Experiment Title: Acid-Base Titrations

Author's Name:

Submitting Author's Partner:

TA (Demonstrator)'s Name:

Date Experiment Performed: November 1, 2019

Date Experiment Submitted: November 8, 2019

Introduction:

This lab-based upon the idea of acid-base titrations. This is a systematic process where a known concentration of an acid or a base, which can be used to solve for an unknown concentration of an acid which is added a solution until equilibrium has been reached. Equilibrium is the state in which the number of moles of the acid and the base is equal, at this point in the experiment the titration is complete. In an attempt to understand this process, the Bronsted-Lowry Theory and the Lewis Acid-Base Theory derive an excellent explanation. These theories are used to distinguish acid and bases. Through the Lewis Acid-Base Theory, acids are described as something that accepts electron pairs (electron acceptor)However, bases lose electron pairs (electron donor). Essentially, the Bronsted-Lowry Theory explains that acid will donate a proton and that a base will accept a proton.

Procedure:

Followed from the lab manual: Dr. R. Venkateswaran, "Oh How Bitter a Thing It is" Acid-Base Titrations.

Discussion:

1. Does it matter what volume of concentrated NaOH you use in the beginning?

the volume of concentrated NaOH that is used during the beginning does not matter since it is diluted in a volume of a concentrated solution along with distilled water, creating a new solution. The initial volume of concentration is irrelevant because the NaOH was diluted with H2O producing a stock solution.

2. Why do we determine the concentration of the NaOH just before we use it?

the concentration of NaOH is determined just before it is used, so that the equation C1V1=C2V2 is equal. This allows the concentration of NaOH to be found so that the concentration of the unknown acid can be identified

3. How do the volumes at equivalence point determined by Logger Pro compare to the volumes at which you observed the color change (endpoint)?

The volume at the equivalence point is determined when the color changed from transparent to a light purple/ pink , while using the color indicator method. However, using Logger Pro has much more accuracy,

since the color indicator method may not have calculated the volume of the solution at its fully achieved equivalency.

4. What are the sources of error inherent in the experiment? How does each source of error contribute to the result (ie. does it increase or decrease the value of the concentration?)

Sources of error in the experiment occurred while using LabQuest 2, could be that the lab quest would accidentally get paused before the drops stopped, leaving more drops added to the mixture than recorded As well, the way we had our beaker placed under the dropper, was positioned in a way that some drops could have possibly been hitting the side of the beaker. Meaning some of the drops were possibly being recorded but not fully-added to the solution.

5. ADDITIONAL: in the titration of the unknown acid ONLY, for the following amounts of the added base, DRAW the species you expect to have in solution. If there are MORE than one species, you can indicate them all and their approximate ratios. Explain WHY you expect to see those species in those ratios. (you can draw the molecule/ion or write its chemical formula)

a) At 0 mL of added base

The only species are H2C6H5O7(aq), and H3O+(aq)

b) At midway to the first equivalence point

Very little NaOH due to it being a strong base

Little Na, H2C6H5O7-(aq), Na+(aq), H20(l) and OH-.

c) At the first equivalence point

Only NaOH (aq), H2C6H5O7-(aq), Na+ (aq), H20 (l)

d) At midway to the second equivalence point

Species are H2C6H5O7 HC6H5O7 Na and H20

e) At the second equivalence point

HC6H5O7, Na+, and H20 are present

No protons donated as it is at the equivalence point

Conclusion:

- The average concentration of NaOH was 0.05M. Using said data,
- the average concentration of the unknown acid was 0.05M.

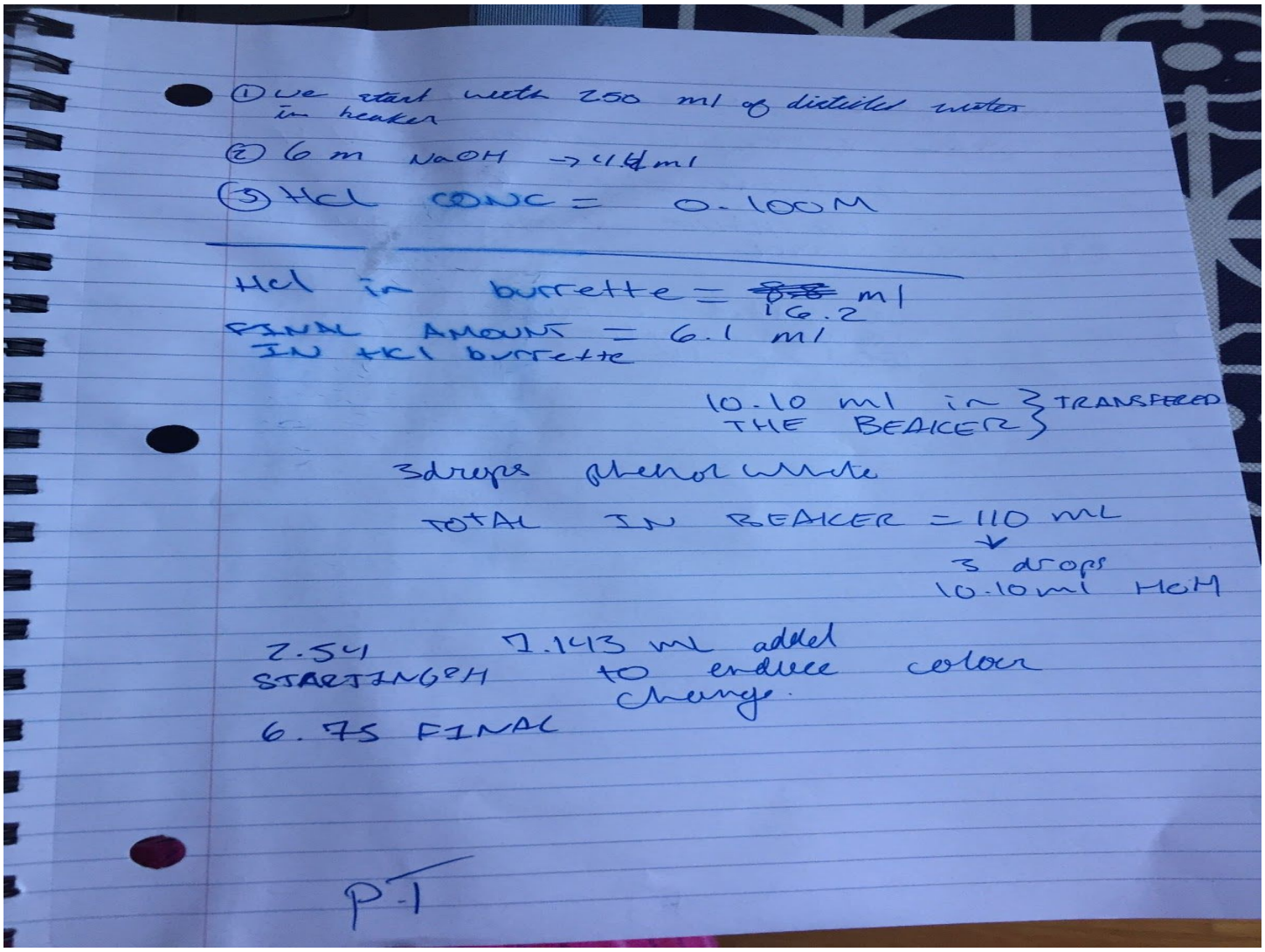
Reference(s):

“What in the World ISN’T Chemistry”, General Chemistry Laboratory Manual, Dr. Rashmi

Venkateswaran, 2019

Appendix:

