Student Name:

Student Number:

Partner's Name and Student #:

Demonstrator's Name: Amin Nozari

PLEASE NOTE: If ANY of the above information is UNCLEAR or not provided, your grade will NOT be recorded!!

Lab Day (circle): *Tues aft* *Tues night* *Wed* *Thurs aft* *Thurs night* *Fri*

Lab Week (circle): *1* *2*

Laboratory Report Form

Experiment 3.

Acid/Base Titrations

Checklist:

- **Raw Data Sheet written in pen, signed by TA AND Raw data from LabQuest attached**
- **Data tables and graphs (12 minimum!) made in Logger Pro attached**
- **Report Form attached**

Student's Initials _____

Introduction:

This lab will be covering the general concept of titrations. To begin, the terms; acids and bases will be used a lot in this lab. Acids are ionic compounds that when in water break apart to form a hydrogen ion(H^+). This means that acids are considered to be donors of protons. Acids usually have the characteristics of having a sour taste, being very reactive to metals and being very corrosive. **[1]** Bases are ionic compounds that when submerged in water break apart to form negatively charged hydroxide ions(OH^-). This means that bases are donors of hydroxide ions. Bases usually have the characteristics of having a sour taste, slippery touch and also have a burning feeling depending on concentration of the base. **[1]**

HNO^3 → H^+ +NO_3^-(Acid) NaOH → OH^- +Na^+(Base) [3]

What defines a strong acid and a strong base is the idea of how many (H^+) or (OH^-) ions are produced in their respected solutions. A strong base is defined by a solution that contains many (OH^-) ions and a strong acid is defined by a solution that contains many (H^+) ions. **[5]** If there is more acid or base compared to water then the concentration of the solution will be higher. If there is less acid or base compared to water, then the concentration of the solution will be less. To determine the concentration of a solution the following equation is used:

Concentration(mol/L) =Amount of solute(mol)/Volume of solute(L){1}[3]

This equation is used to show the amount of acid or base (or in other words the solute) found within a given volume of solution to determine how much of the solute can be found in so many liters of solution. The equation;

Cinitial(mol/L)*Vinitial(L)=Cfinal(mol/L)*Vfinal(L){2}[3]

is used to determine the final concentration of a solution after the original solution has been diluted.

Titration reactions is a reaction between an acid and a base that will cause for neutralization of a solution. **[6]** This is because when the OH- ions and the H+ ions are reacted with; water is a product. **[2]** **OH^- +H^+ → H_2O [2]**

The point in which the solution is considered neutralized is called the equivalence point which is defined as the exact volume of solution needed to titrate a solution. This technique is used to determine the unknown concentrations of solutions by using the known concentration of a solution. **[3]** To determine unknown concentrations the following equation is used;

Concentration of base(mol/L) *Volume of base(L) = (b/a) Concentration of acid(mol/L) *Volume of acid(L){3}[3]

The values of **a** and **b** being the stoichiometric coefficients of the acids and bases (a used for the coefficient of acid and b used for the coefficient of base). **[3]**

The point at which there are equal amounts of acid and base in a reaction is referred to as the end point of a reaction. This point of the reaction can be determined by calculations but visually it is difficult to be determined. This is because most acids and bases have no colour, and so to see a difference it is difficult. To help determine this endpoint an indicator is used, this indicator if chosen well will change colour when the solution is close or equal to the endpoint of the reaction. So a good titration will have a similar endpoint and equivalence point. **[3]**

The concept of this lab is to be able to determine the concentration of numerous solutions. The first part of the lab is the preparation of a diluted base(NaOH). The second part of the lab is to determine the concentration of this diluted solution using equation (2). The third part is using the diluted base to titrate an unknown acid and juice and determine the concentration of the said unknown acid and juice using the equation (3). Finally, the fourth part is to determine the mass percentage of acid in a juice solution given its concentration(mol/L), density(g/L), molar mass of the acid within(g/mol) and by using the equation:

Mass percent of Acid in Juice= ((c_{acid},mol/L)(MM_{acid}, g/mol)/(density juice, g/mL)x1000)100% {4}.[3]

Procedure:

Refer to lab manual [4]

Observations:

Quantitative:

Data Tables

Table 1. Formation of a stock solution of NaOH

Volume of concentrated NaOH solution (mL)	4.70
Concentration of concentrated NaOH solution (M)	6
Volume of stock solution after dilution (mL)	254.70
Approximate concentration of stock solution (M)	0.1

Table 2. Standardization of Stock Solution of NaOH

Data	Trial 1(Run #9)	Trial 2(Run#2)	Trial 3(Run#3)
Concentration of Standard Acid solution (M)	0.1000	0.1000	0.1000
Volume of Standard Acid solution (mL)	10.1	10.0	10.0
Volume of stock solution of NaOH (mL)	Colour change: 9.50 Final volume: 11.00	Colour Change: 8.00 Final volume: 12.00	Colour Change: 9.00 Final volume: 15.00
Concentration of stock solution of NaOH (M)	Visually: 0.125 Graphically: 0.0466	Visually: 0.105 Graphically: 0.0402	Visually: 0.100 Graphically: 0.0414
Average Concentration of stock solution of NaOH (M)	0.0764		

Table 3. Determination of the Concentration of an Unknown Acid

Data	Trial 1(Run#4)	Trial 2(Run#5)	Trial 3
Sample Number of Unknown Acid	2	2	N/A
Volume of Unknown Acid solution (mL)	10.10	10.00	N/A
Volume of stock solution of NaOH (mL)	Colour change: 5.50 Final volume: 7.50	Colour change: 4.00 Final volume: 9.00	N/A
Concentration of stock solution of NaOH (M)	0.0764	0.0764	N/A
Concentration of Unknown Acid Solution (M)	Visually: 0.0208 Graphically: 0.0469	Visually: 0.0153 Graphically: 0.0477	N/A
Average Concentration of Unknown Acid solution (M)	0.0327		

Table 4. Determination of the Mass Percentage of Acid in a Juice

Data	Trial 1(Run#6)	Trial 2(Run#7)	Trial 3(Run#8)
Sample Number of Juice	1	1	1
Volume of Juice (mL)	10.00	10.00	10.00
Volume of stock solution of NaOH (mL)	Colour change: 8.00 Final volume: 10.00	Colour change: 8.00 Final volume: 10.00	Colour change: 8.00 Final volume: 10.00
Concentration of stock solution of NaOH (M)	0.0764	0.0764	0.0764
Concentration of acid in Juice (M)	Visually: 0.0204 Graphically: 0.0514	Visually: 0.0204 Graphically: 0.0508	Visually: 0.0204 Graphically: 0.0511
Average Concentration of Acid in Juice (M)	0.0357		
Density of Juice (g/mL)	1.0003		
Molar Mass of acid in Juice (g/mol)	192.14		
Mass Percent of Acid in Juice (%)	0.686%		

Qualitative:

The stock solution of NaOH was a clear transparent liquid and when enough stock solution was added to the clear transparent liquid HCl a colour change was noticed. The colour changed from two clear transparent liquids to a soft pink coloured transparent liquid. The unknown acid #2 was a clear, transparent liquid that turned a transparent soft pink colour when enough NaOH was added to the acid. The juice also was a clear transparent liquid and that when mixed with sufficient amount of NaOH stock solution would have a colour change making the solution a soft pink coloured transparent liquid.

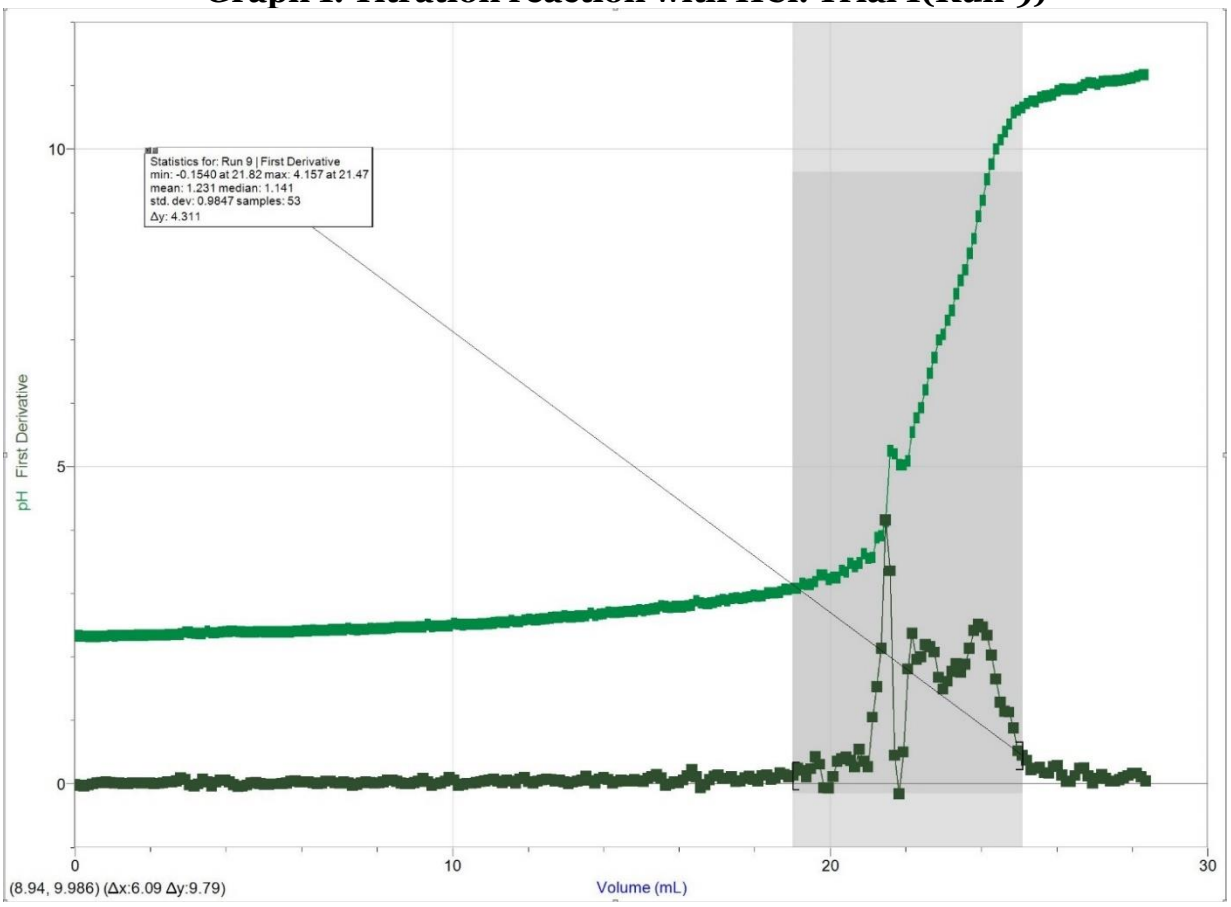
Table 5. First derivatives of graphs (Run 1 to 5)

