

Introduction:

Acids and bases are chemical terms used in science to describe many substances such as the solutions in the following lab's acid-base titration. There are a number of characteristics which define acids and bases; acids are bitter substances, have a PH between 0 and 7 and give up an H^+ proton when dissolved in water. Bases, on the other hand, are bitter substances which, with PHs between 7 and 14; when dissolved in water, bases give up an OH^- ion. These donor properties can be seen by the following reaction equations:



Observe how the acid, HNO_3 , acts as a proton donor when in an aqueous form.



Here the base, $NaOH$, is also a donor in the presence of water but because it is a base it gives up its OH^- ion rather than an H^+ as seen in the case of acids (Venkateswaran).

Acids and bases vary in strength and acids and bases are usually referred to as either being weak or strong. Often time the strength of acids and bases can be determined by their concentrations, with high concentrations being strong and low concentrations being weak. Acids and bases at high concentration dissociate more quickly and more completely than those at lower concentration. This means that when a strong acid or base is added to water the H^+ protons and OH^- ions will dissociate faster than an acid or base at a lower concentration and that there will be less acid or base reactant remaining after a reaction with a strong acid or base than there would be with a weaker one.

Concentration of an acid or base can be calculated using the following equation:

$$C = n/V$$

In which C is concentration, measured in mol/L (M); n is the amount of solute, measured in moles (mol); and V is the volume of the solution, measured in liters (L).

When diluting an acid or a base the concentration or volume of either the concentrated or diluted solution can be calculated using the following equation:

$$C_C V_C = C_D V_D$$

In which C_C is the concentrated concentration or initial concentration, measured in mol/L (M); V_C is volume of the concentrated solution, measured in liters (L); and C_D and V_D concentration and volume of the diluted solution in the same units as their concentrated counterparts (Olmsted, Williams, Burk).

In a titration, acids and bases react with one another to form water and salt in what is known as a neutralisation reaction. When the exact amount of acid needed to neutralize a base (or vice versa) is added, causing the PH to become 0 this is known as an equivalent point (Venkateswaran).

Procedure:

Refer to lab manual for complete procedure (Venkateswaran).

Table 1. Formation of a stock solution of NaOH

Volume of concentrated NaOH solution (mL)	4.0mL
Concentration of concentrated NaOH solution (M)	6.0M
Volume of stock solution after dilution (mL)	250mL
Approximate concentration of stock solution (M)	0.10M

Table 2. Standardization of Stock Solution of NaOH

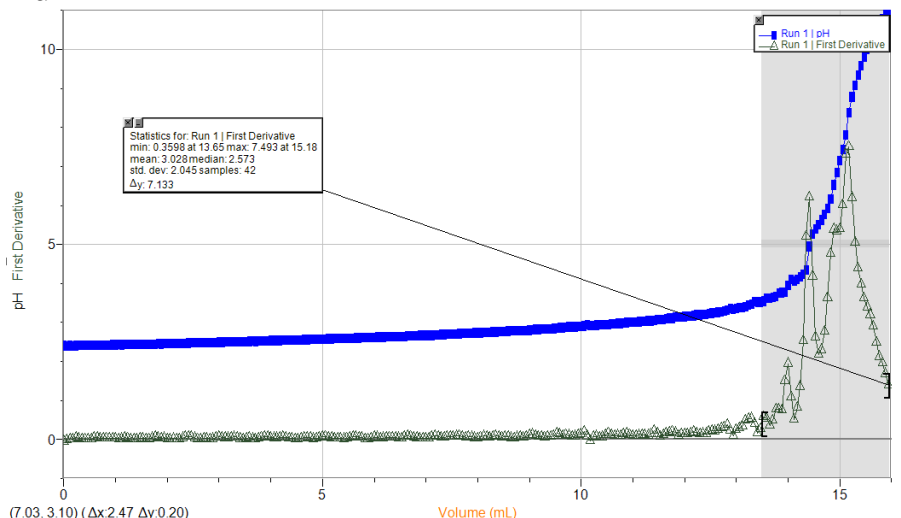
Data	Trial 1	Trial 2	Trial 3
Concentration of Standard Acid solution (M)	0.100M	0.100M	N/A
Volume of Standard Acid solution (mL)	10.0mL	10.0mL	N/A
Volume of stock solution of NaOH (mL)	48.0mL	45.0mL	N/A
Concentration of stock solution of NaOH (M)	0.0222M	0.0222M	N/A
Average Concentration of stock solution of NaOH (M)	0.0215M		

Table 5. Partial Representation of Data Collected from Standardized Stock Solution of NaOH Titration

