

OH HOW BITTER A THING IT IS

Acid Base Titrations Lab

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Introduction

Acids and bases are present in our everyday lives, from the food we eat to various cleaning products used all around the world. Although they are often placed under the same category, they are quite different and it is important to know the difference. An acid is an ionic compound, meaning that it can have either a positive or negative charge. When acids are placed in water, they break apart and a hydrogen ion is formed (H^+). Therefore, the amount of hydrogen ions (H^+) determines the strength of the acid in question, and so some acids are much stronger than others as a result. Bases on the other hand, are quite different. A base is also an ionic compound, so it has a partial charge, either positive or negative. However, when a base disassociates in water, it forms a negatively charged hydroxide ion (OH^-). As well, the concentration of hydroxide ions (OH^-) affects the strength of the given base. There were three acids used in this experiment, which include; 0.1M HCl, a sample of juice containing citric acid, as well as an unknown acid solution that was left to be determined. The only base used in the following experiment was concentrated 6.0M NaOH, otherwise known as Sodium hydroxide. A titration between an acid and base was the objective of this lab and the purpose was to study the effects of a titration between an acid and a base. A titration involves a neutralization reaction between the given acid and base and at the point of equivalence, when both compounds have been neutralized, the amount of both the acid and the base should be equal at this point. On top of there being acids and bases, there are also strong acids and strong bases. These are compounds that are ionized completely when dissolved in water. Coincidentally, the standard acid and base used in this reaction were very high strength. Hydrochloric acid (HCl) and Sodium hydroxide (NaOH) are each an example of a strong acid and a strong base, respectively. Due to the fact that these are strong acids and bases, it makes it much easier to calculate the pH of the reactions used. With weak acids and bases, the ionic compounds do not dissociate completely in water, so it is a much more complicated process in order to determine the pH at equilibrium. A titration curve (otherwise known as a pH curve), is a plot of the changing pH as a function of the volume added at a constant rate. For this lab, the pH curve was similar for the different titrations performed and this is due to the fact that the acids and base used were strong and so the result/equivalence point was very similar between the trials.

Broderick, Catherine. "Acid/Base Basics" www.chem.libretexts.org. 10 July, 2016.

Dr. R. Venkateswaran, "What in the World isn't Chemistry?", General Chemistry Laboratory Manual, 2016, Experiment 3. p(74-77).

Student's Initials SC

Data Tables

Table 1. Formation of a stock solution of NaOH

Volume of concentrated NaOH solution (mL)	5.10mL
Concentration of concentrated NaOH solution (M)	6.00M
Volume of stock solution after dilution (mL)	255.10mL
Approximate concentration of stock solution (M)	0.12M

Table 2. Standardization of Stock Solution of NaOH

Data	Trial 1	Trial 2
Concentration of Standard Acid solution (M)	0.1000M HCl	0.1000M HCl
Volume of Standard Acid solution (mL)	10.05mL	10.25mL
Volume of stock solution of NaOH (mL)	9.554mL	7.427mL
Concentration of stock solution of NaOH (M)	0.11M	0.14M
Average Concentration of stock solution of NaOH (M)	0.13M	

Table 3. Determination of the Concentration of an Unknown Acid

Data	Trial 1	Trial 2	Trial 3
Sample Number of Unknown Acid	ACID #3	ACID #3	ACID #3
Volume of Unknown Acid solution (mL)	14.8mL	15.1mL	10.1mL
Volume of stock solution of NaOH (mL)	24.88mL	11.00mL	7.502mL
Concentration of stock solution of NaOH (M)	0.13M	0.13M	0.13M
Concentration of Unknown Acid Solution (M)	0.11 M	0.047M	0.048M
Average Concentration of Unknown Acid solution (M)	0.068M		

Observations (all parts of the experiment):

For all of the trials that were performed, the results were very similar. As the Sodium hydroxide solution was added dropwise into the solution containing the acid, there was a color change that occurred. Initially, all of the acids used were clear and colorless before the reaction between the acid and the base solution. The sodium hydroxide solution was also clear and colorless prior to the reaction. The juice used was clear but was not colorless, and had a slight yellow tint to the color. As the base solution was added dropwise into the acid, the pH slowly started rising at a constant rate and as a certain point, the pH spiked rapidly and the color that appeared was a clear and purple solution. This was caused due to the clear colorless Phenolphthalein color indicator that was in the solution which changes color when there is a large change in pH.

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

Data	Trial 1	Trial 2	Trial 3
Sample Number of Juice	Juice #4	Juice #4	N/A
Volume of Juice (mL)	9.50mL	9.70mL	N/A
Volume of stock solution of NaOH (mL)	7.877mL	4.876mL	N/A
Concentration of stock solution of NaOH (M)	0.13M	0.13M	N/A
Concentration of acid in Juice (M)	0.036M	0.022M	N/A
Average Concentration of Acid in Juice (M)	0.029M		
Density of Juice (g/mL)	0.9997g/mL		
Molar Mass of acid in Juice (g/mol)	192.12g/mol		
Mass Percent of Acid in Juice (%)	0.56%		

