Experiment (3):

Conductometric titrations of acids with strong base

Introduction

Conductometric titrations used to investigate neutralization titrations by observing the change in electrical conductivity. The principle of conductometric titration is based on the fact that during the titration, one of the ions is replaced by the other and invariably these two ions differ in the ionic conductivity with the result that conductivity of the solution varies during the course of titration. The titration reaction involve the addition the reagent to a solution that contains a substance with unknown molarity. Just before and after the equivalence point, there is a marked difference in the rate of change of conductivity with addition of reagent. The curve of titration involve plotting conductivity of the solution against the volume of standard reagent. The use of an excess of the standard reagent establishes the correct location of the equivalence point therefore it is then possible to find the volume of reagent equivalent to the solution titrated by measuring the conductivity.

There are some advantages of conductometric titration:

1) *No need to indicator.*
2) *The end point identified graphically with minimum error.*
3) *Used with colored liquids for which ordinary indicators cannot work.*
4) *Used for dilute solutions as well as for very weak acids.*

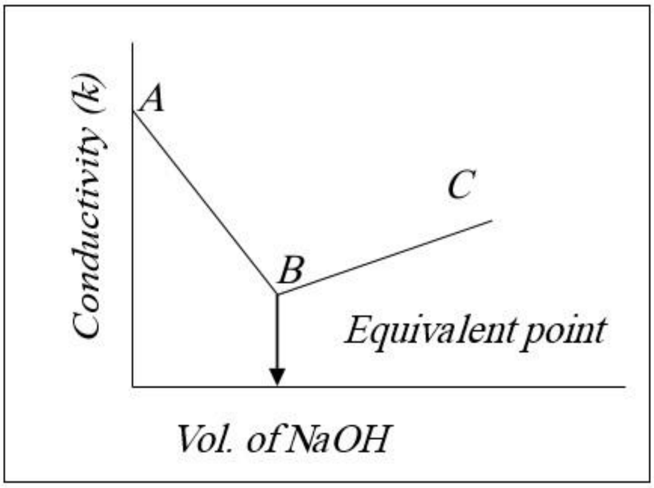
Examples about conductometric titrations:

1) ***Titration of strong acid (HCl) with strong base (NaOH).***

In first, the solution of HCl is unknown molarity; it is possible to find the concentration of HCl by titration with NaOH (known concentration) and using the titration curve. Before the addition of the base, the acid solution has a high conductivity (due to completely ionized in aqueous medium furthermore as H^+ *ion has very large ionic mobility). As base added, the* H^+ *ion has react with* OH^- *ion to form water and being each* H^+ *ion replaced by Na+ ion (where the conductivity of* Na^+ *less than conductivity of* H^+*). Consequently, the conductivity of the* *solution decreases and keeps on falling with addition of the base until reached to the equivalent point. At the equivalence point, the solution contains only NaCl.*

$$\mathbf{HCl + NaOH \longrightarrow H_2O + Na^+ + Cl^-}$$

Further addition of alkali introduces now an excess of the fast OH^- ions and they causes the conductivity to rise again. This variation of solution conductivity plotted against the volume of alkali added. The result of the titration curve looks like the curve ABC shown in following figure:



Where point (B) represents the minimum conductivity there is no excess present of either acid or base and hence it is the equivalent point. .

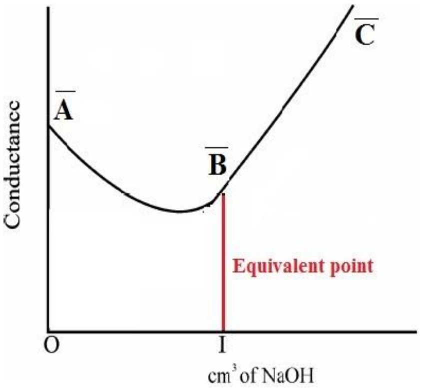
2) **Titration of weak acid (CH_3COOH) with strong base (NaOH)**.

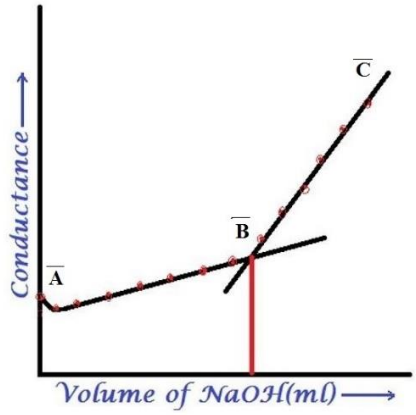
Since the acid is weak, its conductivity is relatively low. On the addition of base, there is decrease in conductance not only due to the replacement of H^+ by Na^+ but also suppresses the dissociation of acetic acid due to common ion acetate. But very soon, the conductance increases on adding NaOH as NaOH neutralizes the un-dissociated CH_3COOH to CH_3COONa which is the strong electrolyte.

This increase in conductance continues raise up to the equivalence point. The graph near the equivalence point is curved due the hydrolysis of salt CH_3COONa. Beyond the equivalence point, conductance increases more rapidly with the addition of NaOH due to the highly conducting OH^- ions.

$$CH_3COOH + NaOH \rightleftharpoons H_2O + CH_3COONa$$

The variation of conductivity with volume of NaOH gives curve looks like the curve $\bar{A}\bar{B}\bar{C}$.





Where point (B) (in cases titration HCl or CH_3COOH with NaOH) represents the equivalent point or the neutralization point. In this point, moles number of H^+ ions is equal to the moles number of OH^- ions, hence mole balance at the neutralization points yields:

$$n\,H^+ = n\,OH^- \qquad \dots\dots\dots\dots (1)$$

$$M_{acid} \times V_{acid} = M_{base} \times V_{base} \qquad \dots\dots\dots (2)$$

Procedure:

A- Titration HCl with NaOH:

(95mL) of distilled water added to (5mL) of HCl (unknown concentration) and its conductivity is measured, then it is measured after addition of (1mL) from solution (0.1M) of NaOH. This is repeated until (10mL) of NaOH is added.

B- Titration of CH_3COOH with NaOH:

Withdraw (5mL) of CH_3COOH from the stock solution (unknown concentration) and add (95mL) of distilled water, measure its conductivity, then add (1mL) of NaOH (0.1M) on solution of CH_3COOH and measure conductivity of solution. This is repeated until (10mL) of NaOH is added.

Calculations:

1- For each experiment, draw the conductivity (k) versus the volume of NaOH added.

2- Find the concentration of CH_3COOH and HCl.

Discussion:

1- What is the principle that the conductometric titration depend on it?

2- How can you know the neutralization point during the conductometric titration? Explain it.

3- We don’t need indicator when we use the conductometric titration. Why?

4- When do you prefer the conductometric titration on the ordinary indicators?

5- At conductometric titration, we prefer use concentration of reagent greater than concentration of solution titrated, why?