Raw Data



① we start with 250 ml of distilled water in beaker

② 6 m NaOH → 4.4 ml

③ HCl CONC = 0.100 M

HCl in burrette = ~~0.00~~ 16.2 ml

FINAL AMOUNT = 6.1 ml
IN HCl burrette

10.10 ml in } TRANSFERED
THE BEAKER }

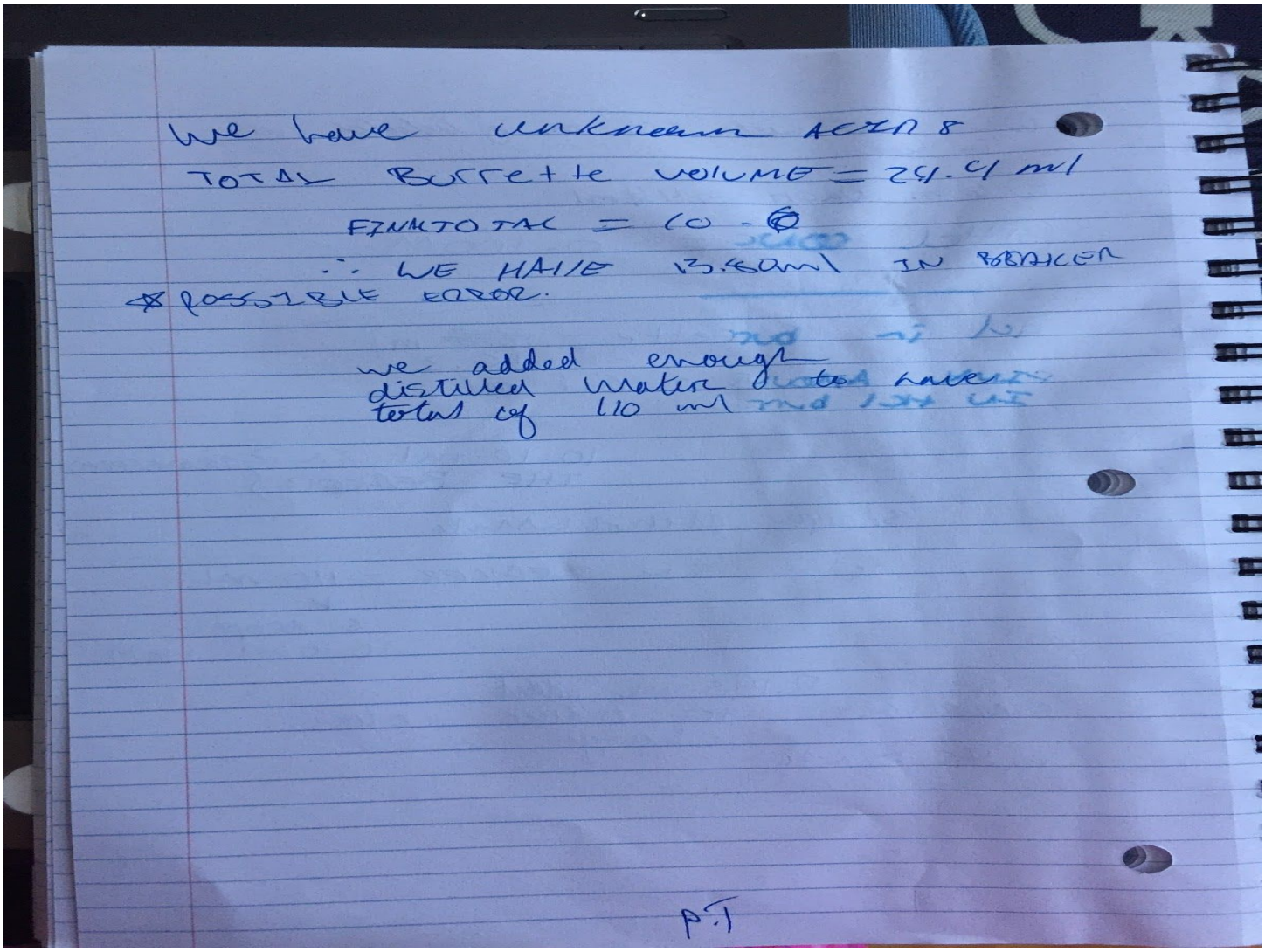
3 drops phenolphthalein

TOTAL IN BEAKER = 110 mL
↓
3 drops
10.10 ml HCl

2.54 STARTING pH — 7.143 mL added to endure colour change.

6.75 FINAL

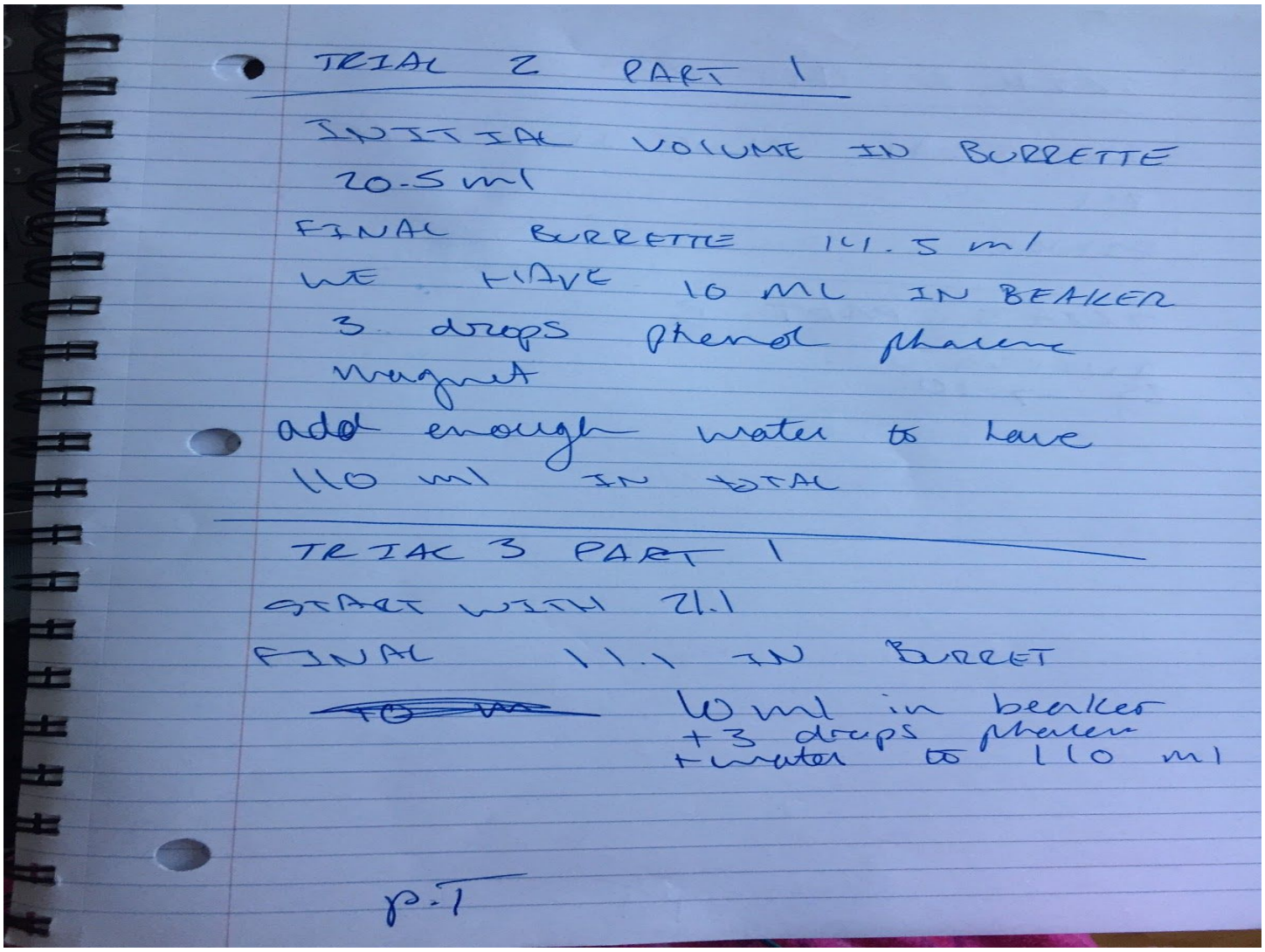
P.1



We have unknown ACID 8
TOTAL Burette volume = 24.4 ml
FINAL TOTAL = 10 - 0
∴ WE HAVE 13.6 ml IN BEAKER
* POSSIBLE ERROR.