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

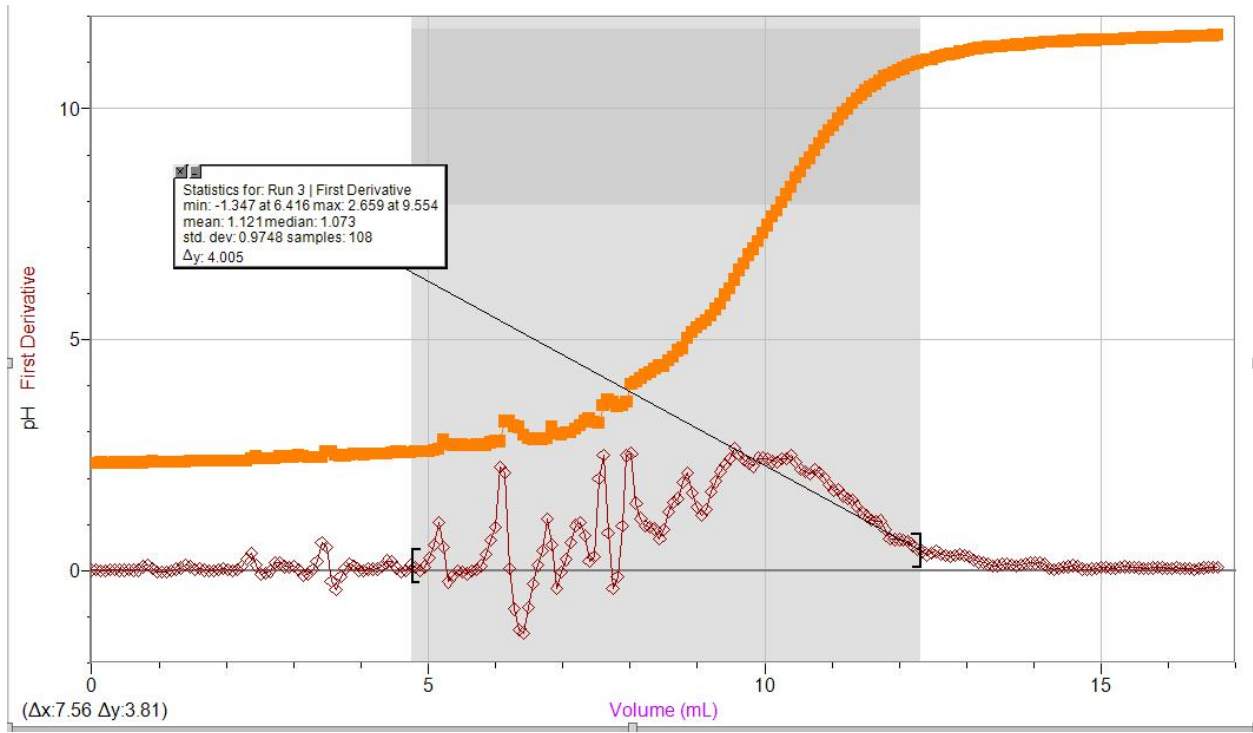


Figure 1: Representation of the standardization of the Base, TRIAL #1.

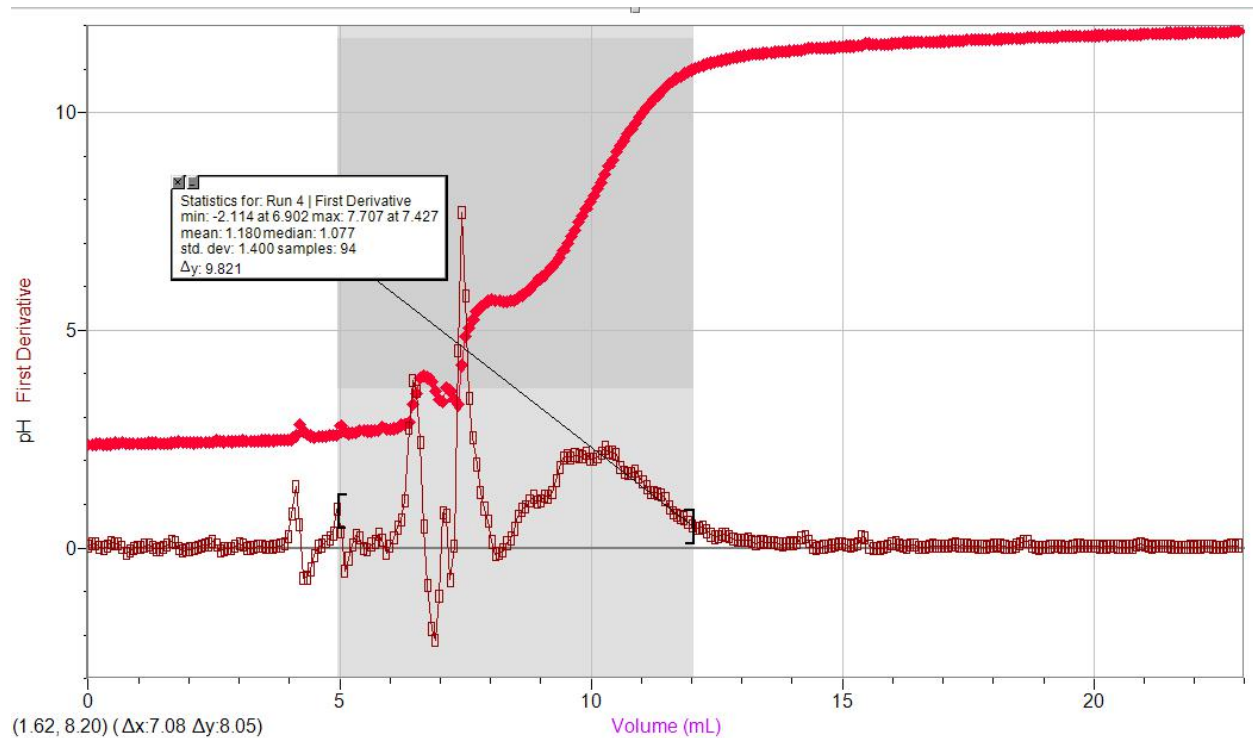


Figure 2: Representation of the standardization of the Base, TRIAL #2.

