

Formal Lab – Experiment 4

Experiment Title: Acid-Base Titrations

Author's Name:

Submitting Author's Partner:

TA (Demonstrator)'s Name:

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Date Experiment Submitted: November 7th, 2019

Attach here (if required, indicate the appropriate document(s)):

Medical or other Acceptable Document: _____

Change of Lab Day Form: _____

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Late Pass: _____

Introduction:

Acids and bases are substances that can be classified in many ways. The Arrhenius definition describes acids as proton donors, meaning they give away H^+ ions when dissolved in water, and bases as a hydroxide ion donors, meaning they give away OH^- ions when dissolved in water, however, this does not fully explain how many bases do not have OH^- ions to donate. An expanded theory is the Brønsted-Lowry theory, where acids remain the same as previously defined, however, bases are defined as substances that accept H^+ ions when placed in water, but this does not explain how many acids and bases do not have H^+ ions. The most expanded definition is the Lewis definition, where acids are described as electron-pair acceptors and bases are electron-pair donors. For this experiment, the Arrhenius definition will be used as all of the chemicals being used have H^+ and OH^- ions.

Acids and bases can be classified based on their strength. Strong acids and bases almost fully dissociate when placed in water to form ions, where weak acids and bases do not completely dissociate. Lastly, acids and bases can be described by their concentration. Concentration depends on the amount of acid or base in a certain volume of water and is measured as moles/litres. If there are more moles of acid/base and less water, the solution has a high concentration, but if there are fewer moles of acid/base and more water, the solution has a low concentration.

The technique used for determining the unknown concentration of an acid or base is called a titration, where drops of titrant are added until an equivalence point is reached indicating that there is exactly enough acid to neutralize the base. The equation that describes this is,

$$(C_1V_1) = (C_2V_2)$$

Where " C_1 " is the known concentration, " V_1 " is the volume of the known concentration, " V_2 " is the volume of the unknown concentration and " C_2 " is the unknown concentration. The volumes are determined by the equivalence point. To find the unknown concentration, the equation is adjusted.

$$C_2 = (C_1V_1) / (V_2)$$

The equivalence point is measured using an indicator like phenolphthalein which changes colour when the equivalence point is reached. The point where this colour change is reached is called the endpoint, therefore endpoint and equivalence point should be very close [2].

Procedure:

As described in the lab manual (“Oh How Bitter a Thing is...” Acid Base Titrations, Dr. Rashmi Venkateswaran, 2019, Exp. 4, p. 1).

Discussion:

Preparation of diluted NaOH

Component	Volume (L)
6.00M NaOH	0.004
Distilled water	0.25

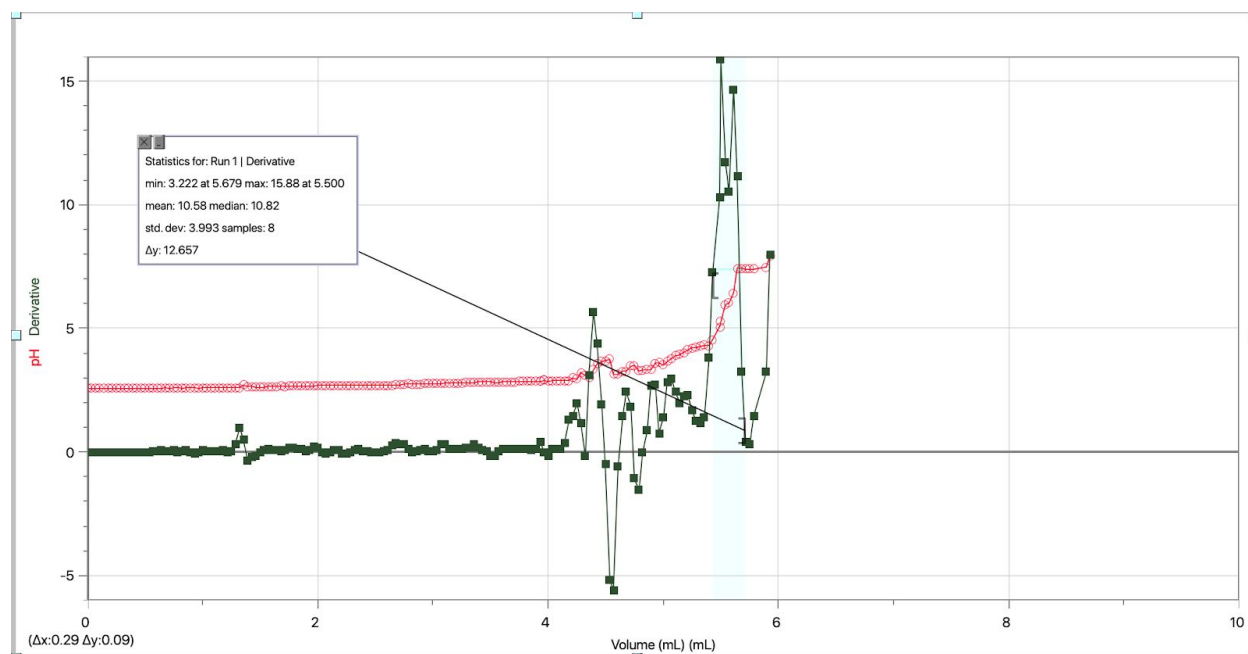
Table 1: Components of the diluted solution

Distilled water was added to a stock solution of 6.00M of NaOH to form a diluted solution which was used throughout the rest of the experiment. After adding the components and calculating the concentration, the solution was found to have a concentration of 0.096M. It was important to note the exact volume of concentrated NaOH used to get the most accurate results when finding the concentration. The concentration of this solution was determined before using it because it is the basis of the rest of the calculations from the titration.

Standardization of NaOH

Trial	Concentration of HCL (M)	Volume of HCL (L)	Initial volume of NaOH (L)	Final volume of NaOH (L)	Total volume of NaOH used (L)
1	0.100	0.010	0.040	0.029	0.011
2	0.100	0.010	0.041	0.029	0.012
3	0.100	0.010	0.041	0.028	0.013
Average	0.100	0.010	0.041	0.029	0.012

