EXPERIMENT REPORT

CONVENTIONAL METHOD OF MEASURING pH

Course： BACHELOR OF BIOMEDICAL ENGINEERING

Matrix Number： KIB 170025 (GROUP 3)

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ABSTRACT

In our experiment , we solved the pH measurement problem by using different pH method . The ability to successfully perform correct pH measurement is highly dependent on apparatus development; pH meter have deviation rates of $\pm$ 0.88 or less, while pH paper may have deviation rates of more than ± 1 , which could lead to incorrect laboratory result. Nevertheless, only pH paper has the flexibility in testing all eight solution . By varying the amount of acid/base , the pH rate of change of buffer was proven lower than deionized water , with acid ; m = -0.0083 , and base ; m = 0.006 , through graphical method . The results had a relatively above-average uncertainties of $R^2 > 0.5$, which may be attributed to the assumption of a vacuum atmosphere . To account for this error , future work would be determine to incorporate the temperature factor toward pH measurement , which we neglected , using Nernst Equation .

OBJECTIVE

1) To measure the pH of the sample solution
2) To study the mechanism of hydrolysis, acids and bases solutions, buffers and salt solutions
3) To differentiate the critical data accuracy com`ponent between the pH measurement methods.
4) To identify the limitation properties of the methods which effect the pH measurement.

INTRODUCTION

A fundamental concept in any chemical analysis is the measurement of pH , which defined as the standard scale in determining acidity or basicity of an aqueous solution based on the concentration of hydronium ion . pH measurement has many applications in engineering , such as ; food quality control, drugs production and mining site determination . It is used to understand the behavioral of solution experimented before they tested with other chemical . The general formula for pH is **Equation 1**.

$$pH = -\log[\mathrm{H3O+}]$$

Equation 1 : pH formula

This equation states that pH is the negative logarithm of the H_3O^+ ion concentration . The negative logarithmic is due to the concentration of H_3O^+ and OH^- ion usually less than 1 M in most occurrence .

In this experiment , the **Equation 1** will be self-calculated by the pH measurement equipment which the deviation of the data will be our case of study to answer the research question , " Which method would give the most accurate pH value ? " . We hypothesize the selected solution with pH less than 7 are acidic and those with pH more than 7 are basic , which is the approximate average expected results of most pH equipment in either common indicator or laboratory apparatus .

MATERIAL AND APPARATUS

i. 1 M HCl
ii. 1 M H_3BO_3
iii. 1 M $NH_{3\ (aq)}$
iv. 1 M NaOH
v. 1 M Na_2CO_3
vi. 1 M $(NH_4)_2SO_4$
vii. 1 M NaCl
viii. Selected household chemicals
ix. Deionised water
x. 0.1M NaC2H3O2
xi. 0.1M HC2H3O2

xii. pH meter
xiii. pH paper
xiv. Pipette
xv. Beaker
xvi. Dropper

PROCEDURE

Experiment 1.1.1

1. The **1M HCl** was prepared in beaker and was diluted until it reached constant volume of **25ml** and concentration of **0.1M** . **Equation 2** were used for dilution of liquid subtance while **Equation 3** were used for hydrolysis of powder substance .

$$M_1V_1 = M_2V_2$$

Equation 2 : Dilution Equation

$$m = c_i \times V \times M_r$$

Equation 3 : Molarity Equation

2. The **0.1M HCl** were left for few min to allow constant temperature between all tested solutions.
3. The pH paper was immersed in the **0.1M HCl** to initiate the reading of pH paper.Observation were recorded.
4. The pH meter was being turned on and left for 1 min to allow stable calibration.
5. The electrode was taken out of the storage cap and rinsed using distilled water . Dried gently with tissue .
6. The electrode was being immersed in **0.1M HCl** to initiate the reading of pH meter.Left for 3 min to stabilize the pH reading.
7. The pH reading was being set and the observation recorded.
8. The experiment were repeated with **1M of HCl** was exchanged with **1M of H_3BO_3, 1M of NH_3 (aq),1M of NaOH,1M of Na_2CO_3, 1M of $(NH_4)_2SO_4$, 1M of NaCl** respectively.
9. The data were tabulated in **table A**.

Experiment 1.1.2

1. 10 drop of **household chemical** was being put in the petri dish using dropper .
2. The pH paper was being immersed in the household chemical solution to initiate the reading of pH paper.Observation was recorded.
3. The data was tabulated in **table A**.