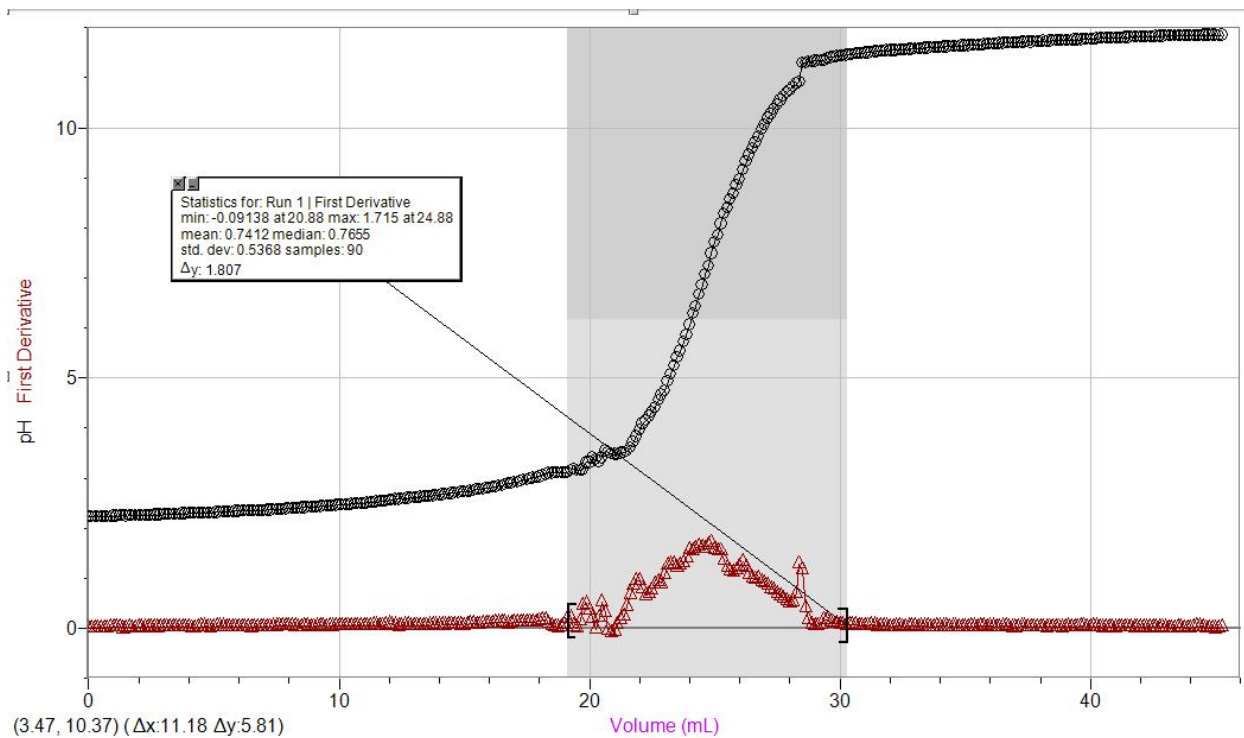


Figure 3: Representation of the titration of the Unknown acid, TRIAL#1.

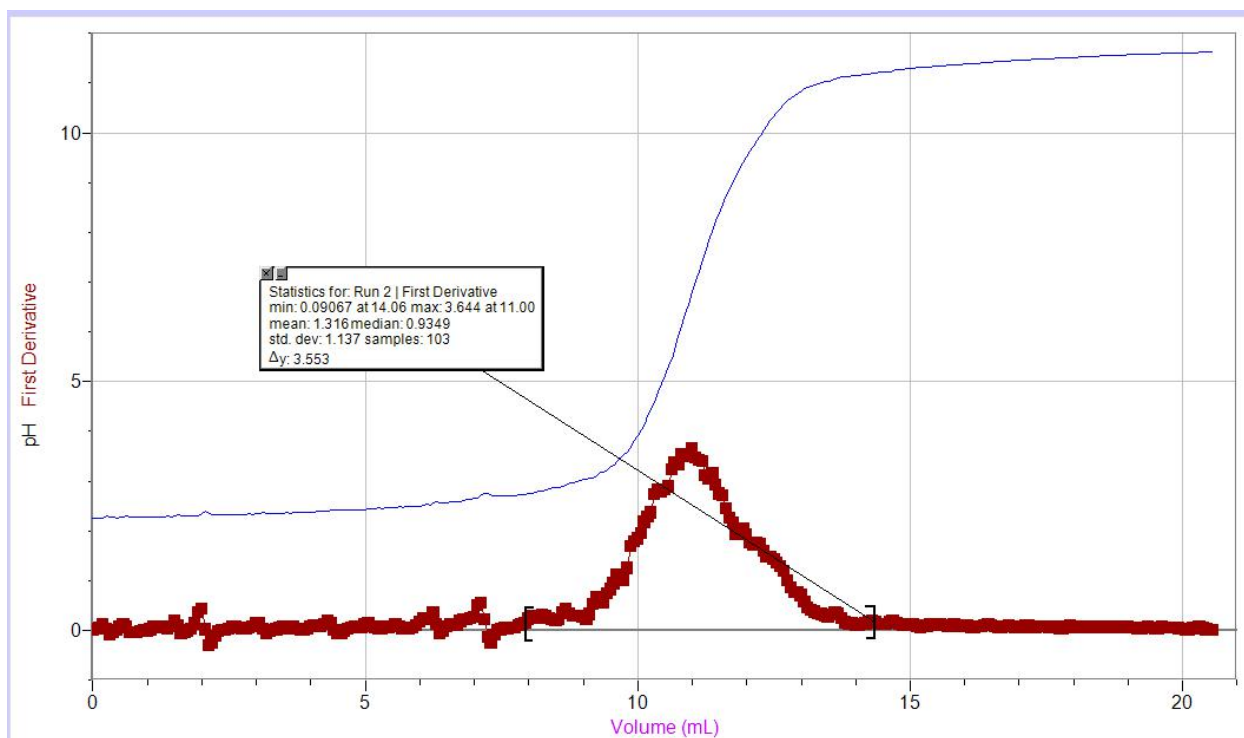


Figure 4: Representation of the titration of the Unknown acid, TRIAL#2.