Table 2: Final results from the standardization of NaOH



Graph 1: Results from the standardization of NaOH

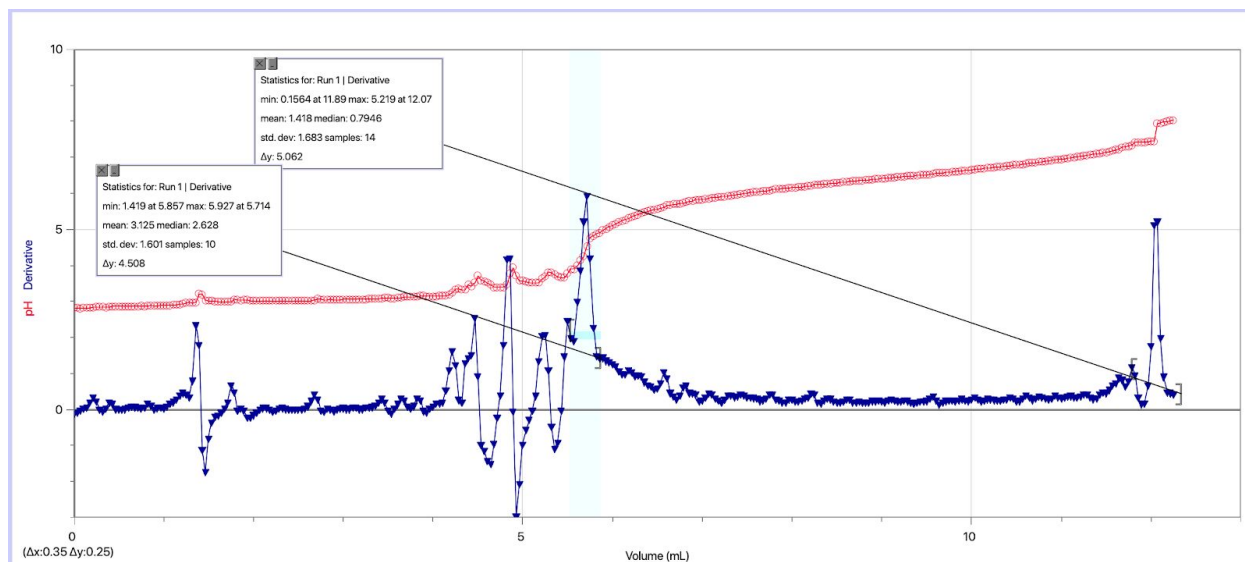
Standardization was used to confirm the concentration of the prepared NaOH solution, which was done using a titration with 0.1M HCl. In the lab. Water was added to the beaker with the acid, however, this did not affect the titration. This is because the water only changed the volume of the acid, not the amount of moles inside of it [1]. The addition of water allows the endpoint to be displayed more clearly. Using the average collected values from the three trials, the concentration was calculated to be 0.083M even though it was supposed to be very close to 0.096M. This is a 0.013M difference in concentration which displays an error of 13.5%. This error occurred for many different reasons. First, the drop counter failed as it was not calibrated properly so it did not measure anything close to accurate data. Due to this, the calculations were done based on raw data, which leaves a possibility for human error. To expand on that, the readings taken from the burette may not be accurate, which leads to the data not being accurate. The pH probe that was used also did not display the most accurate results. To elaborate, when the solution reached endpoint, the pH probe displayed that the pH was 5-6 for trials 2 and 3 even though it should have been around 7. Trial 1 was the only trial where the endpoint was shown as close to 7. The equivalence point and endpoint should be close considering colour change occurs when the equivalence point is reached. Since this data is not accurate, the calculated concentration is also not accurate. Due to these errors, the standardized value of the diluted NaOH solution will not be used to find the concentration of the unknown acid. Instead, the value 0.096M that was originally calculated will be used as it is more precise.

Concentration of Unknown acid

Trial	Volume of unknown acid (L)	Initial volume of NaOH (L)	Final volume of NaOH (L)	Total volume of NaOH used (L)
1	0.010	0.040	0.020	0.020
2	0.010	0.040	0.019	0.021

3	0.010	0.042	0.024	0.018
Average	0.010	0.041	0.021	0.020

Table 3: Final results from titration of unknown acid



Graph 2: Final results from titration of unknown acid

The diluted NaOH was used in a titration to determine the concentration of the unknown diprotic acid #5. Using the average values collected from the three trials, the concentration of the unknown acid was found to be 0.096M. Since the unknown acid was diprotic, it donated 2H^+ ions, which is displayed by two sharp inclines on Graph 2. The equation for the titration of a diprotic acid is $\text{H}_2\text{A} + 2\text{NaOH} \rightarrow \text{Na}_2\text{A} + 2\text{H}_2\text{O}$. In this case, there is a 1:2 ratio between the acid and base, therefore the equation to find the concentration must change to $(C_1V_1) / (2)(V_2) = C_2$. The result of the unknown concentration may not be the most accurate as errors occurred again with the drop counter so the raw data was used for the calculations. Since raw data is not very accurate, the calculations may be inaccurate as well.

Conclusion:

In conclusion, the approximate concentration of the diluted NaOH solution was found to be 0.096M. This value was used to determine the concentration of an unknown diprotic acid #5. Using the technique of titration, the concentration of this acid was found to be 0.096M.

