Experiment 10: Estimation of Acids in acid mixture conductometrically

Significance of the experiment: Conductivity (or specific conductance) of an electrolyte solution is a measure of its ability to conduct electricity.[1] The SI unit of conductivity is siemens per meter (S/m). Conductivity measurements are used routinely in many industrial and environmental applications as a fast, inexpensive and reliable way of measuring the ionic content in a solution.[2] For example, the measurement of product conductivity is a typical way to monitor and continuously trend the performance of water purification systems.In many cases, conductivity is linked directly to the total dissolved solids (T.D.S.). High quality deionized water has a conductivity of about 5.5 μS/m, typical drinking water in the range of 5-50 mS/m, while sea water about 5 S/m.[3] (i.e., sea water's conductivity is one million times higher than that of deionized water).Conductivity is traditionally determined by measuring the ACresistance of the solution between two electrodes. Dilute solutions follow Kohlrausch's Laws of concentration dependence and additivity of ionic contributions. Lars Onsager gave a theoretical explanation of Kohlrausch's law by extending Debye–Hückel theory.

Aim : To estimate HCl and CH_3COOH by conductometrically using standard sodium hydroxide solution.

Principle : Conductometry is based on Ohm's law.

- Ohm's law states that the current i (amperes) flowing in a conductor is directly proportional to the applied electromotive force, E (volts), and inversely proportional to the resistance R (ohms) of the conductor.

$$i = \frac{E}{R}$$

- The reciprocal of the resistance is called the conductance. The resistance of a homogeneous material of uniform cross section with an area of a sq. cm. and length *l* cm is given by

$$R = \frac{\rho \times l}{a}; \quad \mathbf{k = C\ [l/a]}$$

whereρ is the specific resistance. The reciprocal of the specific resistance is termed the specific conductance, κ.

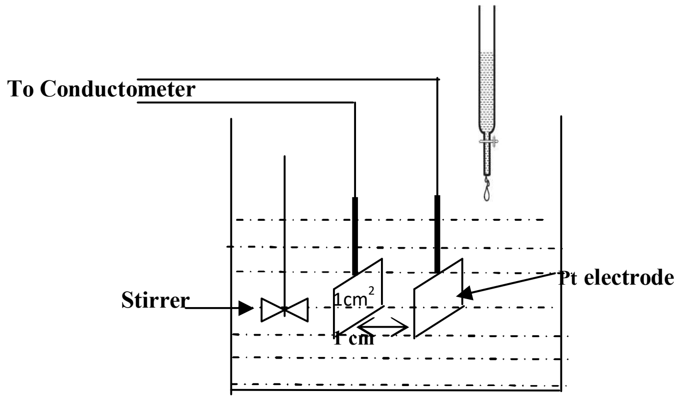
Specific conductance: Specific conductance of a solution is defined as the conductance of a solution present between two parallel electrodes which have 1cm^2 area of cross section and which have kept 1 cm apart.
The principle underlying conductometric titrations is the substitution of ions with a specific mobility by ions of another specific mobility.Therefore, the conductance of solution depends on the number of mobility of ions. The equivalence point is determined graphically by plotting conductance against titer values.

Let V_1 and V_2 ml be the volume of NaOH corresponding to first and second breakes respectively then 'a' ml of NaOH = HCl and (V_2 - V_1) ml of NaOH = CH_3COOH.

$NaOH + HCl \rightarrow NaCl + H_2O$

$NaOH + CH_3COOH \rightarrow CH_3COONa + H_2O$

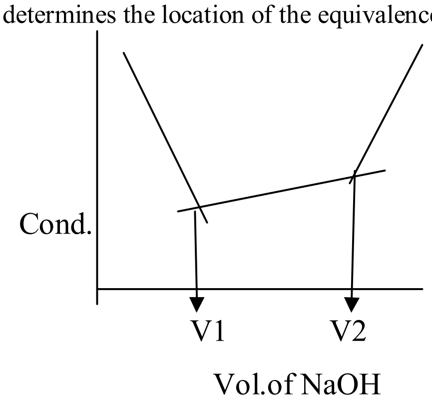
Instrumentation : Conductometer consists of conductivity cell having two platinum electrodes and a conductance measuring device. The two electrodes have unit area of cross section and are placed unit distance apart. A simple arrangement of conductometric titration is depicted in figure. The solution to be titrated is taken in the beaker.



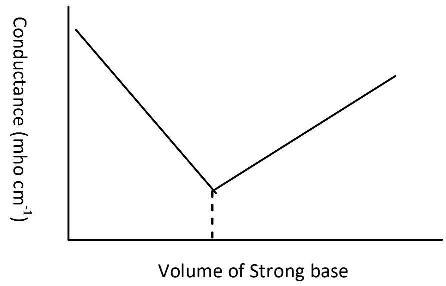
Procedure : Exactly 50ml of the given acid mixture was pipette out into a clean 100ml beaker the electrode of the conductivity cell was washed well with distilled water and then immersed into the beaker containing acid mixture. The conductivity was noted before adding the titrant, then 1N NaOH solution was added from the micro burette 1 ml at time and the conductivity was noted at each time. Then the graph was plotted with the volume of NaOH along X-axis and the conductivity along the y-axis. From the graph was plotted with the volume of burette solution required to neutralize the solution taken in the beaker was found out, using the normality equations that is $N_1V_1=N_2V_2$.We can found out concentrations of strong acid and weak acid.