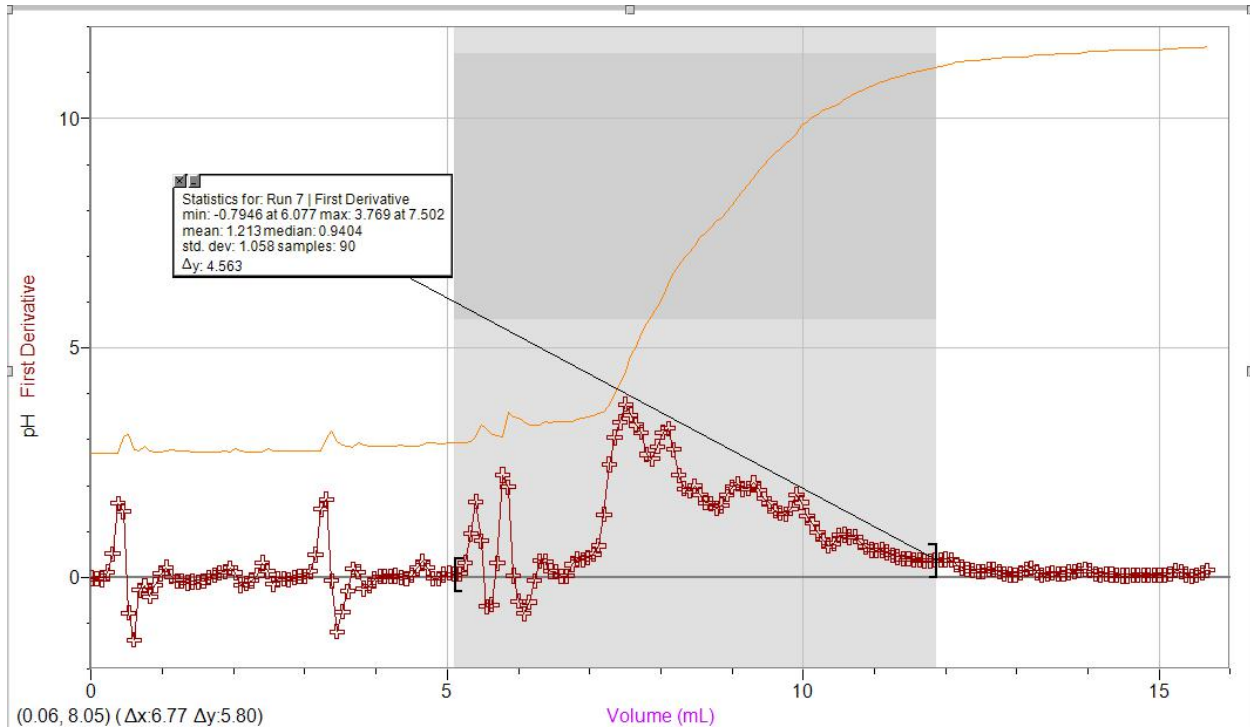


Figure 5: Representation of the titration of the Unknown acid, TRIAL#3.

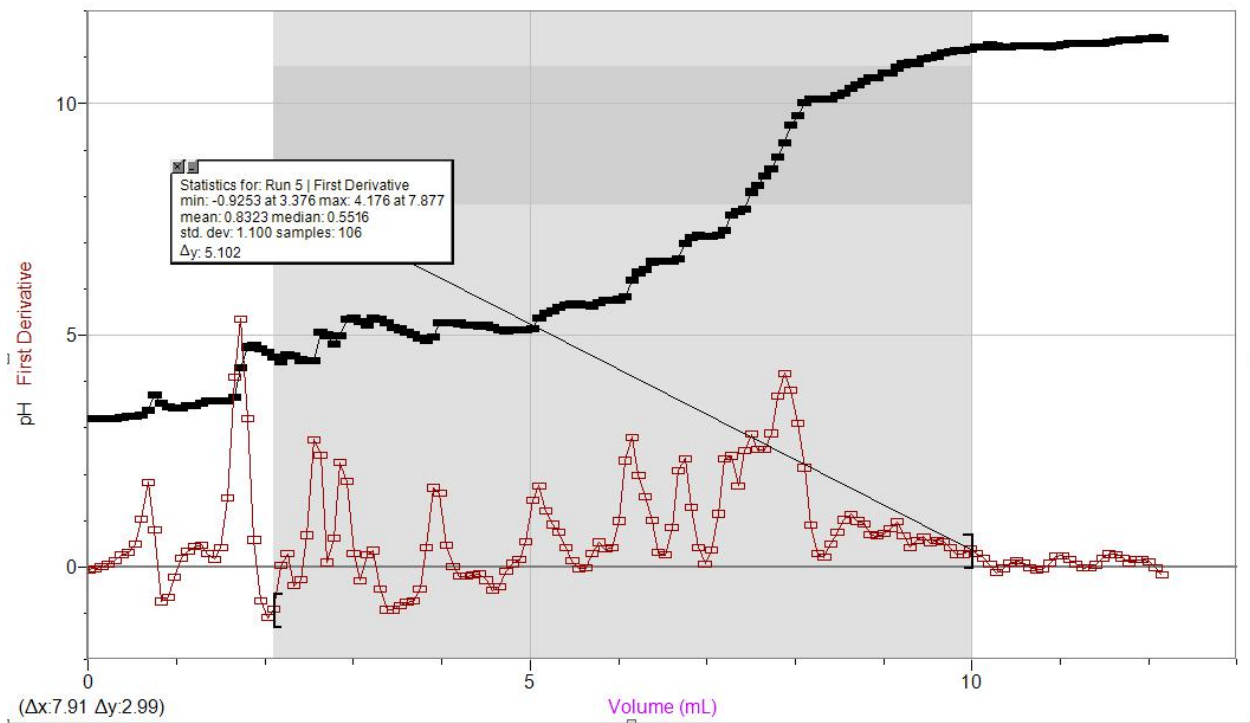


Figure 6: Representation of the titration of the Juice#4, TRIAL #1.

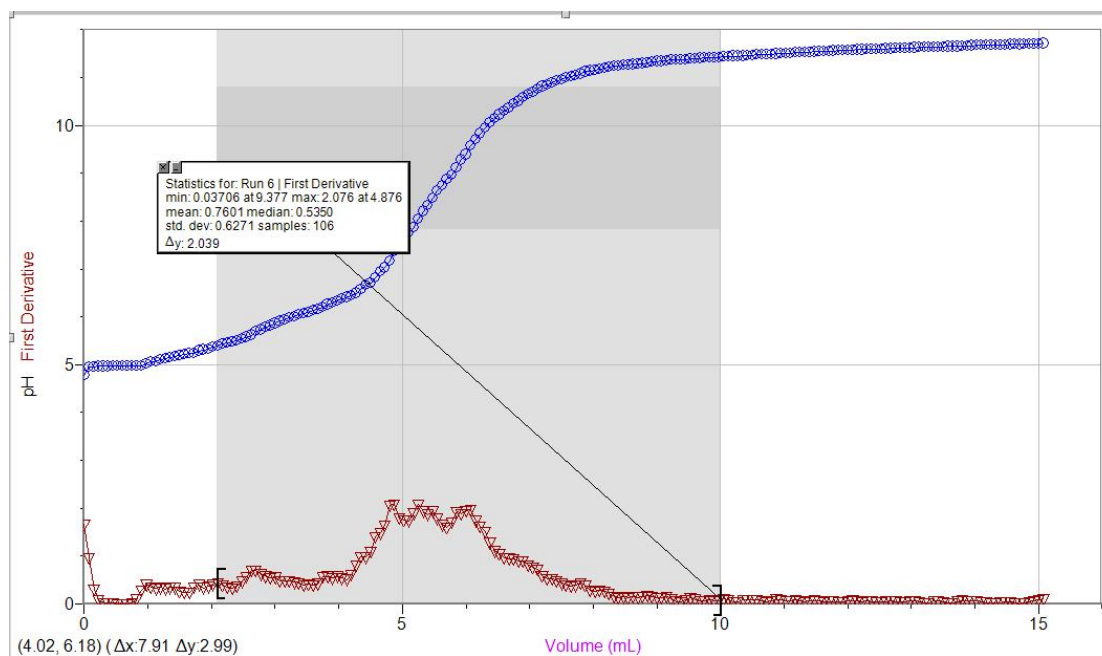


Figure 7: Representation of the titration of the Juice#4, TRIAL #2.