we added enough distilled water to have a total of 110 ml

P.T



TRIAL 2 PART 1

INITIAL VOLUME IN BURRETTE
20.5 ml

FINAL BURRETTE 141.5 ml

WE HAVE 10 ML IN BEAKER
3 drops phenol pharem
magnet

add enough water to have
110 ml IN TOTAL

TRIAL 3 PART 1

START WITH 21.1

FINAL 111.1 IN BURRET

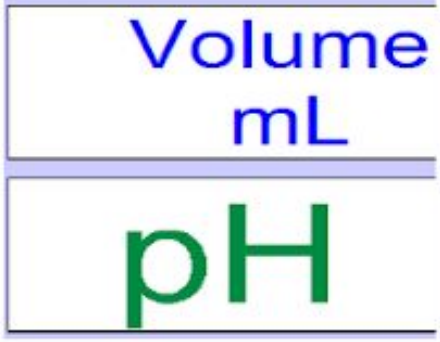
~~10~~ 10 ml in beaker
+3 drops phenol
+water to 110 ml

p.1

Additional Data

Trial 1 -HCL

	Run 1		
	Volume (mL)	pH	Vo (r
1	0.000	2.54	
2	0.057	2.55	
3	0.114	2.58	
4	0.171	2.56	
5	0.229	2.56	
6	0.286	2.62	
7	0.343	2.58	
8	0.400	2.58	
9	0.457	2.59	
10	0.514	2.58	
11	0.571	2.64	
12	0.629	2.58	
13	0.686	2.71	
14	0.743	2.60	
15	0.800	2.62	
16	0.857	2.64	
17	0.914	2.61	
18	0.971	2.63	
19	1.029	2.61	
20	1.086	2.62	
21	1.143	2.62	

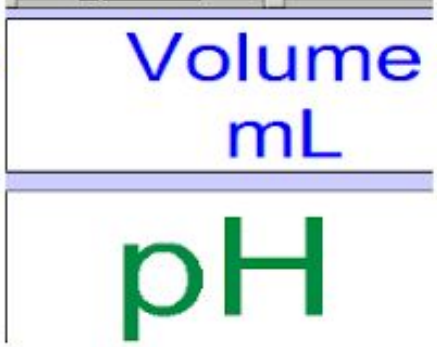


Initial pH

	Run 1		
	Volume (mL)	pH	Vo (r
113	6.400	4.24	
114	6.457	4.23	
115	6.514	4.45	
116	6.571	4.34	
117	6.629	4.24	
118	6.686	4.07	
119	6.743	4.09	
120	6.800	4.22	
121	6.857	4.56	
122	6.914	5.38	
123	6.971	5.67	
124	7.029	5.96	
125	7.086	6.42	
126	7.143	6.75	
127	7.200	7.14	
128	7.257	8.91	
129	7.314	8.94	
130	7.371	9.21	
131	7.429	9.35	
132	7.486	9.47	
133	7.543	9.61	

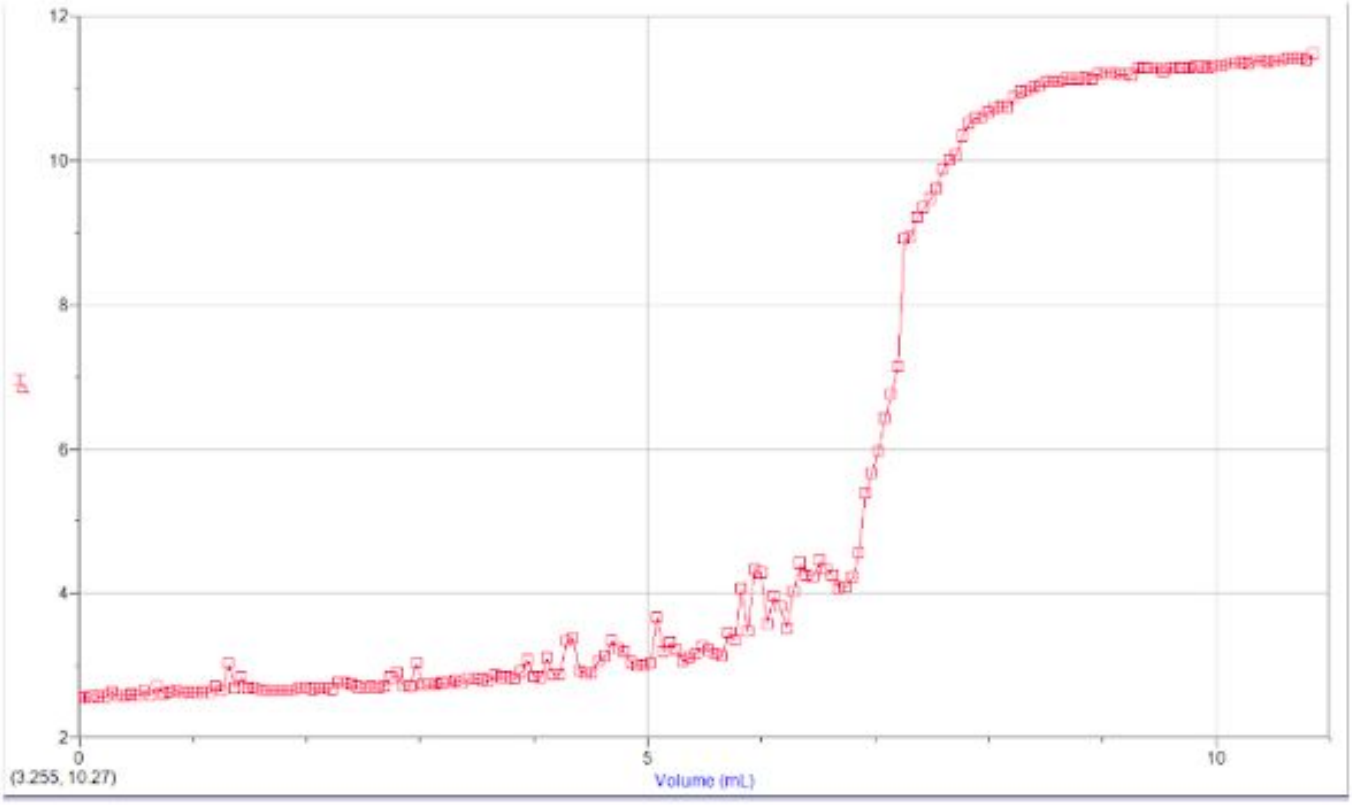
pH at colour change

	Run 1		
	Volume (mL)	pH	Vol (n
172	9.771	11.29	
173	9.829	11.30	
174	9.886	11.29	
175	9.943	11.29	
176	10.000	11.31	
177	10.057	11.32	
178	10.114	11.35	
179	10.171	11.35	
180	10.229	11.36	
181	10.286	11.34	
182	10.343	11.37	
183	10.400	11.38	
184	10.457	11.37	
185	10.514	11.37	
186	10.571	11.38	
187	10.629	11.41	
188	10.686	11.41	
189	10.743	11.41	
190	10.800	11.39	
191	10.857	11.47	
192			