Experiment 1.1.3

1. **25 ml of 0.1M NaC2H3O2** and **25ml of 0.1M HC2H3O2** was added into a same beaker using pipette .The solution formed is a buffer solution .
2. The pH paper was immersed in the buffer solution to initiate the reading of pH paper.Observation were recorded.
3. The pH meter was being turned on and left for 1 min to allow stable calibration
4. The electrode was rinsed using distilled water . Dried gently with tissue .
5. The electrode was being immersed in buffer solution to initiate the reading of pH meter.The pH reading was being set and the observation recorded.
6. Step 2,5 and 6 were repeated with addition of 1 drop of **1M HCl** using dropper.The beaker was swirled beforehand. The experiment continued until the number of drop achieved was 5 .

7. 5 drop of **1M NaOH** were added to initialize the pH back to origin pH.
8. Step 2,5 and 6 were repeated with addition of 1 drop of **1M NaOH** using dropper.The beaker was swirled beforehand. The experiment continued until the number of drop achieved was 5 .
9. The buffer was exchanged with deionized water . **25ml deionized water** was being placed in a beaker and heated on hot plate until it reach 100℃ .
10. Step 2,5 and 6 were repeated with addition of 1 drop of **1M HCl** using dropper.The beaker was swirled beforehand. The experiment continued until the number of drop achieved was 5 .
11. The **25 ml deionized water** was being renewed and heated.
12. Step 2,5 and 6 were repeated with addition of 1 drop of **1M NaOH** using dropper.The beaker was swirled beforehand. The experiment continued until the number of drop achieved was 5 .
13. The data were tabulated in **table B**

RESULT

The types of selected solution	Experimental pH		Theoretical pH (± 0.01)	Temperature (℃)
	pH meter (± 0.01)	pH paper (± 1)		
HCl	0.83	1	1.00	21.2
Selected household chemicals	–	8	–	–
H_3BO_3	5.30	5	5.11	21.2
NH_3	9.96	8	11.13	21.2
NaOH	12.93	13	13.00	21.2
Na_2CO_3	12.77	12	11.16	21.2
$(NH_4)_2SO_4$	5.86	5	5.50	21.2
NaCl	5.90	5	7.00	21.2

Table A : The pH reading of selected reagents with relative to the type of reagents

The temperature was being constant to eradicate the dependence of temperature toward pH , which based on atmospheric temperature .The theoretical pH data was gained based on our reference .The theoretical will be treated as control (d_{ti}) .

From the theoretical , **Equation 4** formulated to obtain the standard deviation .

$$\sigma_d = \sqrt{\frac{\sum_{i=1}^{N}(|d_i - d_{ti}|)^2}{N}}$$

Equation 4 : standard deviation

Experiment 1.1.2 data will be exclude from the deviation calculation due to the flaw of pH meter which unsuitable to measure small amount of sample .

Thus , the standard deviation for pH meter and pH paper indicate the accuracy of the method .

For pH paper ,

$$\sigma = \sqrt{\frac{14.7646}{7}} = \pm 1 \text{ pH unit}$$

For pH meter ,

$$\sigma = \sqrt{\frac{5.3705}{7}} = \pm 0.88 \text{ pH unit}$$

pH reading of sample / Number of drop of solute		Buffer solution			Deionized water		
		pH meter	pH paper	Temperature (℃)	pH meter	pH paper	Temperature (℃)
1M HCl	0	3.54	4		4.6	4	64
	1	3.52	4		2.73	3	59
	2	3.52	4		2.43	3	56.3
	3	3.51	4		2.23	3	53.7
	4	3.51	4		2.17	3	52.4
	5	3.49	4		2.02	3	50.3
1M NaOH	0	3.53	4		5.31	5	71.4
	1	3.53	4		9.93	11	68.2
	2	3.54	4		10.35	11	65.8
	3	3.54	4		10.63	11	63.8
	4	3.55	4		10.78	11	61.8
	5	3.56	4		10.93	11	60.1

Table B : The pH reading of solution with relative to the addition of acid/base

The temperature of buffer solution is not taken as the purpose of temperature in **Experiment 1.1.3** is to show the relevance of our deionized water as freshly boiled deionized water in our experiment .

The graph of pH value vs number of drop of HCl was plotted in **Figure 1** from the data in **table A** , while the graph of pH value vs number of drop of NaOH was plotted in **Figure 2** from the data in **table B .**

