Exp. 7

AIM: Use Conductometry to determine the concentration of HCl

Apparatus Required: 100ml beaker, tissue paper, burette, Conductivity cell, digital conductivity meter, distilled water, pipette

Chemicals Required: 0.1 M NaOH, HCl solution, ~~tap water~~, KCl solution

Principle: Compounds that wholly or partially dissociate into ions in water/solvents are electrolytes. The conductance depends upon
- concentration of ions
- temperature of the solution
- nature of the ion (charge per ion, mobility/size, etc.)

Conductivity here in the solution is different than we talk in solid state, because conductivity here is due to electrolytes.
In this experiment, we will measure conductivity of HCl solution as a function of vol. of NaOH added to it.

By applying electric field, using 2 electrodes, one can basically get ions in the solution transported across the electrodes and can get electrical conductivity. We use a combined electrode which has 2 electrode plates in it, kept at a fixed distance, such that Area/distance ratio would be around 1, which is called cell const. ~~the~~ These 2 electrodes are connected to digital conductivity meter which gives conductivity of solution in which it is immersed, in mho/cm or S/cm units.

Conductivity is an intrinsic property. In the experiment, we will determine unknown concentration of HCl using a conductometric titration. ~~and by putting~~

We will be titrating HCl solution of known volume with NaOH and continuously measuring the conductivity and plot it

Basically, what will happen is initially as the NaOH is added it will start neutralizing HCl. So the conductivity decreases, although NaCl will be formed but its conductivity is less than HCl also water is forming which will act as diluting the solution. But as soon as HCl is totally neutralized, now NaOH itself is a electrolyte so it increases the conductivity so an Inversion point can be noted from where conductivity starts increasing from decreasing and at this point HCl is neutralized, and conductivity is minimum.

Some terms –

specific conductance (K) : the conductance of 1 cm³ of a material, which is an inherent property of material.

unit of K   mhos/cm or Siemens/cm

molar conductivity (Λ_{mol}) : The conductivity of a solution that contains 1 mole of the substance (solute) in 1 liter. Unit of Λ is $Scm^2 mol^{-1}$.

$$\Lambda_{mol} = K/C$$ where C is conc in mol/liter (molarity)

equivalent conductivity (Λ_{eq}) : conductivity per gram equivalent of electrolyte.

$$\Lambda_{eq} = K/C_{eq}$$

C_{eq} = Normality

We know about conductivity that it is dependent also on mobility of ions, eg, it may look strange that small Li^+ has less mobility than Na^+ in aqueous because of its small size, charge density is more, its (Li^+) pulling power for water is more, which causes a bigger cluster formation around its ions. In turn, heavy molecule of cluster has less mobility. ($Li^+ < Na^+ < K^+$) ($F^- < Cl^- < Br^-$)

It is also important in this experiment to caliberate the digital conductivity meter/electrode/conductivity cell with a primary standard solution like KCl solution.

Reactions:

$$NaOH_{(aq)} + HCl_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O$$

Procedure:

(A) Calibaration of electrode:

Before doing any experiment, calibarate the electrode using a primary standard solution. like KCl solution.

So, do take the standard solution whose conductivity is known, put electrode in that solution and verify the reading with value of conductivity already known.

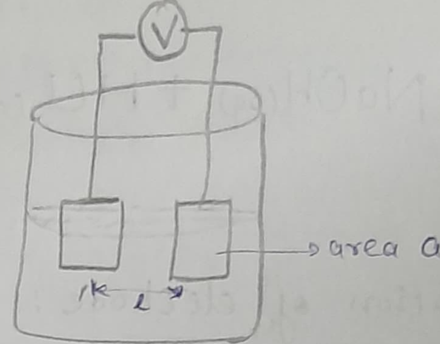
(B) Titration

1) Take 25 ml HCl in 100/150 ml beaker using pipette
2) Add 25 ml of distilled water to this to inc. volume.
3) Take 0.1M NaOH solution in 50ml burette and adjust zero reading.
4) Now ~~add~~ put electrode in the solution after wiping it with tissue paper, and record initial conductivity.
5) Now add the NaOH solution from the burette in 0.2ml increments and record conductivity after mixing the solution, stir each time.
6) Repeat the experiment twice.
7) Plot the graph of vol. of NaOH vs conductivity and determine the equivalence point of titration.
8) Calculate the molarity /normality of HCl solution.

Conductivity cell :

~~cell constant~~

~~$K = G(\frac{l}{a})$~~



$K = G\left(\frac{l}{a}\right)$

K → conductivity

G → conductance ($\frac{1}{R}$, R = Resistance)

$\frac{l}{a}$ → cell constant

Observations & Calculations :

From graph (on next page)

Note that end point of titration in this case is at 2.2 ml ~~of NaOH~~ of NaOH

At the end point, (Given concentration of NaOH solution = 0.1M)