	Run 1			Run 2			Run 3			Run 4			Run 5		
	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD
1	0.000	2.33	0.000	0.000	2.18	0.000	0.000	2.19	0.000	0.000	2.86	0.000	0.000	2.61	-0.009
2	0.117	2.33	0.000	0.117	2.18	0.000	0.117	2.19	-0.002	0.117	2.86	0.000	0.117	2.61	-0.016
3	0.233	2.33	0.000	0.233	2.18	-0.001	0.233	2.19	-0.005	0.233	2.86	0.001	0.233	2.60	-0.013
4	0.350	2.33	0.000	0.350	2.18	-0.004	0.350	2.19	-0.014	0.350	2.86	0.003	0.350	2.60	0.001
5	0.467	2.33	0.000	0.467	2.18	-0.011	0.467	2.18	-0.014	0.467	2.86	0.010	0.467	2.60	0.018
6	0.583	2.33	0.000	0.583	2.18	0.000	0.583	2.18	-0.004	0.583	2.86	0.002	0.583	2.61	0.030
7	0.700	2.33	0.000	0.700	2.18	0.011	0.700	2.18	-0.001	0.700	2.86	0.001	0.700	2.61	0.022
8	0.817	2.33	0.000	0.817	2.18	0.004	0.817	2.18	0.000	0.817	2.86	0.035	0.817	2.61	0.016
9	0.933	2.33	0.000	0.933	2.18	0.000	0.933	2.18	0.000	0.933	2.87	0.060	0.933	2.62	0.001
10	1.050	2.33	0.000	1.050	2.18	-0.004	1.050	2.18	0.001	1.050	2.88	0.048	1.050	2.61	-0.011
11	1.167	2.33	0.000	1.167	2.18	-0.011	1.167	2.18	0.004	1.167	2.88	0.044	1.167	2.61	-0.004
12	1.284	2.33	0.000	1.284	2.18	-0.001	1.284	2.18	0.014	1.284	2.89	0.044	1.284	2.61	-0.001
13	1.400	2.33	0.000	1.400	2.18	0.007	1.400	2.19	0.014	1.400	2.89	0.021	1.400	2.61	0.000
14	1.517	2.33	0.000	1.517	2.18	-0.007	1.517	2.19	0.004	1.517	2.89	0.034	1.517	2.61	0.002
15	1.634	2.33	0.000	1.634	2.18	0.002	1.634	2.19	0.001	1.634	2.90	0.065	1.634	2.61	0.010
16	1.750	2.33	0.000	1.750	2.18	0.015	1.750	2.19	0.001	1.750	2.91	0.064	1.750	2.61	0.033
17	1.867	2.33	0.000	1.867	2.18	0.017	1.867	2.19	0.003	1.867	2.92	-0.001	1.867	2.62	0.044
18	1.984	2.33	0.000	1.984	2.19	0.012	1.984	2.19	0.012	1.984	2.91	-0.068	1.984	2.63	0.022
19	2.100	2.33	0.000	2.100	2.19	-0.006	2.100	2.19	0.009	2.100	2.89	-0.038	2.100	2.62	0.030
20	2.217	2.33	0.000	2.217	2.18	0.001	2.217	2.19	0.021	2.217	2.90	0.018	2.217	2.63	0.023
21	2.334	2.33	0.000	2.334	2.19	0.010	2.334	2.20	0.031	2.334	2.90	0.071	2.334	2.63	-0.012
22	2.450	2.33	0.000	2.450	2.19	0.003	2.450	2.20	0.022	2.450	2.90	0.202	2.450	2.63	0.002
23	2.567	2.33	0.000	2.567	2.19	0.001	2.567	2.20	0.017	2.567	2.96	0.179	2.567	2.63	0.022
24	2.684	2.33	0.000	2.684	2.19	0.000	2.684	2.20	0.004	2.684	2.95	0.101	2.684	2.63	0.046
25	2.800	2.33	-0.001	2.800	2.19	0.000	2.800	2.20	0.001	2.800	2.98	0.057	2.800	2.64	0.042
26	2.917	2.33	-0.003	2.917	2.19	0.000	2.917	2.20	0.001	2.917	2.96	0.007	2.917	2.64	0.004
27	3.034	2.33	-0.010	3.034	2.19	0.000	3.034	2.20	0.004	3.034	2.96	0.104	3.034	2.64	0.006
28	3.151	2.32	0.001	3.151	2.19	0.000	3.151	2.20	0.014	3.151	3.01	0.037	3.151	2.64	0.027
29	3.267	2.33	0.014	3.267	2.19	0.000	3.267	2.21	0.016	3.267	2.98	-0.061	3.267	2.64	0.061
30	3.384	2.33	0.014	3.384	2.19	0.000	3.384	2.21	0.009	3.384	2.97	0.016	3.384	2.65	0.122
31	3.501	2.33	0.001	3.501	2.19	0.000	3.501	2.21	0.016	3.501	2.98	0.129	3.501	2.69	0.077
32	3.617	2.33	-0.011	3.617	2.19	0.000	3.617	2.21	0.015	3.617	2.99	0.295	3.617	2.67	0.023
33	3.734	2.33	-0.004	3.734	2.19	0.001	3.734	2.21	0.007	3.734	3.04	0.464	3.734	2.68	0.036
34	3.851	2.33	-0.001	3.851	2.19	0.006	3.851	2.21	0.010	3.851	3.18	0.087	3.851	2.68	0.054
35	3.967	2.33	0.000	3.967	2.19	0.020	3.967	2.21	0.029	3.967	3.04	-0.157	3.967	2.70	0.064

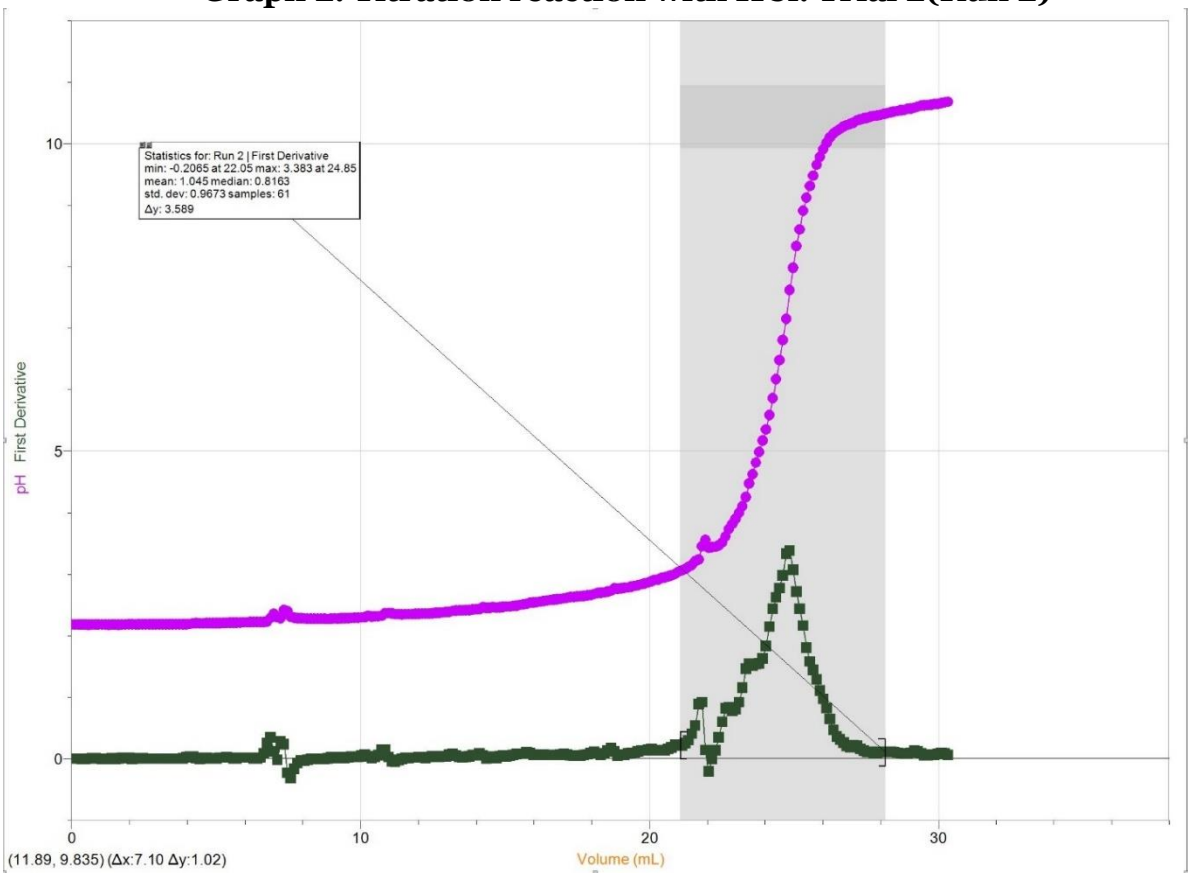
Table 6. First derivatives of graphs (Run 6 to 9)