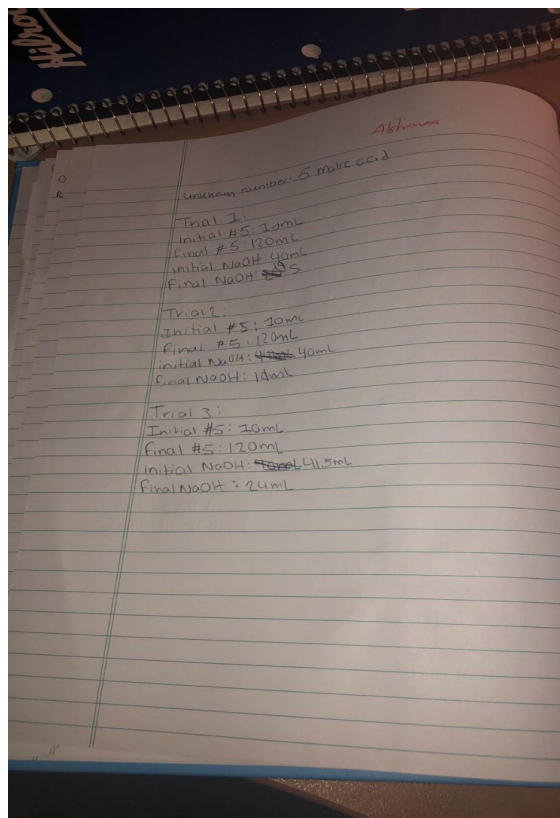
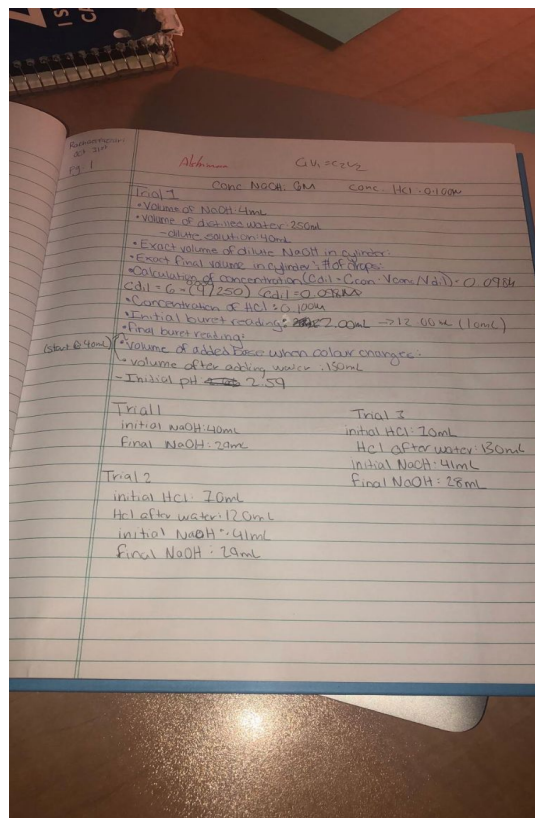
Reference(s):

[1] DeLorenzo, Ronald. A Dating Analogy for Acid-Base Titration Problems. Journal of Chemical Education. Vol. 72. American Chemical Society Division of Chemical Education, 1995. <https://doi.org/10.1021/ed072p1011>.