Table 1: Partial representation of Standardization of Base TRIAL 1&2

Run 3			Run 4		
Volume (mL)	pH	FD	Volume (mL)	pH	FD
0.000	2.33	0.011	0.000	2.37	0.050
0.070	2.33	0.017	0.075	2.37	0.089
0.139	2.33	0.002	0.150	2.38	0.099
0.209	2.33	-0.009	0.225	2.39	0.011
0.279	2.33	0.019	0.300	2.37	0.000
0.349	2.33	0.022	0.375	2.38	0.042
0.418	2.33	0.009	0.450	2.38	0.114
0.488	2.33	0.007	0.525	2.41	0.106
0.558	2.33	0.017	0.600	2.39	0.094
0.628	2.34	0.006	0.675	2.43	0.022
0.697	2.33	0.012	0.750	2.40	-0.117
0.767	2.33	0.088	0.825	2.39	-0.067
0.837	2.35	0.131	0.900	2.39	-0.019
0.907	2.36	0.045	0.975	2.39	0.013
0.976	2.35	-0.029	1.050	2.40	0.006
1.046	2.35	-0.034	1.125	2.39	0.052
1.116	2.35	-0.026	1.200	2.41	0.076
1.185	2.35	0.000	1.275	2.41	0.012
1.255	2.35	0.032	1.350	2.41	-0.033
1.325	2.35	0.059	1.425	2.40	-0.026
1.395	2.35	0.118	1.500	2.40	0.009
1.464	2.37	0.086	1.575	2.40	0.063
1.534	2.37	0.020	1.650	2.41	0.157
1.604	2.37	0.039	1.725	2.43	0.127
1.674	2.37	0.010	1.800	2.44	-0.013
1.743	2.37	0.004	1.875	2.42	-0.072
1.813	2.37	0.004	1.950	2.42	-0.032
1.883	2.37	0.013	2.026	2.42	-0.028

Table 2: Partial representation of Titration of Diprotic Acid TRIAL 1&2

	Run 1			Run 2		
	Volume (mL)	pH	FD	Volume (mL)	pH	FD
1	0.000	2.24	0.000	0.000	2.26	0.000
2	0.125	2.24	0.000	0.063	2.26	0.019
3	0.250	2.24	0.000	0.125	2.26	0.041
4	0.375	2.24	0.000	0.188	2.26	0.124
5	0.500	2.24	0.000	0.250	2.29	0.027
6	0.625	2.24	0.001	0.313	2.27	-0.093
7	0.750	2.24	0.004	0.375	2.27	-0.047
8	0.875	2.24	0.016	0.438	2.26	0.006
9	1.000	2.24	0.023	0.500	2.27	0.077
10	1.125	2.24	0.029	0.563	2.27	0.125
11	1.250	2.25	0.022	0.625	2.29	0.057
12	1.375	2.25	-0.010	0.688	2.28	-0.049
13	1.500	2.24	0.002	0.750	2.28	-0.045
14	1.625	2.25	0.019	0.813	2.28	-0.040
15	1.750	2.25	0.007	0.875	2.27	-0.031
16	1.875	2.25	0.007	0.938	2.27	-0.015
17	2.000	2.25	0.014	1.000	2.27	-0.019
18	2.125	2.26	0.015	1.063	2.27	0.011
19	2.250	2.26	0.010	1.125	2.27	0.057
20	2.375	2.26	0.019	1.188	2.28	0.072
21	2.500	2.26	0.027	1.250	2.28	0.072
22	2.625	2.26	0.019	1.313	2.29	0.059
23	2.750	2.26	0.011	1.375	2.29	0.034
24	2.875	2.26	0.020	1.438	2.29	0.062
25	3.000	2.27	0.029	1.500	2.29	0.179
26	3.125	2.27	0.022	1.563	2.33	0.081
27	3.250	2.27	0.020	1.625	2.31	-0.077
28	3.375	2.28	0.020	1.688	2.30	-0.046

Table 3: Partial representation of Titration of Diprotic Acid TRIAL 3

Run 7		
Volume (mL)	pH	FD
0.000	2.71	-0.018
0.075	2.71	-0.033
0.150	2.71	-0.044
0.225	2.70	0.110
0.300	2.71	0.510
0.375	2.70	1.615
0.450	3.05	1.440
0.525	3.10	-0.780
0.600	2.79	-1.365
0.675	2.75	-0.281
0.750	2.85	-0.191
0.825	2.75	-0.418
0.900	2.74	-0.169
0.975	2.73	0.079
1.050	2.76	0.212
1.125	2.79	0.015
1.200	2.75	-0.074
1.275	2.77	-0.073
1.350	2.75	-0.119
1.425	2.74	-0.091
1.500	2.74	-0.109
1.575	2.72	-0.089
1.650	2.72	0.001
1.725	2.73	0.041
1.800	2.72	0.106
1.875	2.75	0.122
1.950	2.73	0.208
2.026	2.80	0.097