	Run 6			Run 7			Run 8			Run 9		
	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD	Volume (mL)	pH	FD
1	0.000	3.19	-0.024	0.000	3.13	0.000	0.000	3.20	0.009	0.000	2.34	-0.011
2	0.117	3.19	-0.005	0.117	3.13	0.000	0.117	3.20	0.018	0.117	2.34	-0.023
3	0.233	3.19	0.000	0.233	3.13	0.000	0.233	3.20	0.022	0.233	2.33	-0.030
4	0.350	3.19	0.004	0.350	3.13	0.000	0.350	3.20	0.029	0.350	2.33	-0.019
5	0.467	3.19	0.012	0.467	3.13	0.000	0.467	3.21	0.053	0.467	2.33	-0.001
6	0.583	3.19	0.004	0.583	3.13	0.000	0.583	3.22	0.065	0.583	2.33	0.016
7	0.700	3.19	0.001	0.700	3.13	0.000	0.700	3.22	0.117	0.700	2.33	0.023
8	0.817	3.19	0.001	0.817	3.13	0.000	0.817	3.25	0.145	0.817	2.33	0.030
9	0.933	3.19	0.004	0.933	3.13	0.000	0.933	3.25	0.175	0.933	2.34	0.020
10	1.050	3.19	0.013	1.050	3.13	0.000	1.050	3.26	0.365	1.050	2.34	0.009
11	1.167	3.20	0.011	1.167	3.13	0.000	1.167	3.37	0.263	1.167	2.34	0.012
12	1.284	3.20	-0.006	1.284	3.13	0.000	1.284	3.35	-0.023	1.284	2.34	0.005
13	1.400	3.19	0.006	1.400	3.13	0.000	1.400	3.33	-0.084	1.400	2.34	0.006
14	1.517	3.20	0.030	1.517	3.13	-0.001	1.517	3.33	-0.089	1.517	2.34	0.015
15	1.634	3.20	0.071	1.634	3.13	-0.003	1.634	3.31	-0.025	1.634	2.34	0.016
16	1.750	3.22	0.091	1.750	3.13	-0.011	1.750	3.31	0.092	1.750	2.34	0.009
17	1.867	3.23	0.052	1.867	3.13	-0.004	1.867	3.33	0.205	1.867	2.34	0.016
18	1.984	3.23	0.030	1.984	3.13	-0.004	1.984	3.39	0.104	1.984	2.35	0.014
19	2.100	3.23	0.026	2.100	3.13	-0.012	2.100	3.36	-0.062	2.100	2.35	0.006
20	2.217	3.23	0.035	2.217	3.13	-0.007	2.217	3.34	-0.024	2.217	2.35	0.007
21	2.334	3.24	0.038	2.334	3.13	-0.011	2.334	3.35	0.092	2.334	2.35	0.019
22	2.450	3.24	0.034	2.450	3.13	0.000	2.450	3.38	0.145	2.450	2.35	0.031
23	2.567	3.24	0.052	2.567	3.13	0.010	2.567	3.39	0.150	2.567	2.36	0.031
24	2.684	3.25	0.056	2.684	3.13	0.002	2.684	3.40	0.215	2.684	2.36	0.046
25	2.800	3.26	0.049	2.800	3.13	-0.003	2.800	3.46	0.134	2.800	2.36	0.097
26	2.917	3.26	0.052	2.917	3.13	-0.014	2.917	3.43	0.069	2.917	2.39	0.068
27	3.034	3.27	0.042	3.034	3.13	-0.014	3.034	3.45	0.160	3.034	2.39	-0.020
28	3.151	3.27	0.035	3.151	3.13	-0.004	3.151	3.48	0.150	3.151	2.38	-0.034
29	3.267	3.28	0.054	3.267	3.13	-0.001	3.267	3.48	0.215	3.267	2.37	0.001
30	3.384	3.29	0.063	3.384	3.13	0.000	3.384	3.54	0.184	3.384	2.37	0.073
31	3.501	3.29	0.076	3.501	3.13	0.000	3.501	3.53	0.085	3.501	2.41	0.030
32	3.617	3.31	0.077	3.617	3.13	0.000	3.617	3.54	0.121	3.617	2.38	-0.031
33	3.734	3.31	0.069	3.734	3.13	0.000	3.734	3.57	0.100	3.734	2.38	0.025
34	3.851	3.32	0.074	3.851	3.13	0.000	3.851	3.57	0.085	3.851	2.39	0.059
35	3.967	3.33	0.066	3.967	3.13	0.000	3.967	3.57	0.164	3.967	2.40	0.056

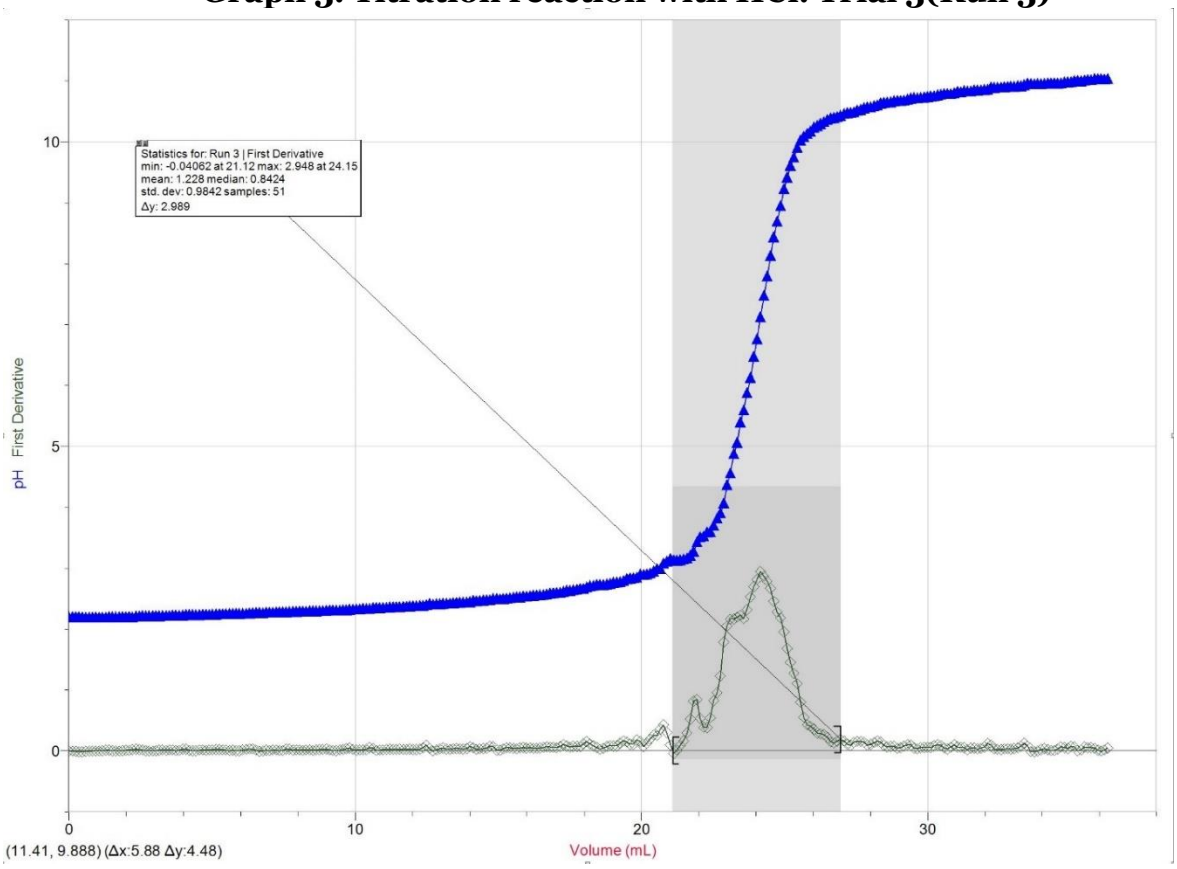
Graph 1. Titration reaction with HCl. Trial 1(Run 9)



