Analyzing the Relationship Between the Acidity and the Conductivity of a Solution

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1 Purpose

Understand how standing H^+ and/or OH^- ion concentration in a solution affects conductivity measured in µS.

1.1 Hypothesis

Conductivity will decrease as pH approaches 7, as the ions that would otherwise facilitate the conduction of electricity (H^+/OH^-) would be neutralized.

2 Materials

- 150 mL 0.10 M HCl
- 150 mL 0.10 M NaOH
- 1 100 mL buret+stand
- 1 250 mL beaker
- 1 50 mL graduated cylinder
- 1 stir plate+bar
- 1 logging device
- 1 pHprobe
- 1 conductivity probe
- 1 USB flash disk
- phenolphthalein

3 Procedure

1. Turn on logger
2. Plug in probes and USB disk
3. Set up buret with stand
4. Put stir plate below buret
5. Fill graduated cylinder with 50 mL HCl
6. Fill buret with 50 mL NaOH
7. Transfer HCl to beaker
8. Put 2-3 drops of phenolphthalein in the beaker
9. Calibrate probes
10. Put beaker on top of stir plate
11. Put the stir bar in the beaker
12. Set the stir bar spinning at $\frac{1}{4}$ speed
13. Open the buret so there is ~ 1 drop s^{-1}
14. Start logger
15. Let experiment run for 50 seconds
16. Stop logger
17. Export data to USB disk
18. Neutralize any remaining HCl
19. Turn off stir plate
20. Remove stir bar
21. Clean beaker
22. Repeat $5 - 21$ as necessary for data collection

Table 1: Trial 1

Time s	pH	*Conductivity* µS	
0.00	1.01±0.20	19 352.00	±800.
2.00	1.02±0.20	19 374.00	±800.
4.00	1.04±0.20	19 323.00	±800.
6.00	1.07±0.20	19 293.00	±800.
8.00	1.11±0.20	19 272.00	±800.
10.00	1.08±0.20	19 301.00	±800.
12.00	1.14±0.20	19 264.00	±800.
14.00	1.17±0.20	19 293.00	±800.
16.00	1.17±0.20	19 257.00	±800.
18.00	1.19±0.20	19 257.00	±800.
20.00	1.21±0.20	19 257.00	±800.
22.00	1.24±0.20	19 228.00	±800.
24.00	1.34±0.20	19 220.00	±800.
26.00	1.27±0.20	19 176.00	±800.
28.00	1.35±0.20	19 191.00	±800.
30.00	1.35±0.20	19 139.00	±800.
32.00	1.42±0.20	19 125.00	±800.
34.00	1.39±0.20	19 088.00	±800.
36.00	1.37±0.20	19 030.00	±800.
38.00	1.42±0.20	18 985.00	±800.
40.00	1.47±0.20	18 949.00	±800.
42.00	1.45±0.20	18 934.00	±800.
44.00	1.50±0.20	18 905.00	±800.
46.00	1.49±0.20	18 846.00	±800.
48.00	1.49±0.20	18 839.00	±800.
50.00	1.57±0.20	18 780.00	±800.

Table 2: Trial 3

Time s	pH	*Conductivity* µS	
0.00	0.82±0.20	19 646.00	±800.
2.00	0.79±0.20	19 669.00	±800.
4.00	0.83±0.20	19 646.00	±800.
6.00	0.84±0.20	19 661.00	±800.
8.00	0.86±0.20	19 639.00	±800.
10.00	0.87±0.20	19 632.00	±800.
12.00	0.90±0.20	19 609.00	±800.
14.00	0.94±0.20	19 579.00	±800.
16.00	0.98±0.20	19 579.00	±800.
18.00	0.95±0.20	19 579.00	±800.
20.00	0.97±0.20	19 541.00	±800.
22.00	1.01±0.20	19 527.00	±800.
24.00	0.98±0.20	19 504.00	±800.
26.00	1.04±0.20	19 474.00	±800.
28.00	1.03±0.20	19 451.00	±800.
30.00	1.08±0.20	19 421.00	±800.
32.00	1.05±0.20	19 414.00	±800.
34.00	1.06±0.20	19 369.00	±800.
36.00	1.13±0.20	19 331.00	±800.
38.00	1.11±0.20	19 286.00	±800.
40.00	1.11±0.20	19 264.00	±800.
42.00	1.13±0.20	19 226.00	±800.
44.00	1.17±0.20	19 226.00	±800.
46.00	1.19±0.20	19 174.00	±800.
48.00	1.21±0.20	19 144.00	±800.
50.00	1.22±0.20	19 099.00	±800.