Table 4: Partial representation of Titration of Juice #4 TRIAL 1&2

	Run 5			Run 6		
	Volume (mL)	pH	FD	Volume (mL)	pH	FD
1	0.000	3.21	-0.058	0.000	4.78	1.674
2	0.075	3.20	-0.042	0.075	4.95	0.959
3	0.150	3.20	0.001	0.150	4.96	0.315
4	0.225	3.20	0.053	0.225	4.96	0.096
5	0.300	3.20	0.146	0.300	4.96	0.016
6	0.375	3.22	0.263	0.375	4.96	0.024
7	0.450	3.25	0.304	0.450	4.97	0.023
8	0.525	3.26	0.493	0.525	4.97	0.007
9	0.600	3.29	1.022	0.600	4.97	0.002
10	0.675	3.38	1.825	0.675	4.97	0.004
11	0.750	3.72	0.811	0.750	4.97	0.028
12	0.825	3.55	-0.745	0.825	4.97	0.117
13	0.900	3.46	-0.653	0.900	4.98	0.290
14	0.975	3.43	-0.223	0.975	5.02	0.409
15	1.050	3.44	0.191	1.050	5.06	0.349
16	1.125	3.48	0.331	1.125	5.07	0.320
17	1.200	3.49	0.434	1.200	5.10	0.344
18	1.275	3.55	0.476	1.275	5.12	0.318
19	1.350	3.58	0.286	1.350	5.14	0.342
20	1.425	3.58	0.168	1.425	5.17	0.342
21	1.500	3.59	0.412	1.500	5.20	0.273
22	1.575	3.59	1.484	1.575	5.21	0.240
23	1.650	3.67	4.090	1.650	5.23	0.248
24	1.725	4.30	5.352	1.725	5.24	0.352
25	1.800	4.75	3.206	1.800	5.29	0.407
26	1.875	4.80	0.583	1.875	5.31	0.341
27	1.950	4.72	-0.725	1.950	5.33	0.364
28	2.026	4.64	-1.101	2.026	5.37	0.407

TABLE 5: Partial representation of the raw data for all of the titration trials

	Run 1		Run 2		Run 3		Run 4		Run 5		Run 6		Run 7	
	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH	Volume (mL)	pH
1	0.000	2.24	0.000	2.26	0.000	2.33	0.000	2.37	0.000	3.21	0.000	4.78	0.000	2.71
2	0.125	2.24	0.063	2.26	0.070	2.33	0.075	2.37	0.075	3.20	0.075	4.95	0.075	2.71
3	0.250	2.24	0.125	2.26	0.139	2.33	0.150	2.38	0.150	3.20	0.150	4.96	0.150	2.71
4	0.375	2.24	0.188	2.26	0.209	2.33	0.225	2.39	0.225	3.20	0.225	4.96	0.225	2.70
5	0.500	2.24	0.250	2.29	0.279	2.33	0.300	2.37	0.300	3.20	0.300	4.96	0.300	2.71
6	0.625	2.24	0.313	2.27	0.349	2.33	0.375	2.38	0.375	3.22	0.375	4.96	0.375	2.70
7	0.750	2.24	0.375	2.27	0.418	2.33	0.450	2.38	0.450	3.25	0.450	4.97	0.450	3.05
8	0.875	2.24	0.438	2.26	0.488	2.33	0.525	2.41	0.525	3.26	0.525	4.97	0.525	3.10
9	1.000	2.24	0.500	2.27	0.558	2.33	0.600	2.39	0.600	3.29	0.600	4.97	0.600	2.79
10	1.125	2.24	0.563	2.27	0.628	2.34	0.675	2.43	0.675	3.38	0.675	4.97	0.675	2.75
11	1.250	2.25	0.625	2.29	0.697	2.33	0.750	2.40	0.750	3.72	0.750	4.97	0.750	2.85
12	1.375	2.25	0.688	2.28	0.767	2.33	0.825	2.39	0.825	3.55	0.825	4.97	0.825	2.75
13	1.500	2.24	0.750	2.28	0.837	2.35	0.900	2.39	0.900	3.46	0.900	4.98	0.900	2.74
14	1.625	2.25	0.813	2.28	0.907	2.36	0.975	2.39	0.975	3.43	0.975	5.02	0.975	2.73
15	1.750	2.25	0.875	2.27	0.976	2.35	1.050	2.40	1.050	3.44	1.050	5.06	1.050	2.76
16	1.875	2.25	0.938	2.27	1.046	2.35	1.125	2.39	1.125	3.48	1.125	5.07	1.125	2.79
17	2.000	2.25	1.000	2.27	1.116	2.35	1.200	2.41	1.200	3.49	1.200	5.10	1.200	2.75
18	2.125	2.26	1.063	2.27	1.185	2.35	1.275	2.41	1.275	3.55	1.275	5.12	1.275	2.77
19	2.250	2.26	1.125	2.27	1.255	2.35	1.350	2.41	1.350	3.58	1.350	5.14	1.350	2.75
20	2.375	2.26	1.188	2.28	1.325	2.35	1.425	2.40	1.425	3.58	1.425	5.17	1.425	2.74
21	2.500	2.26	1.250	2.28	1.395	2.35	1.500	2.40	1.500	3.59	1.500	5.20	1.500	2.74
22	2.625	2.26	1.313	2.29	1.464	2.37	1.575	2.40	1.575	3.59	1.575	5.21	1.575	2.72
23	2.750	2.26	1.375	2.29	1.534	2.37	1.650	2.41	1.650	3.67	1.650	5.23	1.650	2.72
24	2.875	2.26	1.438	2.29	1.604	2.37	1.725	2.43	1.725	4.30	1.725	5.24	1.725	2.73
25	3.000	2.27	1.500	2.29	1.674	2.37	1.800	2.44	1.800	4.75	1.800	5.29	1.800	2.72
26	3.125	2.27	1.563	2.33	1.743	2.37	1.875	2.42	1.875	4.80	1.875	5.31	1.875	2.75
27	3.250	2.27	1.625	2.31	1.813	2.37	1.950	2.42	1.950	4.72	1.950	5.33	1.950	2.73
28	3.375	2.28	1.688	2.30	1.883	2.37	2.026	2.42	2.026	4.64	2.026	5.37	2.026	2.80

CALCULATIONS

(Part 1)

1. Approximate concentration of stock solution

$$\begin{aligned}C_1 &= 6.0\text{M} \\V_1 &= 5.10\text{mL} \\V_2 &= 255\text{mL}\end{aligned}$$

$$\begin{aligned}C_1V_1 &= C_2V_2 \\C_2 &= (C_1V_1)/V_2 \\C_2 &= (6.0\text{M} \times 5.10\text{mL})/255\text{mL}\end{aligned}$$

$$C_2 = 0.12\text{M}$$

(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):