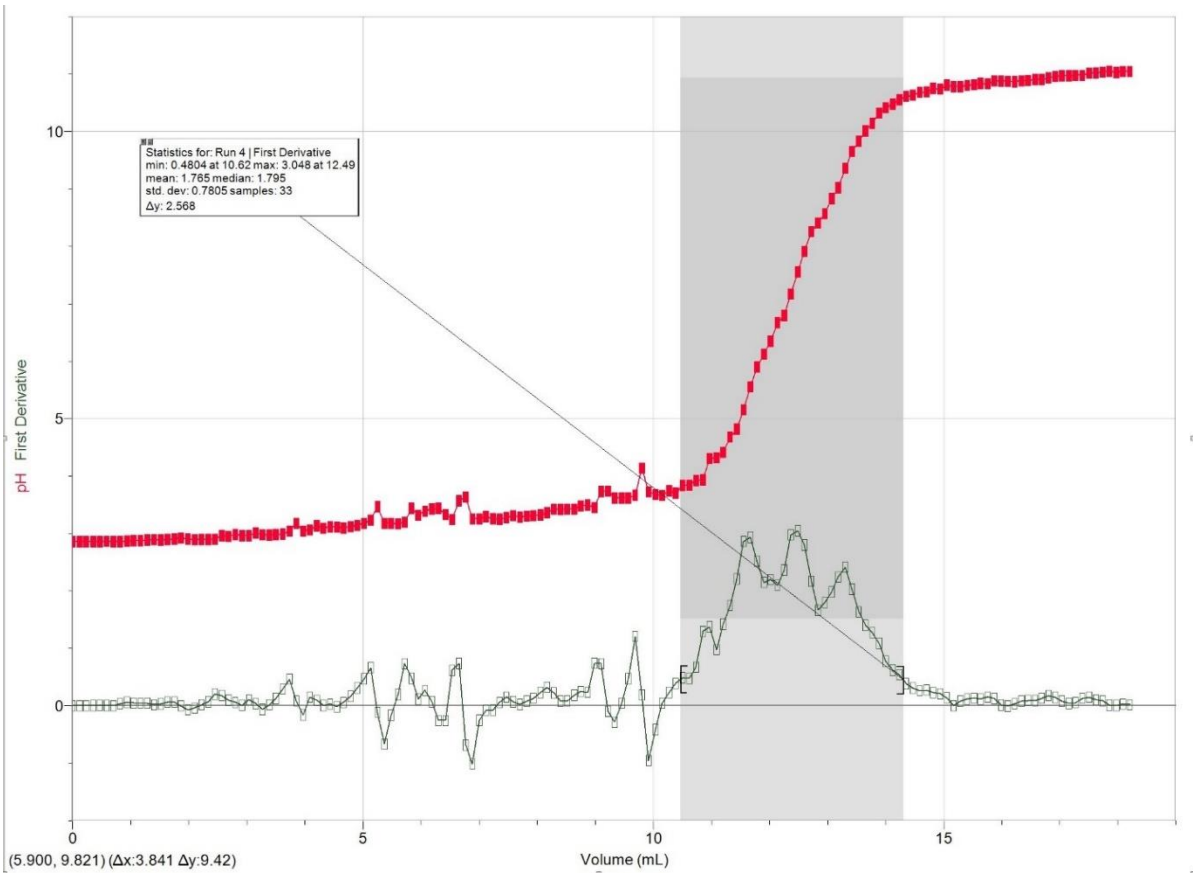
Graph 2. Titration reaction with HCl. Trial 2(Run 2)



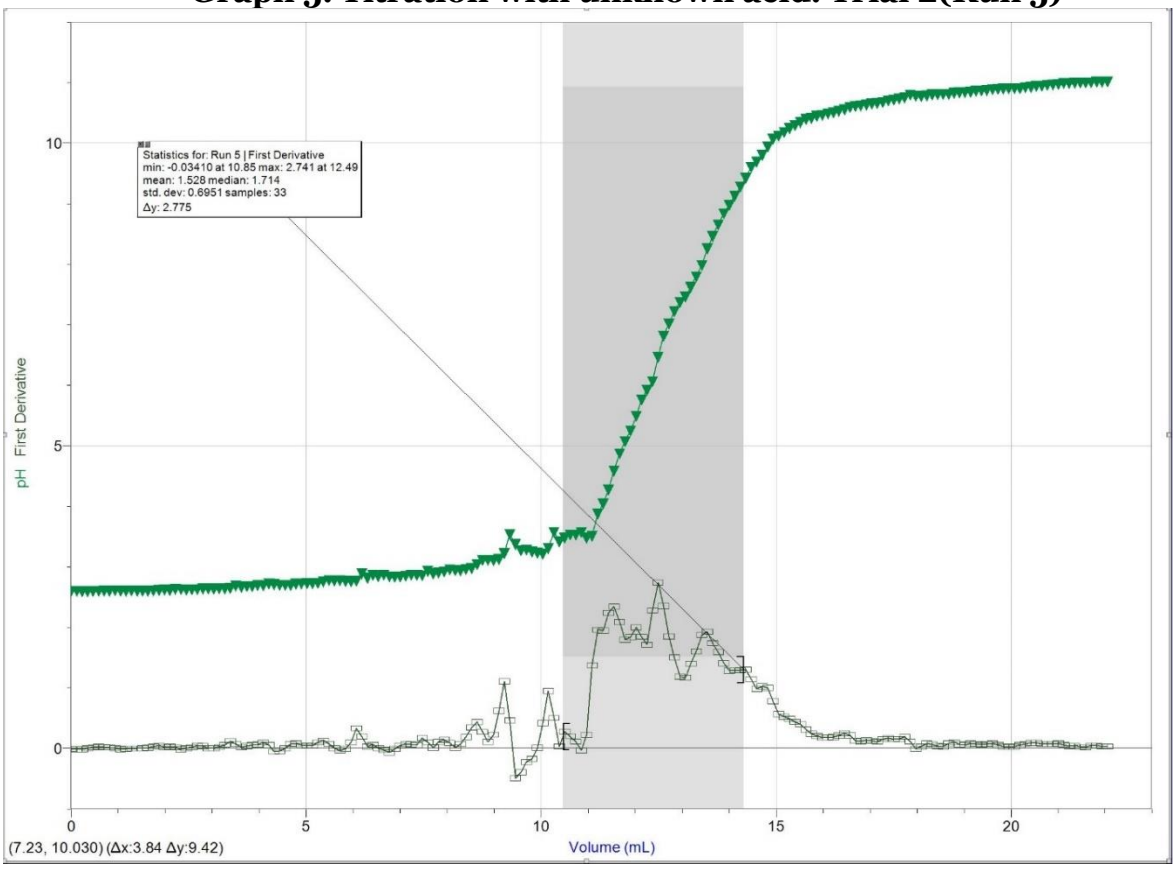
Graph 3. Titration reaction with HCl. Trial 3(Run 3)



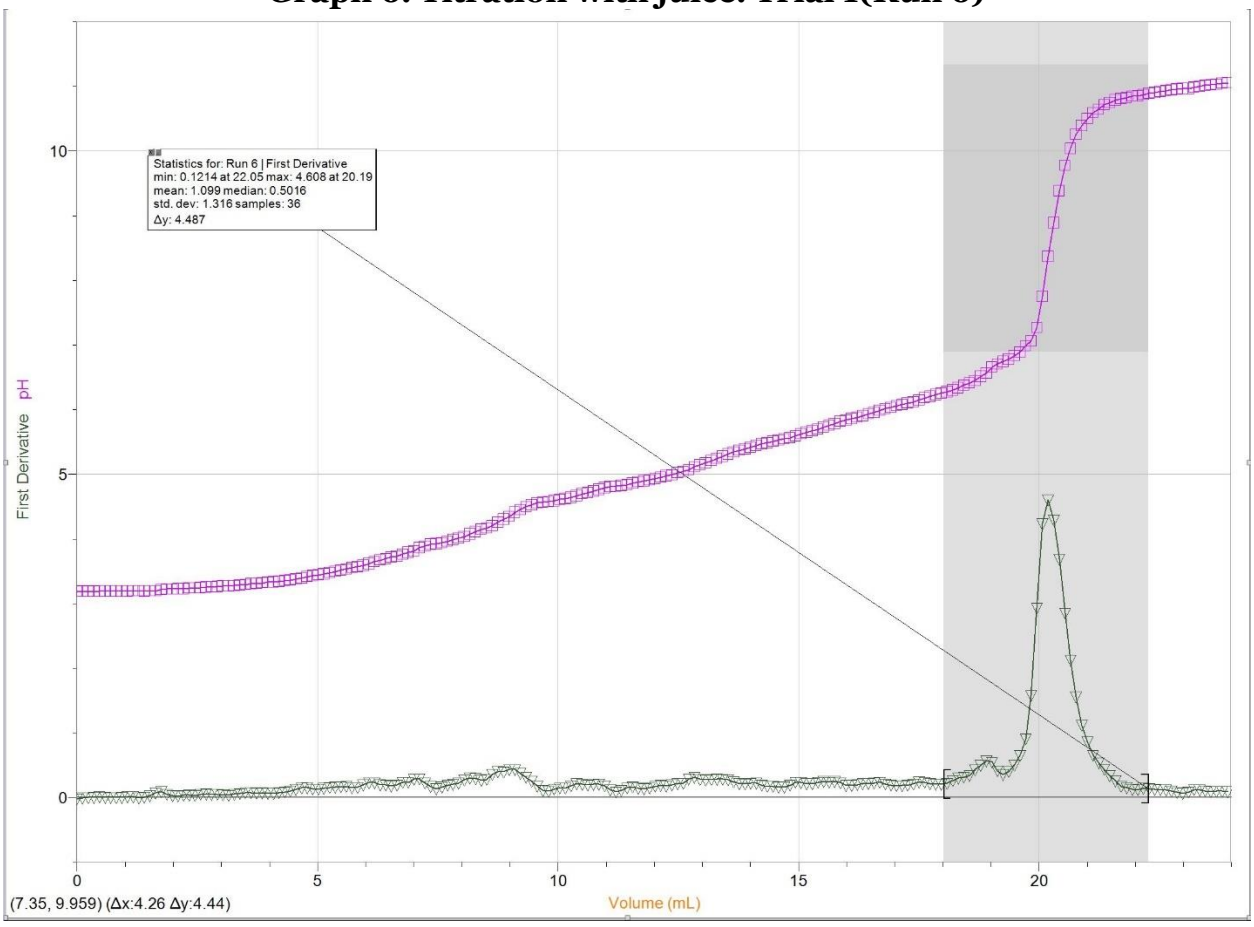
Graph 4. Titration reaction with unknown acid. Trial 1(Run 4)