Run 1			Run 2		
Volume (mL)	PH	f'	Volume (mL)	PH	f'
0.0000	2.4070	-0.0431	0.0000	2.4444	0.0000
0.0588	2.4024	-0.0086	0.0588	2.4444	0.0000
0.1176	2.4070	0.0027	0.1176	2.4444	0.0000
0.1765	2.4024	0.0156	0.1765	2.4444	0.0066
0.2353	2.4070	0.0514	0.2353	2.4444	0.0220
0.2941	2.4118	0.0363	0.2941	2.4444	0.0704
0.3529	2.4118	0.0113	0.3529	2.4583	0.0372
0.4118	2.4118	0.0023	0.4118	2.4489	-0.0016
0.4706	2.4118	0.0043	0.4706	2.4538	0.0208
0.5294	2.4118	0.0173	0.5294	2.4538	0.0133
0.5882	2.4118	0.0561	0.5882	2.4538	0.0282
0.6471	2.4209	0.0584	0.6471	2.4583	0.0237
0.7059	2.4209	0.0264	0.7059	2.4583	-0.0022
0.7647	2.4209	0.0363	0.7647	2.4538	0.0302
0.8235	2.4258	0.0384	0.8235	2.4629	0.0474
0.8824	2.4258	0.0394	0.8824	2.4629	0.0151
0.9412	2.4304	0.0368	0.9412	2.4629	0.0043
1.0000	2.4304	0.0302	1.0000	2.4629	0.0000
1.0588	2.4349	0.0131	1.0588	2.4629	0.0044
1.1176	2.4304	0.0178	1.1176	2.4629	0.0156
1.1765	2.4349	0.0514	1.1765	2.4629	0.0492
1.2353	2.4398	0.0363	1.2353	2.4723	0.0298
1.2941	2.4398	0.0113	1.2941	2.4678	-0.0081
1.3529	2.4398	0.0044	1.3529	2.4678	0.0066
1.4118	2.4398	0.0086	1.4118	2.4678	0.0345
1.4706	2.4398	0.0280	1.4706	2.4723	0.0561
1.5294	2.4444	0.0280	1.5294	2.4769	0.0390
1.5882	2.4444	0.0108	1.5882	2.4769	0.0199
1.6471	2.4444	0.0152	1.6471	2.4769	0.0319

Graph 1. Standardized Stock Solution of NaOH Titration, PH & First Derivative vs. Volume (mL)

Run 1



Graph 2. Standardized Stock Solution of NaOH Titration, PH & First Derivative vs. Volume (mL)

