

Experiment No. - 1

Aim: Conductometric Titration- Determination of the strength of a solution of hydrochloric acid by a standard solution of sodium hydroxide

Theory:-

Electrolytic conductivity is a measure of the ability of a solution to carry electric current. Electrolytic solutions conduct electric current by the migration of ions under the influence of electric field. According to Ohms Law, the current strength flowing through a conductor is directly proportional to the potential difference (E) and inversely proportional to the resistance (R) of the conductor.

$$\text{i.e. } I = E/R \quad \text{or, } R = E/I$$

where, the resistance (R) is the hindrance provided by the solution. The resistance of any conductor varies directly with the length and inversely with its area of cross-section.

$$R = (\rho \cdot l)/a$$

Where, ρ is the specific resistance and it is the resistance of a unit length of conductor of unit cross-section. l/a is called cell constant.

The reciprocal of specific resistance is called specific conductance or conductivity.

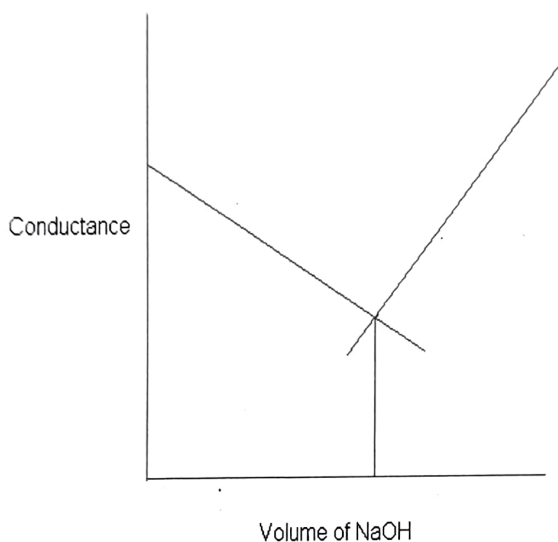
$$\text{Specific conductance } (\kappa) = 1/\rho = (l/a) \cdot (1/R)$$

Conductance of electrolyte depends upon i) number of free ions, ii) charges on the free ions and iii) mobility of the ions on the substitution of one ion by another of different mobility (speed of ions). So, conductometric method can be used to determine the end point of ionic titrations like i) acidimetric titration, ii) precipitation titration, iii) titration involving the formation of complex ion.

When hydrochloric acid solution (HCl) is titrated with sodium hydroxide solution (NaOH), the highly mobile hydrogen ions ($\lambda_{\text{H}^+}^{\circ} = 350 \text{ ohm}^{-1} \text{ cm}^{-1}$) are progressively replaced by slower moving sodium ions ($\lambda_{\text{Na}^+}^{\circ} = 50 \text{ ohm}^{-1} \text{ cm}^{-1}$) and the conductance of the solution decreases. After the end point, the conductance of the solution rises sharply due to the presence of excess, highly mobile hydroxide ion ($\lambda_{\text{(OH)}^-}^{\circ} = 198 \text{ ohm}^{-1} \text{ cm}^{-1}$). Thus the neutralization of a strong acid by addition of a strong base leads to a minimum conductance at the end points. This is due to the

disappearance of H^+ ions and their replacement by slower moving Na^+ ions of the base followed by the presence of highly mobile OH^- ions after the end point.

Therefore, the nature of the graph will be as given below;



The conductivity cell used for this titration should permit stirring by shaking and to which the reagent can be added from burette. A large increase in volume during titration should be avoided.

Apparatus and Reagents:-

- | | |
|----------------------|------------------------------------|
| • Conductivity meter | standard sodium hydroxide solution |
| • Conductivity cell | unknown hydrochloric acid solution |
| • Beaker (100ml) | distilled water |
| • Pipette (25ml) | |
| • Microburette | |

Procedure:-

Step-1:- Unknown HCl solution is provided

Step-2:- 0.1 (N) NaOH solution is provided

Step 3:- Calibrated instrument is provided

Step 4:- Conductometric Titration.

- i) Rinse the conductivity cell a number of times with distilled water.
- ii) Pipette out 25ml of HCl in a beaker and dip the conductivity cell in it, so that the cell should dip completely in solution.
- iii) Note the temperature of the sample solution and accordingly set the temperature control. Then take the first observation i.e, before addition of NaOH solution.
- iv) Now, every time add small amount of NaOH solution (0.5ml) from microburette, stir it and measure the conductance after each addition.
- v) Take at least five readings beyond the end point.

Result and Calculations:-

Lab Temperature = ----- $^{\circ}\text{C}$

Table 1:- Conductometric Titration

No. of obs.	Volume of HCl taken (V_1)ml	Volume of NaOH added (ml)	Total Volume of NaOH (V_2)ml	Conductance
1	25ml			
:				
:				
:				
:				
21				

Plot Conductance against volume of titrant (NaOH solution). Two intersecting lines will be obtained (as given in the fig.) and the points of intersection of these lines represent the equivalence point.

Let, V_3 be the volume of NaOH at the equivalence point and the strength of acid is S_1

Then, $25.S_1 = V_3 S_2$

$$\therefore S_1 = (V_3 S_2 / 25) \text{ (N)}$$

The strength of acid is _____ (N)

Discussions:-

- i) Normally, the coloured solution which can not be titrated with volumetric method using indicator can be titrated by the conductometric method.
- ii) The conductometric titration method can be used in case of weak acid vs weak base and also in case of very dilute solutions.
- iii) Near the end point, no special case is necessary as it is determined graphically.

Precautions:-

- i) Electrical connection should be made carefully.
- ii) Temperature during the experiment should be kept constant as conductance depends on temperature.
- iii) Stirring should be done after each addition of titrant.
- iv) To avoid the dilution effect, the concentration of the titrant should be 5-10 times more than that of the solution to be titrated.

Conclusion:-

The strength of unknown acid solution is _____ (N)