Liyanage L.H.K. **Chemistry lab report 1** **HS21911262**

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Title:- Strong acid and strong base titration

Objective:- To introduce identification of end point related to phenolphthalein indicator in acid base titration.

To learn proper pipetting technique.

To learn titration a strong acid with a strong base.

To determine the molar and pH of an acid solution.

Introduction:-

Titration is an analytical method used to determine the exact amount of a substance by reacting that substance with a known amount of unknown amount. The completed reaction of a titration is usually indicated by a color change of end point. An acid and base neutralization reaction will receive salt and water. In acid base titration, the neutralization the acid and base can be measured with a color indicator.

Acid + Base $\longrightarrow$ Salt + Water

In this experiment, a phenolphthalein color indicator can be used. Phenolphthalein is colorless un acidic solutions and pink in basic solutions. Molar concentration is a common unit for expressing the concentration of solution.

An acid is a chemical term for sour materials that have a pH below neutralization and a base is substance that can neutralize the acid reacting with hydrogen ions. pH is a scale used to specify the acidity or basicity of an aqueous solution.

Acid is a chemical substance which gives hydronium ion, H_3O+, when dissolved in water. Also acid acts as a proton donor. Base in a way that is gives hydroxide ion, OH^- , when dissolved in water. Base acts a as a proton acceptor.

$H_3O+_{(aq)} + OH^-_{(aq)} \longrightarrow 2H_2O_{(l)}$

In the neutralization reaction of hydrochloric acid (HCl) and sodium hydroxide (NaOH), the equivalence point occurs when one mole of HCl reacts with one mole of NaOH.

$HCl + NaOH \longrightarrow NaCl + H_2O$

An indicator is a substance which undergoes a distinct color change at or near the equivalence point. The point at which the indicator changes color and the titration is stopped is called the end point. Ideally, the end point should coincide with the equivalence point. Phenolphthalein is colorless in acidic solution and reddish violet in basic solution.

Molar (M) is used to define concentration of a solution more clearly, and it is defined as the number of moles of solute per litter of solution., or the number of millimoles of solute per milliliter of solution.

$$M = \frac{\text{moles. Solute}}{\text{Volume of solution}} = \frac{10^{-3}\text{ mole}}{10^{-3}\text{ liter}} = \frac{\text{mmol}}{\text{mL}}$$

Material and methods:-

Material:- Sodium hydroxide($NaOH$), Hydrochloric acid(HCl), phenolphthalein solution, wash bottle, Beaker, Titration Flask, Burette, Ring stand, Burette clamp, Balance, pipette

Method/ procedure:-

1. Burette, pipette and titration flask were washed by distilled water.
2. Pipette and burette were washed respectively NaOH solution and HCl solution.
3. $10.00cm^3$ NaOH solution of unknown concentration was transferred to the titration flask by pipette
4. Phenolphthalein indicator was added 1-2 drops form the to the titration flask.
5. Took $1.20*10^{-2}$ mol dm^{-3} hydrochloric acid and that was added to the burette until 0 calibration line.
6. HCl solution was added to the titration flask slowly and until the end point is reached.
7. Burette reading was read at the end point.
8. The experiment was repeated three times.

Results:-

Concentration of HCl = $1.20*10^{-2}$ mol dm^{-3}

Volume of sodium hydroxide solution = $10.00cm^3$

Trial number	**Initial burette reading (cm^3) +/-$0.05cm^3$**	**Final burette reading (cm^3) +/-$0.05cm^3$**	**Volume transferred (cm^3) +/-$0.05cm^3$**
1	0.00	13.30	13.30

2	0.00	11.50	11.50
3	0.00	11.80	11.80

Calculation:-

Concentration of NaOH solution can be calculated by using the equation.

The average of the volume is found by adding two and three volume and they dividing by two.

Average of transferred volume $\overline{x} = (1/n) \sum_{i=1}^{n} x_i$

$$= \frac{11.50cm^3 + 11.80cm^3}{2}$$

$= 11.65cm^3$

Due to hydrochloric acid concentration is $1.20*10^{-3}$mol dm^3 and sodium hydroxide volume is $10.00cm^3$,

Amount of HCl molar = concentration of HCl × average volume of HCl

(mol dm^{-3}) (dm^3)

$= 1.20\times 10^{-2}mol\ dm^{-3} \times \frac{11.65}{1000} dm^3$

$= 1.39\times 10^{-4}$ mol

$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

1 : 1

Due to equal molar ratio of NaOH and HCl,

Amount of NaOH molar = Amount of HCl molar

$= 1.39\times 10^{-4}$ mol

Concentration of NaOH $= \frac{\text{Amount of NaOH molar}}{\text{Volume of NaOH}} \times 1000$