Final pH

Colour change (approximation): pH=6.75 vol=7.143mL

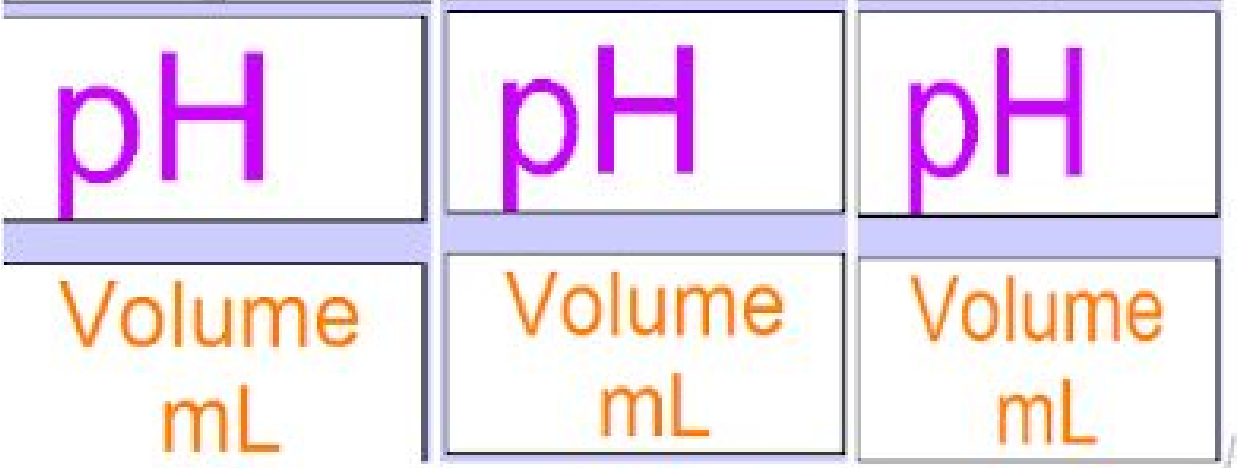

12
10
8
6
4
2
0
5
10
(3.255, 10.27)
Volume (mL)

Trial 2 -HCL

	Run 1	
	Volume (mL)	pH
1	0.000	2.62
2	0.036	2.62
3	0.071	2.62
4	0.107	2.61
5	0.143	2.63
6	0.179	2.74
7	0.214	2.63
8	0.250	2.62
9	0.286	2.64
10	0.321	2.64
11	0.357	2.64
12	0.393	2.64
13	0.429	2.65
14	0.464	2.65
15	0.500	2.64
16	0.536	2.66
17	0.571	2.74
18	0.607	2.66
19	0.643	2.66
20	0.679	2.66
21	0.714	2.68

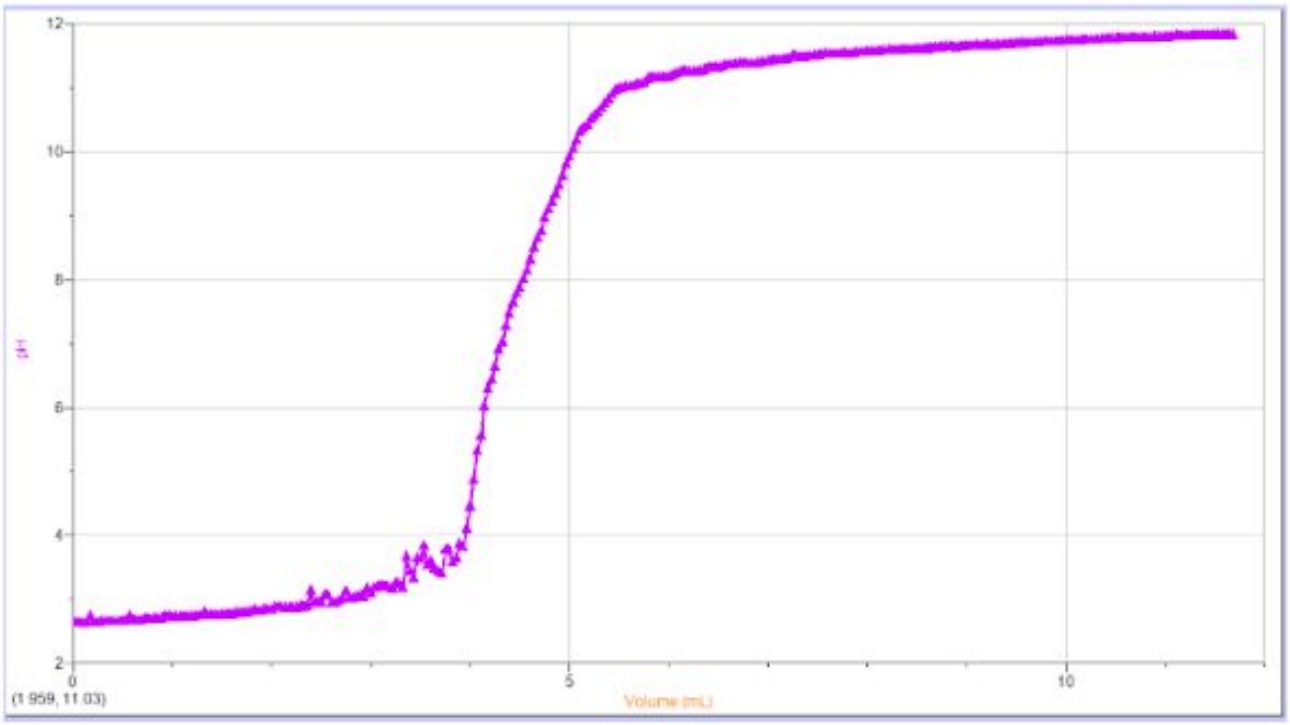
	Run 1	
	Volume (mL)	pH
113	4.000	4.44
114	4.036	4.86
115	4.071	5.31
116	4.107	5.55
117	4.143	6.02
118	4.179	6.27
119	4.214	6.43
120	4.250	6.63
121	4.286	6.89
122	4.321	7.02
123	4.357	7.27
124	4.393	7.46
125	4.429	7.63
126	4.464	7.78
127	4.500	7.87
128	4.536	8.00
129	4.571	8.14
130	4.607	8.29
131	4.643	8.49
132	4.679	8.64
133	4.714	8.75

	Run 1	
	Volume (mL)	pH
309	11.000	11.78
310	11.036	11.78
311	11.071	11.80
312	11.107	11.80
313	11.143	11.80
314	11.179	11.80
315	11.214	11.80
316	11.250	11.80
317	11.286	11.82
318	11.321	11.81
319	11.357	11.81
320	11.393	11.81
321	11.429	11.81
322	11.464	11.81
323	11.500	11.82
324	11.536	11.82
325	11.571	11.82
326	11.607	11.82
327	11.643	11.82
328	11.679	11.82
329		



Initial pH *pH at colour change* *Final pH*

Colour change (approximation): pH=7.00 vol=4.300mL

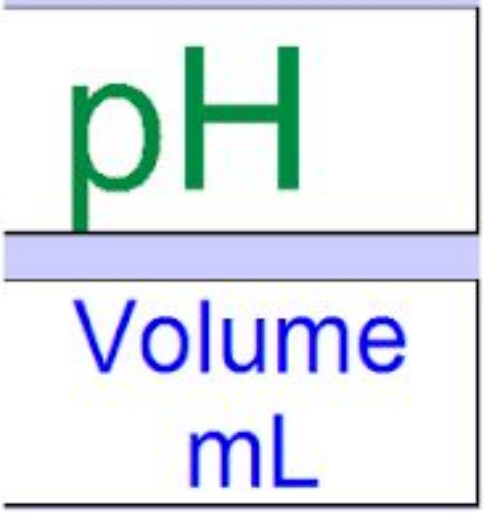

12
10
8
6
4
2
pH
0
5
10
(1.959, 11.03)
Volume (mL)

