration = [($C_1$from trial 1)+($C_1$from trial 2)+($C_1$from trial 3)] / 3

= [(0.1168)+(0.1048)+(0.08937)]/3

= 0.1029 M

3. Concentration of unknown diprotic acid (used bottle labelled #1)

Givens:

- Concentration of $NaOH_{(aq)}$
(C_{base}) = 0.1029 M
- Volume of NaOH(aq)
(V_{base}) = 0.01270 L (found in Logger Pro)
- Volume of unknown acid used (V_{acid}) = 0.01015 L
- Concentration of unknown acid (C_{acid}) = ?
- Balanced chemical equation: $H_2A + 2NaOH \rightleftharpoons Na_2A + 2H_2O$

$C_{Base}gV_{base} = 2/1\ C_{acid}gV_{acid}$

$[(0.1029)(0.01270) / 0.01015)]/2 = C_{acid}$
$C_{acid} = 0.06438M$

Trial 2- 0.06026M
Trial 3- 0.06907M

Average concentration of unknown acid #1:

Average concentration = [($C_1$from trial 1)+($C_1$from trial 2)+($C_1$from trial 3)] / 3
= [(0.06458)+(0.06026)+(0.06907)]/3
= 0.06457M

4. This calculation is unfortunately not able to be done as we did not record our visual endpoints during the lab. In theory, the concentrations calculated using the number would be close to the concentration found using the equivalence point but not exactly.

Table 1.0- Preparing NaOH solution from concentrated 6M NaOH

Concentration of Concentrated NaOH solution (mol/L)	Volume of NaOH (mL)	Volume of Distilled Water (mL)	**Calculated** Concentration of New NaOH solution (mol/L)
6.0	4.10	247.0	0.0980

Table 2.0- Standardization of the diluted NaOH

	Trial 1	Trial 2	Trial 3	Average
Concentration of HCL (mol/L)	0.1	0.1	0.1	
Volume of HCL (mL)	15.80	10.80	10.00	
Final Volume of NaOH (mL)	13.53	10.31	11.19	
Concentration of NaOH (mol/L)	0.1168	0.1048	0.08937	0.1029

Table 3.0- Titration of Unknown Acid

	Trial 1	Trial 2	Trial 3	Average
volume of unknown acid #1 (mL)	10.15	10.05	9.90	
Volume of NaOH (mL)	12.70	11.77	13.29	
Concentration of NaOH (mol/L)	0.1029	0.1029	0.1029	
Concentration of unknown acid #1 (mol/L)	0.06438	0.06026	0.06907	0.06457