DISSCUSSION

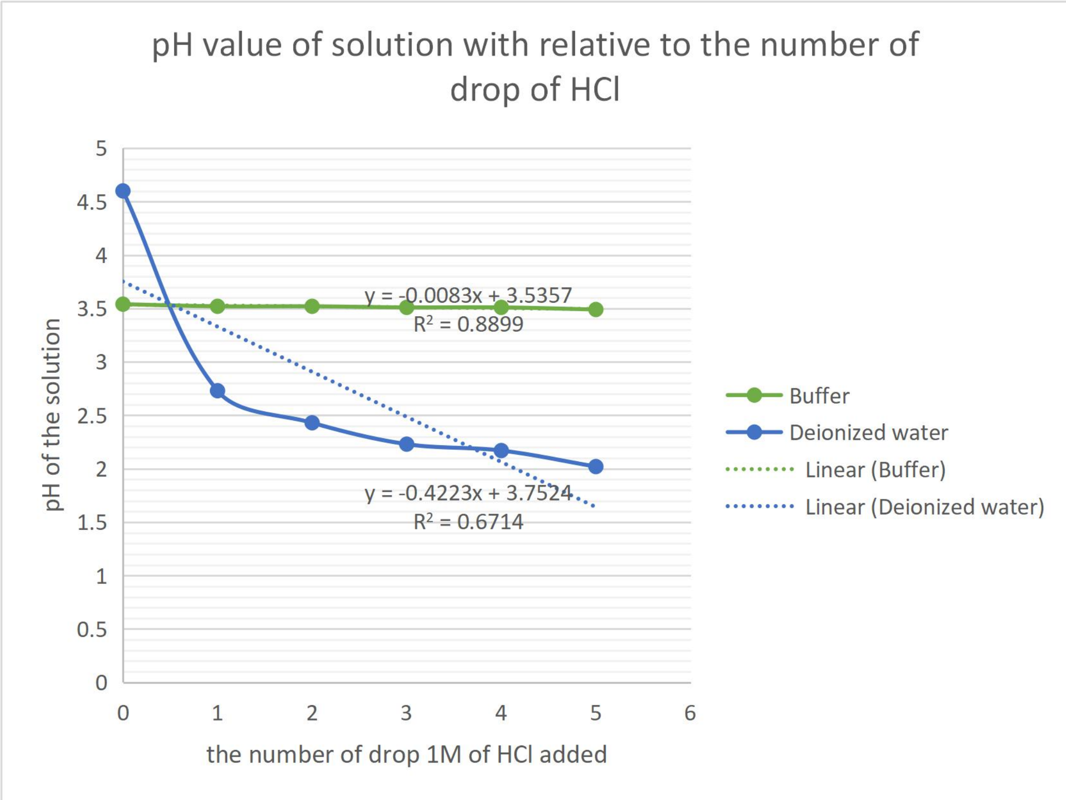

Figure 1 : the change of pH value for varying the number of drops of HCl and the type of solution experimented

1. Based on the the graph plotted , the buffer has m=-0.0083 while dionized water has m=-0.4223 . The gradient indicate that minimization of change in pH occurred which the pH change rate in buffer is less than deionized water with relative to addition of 1M of HCl .

This is due to the unique mechanism of buffer solution .When HCl was entering the buffer system , there exist abundance of H+ ion from the dissociation of salt .These abundance ion will then react with the weak base from buffer solution in which cause formation of weak acid . The formation will used up the excess H+ ion , causing an effect based on Equation 1 in which minimize the change in pH with each addition of HCl compared to deionized water.