Run 2

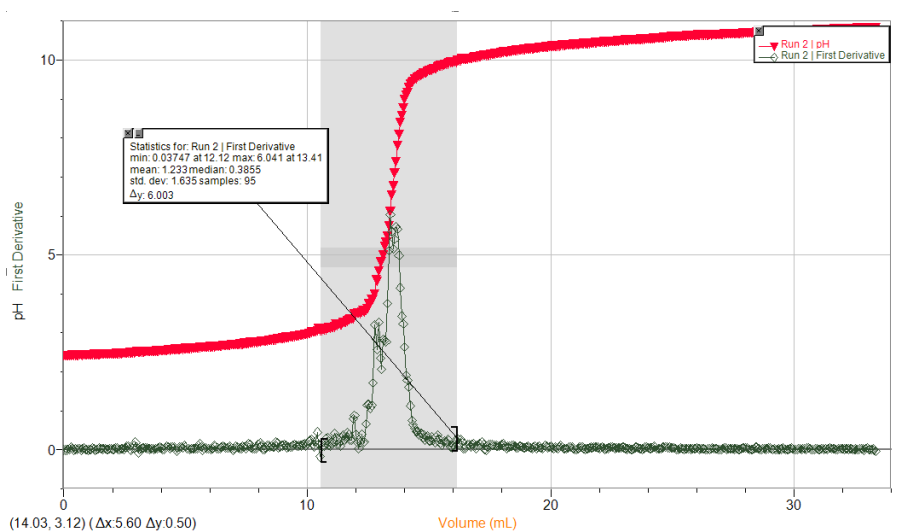


Table 3. Determination of the Concentration of an Unknown Acid

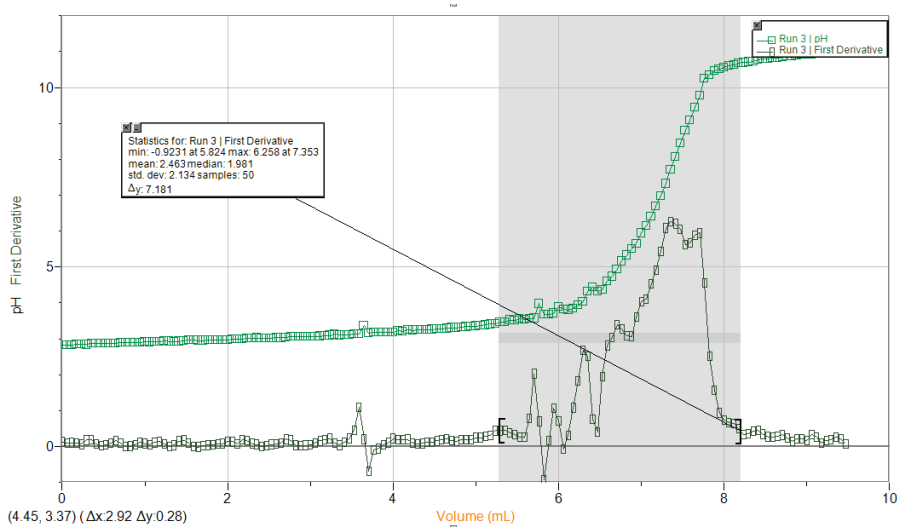
Data	Trial 1	Trial 2	Trial 3
Sample Number of Unknown Acid	4	4	N/A
Volume of Unknown Acid solution (mL)	10.0mL	10.0mL	N/A
Volume of stock solution of NaOH (mL)	6.82mL	7.00mL	N/A

Concentration of stock solution of NaOH (M)	0.096M	0.096M	N/A
Concentration of Unknown Acid Solution (M)	0.032M	0.034M	N/A
Average Concentration of Unknown Acid solution (M)	0.033M		

Table 6. Partial Representation of Data Collected from Unknown Acid Titration

Run 3			Run 4		
Volume (mL)	PH	f'	Volume (mL)	PH	f'
0.0000	2.8171	0.1289	0.0000	2.8360	-0.0412
0.0588	2.8266	0.1008	0.0588	2.8311	0.0000
0.1176	2.8266	0.1033	0.1176	2.8360	0.0258
0.1765	2.8405	0.0971	0.1765	2.8360	0.0241
0.2353	2.8405	0.0598	0.2353	2.8360	0.0716
0.2941	2.8360	0.1783	0.2941	2.8451	0.1089
0.3529	2.8685	0.1911	0.3529	2.8451	0.1868
0.4118	2.8685	0.0615	0.4118	2.8731	0.1696
0.4706	2.8685	0.0263	0.4706	2.8731	0.0379
0.5294	2.8685	0.0481	0.5294	2.8685	0.0355
0.5882	2.8731	0.0972	0.5882	2.8731	0.0927
0.6471	2.8779	0.1631	0.6471	2.8825	0.1130
0.7059	2.9011	0.0972	0.7059	2.8919	0.0458
0.7647	2.8919	-0.0080	0.7647	2.8871	-0.0140
0.8235	2.8919	0.0089	0.8235	2.8871	-0.0152
0.8824	2.8919	0.0480	0.8824	2.8825	0.0355
0.9412	2.8965	0.1074	0.9412	2.8871	0.1437
1.0000	2.9105	0.0795	1.0000	2.9059	0.1502
1.0588	2.9059	0.0530	1.0588	2.9105	0.0702
1.1176	2.9105	0.1080	1.1176	2.9105	0.0353
1.1765	2.9199	0.1388	1.1765	2.9105	0.0600
1.2353	2.9339	0.0696	1.2353	2.9199	0.0600
1.2941	2.9290	-0.0094	1.2941	2.9199	0.0286
1.3529	2.9245	0.0373	1.3529	2.9199	0.0390
1.4118	2.9290	0.1500	1.4118	2.9245	0.0519
1.4706	2.9479	0.1760	1.4706	2.9290	0.0264
1.5294	2.9570	0.0852	1.5294	2.9245	0.0427
1.5882	2.9570	0.0003	1.5882	2.9339	0.0600
1.6471	2.9524	-0.0151	1.6471	2.9339	0.0481