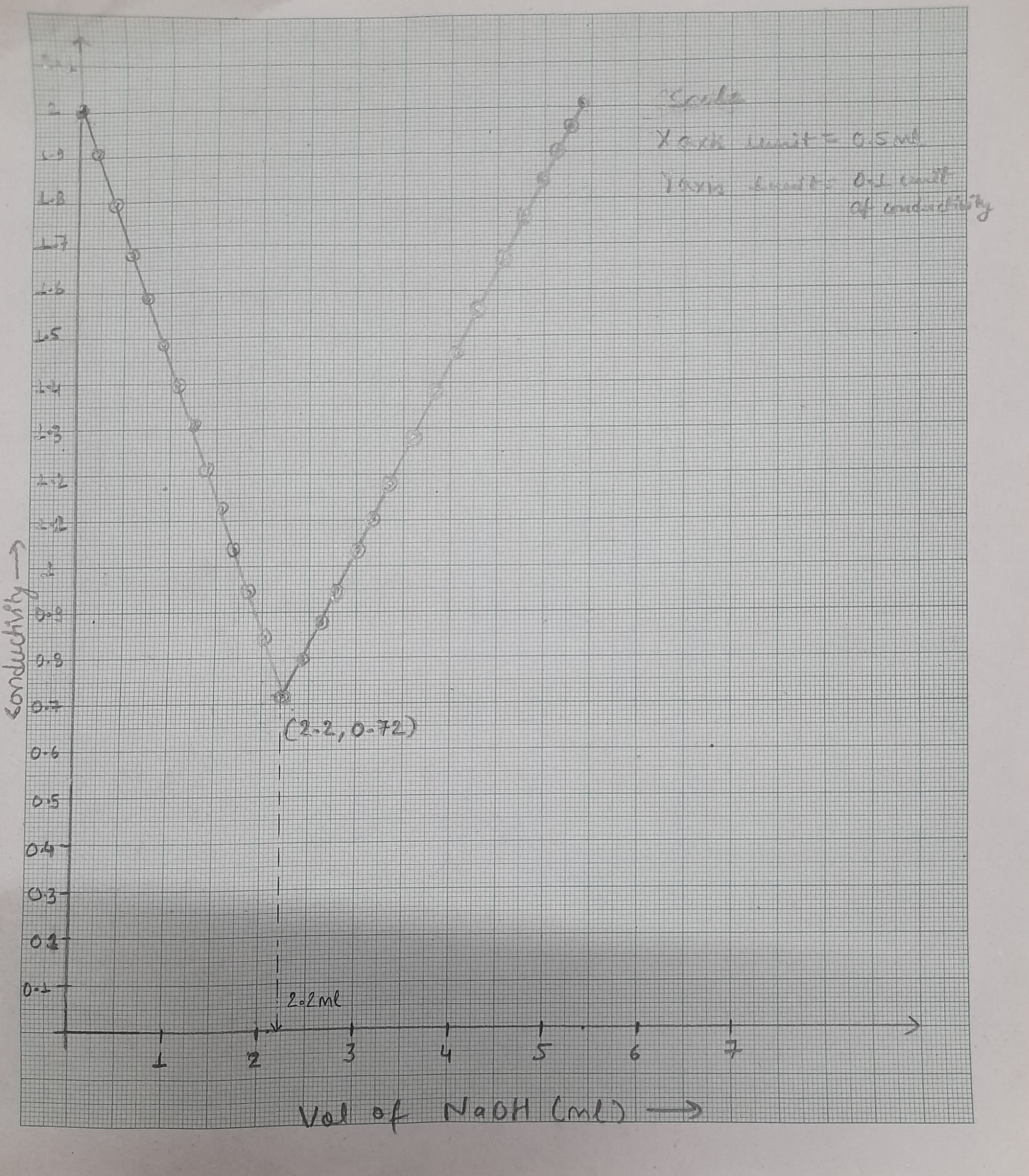
$$\text{moles of NaOH} = \text{moles of HCl}$$

$$M_{NaOH} \times V_{NaOH} = M_{HCl} \times V_{HCl}$$

$$0.1 \times 2.2 = M_{HCl} \times 25$$

$$\text{Molarity of HCl} = 0.009\ M$$

Vol. NaOH (in ml)	Conductivity	Vol. NaOH (in ml)	Conductivity
0	2.06	2.6	0.88
0.2	1.92	2.8	0.98
0.4	1.86	3	1.05
0.6	1.78	3.2	1.14
0.8	1.63	3.4	1.21
1	1.49	3.6	1.3
1.2	1.34	3.8	1.4
1.4	1.24	4	1.5
1.6	1.09	4.2	1.58
1.8	0.95	4.4	1.64
2	0.86	4.6	1.72
2.2	0.72	4.8	1.83
2.4	0.82	5	1.89
		5.2	1.99
		5.4	2.07



Scale
X axis unit = 0.5 ml
Y axis unit = 0.1 unit of conductivity
(2.2, 0.72)
2.2ml
conductivity →
Vol of NaOH (ml) →

Advantages of Conductometric titration:

1) No need of indicator.
2) Color or dilute solutions or turbid solutions can be used for titrations
3) Temprature is maintained constant throughout the titration
4) End point can be determined accurately, and errors are minimized as the end point is being determined graphically.

Results: 1) Conductometric titration was performed to determine the concentration of a given acid sample

2) Molarity of given HCl = 0.009 M

Precautions: 1) Calibaration of electrode must be done

2) Maintain constant temprature to avoid errors.