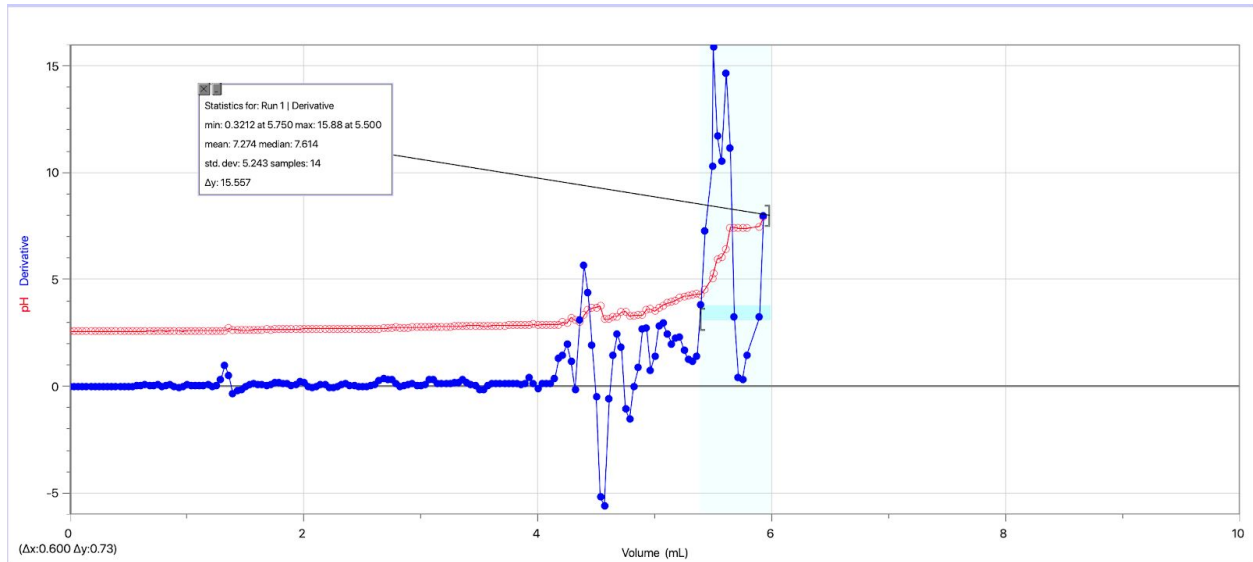
[2] ("Oh How Bitter a Thing is..." Acid Base Titrations, Dr. Rashmi Venkateswaran, 2019, Exp.4, p. 1).

Appendix:

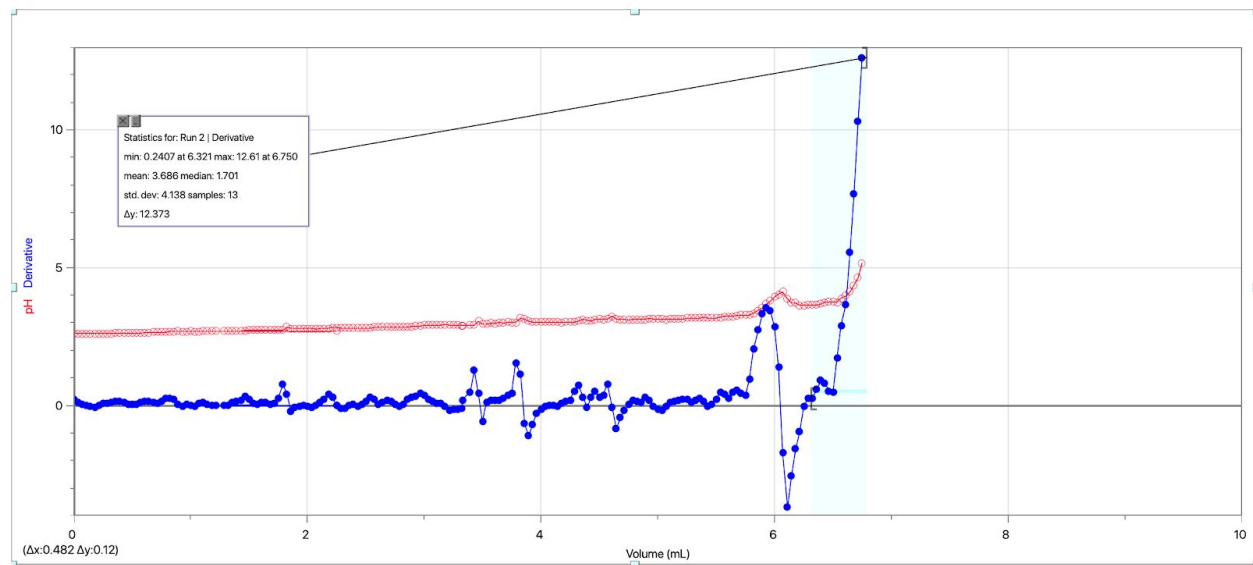
Raw Data



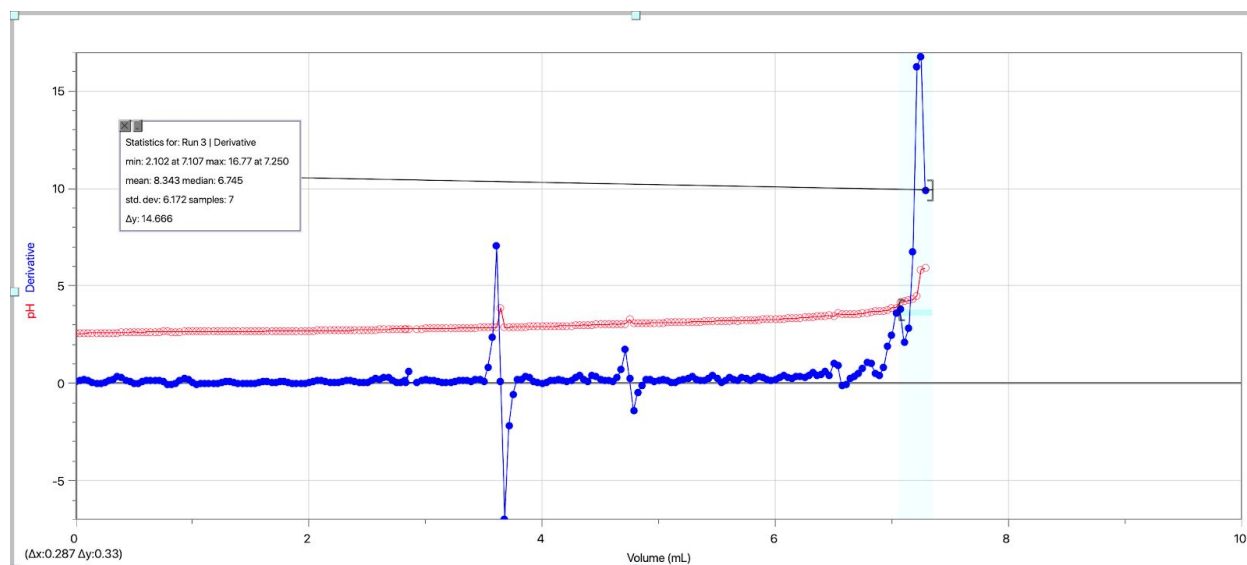
Additional Graphs



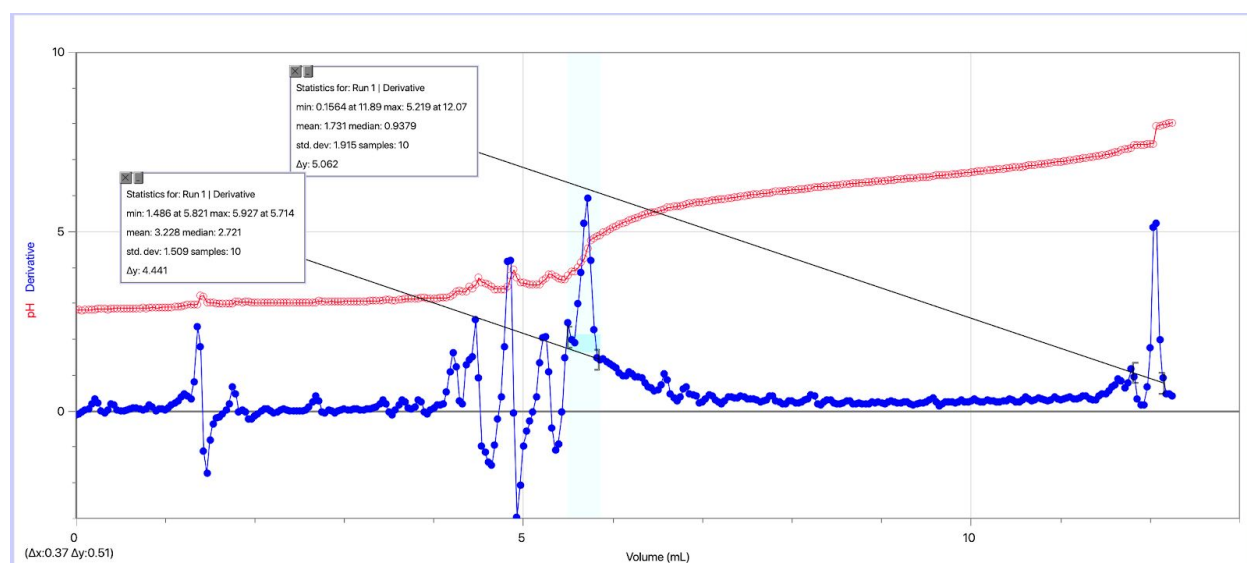
Graph 3: Standardization trial 1



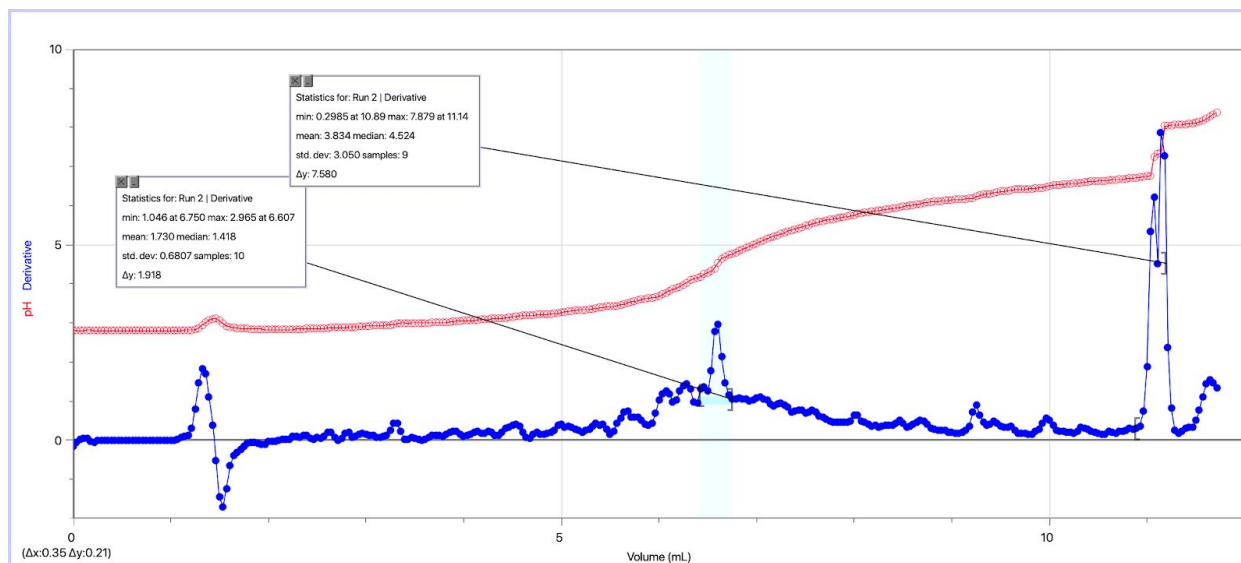
Graph 4: Standardization trial 2



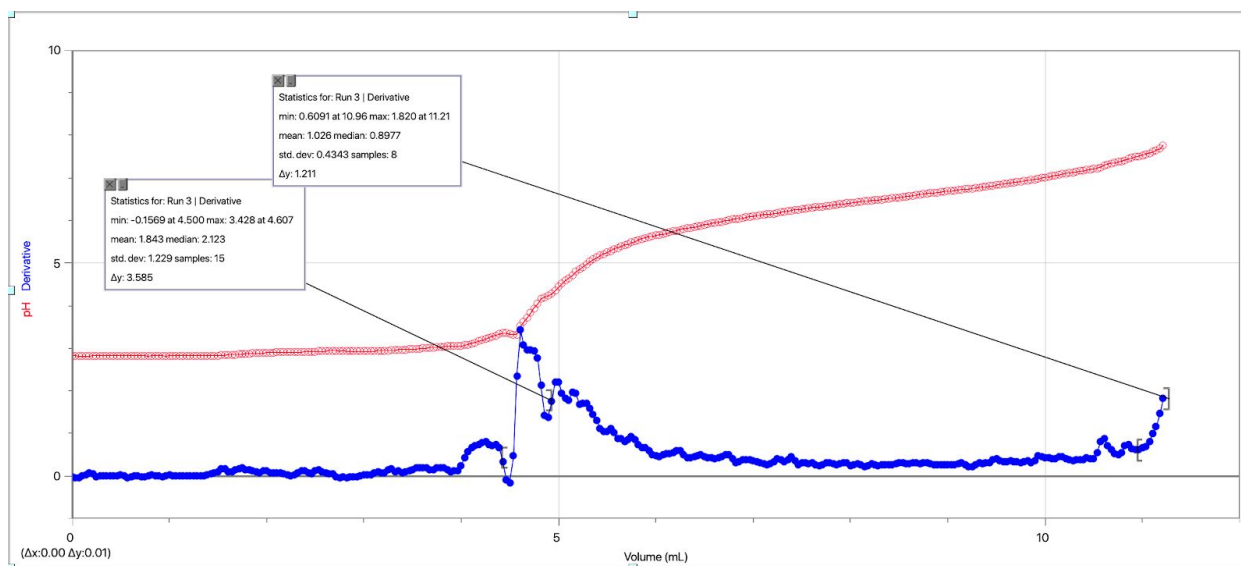
Graph 5: Standardization trial 3



Graph 6: Unknown acid trial 1



Graph 7: Unknown acid trial 2