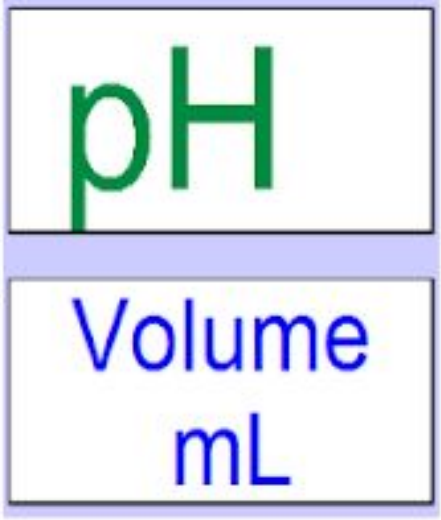
Trial 3 -HCL

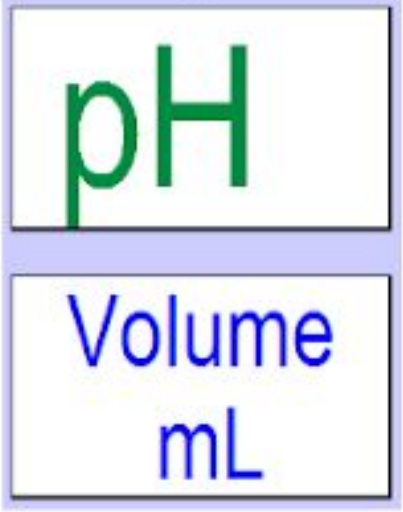
	Run 1	
	Volume (mL)	pH
1	0.000	2.58
2	0.036	2.58
3	0.071	2.58
4	0.107	2.58
5	0.143	2.58
6	0.179	2.58
7	0.214	2.58
8	0.250	2.58
9	0.286	2.58
10	0.321	2.58
11	0.357	2.58
12	0.393	2.58
13	0.429	2.60
14	0.464	2.63
15	0.500	2.64
16	0.536	2.63
17	0.571	2.64
18	0.607	2.67
19	0.643	2.71
20	0.679	2.74
21	0.714	2.78

	Run 1	
	Volume (mL)	pH
207	7.357	6.29
208	7.393	6.36
209	7.429	6.41
210	7.464	6.47
211	7.500	6.59
212	7.536	6.62
213	7.571	6.69
214	7.607	6.77
215	7.643	6.88
216	7.679	6.99
217	7.714	7.11
218	7.750	7.30
219	7.786	7.45
220	7.821	7.57
221	7.857	7.69
222	7.893	7.83
223	7.929	7.99
224	7.964	8.11
225	8.000	8.24
226	8.036	8.37
227	8.071	8.56

	Run 1	
	Volume (mL)	pH
259	9.214	11.29
260	9.250	11.30
261	9.286	11.32
262	9.321	11.33
263	9.357	11.34
264	9.393	11.35
265	9.429	11.37
266	9.464	11.37
267	9.500	11.38
268	9.536	11.39
269	9.571	11.40
270	9.607	11.40
271	9.643	11.40
272	9.679	11.41
273	9.714	11.42
274	9.750	11.44
275	9.786	11.44
276	9.821	11.45
277	9.857	11.46
278	9.893	11.47
279		