$$HCl + CH3COO^{-} \leftrightarrow CH3COOH + Cl^{-}$$

Hydrochloric acid + acetate ion ⟵⟶ acetic acid + chlorine ion

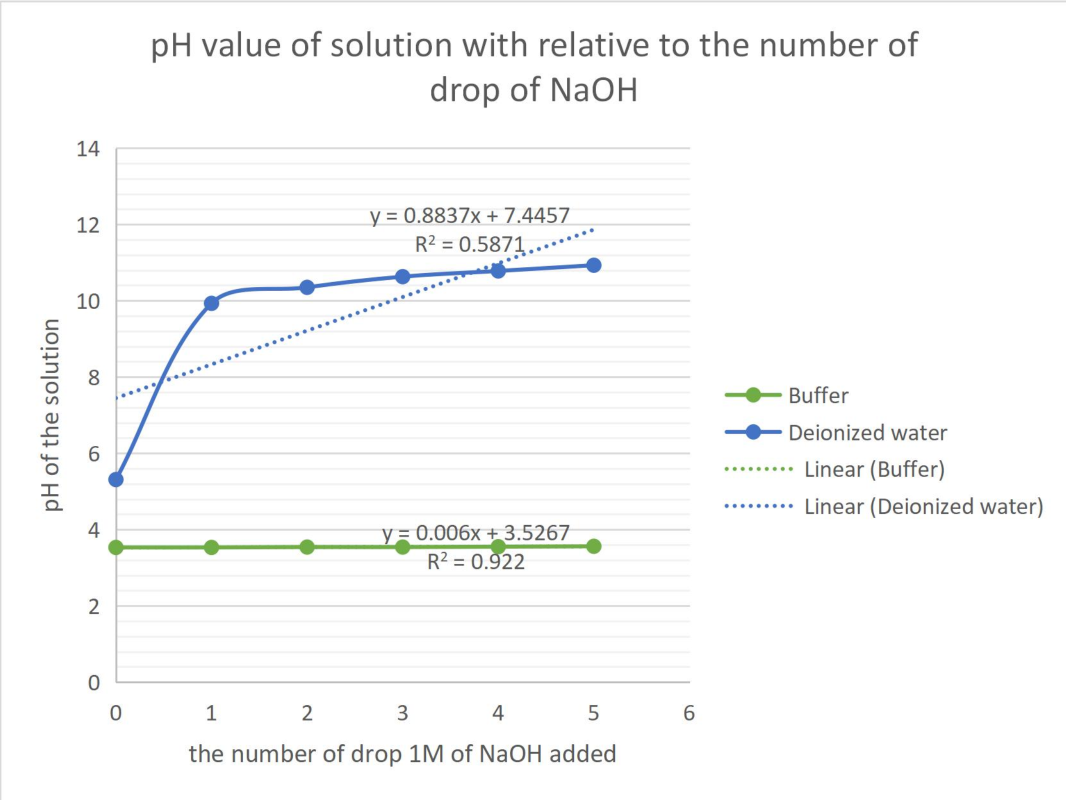

Figure 2 : the change of pH value for varying the number of drops of NaOH and the type of solution experimented

2. Based on the the graph plotted , the buffer has m=0.006 while dionized water has m=0.8837 . The gradient indicate that minimization of change in pH occurred which the pH change rate in buffer is less than deionized water with relative to addition of 1M of NaOH .

This is due to the unique mechanism of buffer solution .When NaOH was entering the buffer system , there exist abundance of OH- ion from the dissociation of salt .These abundance ion will then react with the weak acid from buffer solution in which cause formation of water and conjugate base . The formation will used up the excess OH- ion , causing an effect based on Equation 1 in which minimize the change in pH with each addition of NaOH compared to deionized water.

$$OH^- + CH_3COOH \leftrightarrow CH_3COO^- + H_2O$$

Hydroxide ion + acetic acid ⟵⟶ acetate ion + water

3. For **Experiment 1.1.3** , there may be some deviation of data as the pH of freshly boiled deionized water can be affect by the atmospheric air in a small extent.

When the deionized water in a favorable temperature , the atmospheric disturbance cannot occur . As it reached unfavorable temperature by cooling down , CO2 gas from atmosphere can be dissolve in deionized water .This will result a reaction in which formation of weak acid occur ;

$$H_2O + CO_2 \rightarrow H_2CO_3$$

Water + carbon dioxide → carbonic acid

The reaction caused a small increase in H3O+ ion concentration in which ;

$$H^+ + H_2CO_3 \rightarrow H_3O^+ + CO^{2-}$$

Hydrogen ion + carbonic acid → hydronium ion + bicarbonate ion

The increase in concentration causing pH to decrease based on **Equation 1 .**

CONCLUSION

For conclusion , the best method in pH measurement is based on **Experiment 1.1.1** , by using pH meter which has standard deviation of ±0.88 (high accuracy) . The pH paper still has significant role in pH measurement as which only pH paper can be used in **Experiment 1.1.2** with the value of 8 . The set-up of this experiment was simplistic and could account for large uncertainty in this measurement . **Figure 1** and **2** are averagely acceptable as when performing a linear fit , the overall uncertainties gained was R^2 value > 0.5 . A shortcoming in this set-up might be the assumption of vaccum atmosphere . **Table B** shown the initial temperature of **Experiment 1.1.3** for deionized water is not > 80℃ . This would indicate heat being lost , in which the chances of atmospheric disturbances should not be excluded . Inclusion of such term would slightly effect the pH measurement by both pH paper and meter.

Further experimentation could be done to measure the temperature factor in pH measurement . This could be done by including Nernst Equation in the research in which by obtaining all the related parameter , the temperature dependence experiment can be conducted .

REFERENCES

http://www.aqion.de/site/191
http://chemcollective.org/activities/tutorials/buffers/buffers3
https://www.merriam-webster.com/dictionary/pH
https://www.elsevier.com/search?query=APPLICATION+OF+PH
http://www.horiba.com/application/material-property-characterization/water-analysis/water-quality-electrochemistry-instrumentation/the-story-of-ph-and-water-quality/the-story-of-ph/ways-of-measuring-ph/

APPENDIX

All the chemical substances and laboratory equipment stated above in MATERIAL AND APPARATUS section has been prepared by the laboratory management section of Cellular Engineering Lab in University of Malaya . The " selected household chemical " was been deliberately kept confidential by the lab management in which only the pH was in our information scope .