Graph 8: Unknown acid trial 3

Sample Calculations**Prep of diluted NaOH**

Concentration of diluted NaOH:

$$C_1: 6.00M \quad V_1: 0.004L$$

$$C_2: ? \quad V_2: 0.250L$$

$$C_1V_1 = C_2V_2$$

$$(6.00)(0.004) = (C_2)(0.250)$$

$$(6.00)(0.004) / (0.250) = C_2$$

$$0.096M = C_2$$

Standardization

Confirming concentration of diluted NaOH:

$$C_1: 0.100M \quad V_1: 0.010L$$

$$C_2: ? \quad V_2: 0.012L$$

$$C_1V_1 = C_2V_2$$

$$(0.100)(0.010) = (C_2)(0.012)$$

$$(0.100)(0.010) / (0.012) = C_2$$

$$C_2 = 0.083$$

Difference from actual:

$$0.096 - 0.083 = 0.013$$

% Error:

$$(0.013/0.096) \times 100\%$$

$$= 13.5\%$$

Unknown acid

Finding concentration of unknown acid #5:

$$C_1: 0.096M \quad V_1: 0.020L$$

$$C_2: ? \quad V_2: 0.010L$$

$$C_1V_1 = C_2V_2$$

$$(0.096)(0.020) = 2(C_2)(0.010)$$

$$(0.096)(0.020) / 2 (0.010) = C_2$$

$$C_2 = 0.096M$$