**Graph 3. Unknown Acid Titration, PH & First Derivative vs. Volume (mL)
Run 3**



**Graph 4. Unknown Acid Titration, PH & First Derivative vs. Volume (mL)
 Run 4**

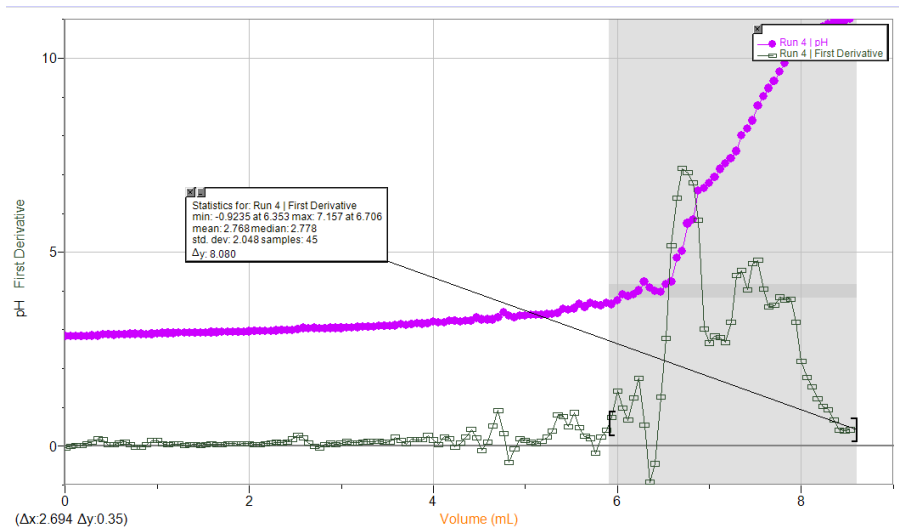


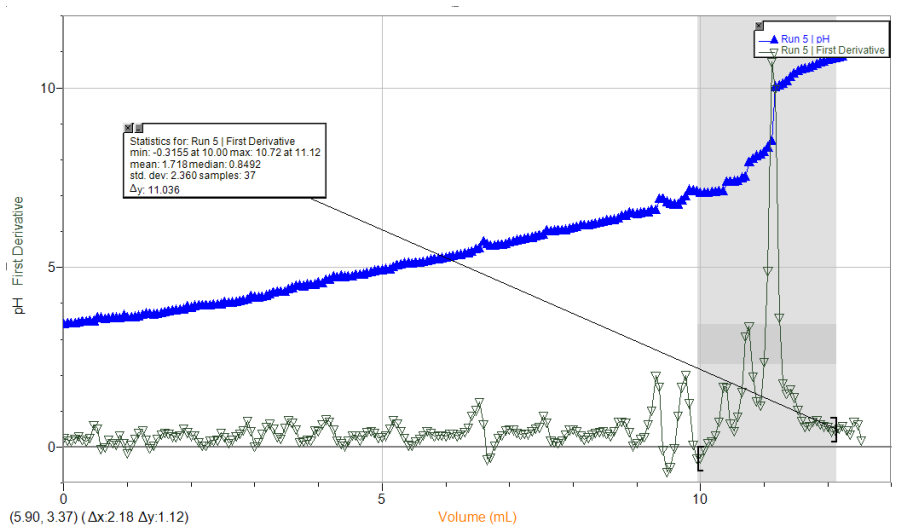
Table 4. Determination of the Mass Percentage of Acid in a Juice

Data	Trial 1	Trial 2	Trial 3
Sample Number of Juice	1	1	1
Volume of Juice (mL)	10.0mL	10.0mL	10.0mL
Volume of stock solution of NaOH (mL)	11.0mL	10.0mL	9.3mL
Concentration of stock solution of NaOH (M)	0.096M	0.096M	0.096M
Concentration of acid in Juice (M)	0.035M	0.032M	0.030M
Average Concentration of Acid in Juice (M)	0.032M		
Density of Juice (g/mL)	1.0003g/mL		
Molar Mass of acid in Juice (g/mol)	192.14g/mol		
Mass Percent of Acid in Juice (%)	0.615%		

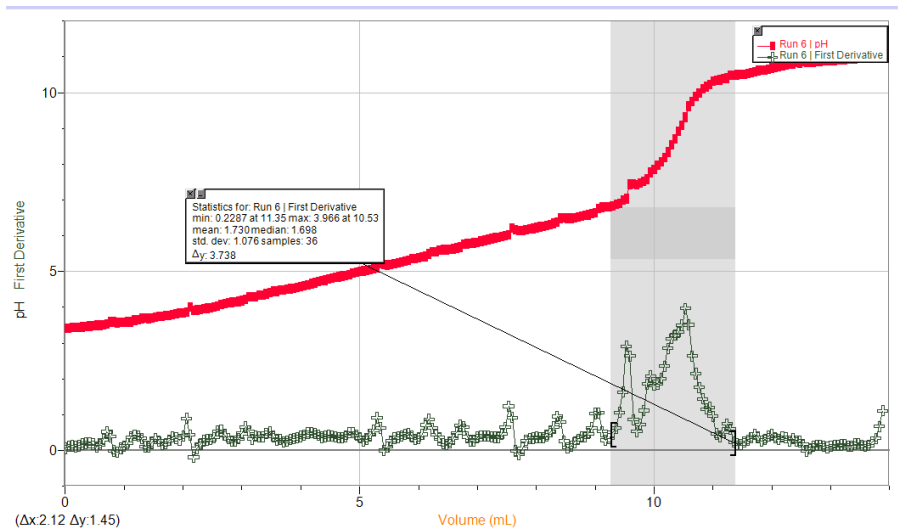
Table 7. Partial Representation of Data Collected from Acid in Juice Titration

