Laboratory Report: Experiment 1

Standardization of hydrochloric acid by sodium carbonate solution

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Objective:

To determine the concentration of hydrochloric acid using sodium carbonate solution as a primary standard in volumetric analysis (acid-base titration)

Principle of method:

The concentration of the hydrochloric acid can be determined by the titration reaction between hydrochloric acid and sodium carbonate solution.

$$Na_2CO_{3\,(aq)} + 2HCl_{\,(aq)} \longrightarrow H_2O_{\,(l)} + CO_{2\,(g)} + 2NaCl_{\,(aq)}$$

From the above equation,

$$\frac{\text{No. of moles of HCl}}{\text{No. of moles of } Na_2CO_3} = \frac{2}{1}$$

We measure the volume of hydrochloric acid used in the titration (the difference of reading on the burette) and use it in calculating the concentration of hydrochloric acid.

So the molarity of the hydrochloric acid

$$= \frac{\text{No. of moles of HCl}}{\text{Volume of HCl used}}$$

$$= \frac{\text{No. of moles of } Na_2CO_3 \times 2}{\text{Volume of HCl used}}$$

$$= \frac{\text{Molarity of } Na_2CO_3 \times \text{Volume of } Na_2CO_3 \text{ used} \times 2}{\text{Volume of HCl used}}$$

Procedures:

1. The mass of anhydrous sodium carbonate required was weighed to prepare 250.0 cm^3 of 0.05M sodium carbonate solution.
2. All anhydrous sodium carbonate was dissolved in a beaker with a suitable amount of deionized water and the mixture was stirred.
3. Sodium carbonate solution was poured into a 250.0 cm^3 volumetric flask and it was made up to the graduated mark using deionized water.
4. The volumetric flask was shaken upside down for several times.
5. 25.0 cm^3 of sodium carbonate solution was pipetted into a conical flask.
6. 3 drops of methyl orange indicator was added into the conical flask.

7. Hydrochloric acid was poured into a burette.
8. The initial burette reading was recorded.
9. The reaction mixture in the conical flask was titrated with hydrochloric acid until it just changes from yellow to orange.
10. The final burette reading was recorded.
11. The titration was repeated several times to obtain 2-3 sets of consistent results.

Results:

Titration between hydrochloric acid and sodium carbonate solution:

Mass of anhydrous sodium carbonate used = 1.325 g

Trial	1	2	3	4
Initial burette reading	8.90	8.30	7.45	8.90
Final burette reading	35.10	34.50	34.00	34.50
Volume of HCl used (cm^3)	26.20	26.20	26.55	25.60

The first trial will not be involved in calculation since it is not accurate.

Average volume of hydrochloric acid used = 26.11 cm^3

No of moles of sodium carbonate used

= 0.05 × 0.025

= 0.00125 mol

No of moles of hydrochloric acid used

= 0.00125 × 2

= 0.0025 mol

Molarity of hydrochloric acid

= 0.0025 ÷ 0.0261

= 0.0957 M

Discussion:

The main aim in this experiment was to determine the concentration of hydrochloric acid by titration reaction with sodium carbonate solution.

It was found that the concentration of the given hydrochloric acid was 0.0957M and this result is quite acceptable and reliable because no great error was made in the experiment. The greatest error in the experiment was that when determining the

end-point of titration, it was easy to get over the end-point with a few drops. Although the color was still orange, the amount of hydrochloric acid used was different.

To improve the experiment and reduce this error, it was suggested to repeat the titration for some more times in order to help adjusting the average volume of hydrochloric acid to a more accurate number or to add in hydrochloric acid drop by drop when it was near to the end-point. Thus even a few over added drops can be avoided.

In the titration, Methyl orange was used as an indicator in the titrations. When hydrochloric acid reacted with sodium carbonate solution, the reaction mixture became less alkaline. When all sodium carbonate was reacted, the solution became neutral and the methyl orange turns from yellow to orange. The appearance of the orange color can indicate the end-point of the titration and thus the methyl orange fulfilled its task as an indicator.

If phenolphthalein was used as the indicator in the titration, the change of burette readings will be smaller. The end-point of phenolphthalein is at about pH 8.2 while that of methyl orange is at about pH 3-4. Therefore less hydrochloric acid is needed to reach the end-point when using phenolphthalein as an indicator in the titration. Thus, the change in burette reading in titration will become smaller. Also, if phenolphthalein was used, the color change of reaction mixture, which was from purple to pink, would be not sharp and so a large error would be made when determining the end-point of the titration.

In this experiment, it must be sure that the sodium carbonate solid prepared at the beginning was anhydrous because if it is hydrated, water in it will affect the mass of solid. Thus, the actual number of moles in the sodium carbonate solution will not be accurate and so the final result would be in great error. Also, sodium hydroxide cannot be a primary standard in this experiment since solid sodium hydroxide absorb water from the air so there will be error just like the case of hydrated sodium carbonate.

Considering the reaction mixture, if small amount of deionized water was added into the conical flask, it will not lead to an error. It is because the number of moles in the reaction mixture is fixed. When deionized water was added, it will not affect the amount of hydrochloric acid needed in the reaction. Thus the final result will not be affected.

However, if large amount of deionized water was added into the conical flask, it

may affect our determination of the end-point because the color of indicator may be not clear. Also, lower concentration of sodium carbonate lead to lower reaction rate. The color change of reaction mixture may be slow and lead to over-adding of hydrochloric acid.

Conclusion:

The concentration of hydrochloric was deduced to be 0.0975M from this experiment. The result was acceptable and thus the objective of the experiment has been fulfilled.

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Reference:

http://en.wikipedia.org/wiki/Phenolphthalein
http://en.wikipedia.org/wiki/Methyl_orange