$= 1.39\times 10^{-4}\ mol \times \frac{1000\ dm^3}{10.00}$

$= 1.39\times 10^{-2}\ mol\ dm^{-3} \approx 1.40 \times 10^{-2}\ mol\ dm^{-3}$

Difference between the experimental and actual concentration of sodium hydroxide,

$= 1.40*10^{-2} mol\ dm^{-3} – 1.00*10^{-2} mol\ dm^{-3}$

$= 0.40*10^{-2} mol\ dm^{-3}$

Error the average of concentration,

$$\% \text{ Error} = \left[\frac{\text{theoretical value- experimental value}}{\text{Theoretical value}} \right] *100\%$$

$$\% \text{ Error} = \left[\frac{1.00*10^{-2} mol\ dm^{-3} - 1.40*10^{-2} mol\ dm^{-3}}{1.00*10^{-2} mol\ dm^{-3}} \right] *100\%$$

$= 40\%$

Standard deviation of the result,

$$S_x = ((\sum_{i=1}^{n} (x_{i-} \bar{x})^2)/ (n-1))^{1/2}$$

$$= \left[\frac{(\text{2 trial volume – average volume})^2 + (\text{3 trial volume – average volume})^2}{2-1} \right]^{1/2}$$

$$= \left[\underline{(11.50cm^3 – 11.65cm^3)^2 + (11.80cm^3 - 65cm^3)^2} \right]^{1/2}$$

$$= \left[(-0.15cm^3)^2 + (0.15cm^3)^2 \right]^{1/2}$$

$= \pm 0.212cm^3$

Discussion:-

Titration is important in chemistry as it allows for an accurate determination of solution concentration of the analyte.

During the course of the titration, the titrate (HCl) was added slowly to the NaOH solution. As it was added, the NaOH was slowly reacted away. If we added quickly we cannot accuracy end point.

Titration is a practical technique used to determine the amount or concentration of a substance in a sample. This concentration can then be calculated. To obtain valid results it is important that measurements are precise and accurate.

In here three trials were completed due to want to receive precision result and received three volume transferred of HCl. But in 1 trial, volume transferred was very different and less than 2 trial and 3 trial. In 1 trial, HCl has been expended $13.30cm^3$, it can exclude and it is not precision. But 2 trial and 3 trial has been expended respectively $11.50cm^3$ and $11.80cm^3$.

so here, average volume transfer was calculated add 2 and 3 trial and divide by 2. Average volume was $11.65cm^3$. precision can be found by calculate standard deviation. Then standard deviation was calculated and it was $\pm 0.212cm^3$. Due to the values of 2 and 3 trials are in this range of standard deviation, which 2 trial and 3 trial are precision. So in this experiment, only two trials are precision.

HCl molar was calculated by using average volume and it's concentration. In NaOH and HCl reaction, due to equal NaOH and HCl molar ratio, NaOH average concentration can be calculated.

So average concentration of NaOH was $1.40*10^{-2}$mol dm^3 . But actual concentration of NaOH was $1.00*10^{-2}$ mol dm^{-3}. So experimental value and theoretical value were different. The different was $0.4*10^{-2}$ mol dm^{-3}. Experimental value concentration of NaOH was high than theoretical value concentration of NaOH. Furthermore in here error percentage of experimental value was 40%. When consider experiment, it is some of higher error percentage of value. So in that experiment, experimental concentration of NaOH is low accuracy because it's a some of higher error than theoretical value.

So in here the correctly volume of transferred in burette should be received and should check the correctly calibration of the burette and should receive lower meniscus it. Exactly it should be stoped, adding HCl to NaOH when end point or color change point.

Pipette, burette and titration flask should bs washed using distilled water and only pipette and burette should be washed solution. Then error of accuracy can be prevented.

Indicators are substances that change colour when they are added to acidic or alkaline solutions. A strong acid – strong base titration is performed using phenolphthalein indicator.

Phenolphthalein is chosen because it changes color in a pH range between 8.3-10. It appears pink basic solution and clear in acidic solutions.

Due to the fact, that all burette are made of glass, it can absorb and remain water on the surface, because of the polarity of the glass and intermolecular forces and have to rinse the burette with a solution which must be filled in it, because distilled water change the concentration of the initial solution.

The limitation of the equipment was realized. Sufficient quantities were used of analytical and titration. The precision of the glassware was verified.

Conclusion:-

In the process of titration, a basic solution is gradually added to the acidic solution till complete neutralization is obtained. The end point of the titration is detected with the help of an indicator as color of the solution changes upon neutralization.

Reference:-

Chemistry 9th edition, Raymond Chang.

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https://youtu.be/HJvALCcKYAc

https://youtu.be/2VQM8suez8U