Determination of pH of unknown solution

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Abstract

This experiment aims to measure the pH of an unknown solution using bromocresol green indicator and a buffer solution of acetic acid and NaOH. Color matching of the unknown solution with known samples allows us to find an approximate value for the pH.

keywords buffer solution, pH, indicator - bromocresol green.

1 Introduction

In this experiment, we determine the pH of an unknown solution, without using a pH meter. We use a buffer solution of various pHs, and see the color of the indicator (*bromocresol green*). pH of solution is given by $-\log_{10} a_{H^+} \cong -\log_{10}[H^+]$ (for dilute solutions) , where a_{H^+} is the *activity* of the hydrogen ion. A buffer solution resists change in pH. The pH of the buffer solution containing weak acid and its salt is given by the Henderson equation:

$$\mathrm{pH} = \mathrm{pKa} + \log \frac{[\mathrm{salt}]}{[\mathrm{acid}]}$$

Earlier, the measurement of pH using indicator could not give a wide range of pH because most indicators gave sharp colour changes at a definite pH range. This is not the case with bromocresol green in buffer solution of various pHs.

2 Experiment

2.1 Apparatus required

Some burettes were used for titration along with pipettes and a few conical flasks, test tubes to store and transfer the solutions.

2.2 Reagents

Glacial acetic acid (17N) and NaOH were used to prepare the buffer solution. Oxalic acid (0.5 N) was also used to standardise NaOH, which in turn was used to standardise acetic acid. Bromocresol green was used as the indicator for the final buffer solution of various pHs. Phenolphthalein was used as indicator in the titrations. Distilled water was used to dilute the solutions.

2.3 Procedure

1. 5g of sodium hydroxide pellets were weighed and then dissolved in 250 mL of distilled water to prepare 0.5N NaOH.
2. 5mL of glacial acetic acid (17N) and mixed with 165mL of distilled water to prepare 0.5N of acetic acid.
3. NaOH in the burette was standardised against 25mL of 0.5N oxalic acid using phenolphthalein indicator.
4. Acetic acid (25mL) in conical flask was standardised against NaOH.
5. NaOH and Acetic acid were diluted to 0.4N by adding requisite amount of water.
6. 0.4N acetic acid, 0.4N NaOH and distilled water were taken in three different burettes. Various amounts of acetic acid, NaOH and distilled water were added to 9 test tubes according to the table below.

test tube no.	2	3	4	5	6	7	8	9	10
vol. of 0.4(N) HAc(mL)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
vol. of 0.4(N) NaOH(mL)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
vol. of H_2O (mL)	4.5	4.0	3.5	3.0	2.5	2.0	1.5	1.0	0.5
pH	3.72	4.05	4.27	4.45	4.63	4.80	4.99	5.23	5.57

   The *unknown* solution is in test tube **1**.
7. 13 drops of bromocresol green were added to each test tube and shaken gently to get a homogeneously coloured solution. Various colours ranging from yellow to blue were observed.
8. The colour of the unknown solution was matched to one of the test tubes to find out its pH.

3 Results and discussion

3.1 Titration of NaOH against oxalic acid (0.5N, 25mL)

reaction $(COOH)_2 + 2NaOH \rightarrow (COONa)_2 + 2H_2O$
25mL of oxalic acid was used in the titration.

Sl	**initial burette reading**	**final burette reading**	**volume of NaOH (mL)**
1	0.5	24.8	24.3
2	24.9	49.7	24.8

Average amount of NaOH is **24.55** mL.
Strength of NaOH $\times$ 24.55 = 25 $\times$ 0.5
$\Rightarrow$ Strength of NaOH = **0.509** (N).

3.2 Titration of acetic acid (25mL) against NaOH

reaction $CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$
25mL of acetic acid was used in the titration.

Sl	initial burette reading	final burette reading	volume of NaOH (mL)
1	0.0	24.9	24.9
2	24.9	49.9	25.0

Average amount of NaOH is **24.95** mL .

Strength of acetic acid $\times$ 25 = 0.509 $\times$ 24.95

$\Rightarrow$ Strength of acetic acid = **0.508** (N).

3.3 pH of the unknown solution

After adding bromocresol green to all ten test tubes (including test tube 1 containing the solution of unknown pH), a colour change was observed in all of them ranging from yellow to blue.

The pH of the unknown solution was the pH of the test tube with which its colour corresponded the closest, and in this case it was **test tube 6**. Reading the known value of pH for test tube 6 from the table, we find that pH of the given unknown solution is **4.63**.

4 Conclusion

The beauty of the experiment is that the solutions are a wide range of colours from yellow to blue, using which we can easily compare the pH of the unknown solution. However, there is always a possibility of human error in matching the colour. So unless we have a solution, whose pH *exactly* matches one of the given solutions, we can never specify the pH exactly, and can only give a range of pH. One advantage is that we do not have to rely on instruments like the pH meter, and this experiment can be done simply using burettes and pipettes. If it were known that the frequency of the colour of the solution depended linearly on the pH, then we could determine pH exactly by doing a linear fit of pH versus frequency. Whether it is a linear dependence or not could be determined by plotting the pH versus frequency and seeing the dependence.

Thus this experiment describes a method of finding the pH that's simple and gives us an idea of the range of pH that the solution is in.

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6 References

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