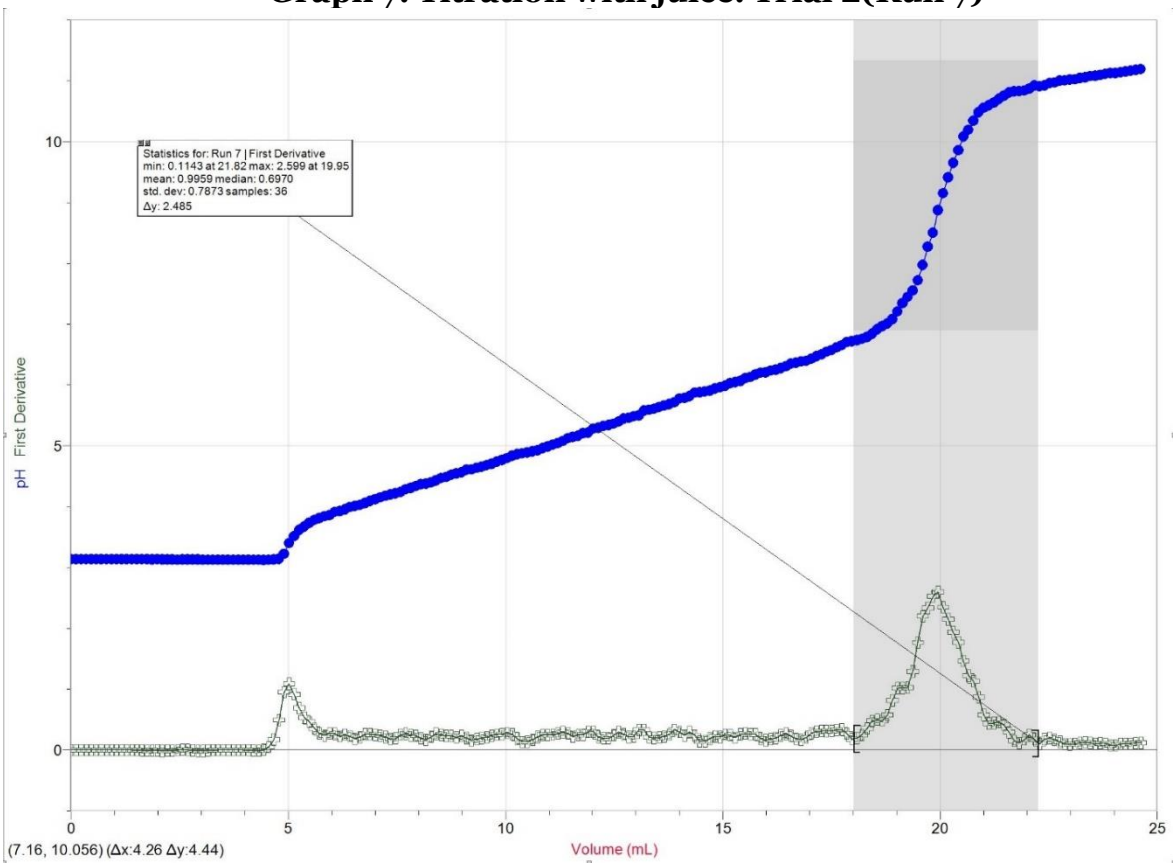
Graph 5. Titration with unknown acid. Trial 2(Run 5)



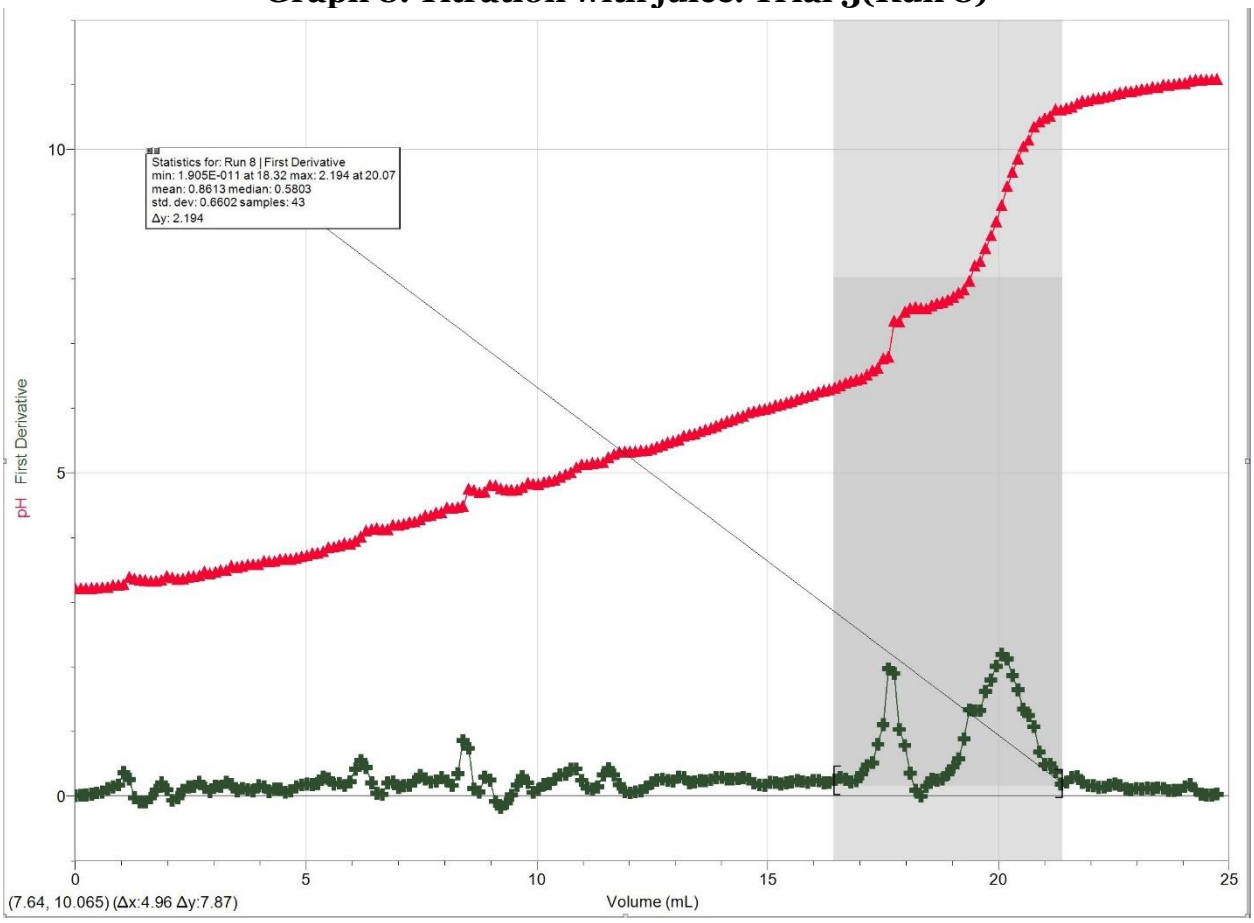
Graph 6. Titration with juice. Trial 1(Run 6)