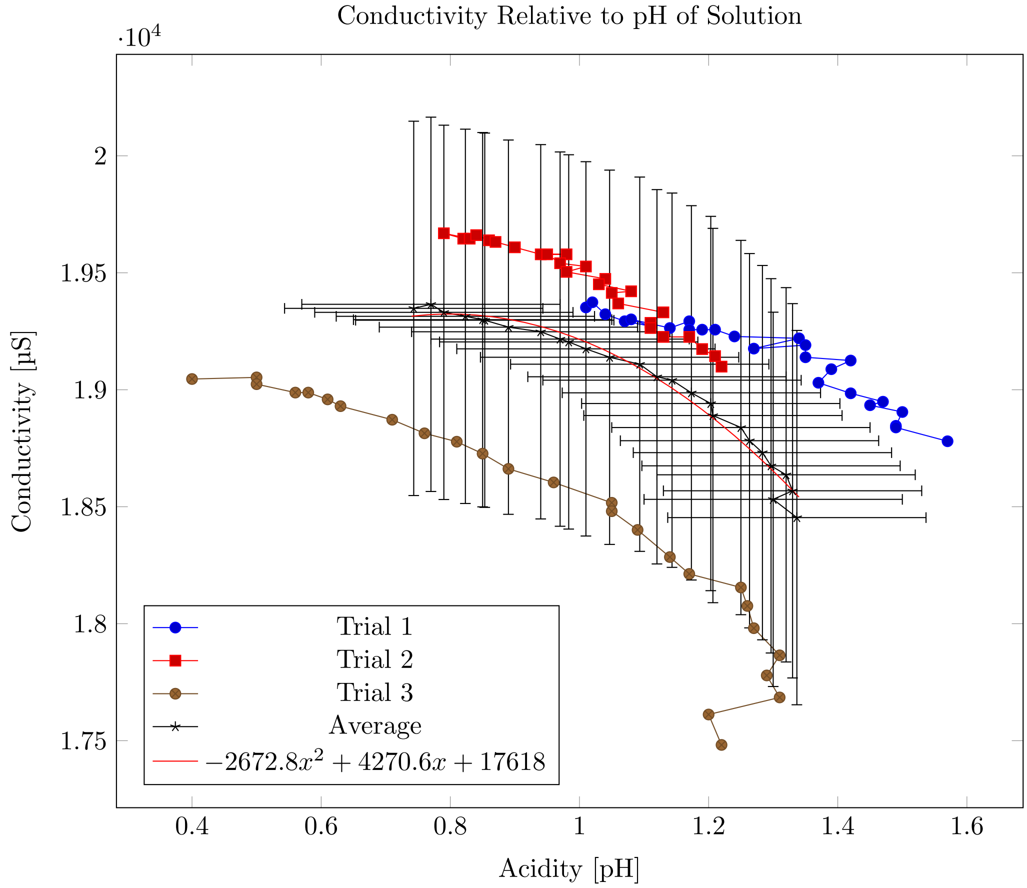
Table 3: Trial 3

Time s	pH	*Conductivity* µS	
0.00	0.40±0.20	19 046.00	±800.
2.00	0.50±0.20	19 053.00	±800.
4.00	0.50±0.20	19 024.00	±800.
6.00	0.56±0.20	18 988.00	±800.
8.00	0.58±0.20	18 988.00	±800.
10.00	0.61±0.20	18 959.00	±800.
12.00	0.63±0.20	18 930.00	±800.
14.00	0.71±0.20	18 872.00	±800.
16.00	0.76±0.20	18 814.00	±800.
18.00	0.81±0.20	18 778.00	±800.
20.00	0.85±0.20	18 727.00	±800.
22.00	0.89±0.20	18 662.00	±800.
24.00	0.96±0.20	18 604.00	±800.
26.00	1.05±0.20	18 517.00	±800.
28.00	1.05±0.20	18 481.00	±800.
30.00	1.09±0.20	18 401.00	±800.
32.00	1.14±0.20	18 285.00	±800.
34.00	1.17±0.20	18 213.00	±800.
36.00	1.25±0.20	18 155.00	±800.
38.00	1.26±0.20	18 076.00	±800.
40.00	1.27±0.20	17 981.00	±800.
42.00	1.31±0.20	17 865.00	±800.
44.00	1.29±0.20	17 779.00	±800.
46.00	1.31±0.20	17 685.00	±800.
48.00	1.20±0.20	17 612.00	±800.
50.00	1.22±0.20	17 482.00	±800.

Table 4: Average

Time s	pH	*Conductivity* µS	
0.00	0.74±0.20	19 348.00	±800.
2.00	0.77±0.20	19 365.33	±800.
4.00	0.79±0.20	19 331.00	±800.
6.00	0.82±0.20	19 314.00	±800.
8.00	0.85±0.20	19 299.67	±800.
10.00	0.85±0.20	19 297.33	±800.
12.00	0.89±0.20	19 267.67	±800.
14.00	0.94±0.20	19 248.00	±800.
16.00	0.97±0.20	19 216.67	±800.
18.00	0.98±0.20	19 204.67	±800.
20.00	1.01±0.20	19 175.00	±800.
22.00	1.05±0.20	19 139.00	±800.
24.00	1.09±0.20	19 109.33	±800.
26.00	1.12±0.20	19 055.67	±800.
28.00	1.14±0.20	19 041.00	±800.
30.00	1.17±0.20	18 987.00	±800.
32.00	1.20±0.20	18 941.33	±800.
34.00	1.21±0.20	18 890.00	±800.
36.00	1.25±0.20	18 838.67	±800.
38.00	1.26±0.20	18 782.33	±800.
40.00	1.28±0.20	18 731.33	±800.
42.00	1.30±0.20	18 675.00	±800.
44.00	1.32±0.20	18 636.67	±800.
46.00	1.33±0.20	18 568.33	±800.
48.00	1.30±0.20	18 531.67	±800.
50.00	1.34±0.20	18 453.67	±800.

4 Data



5 Conclusion