Run 5			Run 6			Run 7		
Volume (mL)	PH	f	Volume (mL)	PH	f	Volume (mL)	PH	f
0.0000	3.3906	0.2548	0.0000	3.4186	0.0572	0.0000	3.4651	0.2267
0.0588	3.4091	0.1973	0.0588	3.4186	0.1111	0.0588	3.4839	0.1231
0.1176	3.4140	0.1772	0.1176	3.4326	0.1305	0.1176	3.4839	0.0363
0.1765	3.4231	0.2402	0.1765	3.4371	0.1081	0.1765	3.4791	0.0786
0.2353	3.4420	0.3044	0.2353	3.4420	0.1320	0.2353	3.4885	0.1934
0.2941	3.4699	0.2061	0.2941	3.4511	0.1798	0.2941	3.5071	0.2375
0.3529	3.4651	0.1599	0.3529	3.4651	0.2006	0.3529	3.5210	0.2031
0.4118	3.4791	0.2580	0.4118	3.4745	0.2116	0.4118	3.5305	0.1748
0.4706	3.4745	0.6109	0.4706	3.4931	0.1747	0.4706	3.5399	0.1608
0.5294	3.5818	0.5136	0.5294	3.4979	0.1023	0.5294	3.5444	0.2085
0.5882	3.5679	-0.0510	0.5882	3.4979	0.1632	0.5882	3.5770	0.0993
0.6471	3.5305	0.0040	0.6471	3.5119	0.3038	0.6471	3.5539	0.0311
0.7059	3.5584	0.2095	0.7059	3.5259	0.5215	0.7059	3.5584	0.2638
0.7647	3.5818	0.1213	0.7647	3.5958	0.3932	0.7647	3.6004	0.2924
0.8235	3.5679	0.0631	0.8235	3.5910	-0.0135	0.8235	3.6050	0.1520
0.8824	3.5630	0.3298	0.8824	3.5679	-0.0485	0.8824	3.6004	0.2321
0.9412	3.6424	0.1130	0.9412	3.5770	0.0594	0.9412	3.6378	0.2383
1.0000	3.5818	-0.1693	1.0000	3.5818	0.1233	1.0000	3.6378	0.1295
1.0588	3.5864	0.0594	1.0588	3.5910	0.1917	1.0588	3.6424	0.1667
1.1176	3.5958	0.2331	1.1176	3.5958	0.3703	1.1176	3.6563	0.2243
1.1765	3.6144	0.4041	1.1765	3.6424	0.4336	1.1765	3.6703	0.2727
1.2353	3.6469	0.4596	1.2353	3.6518	0.3956	1.2353	3.6889	0.3064
1.2941	3.6889	0.2074	1.2941	3.6889	0.3336	1.2941	3.7077	0.3085
1.3529	3.6703	-0.0255	1.3529	3.7029	0.1076	1.3529	3.7263	0.2901
1.4118	3.6658	0.0464	1.4118	3.6889	0.0880	1.4118	3.7448	0.2314
1.4706	3.6703	0.2329	1.4706	3.7029	0.2204	1.4706	3.7497	0.2380
1.5294	3.6983	0.3607	1.5294	3.7169	0.3332	1.5294	3.7682	0.3099
1.5882	3.7169	0.4056	1.5882	3.7542	0.2631	1.5882	3.7868	0.3767
1.6471	3.7497	0.3751	1.6471	3.7497	0.1569	1.6471	3.8196	0.3480