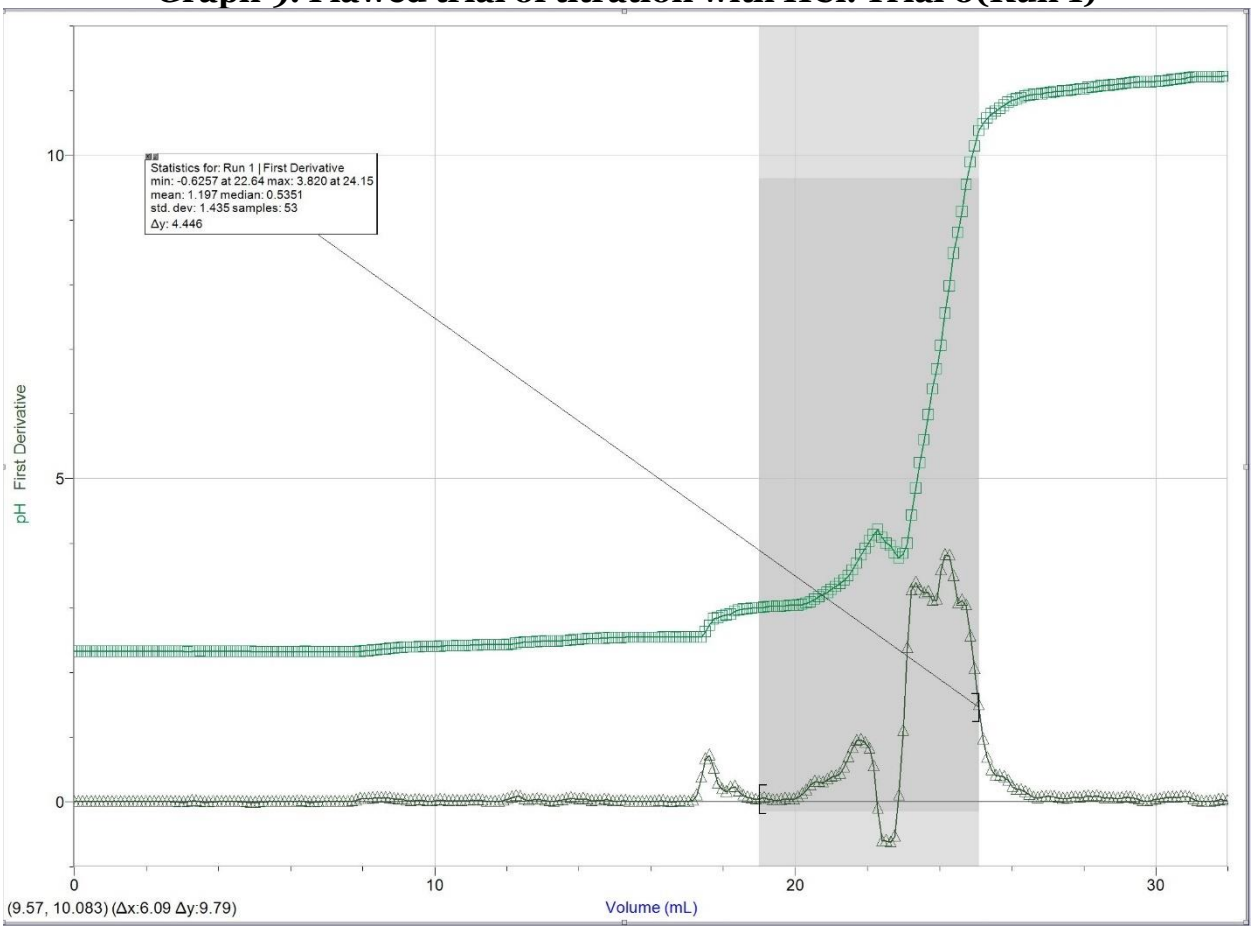
Graph 7. Titration with juice. Trial 2(Run 7)



Graph 8. Titration with juice. Trial 3(Run 8)



Graph 9. Flawed trial of titration with HCl. Trial 0(Run 1)



This trial was not used because the titration was not catalyzed meaning that the magnetic stirrer was not being operated during the time of the catalyst. This caused for the data to be slightly higher than that of what was expected. The data for this trial was not used during the calculations but was replaced by Graph 1. Which is referred to "Trial 1" and it is named "Run 9" in all the data.

Sample Calculation: (Part 1)

1. Approximate concentration of stock solution

$c_{initial} * V_{initial} = c_{final} * V_{final}$

$c_{final} = (c_{initial} * V_{initial})/V_{final}$

$= (6mol/L * 4.7x10\text{-}3L)/0.2547L$

$= 0.11072mol/L$

$= \underline{0.1M}$

Sample Calculation: (Part 2)

2. Exact concentration of stock solution (from visual endpoint and cV calculations AND by first derivative from titration curve using LabQuest 2 data):

SINCE the ratio of NaOH to HCl is 1mol:1mol b/a =(1/1)

Graphically:

Trial 1: $c_{base} * V_{base} = b/a\ c_{acid} * V_{acid}$

$c_{base} = (b * cacid * Vacid)/(a * Vbase)$

$= (1 * 0.1000M * 0.0100L)/(1 * 0.02485L)$

$= \underline{0.0402M}$

Trial 2: $c_{base} = (1 * 0.1000M * 0.0100L)/(1 * 0.02415L)$

$= \underline{0.0414M}$

Trial 3: $c_{base} = (1 * 0.1000M * 0.0100L)/(1 * 0.02147L)$

$= \underline{0.0466M}$

Visually:

Trial 1: $c_{base} = (1 * 0.1000M * 0.0100L)/(1 * 8.00x10\text{-}3L)$

$= \underline{0.125M}$

Trial 2: $c_{base} = (1 * 0.1000M * 0.0100L)/(1 * 9.50x10\text{-}3L)$

$= \underline{0.105M}$

Trial 3: $c_{base} = (1 * 0.1000M * 0.0100L)/(1 * 9.00x10\text{-}3L)$

$= \underline{0.100M}$

3. Average concentration of stock solution:

$Average = (c_{basetrial1G} + c_{basetrial2G} + c_{basetrial3G} + c_{basetrial1V} + c_{basetrial2V} + c_{basetrial3V})/\#of\ trials$

$= (0.0402M+0.0414M+0.0414M+0.125M+0.105M+0.100M)/6$

$=0.0764M$

Sample Calculation: (Part 3)

4. Concentration of Unknown Acid (from visual endpoint and cV calculations AND by first derivative from titration curve using LabQuest data):

SINCE unknown acid is diprotic, ratio of b/a = (2/1)

Graphically:

Trial 1: $c_{base}*V_{base}= b/a\ c_{acid} * V_{acid}$

$c_{acid}= (a * c_{base} * V_{base})/(b * V_{acid})$

$c_{acid}= (1 * 0.0764M * 0.01241L)/(2 * 0.0101L)$

$= \underline{0.0469M}$

Trial 2: $c_{acid}= (1 * 0.0764M * 0.01249L)/(2 * 0.0100L)$

$= \underline{0.0477M}$

Visually:

Trial 1: $c_{acid}= (1 * 0.0764M * 5.50x10\text{-}3L)/(2 * 0.0101L)$

$= \underline{0.0208M}$

Trial 2: $c_{acid} = (1 * 0.0764M * 4.00x10\text{-}3L)/(2 * 0.0100L)$

$= \underline{0.0153M}$

5. Average concentration of unknown acid:

Average= $(c_{acidtrial1G}+ c_{acidtrial2G}+ c_{acidtrial1V}+ c_{acidtrial2V})$/#of trials

$= (0.0469M+0.0477M+0.0208M+0.0153M)/4$

$=\underline{0.0327M}$

Sample Calculation: (Part 4)

6. Concentration of acid in juice (from visual endpoint and cV calculations AND by first derivative from titration curve using LabQuest data):

SINCE the juice is triprotic, ratio of b/a = (3/1)

Graphically:

Trial 1: $c_{base}*V_{base}= b/a * c_{acid} * V_{acid}$

$c_{acid}= (a * c_{base} * V_{base})/(b * V_{acid})$

$c_{acid}= (1 * 0.0764M * 0.02019L)/(3 * 0.0100L)$

$= \underline{0.0514M}$

Trial 2: $c_{acid}= (1 * 0.0764M * 0.01995L)/(3 * 0.0100L)$

$= \underline{0.0508M}$

Trial 3: $c_{acid}= (1 * 0.0764M * 0.02007L)/(3 * 0.0100L)$

$= \underline{0.0511M}$

Visually:

Trial 1: $c_{acid}= (1 * 0.0764M * 8.00x10\text{-}3L)/(3 * 0.010L)$

$= \underline{0.0204M}$

Trial 2: $c_{acid}= (1 * 0.0764M * 8.00x10\text{-}3L)/(3 * 0.010L)$

$= \underline{0.0204M}$

Trial 3: $c_{acid}= (1 * 0.0764M * 8.00x10\text{-}3L)/(3 * 0.010L)$

$= \underline{0.0204M}$

7. Average concentration of acid in juice:

Average= ($c_{acidtrial1G}$+ $c_{acidtrial2G}$+ $c_{acidtrial3G}$+ $c_{acidtrial1V}$+ $c_{acidtrial2V}$+ $c_{acidtrial3V}$)/#of trials
= (0.0514M+0.0508M+0.0511M+0.204M+0.204M+0.204M)/6
=<u>0.0357M</u>

8. Mass percentage of acid in juice:

Mass percent of Acid in Juice= ((c_{acid},mol/L)(MM_{acid}, g/mol)/(density juice, g/mL)x1000)100%
=((0.0357M* 192.14g/mol)/(1.0003g/ml * 1000)) *100%
=<u>0.686%</u>

<u>Discussion:</u>

The average calculated concentration of the NaOH stock solution was 0.0764mol/L. When the stock solution was made, the volume of the concentrated NaOH was crucial, this is because the more of the NaOH added would cause for a higher concentration of the stock solution which would later impact the other calculations for determining the concentration of the acids. If the concentration of the stock solution was higher than expected the concentration of the HCl would result in a higher concentration of HCl. The importance of determining the concentration of the stock solution at the start is because the concentration of the stock solution is crucial for the calculations of the acid concentrations within the lab.