My hypothesis, that the conductivity would decrease as pHapproached 7, was partially correct. I was only able to test with an acidic starting point, meaning that I only observed the pHapproaching 7 from $0 \leq$ pH$l7$. However, I can conclude that as the pHapproaches 7 from $0 \leq$ pH$l7$, the conductivity decreases. Simply from a mathematical standpoint, the Pearson correlation coefficient—the measure of the "correlatedness" of any two datasets—of the pHand conductivity returns -0.95, which is an almost exact (negative) linear relationship. This is evident by looking at the graph, which shows that as the pHincreased, the conductivity decreased. When the pHwas ~ 0.74 (starting pH), the conductivity was 19 348.00 µS. When the pHincreased to ~ 1.34, however, the conductivity decreased to 18 453.70 µS. Of course, there are many more values in between, but the general trend is similar to the one described.
There were many difficulties in the course of this lab. Among the more mundane ones, I accidentally tried to titrate HCl with HCl, which, as expected, did not have much effect. However, my biggest difficulty was keeping the probes calibrated, and it shows in my data. In my lab, I was using 0.10 M HCl and

NaOH, which have pHvalues of 1 and 13, respectively. However, the pHprobe in particular would not hold its calibration, and in my second and third trials, the starting pHof the HCl is incorrectly reported as 0.82 and 0.40. Even so, this does not invalidate my conclusion, because there is still an obvious downward trend in the conductivity-pHgraphs.

The first problem I stated is easy to fix; I need to be more attentive while I am at my lab station. However, the latter problem is more difficult. Lab probes—especially ones that are accurate—are expensive, and are most likely too expensive for my school to purchase. As such, the only practical way to compensate for calibration error right now is to carry out many trials, so that the average data may cancel out any random error introduced by deviation.