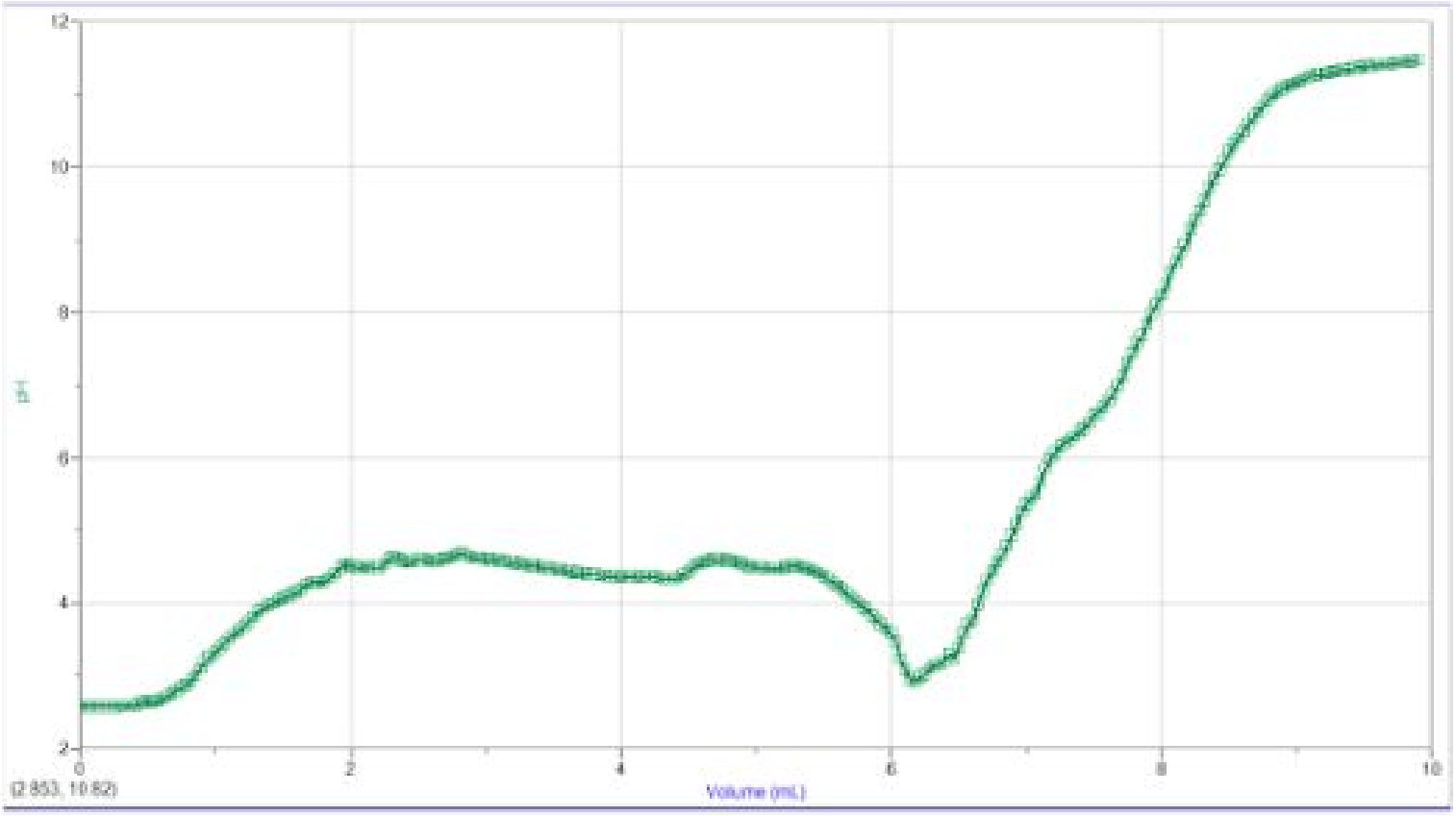






Initial pH *pH at colour change* *Final pH*

Colour change (approximation): pH=6.60 vol=7.520mL

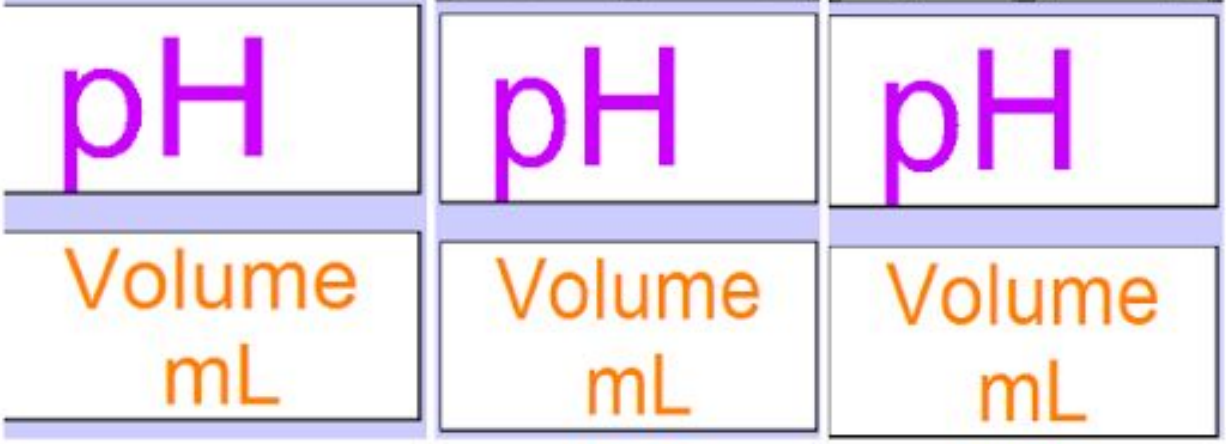


Trial 1 - Unkown acid

	Run 1	
	Volume (mL)	pH
1	0.000	2.69
2	0.036	2.69
3	0.071	2.69
4	0.107	2.69
5	0.143	2.70
6	0.179	2.71
7	0.214	2.70
8	0.250	2.70
9	0.286	2.72
10	0.321	2.71
11	0.357	2.74
12	0.393	2.75
13	0.429	2.72
14	0.464	2.71
15	0.500	2.72
16	0.536	2.72
17	0.571	2.71
18	0.607	2.72
19	0.643	2.74
20	0.679	2.73
21	0.714	2.73

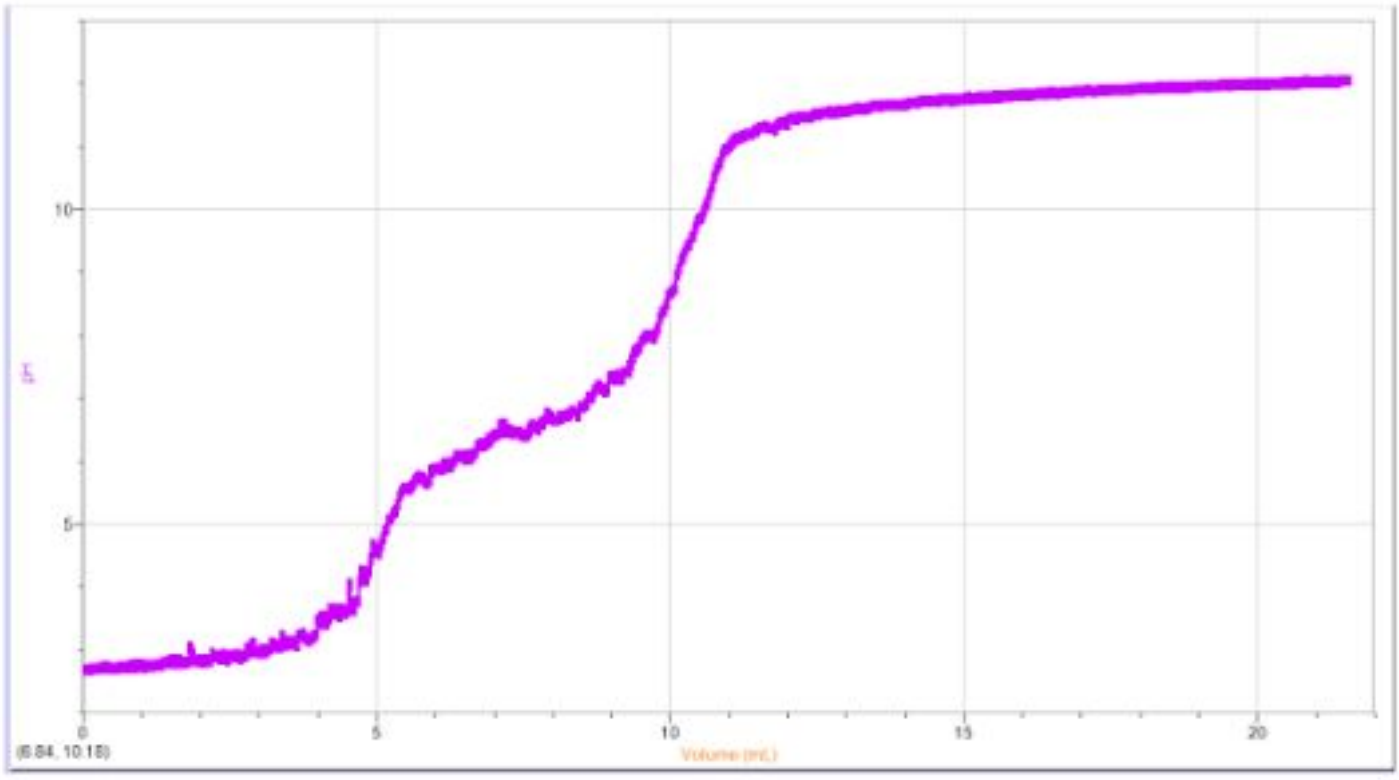
	Run 1	
	Volume (mL)	pH
279	9.929	8.50
280	9.964	8.64
281	10.000	8.66
282	10.036	8.72
283	10.071	8.75
284	10.107	8.96
285	10.143	9.06
286	10.179	9.19
287	10.214	9.25
288	10.250	9.34
289	10.286	9.42
290	10.321	9.45
291	10.357	9.55
292	10.393	9.59
293	10.429	9.71
294	10.464	9.81
295	10.500	9.86
296	10.536	9.88
297	10.571	9.99
298	10.607	10.07
299	10.643	10.13

	Run 1	
	Volume (mL)	pH
585	20.857	12.02
586	20.893	12.02
587	20.929	12.03
588	20.964	12.01
589	21.000	12.01
590	21.036	12.03
591	21.071	12.02
592	21.107	12.03
593	21.143	12.03
594	21.179	12.05
595	21.214	12.03
596	21.250	12.05
597	21.286	12.02
598	21.321	12.03
599	21.357	12.03
600	21.393	12.05
601	21.429	12.05
602	21.464	12.05
603	21.500	12.05
604	21.536	12.05
605		



Initial pH *pH at colour change* *Final pH*

Colour change (approximation): pH=9.00 vol=10.120mL

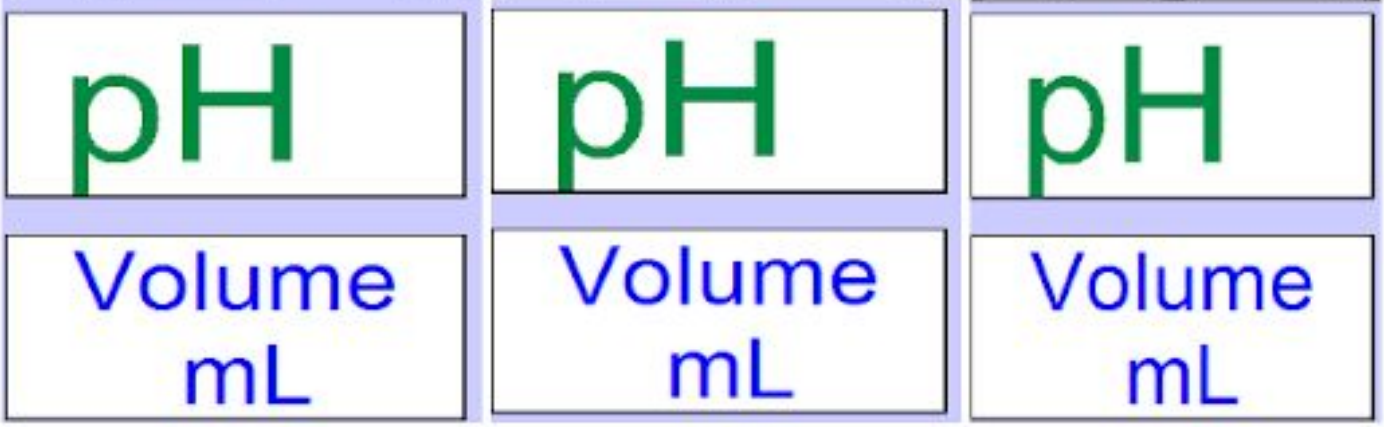

10
5
0
5
10
15
20
(6.84, 10.18)