The average calculated concentration of the HCl, unknown acid and juice was found to be about 0.0764mol/L, 0.0327mol/L and 0.0357mol/L respectively. The lab went well except for the graphs found on logger pro was not close to the observations made during the lab. The values for the colour change were found to be drastically different. For example, the visual observation for colour change of the HCl in trial 1 was found to be 9.50mL where in comparison the graph determined that the colour change occurred at 21.47mL. This change was more than double that of the visually observed value. This being said, while setting up the drop counter must have not been calibrated correctly so therefore the drop counter would count more drops of solution than there were. Since the volumes of stock solution used were much higher than the volume of stock solution observed, the average concentration of the HCl, unknown acid and juice suffered and was lowered in comparison to what the value should have been.

With the error of improperly calibrated the value of the percent mass of citric acid in the juice was lowered. The juice's concentration was lowered because the calculated concentration of the juice was lower (when using results from graph) which lowered the average concentration of the juice. When calculating the percent mass of the citric acid in the juice, it is important that density of the juice is multiplied by 1000 to account for the density being in g/ml. This 1000 factor is important to ensure that the final answer is in the correct units.

Other than the drop counter not being properly calibrated, the lab was completed with little errors. An error that occurred was the first trial made during he lab to determine the concentration of the HCl, this trial was titles "Run 1". The reason the trial was disregarded within the lab calculations was that while the trial was being attempted, the magnetic stirrer was not being operated. With the magnetic stirrer not being operated, the titration was being completed without a catalyst and theoretically the

titration reaction would require more NaOH stock solution to neutralize the HCl and bring the solution to an apparent equivalence point. This trial (Run 1) was replaced with "Run 9" in order for the results to be more consistent through out the lab. Run 9 was then used in Table 2. under "trial 1". An improvement to this lab would be insuring that multiple attempts are made to ensure that there is less room for drastic change in calculated concentration of an acid or a base. This drastic change will be compensated for by the extra attempts that remained close to the consistent attempts.

Conclusion:

The calculated average concentration of the NaOH stock solution was found to be 0.0764mol/L. This calculated average concentration was found to calculate the average concentrations of an unknown acid solution and a juice, having average concentrations of; 0.0327mol/L and 0.0357mol/L and this caused for a mass percent of 0.686% citric acid in the juice.

Bibliography:

[1]-Acid, Base, and pH Tutorial - lrs.ed.uiuc.edu. (N.d.). Retrieved October 19, 2016, from http://lrs.ed.uiuc.edu/students/erlinger/water/background/ph.html

[2]-Ball, David W. "Acids and bases." The Gale Encyclopedia of Science. Ed. K. Lee Lerner and Brenda Wilmoth Lerner. 5th ed. Farmington Hills, MI: Gale, 2014. Science in Context. Web. 21 Oct. 2016.

[3]-Dr. R. Venkateswaran, "What In the World IS NOT Chemistry?" General Chemistry Laboratory Manual, 2016, p 3. Experiment (2-5)

[4]-Dr. R. Venkateswaran, "What In the World IS NOT Chemistry?" General Chemistry Laboratory Manual, 2016, p 3. Experiment (7-11)

[5]-Strong Acids and Bases - University of Waterloo. (N.d.). Retrieved October 19, 2016, from http://www.science.uwaterloo.ca/~cchieh/cact/c123/stacids.html

[6]-What Is a Titration - Purdue University. (N.d.). Retrieved October 19, 2016, from http://chemed.chem.purdue.edu/genchem/lab/techniques/titration/what.html

Trial 3- Solution turned a soft pink colour transparent when 50.5 ml NaOH was added

Data Tables

Table 1. Formation of a stock solution of NaOH

Volume of concentrated NaOH solution (mL)	4.70 mL
Concentration of concentrated NaOH solution (M)	6
Volume of stock solution after dilution (mL)	250.00 $_{H_2O}$ 4.70 NaOH = 254.70
Approximate concentration of stock solution (M)	

- original solution was a clear transparent
- pH leveled out at about 11.00 mL

Table 2. Standardization of Stock Solution of NaOH

Run 1 2 3

Data	Trial 1	Trial 2	Trial 3
Concentration of Standard Acid solution (M)	0.1000	0.1000	0.1000
Volume of Standard Acid solution (mL)	10.1 mL	10.0 mL	10.0 mL
Volume of stock solution of NaOH (mL)	60.00mL - 49.00 = 11.00 mL colour change 50.50	60.00mL → 48.00mL 12.00mL colour change @ 52mL	60.00mL - 45.0 = 15.0 mL colour change - 51.0
Concentration of stock solution of NaOH (M)			
Average Concentration of stock solution of NaOH (M)			

Trial 2 6.00mL 10.00mL

Trial 1
2.2mL H_2O
glad cy
9.10mL total

Trial 2
2.40mL H_2O 2.20mL H_2O
grad 137 drops 36 drops
9.50mL total 4.20mL total

~~2 drops HCl in soln~~
Done w this
initial 8ml
17.8mL
HCl in beaker 9.80mL

Report Form...Page 2

Table 3. Determination of the Concentration of an Unknown Acid

Data	Trial 1	Trial 2	Trial 3
Sample Number of Unknown Acid	2	2	2
Volume of Unknown Acid solution (mL)	18.70 - 18.80 | 10.10.	1.50 - 11.50 | = 10.00	
Volume of stock solution of NaOH (mL)	60.00mL - 52.50 mL 7.50mL Colour change: 54.50	60.00mL - 51.0 9.00 Colour change: 56.00	
Concentration of stock solution of NaOH (M)			
Concentration of Unknown Acid Solution (M)		1.00	
Average Concentration of Unknown Acid solution (M)			

Observations (all parts of the experiment):

Trial 1
- The solution turned a soft pink - transparent colour after about 5.50mL of NaOH was added
- The pH leveled out around 7.50mL
- Solution was clear at first

Trial 2 'transparent' - transparent
- The solution turned a soft pink colour after about 4.00mL of NaOH added
- The solution was clear and transparent
- The pH leveled out around 9.00mL

Trial 1 - The solution turned a soft pink colour - transparent after about 8.00mL of NaOH - PH leveled out at 10.00mL - original solution was clear and transparent

Table 4. Determination of the Mass Percentage of Acid in a Juice

Data	Trial 1	Trial 2	Trial 3
Sample Number of Juice	1	1	1
Volume of Juice (mL)	11.10 - 11.10 = 10.00mL	11.10 - 11.10 = 10.00mL	18.20 - 18.20 = 10.00mL
Volume of stock solution of NaOH (mL)	60.00mL - 50.00mL = 10.00mL colour change 52.00mL	60.00mL - 50.00mL = 10.00mL Colour change: 52.00mL	60.00mL - 50.00mL = 10.00mL colour change: 52.00mL
Concentration of stock solution of NaOH (M)			
Concentration of acid in Juice (M)			
Average Concentration of Acid in Juice (M)			
Density of Juice (g/mL)	1.0003 g/cm³		
Molar Mass of acid in Juice (g/mol)			
Mass Percent of Acid in Juice (%)			

Trig 2:
- The solution turned a soft colour pink - transparent after about 52.00 mL of NaOH
- PH leveled out at mL
- The original solution was clear and transparent
- Error forgot to turn on hot plate for 10s

GRAPHS: Attach Logger Pro data tables AND graphs (at least 12 [2 per trial]) to this form!!

Trig 3: - The solution turned a soft pink colour (transparent) after about 8.00 mL
- The original solution was clear transparent
- The pH leveled out around 10.00 mL

Data Tables

Table 1. Formation of a stock solution of NaOH

Volume of concentrated NaOH solution (mL)	4.70
Concentration of concentrated NaOH solution (M)	6
Volume of stock solution after dilution (mL)	250.00 mL H_2O + 4.70 mL NaOH = 254.70 mL
Approximate concentration of stock solution (M)	

Table 2. Standardization of Stock Solution of NaOH

Data	Trial 1	Trial 2	Trial 3
Concentration of Standard Acid solution (M)	Run 1 0.1000	Run 2 0.1000	Run 3 0.1000
Volume of Standard Acid solution (mL)	[illegible]	10.0 mL	10.00 mL
Volume of stock solution of NaOH (mL)	[illegible]	60.00 − 48.00 12.00 mL colour change: [illegible]	60.00 − 45.00 15.00 mL colour change: 51.00
Concentration of stock solution of NaOH (M)			
Average Concentration of stock solution of NaOH (M)			

Trial 2
0.00 mL in before
10.00 mL after
Trial 1 10.00 mL in [illegible]
Run 1
0.1000
0.80 − 10.70
9.90 mL
60.00 − 49.00
11.00 mL
colour: 50.50

60 mL NaOH diluted
step 15: 2.70 mL H_2O in cylinder
9.10 mL total in cylinder
2.40 mL H_2O in cylinder
9.50 mL total in cylinder
137 drops
2.20 mL H_2O in cylinder
4.20 mL in total cylinder
36.0 drops