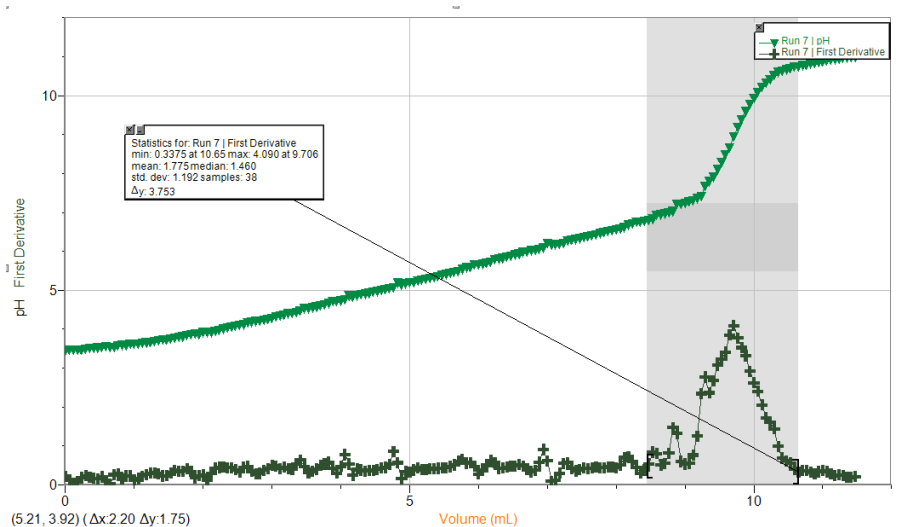
**Graph 5. Acid in Juice Titration, PH & First Derivative vs. Volume (mL)
Run 5**



**Graph 6. Acid in Juice Titration, PH & First Derivative vs. Volume (mL)
Run 6**



Graph 7. Acid in Juice Titration, PH & First Derivative vs. Volume (mL) Run 7*



*Run 7, a third run of the Acid in Juice titration was performed to verify accuracy of visual results which had been recorded in Runs 5 and 6.

Observations (all parts of the experiment):

All solutions used throughout the lab, water, NaOH solution, mystery acid and mystery juice, were transparent and colourless liquids. It was only after the equilibrium point of the titrations were reached that the solution turned bright fuchsia, this was because of the presence of phenolphthalein, an indicator that was added prior to titration. As the titration progresses and the solution began to neutralize, the water slowly began to show pale pink until the entire solution very quickly turned dark fuchsia. The density of the mystery juice was recorded to be 1.0003g/cm^3 .

Sample Calculation: (Part 1)



1. Approximate concentration of stock solution

$$C_c V_c = C_D V_D$$

$$(6.0 \text{ mol/L})(0.0040\text{L}) = C_D(0.250) \text{ L}$$

$$C_D = 0.096 \text{ mol/L}$$

$$C_D = 0.1 \text{ mol/L}$$

Sample Calculation: (Part 2)



1. Exact concentration of stock solution:

Standard Acid Run 1: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$C_{\text{base}}(0.0480 \text{ L}) = (1/1)(0.1000 \text{ mol/L})(0.0100 \text{ L})$$

$$C_{\text{base}} = 0.0208 \text{ mol/L}$$

Standard Acid Run 1: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$C_{\text{base}}(0.0152 \text{ L}) = (1/1)(0.1000 \text{ mol/L})(0.0100 \text{ L})$$

$$C_{\text{base}} = 0.0658 \text{ mol/L}$$

Standard Acid Run 2: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$C_{\text{base}}(0.0450 \text{ L}) = (1/1)(0.1000 \text{ mol/L})(0.0100 \text{ L})$$

$$C_{\text{base}} = 0.0222 \text{ mol/L}$$

Standard Acid Run 2: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$C_{\text{base}}(0.0134 \text{ L}) = (1/1)(0.1000 \text{ mol/L})(0.0100 \text{ L})$$

$$C_{\text{base}} = 0.0746 \text{ mol/L}$$

2. Average concentration of stock solution:

Observed:

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

$$C_{\text{av}} = (0.0208 \text{ mol/L} + 0.0222 \text{ mol/L})/2$$

$$C_{\text{av}} = 0.0215 \text{ mol/L}$$

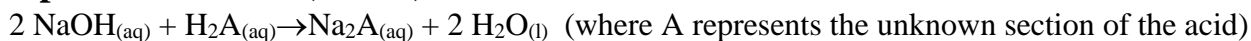
Exact:

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

$$C_{\text{av}} = (0.0658 \text{ mol/L} + 0.0746 \text{ mol/L})/2$$

$$C_{\text{av}} = 0.0702 \text{ mol/L}$$

Sample Calculation: (Part 3)



1. Concentration of Unknown Acid:

Run 3: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$(0.096 \text{ mol/L})(0.0068 \text{ L}) = (2/1)C_{\text{acid}}(0.0100 \text{ L})$$

$$C_{\text{acid}} = 0.032 \text{ mol/L}$$

Run 3: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$

$$(0.096 \text{ mol/L})(0.0074 \text{ L}) = (2/1)C_{\text{acid}}(0.0100 \text{ L})$$

$$C_{\text{acid}} = 0.036 \text{ mol/L}$$

Run 4: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0070 \text{ L}) = (2/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.034 \text{ mol/L}$$

Run 4: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0067 \text{ L}) = (2/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.032 \text{ mol/L}$$