TRIAL 1

$$C_{\text{Acid}} = 0.1000\text{M}$$

$$V_{\text{Acid}} = 10.05\text{mL}$$

$$V_{\text{NaOH}} = 9.554\text{mL}$$

$$n_{\text{NaOH}} = n_{\text{Acid}}$$

$$C_{\text{NaOH}} V_{\text{NaOH}} = C_{\text{Acid}} V_{\text{Acid}}$$

$$C_{\text{NaOH}} = (C_{\text{Acid}} V_{\text{Acid}}) / V_{\text{NaOH}}$$

$$C_{\text{NaOH}} = (0.1000\text{ M} \times 10.05\text{ml}) / 9.554\text{mL}$$

$$C_{\text{NaOH}} = 0.11\text{ M}$$

TRIAL 2

$$C_{\text{Acid}} = 0.1000\text{M}$$

$$V_{\text{Acid}} = 10.25\text{mL}$$

$$V_{\text{NaOH}} = 7.427\text{mL}$$

$$n_{\text{NaOH}} = n_{\text{Acid}}$$

$$C_{\text{NaOH}} V_{\text{NaOH}} = C_{\text{Acid}} V_{\text{Acid}}$$

$$C_{\text{NaOH}} = (C_{\text{Acid}} V_{\text{Acid}}) / V_{\text{NaOH}}$$

$$C_{\text{NaOH}} = (0.1000\text{ M} \times 10.25\text{ml}) / 7.427\text{mL}$$

$$C_{\text{NaOH}} = 0.14\text{ M}$$

3. Average concentration of stock solution:

$$C_1 = 0.11\text{ M}$$

$$C_2 = 0.11\text{ M}$$

$$C_{\text{avg}} = (C_1 + C_2) / 2$$

$$C_{\text{avg}} = (0.11\text{ M} + 0.14\text{ M}) / 2$$

$$C_{\text{avg}} = 0.13\text{ M}$$

(Part 3)

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

TRIAL 1

$$\begin{aligned}C_{\text{NaOH}} &= 0.13 \text{ M} \\V_{\text{NaOH}} &= 24.88 \text{ ml} \\V_{\text{Acid}} &= 14.8 \text{ ml}\end{aligned}$$

$$\begin{aligned}n_{\text{NaOH}} &= 2n_{\text{Acid}} \\C_{\text{NaOH}} V_{\text{NaOH}} &= 2(C_{\text{Acid}} V_{\text{Acid}}) \\C_{\text{Acid}} &= (C_{\text{NaOH}} V_{\text{NaOH}})/2V_{\text{Acid}} \\C_{\text{Acid}} &= (0.13 \text{ M} \times 24.88 \text{ ml})/2(14.8 \text{ ml}) \\C_{\text{Acid}} &= 0.11 \text{ M}\end{aligned}$$

TRIAL 2

$$\begin{aligned}C_{\text{NaOH}} &= 0.13 \text{ M} \\V_{\text{NaOH}} &= 11.00 \text{ ml} \\V_{\text{Acid}} &= 15.1 \text{ ml}\end{aligned}$$

$$\begin{aligned}n_{\text{NaOH}} &= 2n_{\text{Acid}} \\C_{\text{NaOH}} V_{\text{NaOH}} &= 2(C_{\text{Acid}} V_{\text{Acid}}) \\C_{\text{Acid}} &= (C_{\text{NaOH}} V_{\text{NaOH}})/2V_{\text{Acid}} \\C_{\text{Acid}} &= (0.13 \text{ M} \times 11.00 \text{ ml})/2(15.1 \text{ ml}) \\C_{\text{Acid}} &= 0.047 \text{ M}\end{aligned}$$

TRIAL 3

$$\begin{aligned}C_{\text{NaOH}} &= 0.13 \text{ M} \\V_{\text{NaOH}} &= 7.502 \text{ ml} \\V_{\text{Acid}} &= 10.10 \text{ ml}\end{aligned}$$

$$\begin{aligned}n_{\text{NaOH}} &= 2n_{\text{Acid}} \\C_{\text{NaOH}} V_{\text{NaOH}} &= 2(C_{\text{Acid}} V_{\text{Acid}}) \\C_{\text{Acid}} &= (C_{\text{NaOH}} V_{\text{NaOH}})/2V_{\text{Acid}} \\C_{\text{Acid}} &= (0.13 \text{ M} \times 7.502 \text{ ml})/2(10.10 \text{ ml}) \\C_{\text{Acid}} &= 0.048 \text{ M}\end{aligned}$$

5. Average concentration of unknown acid:

$$\begin{aligned}C_1 &= 0.11 \text{ M} \\C_2 &= 0.047 \text{ M} \\C_3 &= 0.048 \text{ M}\end{aligned}$$

$$\begin{aligned}C_{\text{avg}} &= (C_1 + C_2 + C_3)/3 \\C_{\text{avg}} &= (0.11 \text{ M} + 0.047 \text{ M} + 0.048 \text{ M})/3 \\C_{\text{avg}} &= 0.068 \text{ M}\end{aligned}$$

(Part 4)

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

TRIAL 1

$$\begin{aligned}C_{\text{NaOH}} &= 0.13 \text{ M} \\V_{\text{NaOH}} &= 7.877 \text{ ml} \\V_{\text{Acid}} &= 9.50 \text{ ml}\end{aligned}$$

$$\begin{aligned}n_{\text{NaOH}} &= 3n_{\text{Acid}} \\C_{\text{NaOH}} V_{\text{NaOH}} &= 3(C_{\text{Acid}} V_{\text{Acid}}) \\C_{\text{Acid}} &= (C_{\text{NaOH}} V_{\text{NaOH}})/3V_{\text{Acid}} \\C_{\text{Acid}} &= (0.13 \text{ M} \times 7.877 \text{ ml})/3(9.50 \text{ ml}) \\C_{\text{Acid}} &= 0.036 \text{ M}\end{aligned}$$