Trial 2 - Unknown acid

	Run 1	
	Volume (mL)	pH
1	0.000	2.82
2	0.036	2.82
3	0.071	2.82
4	0.107	2.82
5	0.143	2.82
6	0.179	2.82
7	0.214	2.82
8	0.250	2.82
9	0.286	2.83
10	0.321	2.84
11	0.357	2.84
12	0.393	2.84
13	0.429	2.84
14	0.464	2.84
15	0.500	2.85
16	0.536	2.85
17	0.571	2.85
18	0.607	2.85
19	0.643	2.86
20	0.679	2.87
21	0.714	2.86

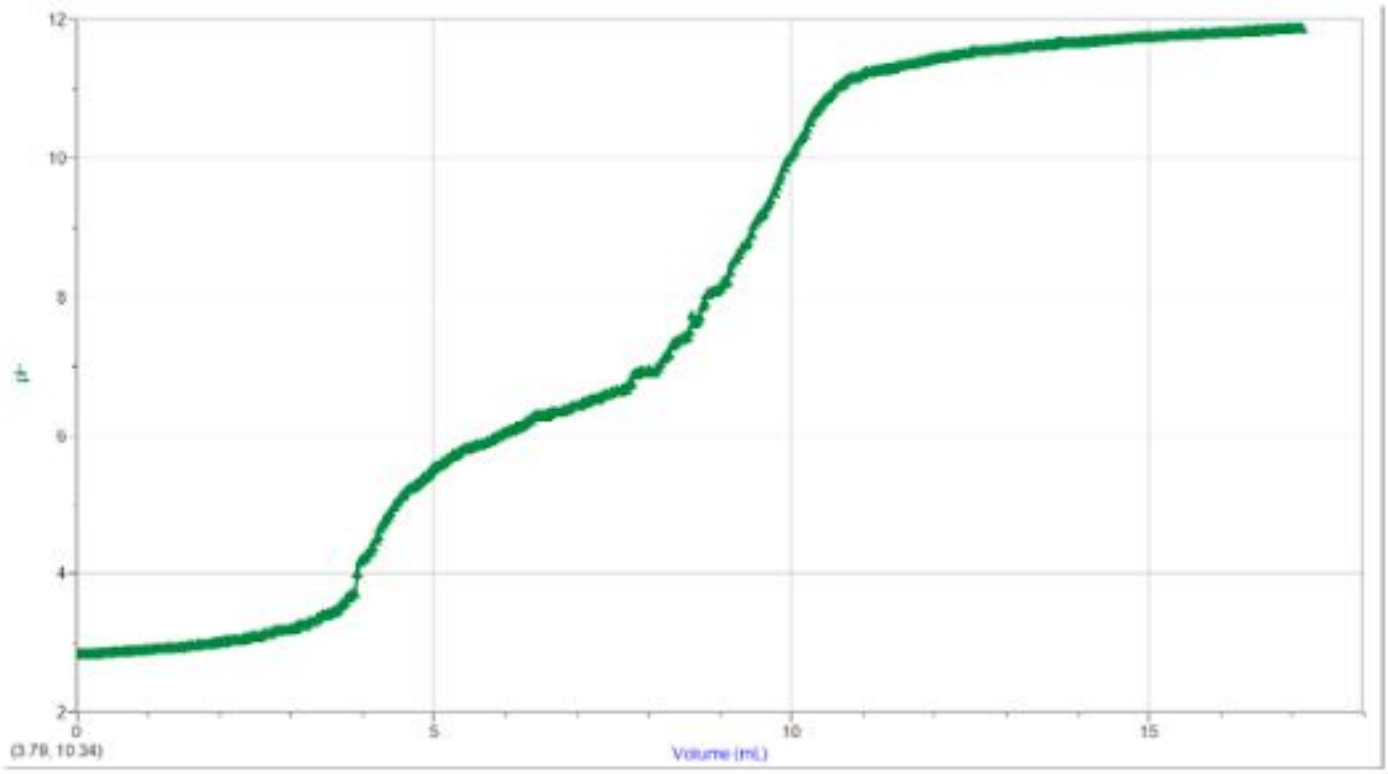
	Run 1	
	Volume (mL)	pH
239	8.500	7.40
240	8.536	7.40
241	8.571	7.49
242	8.607	7.72
243	8.643	7.61
244	8.679	7.64
245	8.714	7.71
246	8.750	7.84
247	8.786	7.92
248	8.821	8.03
249	8.857	8.04
250	8.893	8.06
251	8.929	8.06
252	8.964	8.07
253	9.000	8.12
254	9.036	8.18
255	9.071	8.20
256	9.107	8.21
257	9.143	8.34
258	9.179	8.46
259	9.214	8.53

	Run 1	
	Volume (mL)	pH
462	16.464	11.82
463	16.500	11.83
464	16.536	11.83
465	16.571	11.83
466	16.607	11.83
467	16.643	11.83
468	16.679	11.83
469	16.714	11.84
470	16.750	11.84
471	16.786	11.84
472	16.821	11.84
473	16.857	11.85
474	16.893	11.85
475	16.929	11.85
476	16.964	11.85
477	17.000	11.85
478	17.036	11.85
479	17.071	11.85
480	17.107	11.86
481	17.143	11.86
482		



Initial pH *pH at colour change* *Final pH*

Colour change (approximation): pH=8.20 vol=9.071mL

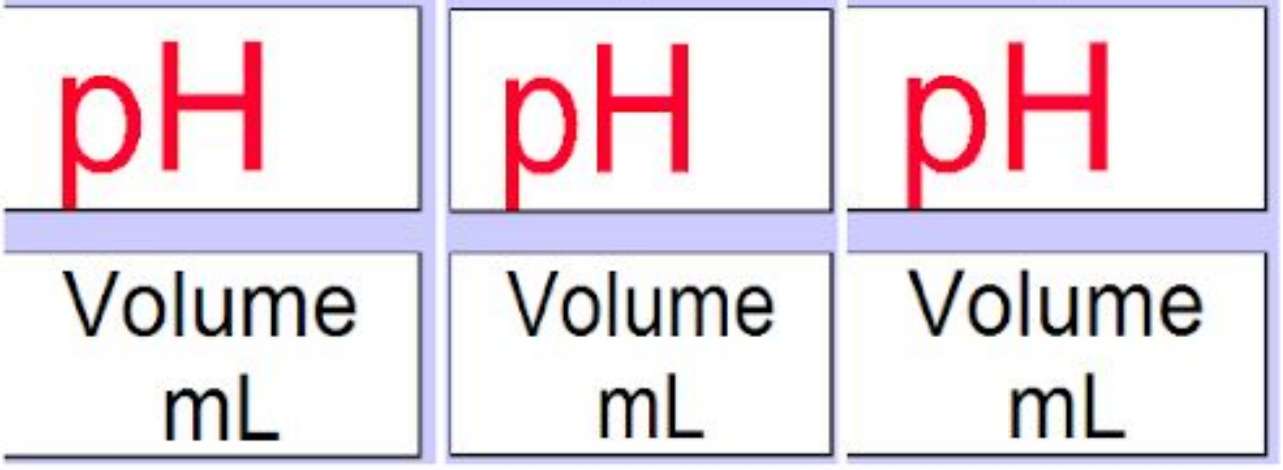

12
10
8
6
4
2
pH
0
5
10
15
(3.79, 10.34)
Volume (mL)