2. Average concentration of unknown acid: (using exact values)

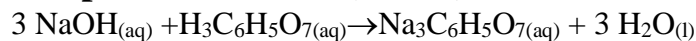
Observed:

$$C_{\text{av}} = (C_1 + C_2)/2$$
$$C_{\text{av}} = (0.032 \text{ mol/L} + 0.034 \text{ mol/L})/2$$
$$C_{\text{av}} = 0.033 \text{ mol/L}$$

Exact:

$$C_{\text{av}} = (C_1 + C_2)/2$$
$$C_{\text{av}} = (0.036 \text{ mol/L} + 0.032 \text{ mol/L})/2$$
$$C_{\text{av}} = 0.034 \text{ mol/L}$$

Sample Calculation: (Part 4)



1. Concentration of acid in juice:

Run 5: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0110 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.035 \text{ mol/L}$$

Run 5: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0111 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.036 \text{ mol/L}$$

Run 6: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0100 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.032 \text{ mol/L}$$

Run 6: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0105 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.034 \text{ mol/L}$$

Run 7: Observed

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0093 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.030 \text{ mol/L}$$

Run 7: Exact

$$C_{\text{base}}V_{\text{base}} = (b/a)C_{\text{acid}}V_{\text{acid}}$$
$$(0.096 \text{ mol/L})(0.0097 \text{ L}) = (3/1)C_{\text{acid}}(0.0100 \text{ L})$$
$$C_{\text{acid}} = 0.031 \text{ mol/L}$$

2. Average concentration of acid in juice :

Observed:

$$C_{\text{av}} = (C_1 + C_2 + C_3)/2$$
$$C_{\text{av}} = (0.035 \text{ mol/L} + 0.032 \text{ mol/L} + 0.030)/3$$
$$C_{\text{av}} = 0.032 \text{ mol/L}$$

Exact:

$$C_{\text{av}} = (C_1 + C_2 + C_3)/2$$
$$C_{\text{av}} = (0.036 \text{ mol/L} + 0.034 \text{ mol/L} + 0.031)/3$$
$$C_{\text{av}} = 0.034 \text{ mol/L}$$

3. Mass percentage of acid in juice:

Observed:

$$\text{mass \% of acid in juice} = [(C_{\text{acid}})(MM_{\text{acid}})]/[(d_{\text{juice}})(1000)]100\%$$
$$\text{mass \% of acid in juice} = [(0.032 \text{ mol/L})(192.14 \text{ g/mol})]/[(1.0003 \text{ g/mL})1000]100\%$$
$$\text{mass \% of acid in juice} = 0.615 \%$$

Exact:

$$\text{mass \% of acid in juice} = [(C_{\text{acid}})(MM_{\text{acid}})]/[(d_{\text{juice}})(1000)]100\%$$
$$\text{mass \% of acid in juice} = [(0.034 \text{ mol/L})(192.14 \text{ g/mol})]/[(1.0003 \text{ g/mL})1000]100\%$$
$$\text{mass \% of acid in juice} = 0.647\%$$

Discussion:

Both volume and concentration measurements are critical components when performing accurate titrations. This is emphasized by the extreme precision used during the lab as photogates, specialized software, and very precise burets were all tools used during the lab. Additionally, every calculation performed in this lab included both volume and concentrations recorded during the experiment. The concentration of NaOH must be determined before proceeding with any other lab calculations because the stock solution is incorporated in each section of the lab, this would make the concentrations of the mystery acid and juice impossible to determine making the lab fruitless.

There is a factor of 1000 included in the equation for the mass percent of acid in the mystery juice because the equation contains a density measured in g/mL to g/L because the concentration deals in liters rather than milliliters and units must be consistent when together in the same equation.

In the first set of titrations, the standardization of the stock solutions, the observed results were consistent however they were vastly different from the results determined by Logger Pro. However for the mystery acid and mystery juice titrations the observed results were so similar to those determined by Logger Pro that the difference between the two sets of data could be considered insignificant. It is believed that as the experimenters became more confident and efficient in titrating throughout the progression of the lab that the accuracy of the observations made improved.

The most source of error is human error as seen in Part 2. The experiment requires one to be able to record the exact volume at which the solution turns dark pink however because this is a gradual change and there is no reference for the exact darkness of the colour it is impossible to get infallible data while doing titrations by eye.

Conclusion:

In conclusion, the stock solution was determined to have an approximate concentration of 0.1M and used throughout the three sections of the lab. The concentrations of the standardized stock solution were calculated to be 0.0658M and 0.0746M to produce an average concentration on 0.0702M. The mystery acid #4 was calculated to have a concentration of 0.036M and 0.032M averaging to a concentration of 0.034M. Finally the concentration of mystery juice #1 was calculated to be 0.036M, 0.034M and 0.031M producing an average of 0.034M and a mass % acid in juice of 0.647%. These results were obtained through the use of concentration equations and acid-base knowledge outlined in the Introduction section of the lab report.