TRIAL 2

$$\begin{aligned}C_{\text{NaOH}} &= 0.13 \text{ M} \\V_{\text{NaOH}} &= 4.876 \text{ ml} \\V_{\text{Acid}} &= 9.70 \text{ ml}\end{aligned}$$

$$\begin{aligned}n_{\text{NaOH}} &= 3n_{\text{Acid}} \\C_{\text{NaOH}} V_{\text{NaOH}} &= 3(C_{\text{Acid}} V_{\text{Acid}}) \\C_{\text{Acid}} &= (C_{\text{NaOH}} V_{\text{NaOH}})/9V_{\text{Acid}} \\C_{\text{Acid}} &= (0.13\text{M} \times 4.876\text{ml})/3(9.70\text{ml}) \\C_{\text{Acid}} &= 0.022 \text{ M}\end{aligned}$$

7. Average concentration of acid in juice:

$$\begin{aligned}C_1 &= 0.036\text{M} \\C_2 &= 0.022\text{M} \\C_{\text{avg}} &= (C_1 + C_2)/2 \\C_{\text{avg}} &= (0.036 \text{ M} + 0.022 \text{ M})/2 \\C_{\text{avg}} &= 0.029\text{M}\end{aligned}$$

8. Mass percentage of acid in juice:

$$\begin{aligned}C_{\text{Acid}} &= 0.029 \text{ M} \\M_{\text{Acid}} &= 192.12\text{g/mol} \\D_{\text{Acid}} &= 0.9997\text{g/mL}(1000\text{mL}/1\text{L}) \\&= 999.7\text{g/L}\end{aligned}$$
$$\begin{aligned}\text{Mass \%} &= [(C_{\text{Acid}} * M_{\text{Acid}})/D_{\text{Acid}}] \times 100\% \\&= (0.029 \text{ M} * 192.12\text{g/mol})/999.7\text{g/L} \\&= 0.0018 \times 100\% \\&= 0.56\%\end{aligned}$$

Discussion:

The volume of concentrated NaOH does not matter for the initial calculations of concentrations and volume of both the NaOH solution as well as the stock solution. The value achieved for this calculation was not used for any other calculations of other concentrations. The achieved value for the concentration is just an approximate calculation and comes before there are any titrations between acids and bases. We were required to calculate the concentration of the NaOH solution following the dilution with water because this value remained constant throughout the rest of the lab. The same concentrated NaOH solution was used for every trial of every titration and so it is important to keep the values constant throughout the entire lab. There was a slight discrepancy between the visual endpoint of the titration and the equivalence point determined by Logger Pro. For the standard acid used, the volumes visually observed were 8.998mL and 8.627mL whereas the Logger Pro data revealed 9.554mL and 7.427mL, respectively. For the diprotic (unknown) acid, the visual endpoints were 23.75mL, 9.688mL and 7.502mL whereas the Logger Pro data was 24.88mL, 11.00mL and 7.502mL, respectively. For the final titration involving the juice, the visual endpoints were at 8.702mL and 8.971mL, compared to the 7.877mL and 4.876mL that were discovered using the first derivative. There is a factor of 1000 associated with the density in the equation for mass percent of the juice because of the fact that the density

is given in (g/mL). Due to the fact that the concentrations and volume are given in L, it is important to convert ml to L which happens to be a factor of 1000. There aren't really many sources of error in this lab due to the precision and accuracy of the tools that were being used. A potential source of error could be with the dropper, and if the rate of the falling drops were to be changed in some way. This occurred with our first trial of the diprotic (unknown) acid, the dropper rate was increased in order to speed up the reaction and this had a large impact on both the calculations as well as the graphs. This error caused the concentration of the acid to increase greatly.

Conclusion:

All in all, with the lab we were able to calculate the concentrations of acids and bases at an equilibrium point in a titration. The concentrations for the standard acid, diprotic unknown acid and the citric acid found in the juice were 0.13M, 0.068M, and 0.029M, respectively.

ROUGH NOTES

Experiment 3 : Acid/Base Titrations

Juice	Density
Juice #2	$d = 1.0001 \text{ g/cm}^3$
* Juice #4	$d = 0.9997 \text{ g/cm}^3$
Juice #6	$d = 0.9994 \text{ g/cm}^3$

Acid #1 - Unknown
~~Acid #2 - Unknown~~
 Acid #3 - Unknown

TRIAL 1
 (Diprotic)

Step 2 - 250 mL Distilled Water
 ↳ 5.10 mL NaOH (6M)

Step 15 → 3.10 mL GC
 Step 19 → 5.00 mL in the GC
 ↳ 40 drops NaOH solution

Step 23 → 24 mL of Acid #3

Step 25 → (5 mL) 24.90 mL Initial → Total Volume of Acid
 (15 mL) 10.10 mL Final 14.8 mL

Step 26 3 drops 32. 23.75 mL 33. 11.85 pH at 45.25

TRIAL 2 (Diprotic)

Step 19 → 2.25 mL (36 drops)
 23 → 26.1 mL

25 → (4.8) 25.20 mL → Total Volume 15.1 mL
 Final (14.9) 10.1 mL

Color Change Final Final Volume
 9.688 mL 11.60 pH 14.750 mL

feed added

nexient

TRIAL ONE Juice #4

25. Initial (6.23) 16.75ml
 Final (15.78) 9.25ml
 $\Delta V = 9.5 \text{ mL}$

32. Color change at 8.702
 11.45 pH at 12.153ml

TRIAL TWO Juice #4

25. Initial (4.63) (20.35ml)
 Final (14.35) (10.65ml)
 $\Delta V = 9.7 \text{ mL}$

32. Color change at 8.971
 12.603ml 11.63 pH

TRIAL THREE Acid #3

25. Initial (4.5) 20.50ml
 Final (14.6) 10.4
 $\Delta V = 10.1 \text{ mL}$

32. Color change at 7.502ml
 15.678ml 11.62 pH

— Jedi Alled —

nexient

TRIAL ONE (Monoprotic Acid) 0.1M HCl

38 drops NaOH Solution

2.65ml

25. Initial (5.35) 19.65ml
 Final (15.4) 9.60
 $\Delta V = 10.05 \text{ mL}$

32. When color change occurred, Volume was 8.996ml and pH 7.32.
 Final volume 11.64 pH at 16.736ml
 $C = 0.1 \text{ M HCl}$

TRIAL TWO (Monoprotic Acid) ~~0.1M HCl~~

32 drops NaOH solution

2.40ml

25. Initial (5.65) 19.35ml
 Final (15.9) 9.1ml
 $\Delta V = 10.25 \text{ mL}$

32. Color change at 8.627ml and pH 7.86
 18.305ml at 11.73 pH plateau.

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