Applications:

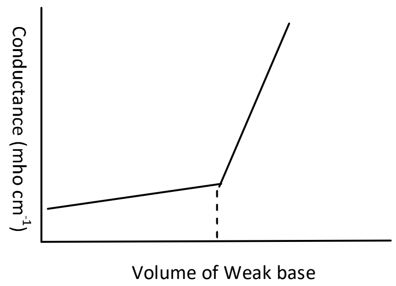
i) Mixture of acids with a Strong base [($HCl+CH_3COOH$)Vs NaOH] : Conductometric titration may be applied for the determination of acids present in a mixture.[1,2] In the titration of a mixture of a week acid (CH_3COOH) and strong acid (HCl) with a strong base (NaOH), the conductance decreases upon adding NaOH to acid mixture owing to the substitution of highly mobile H^+ ions by the less mobile Na^+ ions.This trend continues till all the H^+ ions of HCl replaced i.e, the strong acid is neutralized. Continued addition of NaOH raises the conductance moderately, as the weak acid (CH_3COOH) is converted into its salt (CH_3COONa).Further addition of NaOH raises the conductance steeply due to the presence of OH^-ions. The titration curve in the graph given determines the location of the equivalence points.



ii) Strong acid with a Strong base (HCl Vs NaOH): In case of a strong acid and a strong base, the conductance first falls, due to the replacement of highly mobile H^+ ion by the added cation. After the neutralization point, the conductance rapidly rises with further additions of strong base and is due to increase in the concentration of the OH^- ions.



iii) Weak acid with a strong base: (CH_3COOH Vs NaOH): In the conductometric titration of a weak acid with a strong base, the conductance of the acid will be initially low due to poor dissociation of acetic acid. On complete neutralization of the acid, further addition of base leads to an increase in the number of more mobile OH^- ions. Hence conductance increases sharply.



Advantages:

i) Mixture of acids can be titrated more accurately by conductometric titration.

ii) Conductometric titrations may be applied where potentiometric methods fail.

iii) Accurate in dilute solution as well as in more concentrated solution.

iv) It can be employed with colored solutions.

v) Very weak acids which cannot be titrated potentiometrically in aqueous solutions can be titrated conductometrically with relative ease.

Result:

Weight of HCl in given acid mixture =………………..g

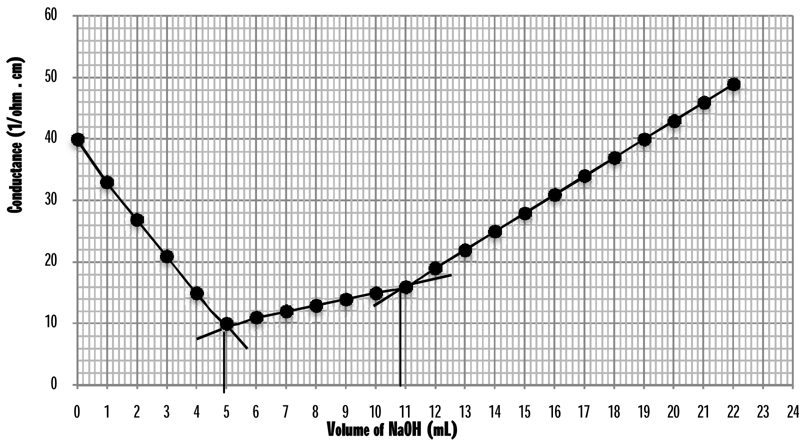
Weight of CH_3COOH in given acid mixture =…………..g

Links to the external sources of information about the topic:

1. http://en.wikipedia.org/wiki/Conductometry
2. Gray, James R. (2004). "Conductivity Analyzers and Their Application". In Down, R.D; Lehr, J.H. *Environmental Instrumentation and Analysis Handbook*. Wiley. pp. 491–510.
3. "Water Conductivity". Lenntech. Retrieved 5 January 2013.
4. www.tau.ac.il/~advanal/ConductometricTitrations.htm

Experiment 10: Observation and calculations

Sl. No.	Volume of NaOH added (mL)	Conductivity (Ohm^{-1} cm^{-1})



Normality ofNaOH solution =**………………** (Will be provided to you)

Normality of HCl=$\frac{Normallity\ X\ VolumeofNaOH\ (V1)}{VolumeofHCl\ (50)}$= …………. (c)

Weight of$\frac{HCl}{Liter\ (L)}$= 'c' x Equivalent weight of HCl (36.5) = …………g (d)

Normality of CH_3COOH = $\frac{NormalityofNaOH\ X\ VolumeofNaOH\ (V2-V1)}{VolumeofCH3COOH\ (50)}$=.... (e)

Weight of$\frac{CH3COOH}{Liter\ (L)}$= Normality of CH_3COOH x Equivalent weight of CH_3COOH

= Normality of CH_3COOH x 60.5 = ……..g of CH_3COOH

Result:

Weight of HCl in given acid mixture =………………..g

Weight of CH_3COOH in given acid mixture =…………..g