2.00 mL HCl in solⁿ
DONE IN Th.
initial on Burette − 8.00 mL
Final " " − 17.80 mL
HCl in beaker 9.80 mL

Table 3. Determination of the Concentration of an Unknown Acid

Data	Trial 1	Trial 2	Trial 3
Sample Number of Unknown Acid	Run 4 2	Run 5 2	2
Volume of Unknown Acid solution (mL)	18.70 - 18.80 10.10	11.50 - 11.50 10.00	
Volume of stock solution of NaOH (mL)	60.00 - 52.50 7.50 color: 54.50	60.00 - [illegible] [illegible].00 color: 56.00	
Concentration of stock solution of NaOH (M)			
Concentration of Unknown Acid Solution (M)		[illegible]	
Average Concentration of Unknown Acid solution (M)			

Observations (all parts of the experiment):

Table 4. Determination of the Mass Percentage of Acid in a Juice

Data	Trial 1 Run6	Run7 Trial 2	Trial 3 Run8
Sample Number of Juice	1	1	1
Volume of Juice (mL)	11.10 – 11.10 = 10.00 mL	11.10 – 11.10 = 10.00 mL	18.20 – 18.20 = 10.00 mL
Volume of stock solution of NaOH (mL)	60.00 – 50.00 = 10.00 colour: 52.00	60.00 – 50.00 = 10.00 colour: 52.00	60.00 – 50.00 = 10.00 colour: 52.00
Concentration of stock solution of NaOH (M)			
Concentration of acid in Juice (M)			
Average Concentration of Acid in Juice (M)			
Density of Juice (g/mL)			
Molar Mass of acid in Juice (g/mol)			
Mass Percent of Acid in Juice (%)			

<u>GRAPHS: Attach Logger Pro data tables AND graphs (at least 12 [2 per trial]) to this form!!</u>

Raw data collected from trials

	Run 1		Run 2		Run 3		Run 4		Run 5		Run 6		Run 7		Run 8		Run 9	
	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH
1	0.000	2.33	0.000	2.18	0.000	2.19	0.000	2.86	0.000	2.61	0.000	3.19	0.000	3.13	0.000	3.20	0.000	
2	0.117	2.33	0.117	2.18	0.117	2.19	0.117	2.86	0.117	2.61	0.117	3.19	0.117	3.13	0.117	3.20	0.117	
3	0.233	2.33	0.233	2.18	0.233	2.19	0.233	2.86	0.233	2.60	0.233	3.19	0.233	3.13	0.233	3.20	0.233	
4	0.350	2.33	0.350	2.18	0.350	2.19	0.350	2.86	0.350	2.60	0.350	3.19	0.350	3.13	0.350	3.20	0.350	
5	0.467	2.33	0.467	2.18	0.467	2.18	0.467	2.86	0.467	2.60	0.467	3.19	0.467	3.13	0.467	3.21	0.467	
6	0.583	2.33	0.583	2.18	0.583	2.18	0.583	2.86	0.583	2.61	0.583	3.19	0.583	3.13	0.583	3.22	0.583	
7	0.700	2.33	0.700	2.18	0.700	2.18	0.700	2.86	0.700	2.61	0.700	3.19	0.700	3.13	0.700	3.22	0.700	
8	0.817	2.33	0.817	2.18	0.817	2.18	0.817	2.86	0.817	2.61	0.817	3.19	0.817	3.13	0.817	3.25	0.817	
9	0.933	2.33	0.933	2.18	0.933	2.18	0.933	2.87	0.933	2.62	0.933	3.19	0.933	3.13	0.933	3.25	0.933	
10	1.050	2.33	1.050	2.18	1.050	2.18	1.050	2.88	1.050	2.61	1.050	3.19	1.050	3.13	1.050	3.26	1.050	
11	1.167	2.33	1.167	2.18	1.167	2.18	1.167	2.88	1.167	2.61	1.167	3.20	1.167	3.13	1.167	3.37	1.167	
12	1.284	2.33	1.284	2.18	1.284	2.18	1.284	2.89	1.284	2.61	1.284	3.20	1.284	3.13	1.284	3.35	1.284	
13	1.400	2.33	1.400	2.18	1.400	2.19	1.400	2.89	1.400	2.61	1.400	3.19	1.400	3.13	1.400	3.33	1.400	
14	1.517	2.33	1.517	2.18	1.517	2.19	1.517	2.89	1.517	2.61	1.517	3.20	1.517	3.13	1.517	3.33	1.517	
15	1.634	2.33	1.634	2.18	1.634	2.19	1.634	2.90	1.634	2.61	1.634	3.20	1.634	3.13	1.634	3.31	1.634	
16	1.750	2.33	1.750	2.18	1.750	2.19	1.750	2.91	1.750	2.61	1.750	3.22	1.750	3.13	1.750	3.31	1.750	
17	1.867	2.33	1.867	2.18	1.867	2.19	1.867	2.92	1.867	2.62	1.867	3.23	1.867	3.13	1.867	3.33	1.867	
18	1.984	2.33	1.984	2.19	1.984	2.19	1.984	2.91	1.984	2.63	1.984	3.23	1.984	3.13	1.984	3.39	1.984	
19	2.100	2.33	2.100	2.19	2.100	2.19	2.100	2.89	2.100	2.62	2.100	3.23	2.100	3.13	2.100	3.36	2.100	
20	2.217	2.33	2.217	2.18	2.217	2.19	2.217	2.90	2.217	2.63	2.217	3.23	2.217	3.13	2.217	3.34	2.217	
21	2.334	2.33	2.334	2.19	2.334	2.20	2.334	2.90	2.334	2.63	2.334	3.24	2.334	3.13	2.334	3.35	2.334	
22	2.450	2.33	2.450	2.19	2.450	2.20	2.450	2.90	2.450	2.63	2.450	3.24	2.450	3.13	2.450	3.38	2.450	
23	2.567	2.33	2.567	2.19	2.567	2.20	2.567	2.96	2.567	2.63	2.567	3.24	2.567	3.13	2.567	3.39	2.567	
24	2.684	2.33	2.684	2.19	2.684	2.20	2.684	2.95	2.684	2.63	2.684	3.25	2.684	3.13	2.684	3.40	2.684	
25	2.800	2.33	2.800	2.19	2.800	2.20	2.800	2.98	2.800	2.64	2.800	3.26	2.800	3.13	2.800	3.46	2.800	
26	2.917	2.33	2.917	2.19	2.917	2.20	2.917	2.96	2.917	2.64	2.917	3.26	2.917	3.13	2.917	3.43	2.917	
27	3.034	2.33	3.034	2.19	3.034	2.20	3.034	2.96	3.034	2.64	3.034	3.27	3.034	3.13	3.034	3.45	3.034	
28	3.151	2.32	3.151	2.19	3.151	2.20	3.151	3.01	3.151	2.64	3.151	3.27	3.151	3.13	3.151	3.48	3.151	
29	3.267	2.33	3.267	2.19	3.267	2.21	3.267	2.98	3.267	2.64	3.267	3.28	3.267	3.13	3.267	3.48	3.267	
30	3.384	2.33	3.384	2.19	3.384	2.21	3.384	2.97	3.384	2.65	3.384	3.29	3.384	3.13	3.384	3.54	3.384	
31	3.501	2.33	3.501	2.19	3.501	2.21	3.501	2.98	3.501	2.69	3.501	3.29	3.501	3.13	3.501	3.53	3.501	
32	3.617	2.33	3.617	2.19	3.617	2.21	3.617	2.99	3.617	2.67	3.617	3.31	3.617	3.13	3.617	3.54	3.617	
33	3.734	2.33	3.734	2.19	3.734	2.21	3.734	3.04	3.734	2.68	3.734	3.31	3.734	3.13	3.734	3.57	3.734	
34	3.851	2.33	3.851	2.19	3.851	2.21	3.851	3.18	3.851	2.68	3.851	3.32	3.851	3.13	3.851	3.57	3.851	
35	3.967	2.33	3.967	2.19	3.967	2.21	3.967	3.04	3.967	2.70	3.967	3.33	3.967	3.13	3.967	3.57	3.967	
36	4.084	2.33	4.084	2.19	4.084	2.22	4.084	3.06	4.084	2.69	4.084	3.33	4.084	3.13	4.084	3.62	4.084	
37	4.201	2.33	4.201	2.20	4.201	2.22	4.201	3.13	4.201	2.73	4.201	3.34	4.201	3.13	4.201	3.62	4.201	
38	4.317	2.33	4.317	2.20	4.317	2.22	4.317	3.09	4.317	2.72	4.317	3.35	4.317	3.13	4.317	3.62	4.317	
39	4.434	2.33	4.434	2.20	4.434	2.22	4.434	3.12	4.434	2.70	4.434	3.36	4.434	3.12	4.434	3.65	4.434	
40	4.551	2.33	4.551	2.20	4.551	2.22	4.551	3.11	4.551	2.70	4.551	3.38	4.551	3.13	4.551	3.65	4.551	
41	4.667	2.33	4.667	2.20	4.667	2.23	4.667	3.10	4.667	2.70	4.667	3.39	4.667	3.13	4.667	3.65	4.667	
42	4.784	2.33	4.784	2.20	4.784	2.23	4.784	3.12	4.784	2.73	4.784	3.42	4.784	3.14	4.784	3.67	4.784	