Logger Pro - c23*

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	Run 1		Run 2		Run 3		Run 4		Run 5		Run 6		Run 7		Run 8	
	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	2.41	0.000	2.44	0.000	2.82	0.000	2.84	0.000	3.39	0.000	3.42	0.000	3.47		
2	0.059	2.40	0.059	2.44	0.059	2.83	0.059	2.83	0.059	3.41	0.059	3.42	0.059	3.48		
3	0.118	2.41	0.118	2.44	0.118	2.83	0.118	2.84	0.118	3.41	0.118	3.43	0.118	3.48		
4	0.176	2.40	0.176	2.44	0.176	2.84	0.176	2.84	0.176	3.42	0.176	3.44	0.176	3.48		
5	0.235	2.41	0.235	2.44	0.235	2.84	0.235	2.84	0.235	3.44	0.235	3.44	0.235	3.49		
6	0.294	2.41	0.294	2.44	0.294	2.84	0.294	2.85	0.294	3.47	0.294	3.45	0.294	3.51		
7	0.353	2.41	0.353	2.46	0.353	2.87	0.353	2.85	0.353	3.47	0.353	3.47	0.353	3.52		
8	0.412	2.41	0.412	2.45	0.412	2.87	0.412	2.87	0.412	3.48	0.412	3.47	0.412	3.53		
9	0.471	2.41	0.471	2.45	0.471	2.87	0.471	2.87	0.471	3.47	0.471	3.49	0.471	3.54		
10	0.529	2.41	0.529	2.45	0.529	2.87	0.529	2.87	0.529	3.58	0.529	3.50	0.529	3.54		
11	0.588	2.41	0.588	2.45	0.588	2.87	0.588	2.87	0.588	3.57	0.588	3.50	0.588	3.58		
12	0.647	2.42	0.647	2.46	0.647	2.88	0.647	2.88	0.647	3.53	0.647	3.51	0.647	3.55		
13	0.706	2.42	0.706	2.46	0.706	2.90	0.706	2.89	0.706	3.56	0.706	3.53	0.706	3.56		
14	0.765	2.42	0.765	2.45	0.765	2.89	0.765	2.89	0.765	3.58	0.765	3.60	0.765	3.60		
15	0.824	2.43	0.824	2.46	0.824	2.89	0.824	2.89	0.824	3.57	0.824	3.59	0.824	3.60		
16	0.882	2.43	0.882	2.46	0.882	2.89	0.882	2.88	0.882	3.56	0.882	3.57	0.882	3.60		
17	0.941	2.43	0.941	2.46	0.941	2.90	0.941	2.89	0.941	3.64	0.941	3.58	0.941	3.64		
18	1.000	2.43	1.000	2.46	1.000	2.91	1.000	2.91	1.000	3.58	1.000	3.58	1.000	3.64		
19	1.059	2.43	1.059	2.46	1.059	2.91	1.059	2.91	1.059	3.59	1.059	3.59	1.059	3.64		
20	1.118	2.43	1.118	2.46	1.118	2.91	1.118	2.91	1.118	3.60	1.118	3.60	1.118	3.66		
21	1.176	2.43	1.176	2.46	1.176	2.92	1.176	2.91	1.176	3.61	1.176	3.64	1.176	3.67		
22	1.235	2.44	1.235	2.47	1.235	2.93	1.235	2.92	1.235	3.65	1.235	3.65	1.235	3.69		
23	1.294	2.44	1.294	2.47	1.294	2.93	1.294	2.92	1.294	3.69	1.294	3.69	1.294	3.71		
24	1.353	2.44	1.353	2.47	1.353	2.92	1.353	2.92	1.353	3.67	1.353	3.70	1.353	3.73		
25	1.412	2.44	1.412	2.47	1.412	2.93	1.412	2.92	1.412	3.67	1.412	3.69	1.412	3.74		
26	1.471	2.44	1.471	2.47	1.471	2.95	1.471	2.93	1.471	3.67	1.471	3.70	1.471	3.75		
27	1.529	2.44	1.529	2.48	1.529	2.96	1.529	2.92	1.529	3.70	1.529	3.72	1.529	3.77		
28	1.588	2.44	1.588	2.48	1.588	2.96	1.588	2.93	1.588	3.72	1.588	3.75	1.588	3.79		
29	1.647	2.44	1.647	2.48	1.647	2.96	1.647	2.93	1.647	3.75	1.647	3.75	1.647	3.80		

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