Trial 3 - unknown acid

	Run 1	
	Volume (mL)	pH
1	0.000	3.09
2	0.036	3.08
3	0.071	3.06
4	0.107	3.05
5	0.143	3.04
6	0.179	3.03
7	0.214	3.02
8	0.250	3.00
9	0.286	3.00
10	0.321	2.99
11	0.357	2.99
12	0.393	2.99
13	0.429	2.99
14	0.464	2.99
15	0.500	2.99
16	0.536	3.02
17	0.571	3.00
18	0.607	3.00
19	0.643	3.01
20	0.679	3.01
21	0.714	2.99

	Run 1	
	Volume (mL)	pH
246	8.750	7.43
247	8.786	7.44
248	8.821	7.53
249	8.857	7.57
250	8.893	7.63
251	8.929	7.71
252	8.964	7.74
253	9.000	7.76
254	9.036	7.78
255	9.071	7.83
256	9.107	7.85
257	9.143	7.86
258	9.179	7.87
259	9.214	7.90
260	9.250	7.93
261	9.286	7.99
262	9.321	8.08
263	9.357	8.20
264	9.393	8.30
265	9.429	8.37
266	9.464	8.43

	Run 1	
	Volume (mL)	pH
315	11.214	11.23
316	11.250	11.23
317	11.286	11.23
318	11.321	11.23
319	11.357	11.24
320	11.393	11.25
321	11.429	11.25
322	11.464	11.27
323	11.500	11.27
324	11.536	11.27
325	11.571	11.28
326	11.607	11.30
327	11.643	11.31
328	11.679	11.33
329	11.714	11.35
330	11.750	11.35
331	11.786	11.34
332	11.821	11.34
333	11.857	11.33
334	11.893	11.34
335		

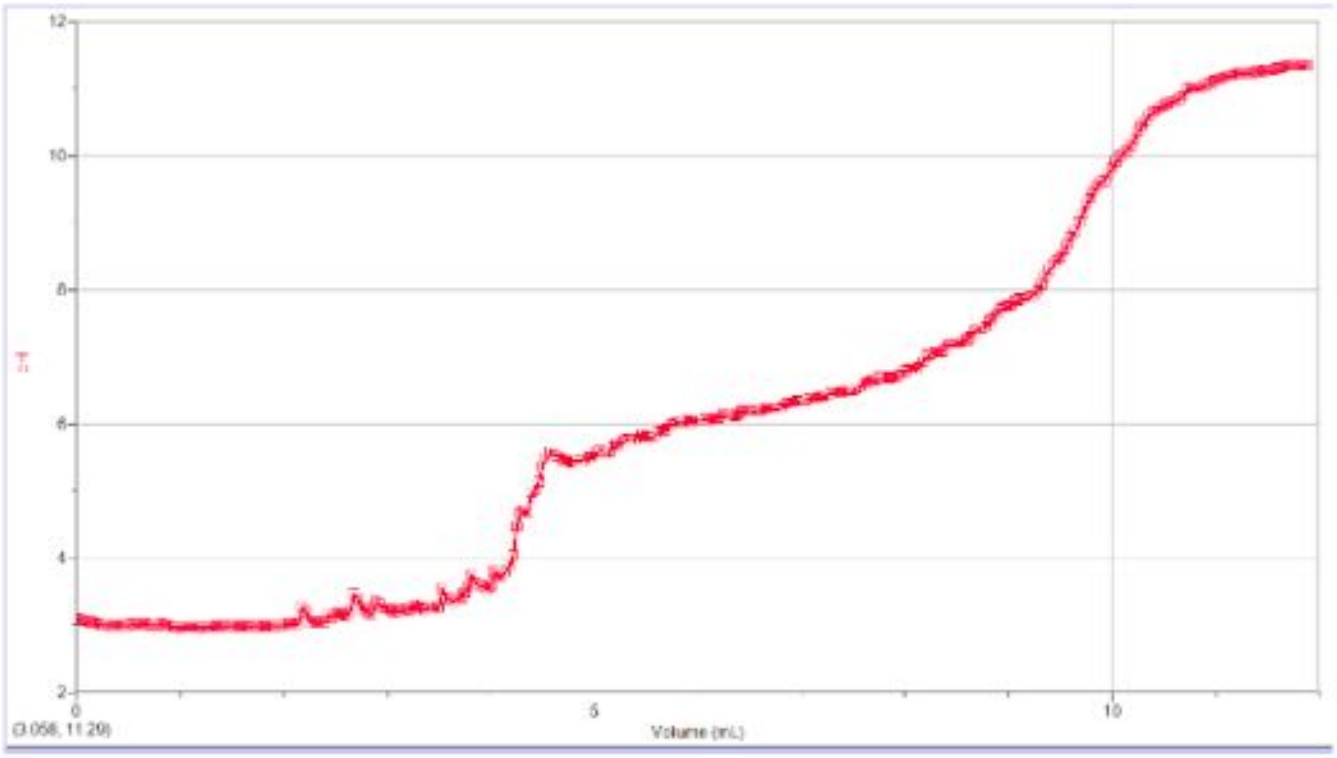


Initial pH

pH at colour change

Final pH

Colour change (approximation): pH=7.60 vol=8.860mL



Monoprotic acid observations

Variables	**Trial 1**	**Trial 2**	**Trial 3**
Initial glass burette reading	16.2 ml	20.5 ml	21.1 ml
Final glass burette reading	6.1 ml	14.5 ml	11.1 ml
Initial plastic burette reading	40 ml	40 ml	40 ml
Final plastic burette reading	29.143	28.321	30.107
Initial pH	2.54	2.62	2.58
Final pH	11.47	11.82	11.47

Sample Calculations

1. Use the initial volume of NaOH, its initial concentration, and the total volume to

determine the approximate concentration of your NaOH solution, in mol/L

Equation: C1V1 = C2V2

C1= 6M

V1= 0.0044L

V2= 0.249.4L

C2= C1V1/V2

= (6M)(0.0044L)/(0.249.4L)

= 0.106 M = 0.1 (one sig fig)

2. Use Logger Pro to determine the equivalence point of your titration.....

Trial 1-Hcl acid

C of HCl= 0.100M

V of HCl= 0.010L

V of NaOH= 0.04 L

C of NaOH V of NaOH= b/a CHClVHCl

C NaOH= C HCl V HCl / V NaOH

= (0.100M)(0.0100L)/(0.040L)

= 0.025M

Trial 2

3. Repeat the procedure outlined in Step 2 of the Calculations to find the exact volume of base used to titrate the unknown acid

Equation of acid: $H_2A(aq) + 2NaOH(aq) \rightarrow Na_2A(aq) + 2H_2O$

2nAcid = nNaOH

2 CAcid V Acid = C NaOH V NaOH

C Acid= C NaOH V NaOH/q(2)(VAcid)

CNaOH= 0.025M

VNaOH= 0.040L

V of Acid= 0.0100L

CAcid= CNaOHVNaOH/((2)(VAcid)

CAcid= (0.025M)(0.040L)/ ((2)(0.0100L))

= 0.0500M

4. Use your visually observed end points for both the HCl and the unknown acid to calculate a second concentration for your HCl and your unknown acid (the calculation is identical, but you do not need to use LabQuest/Logger Pro data).

Trial 1 - HCl acid

Vbase = 0.008457L

b/a = 2 * Diprotic

Vacid = 0.1201L

C base x V base = (b/a)(C acid x V acid)

(C base x V base)/(b/a)/V acid = C acid

C acid = (1.4mol/L x 0.008457L)/(2)/0.1201L

C acid = 0.049291423mol/L

C acid = 0.05mol/L

Trial 2 - Unknown acid

V Base = 0.010714L

Base /Acid = 2 → Diprotic

V acid = 0.12L

C Base x V base = (b/a)(C acid x V acid)

(C base x V base)/(b/a)/V acid = C acid

C acid = (1.1mol/L x 0.010714L)/(2)/0.12L

C acid = 0.049105833mol/L

C acid = 0.05mol/L