Elementary Electrochemistry
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Conductometric Titrations of Strong Acid with Strong Base

Hello everyone. Welcome back to this course Elementary Electrochemistry. As you can understand that today we are going to demonstrate a few experiments, we have already discussed about the potentiometric titration and have done demonstrations on that, hope you have followed those demonstrations and the follow up lectures where we discussed about the calculations and graph plotting after the experiment was conducted.

So, today, we are going to demonstrate the experiments related to conductivity. So, theory part of this has already been discussed in the lecture sessions. So, now I am going to demonstrate three experiments using conductometric titration as a tool and we will see how a conductometry experiment is conducted and then we will see how the conductivity changes for different analyte solutions as was theoretically discussed during the lecture.

So, in the first experiment I am going to demonstrate the conductometric titration of a strong acid that is hydrochloric acid with a strong base.

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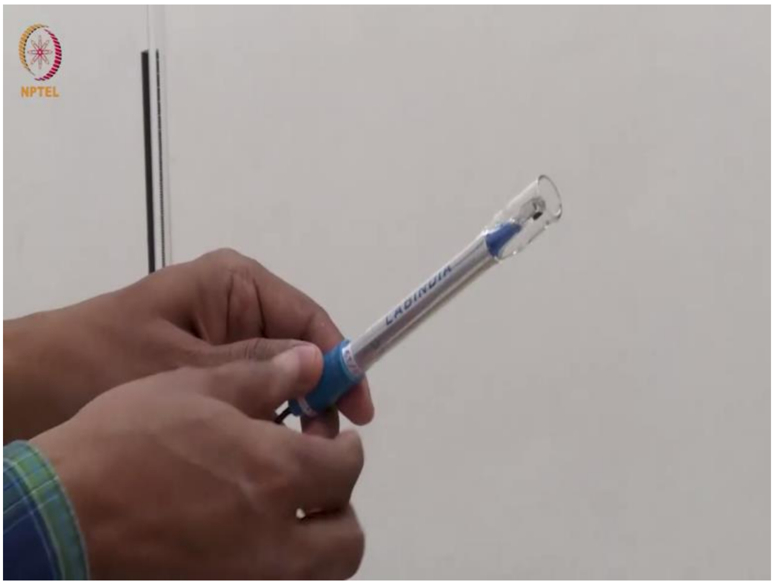
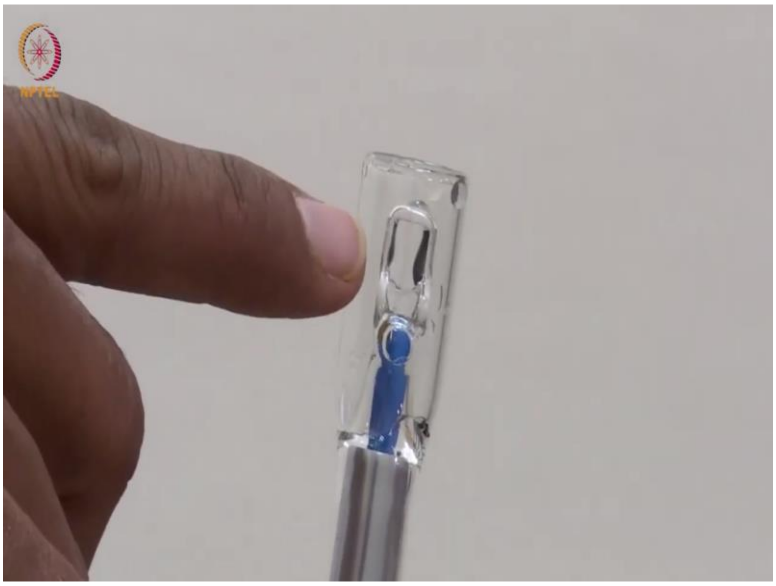

LABINDIA




LABINDIA
pH/CON METER
Con= 1.433mS R6 C
K = 1.025 * 23.0°

So, before we start the actual experiment I would like to explain a bit about this conductivity meter which you can see on your screen. The celcon standard we have here is calibrated to 1.025 and the conductance value that you are seeing here of 1.430 milli-siemens. This conductance is the conductance of a solution of 0.01 molar Kcl which I have prepared by accurate wing.

By accurate wing we mean that the way that was followed for preparation of standard solution of oxalic acid in the previous experiment we use the same method to make a KCL solutions slightly more than 0.01 molar and then we have used accurate dilution technique to dilute it in such a way that the final concentration is exactly 0.01 molar. So, using that 0.01 molar KCL solution we have calibrated this conductivity cell and conductivity instrument.

And what I am trying to show you here is the conductivity electrode. You can see that the electrode is made up of glass and at the opening end here you can see there are two electrodes which are at 1 centimeter apart and the area of those two electrodes which are seen inside is 1 square centimeter. So, when we use this electrode then the solution that is within that 1 centimeter apart electrode within 1 square centimeter area. That means the volume of that quantity of solution is 1 cubic centimeter or 1 cc.

So, that is how one actually measures the conductivity of a solution where we say that the entire volume of the solution is 1 cc and the corresponding cell constant ideally should have been 1, but then while calibrating we had to enter the expected conductance value for 0.01 molar KCL which is actually 1.44 milli-siemens.

But then this solution has slightly different value which you can see as 1.433 that gives us the cell constant value as 1.025. So, after this calibration and getting the correct constant for this cell we will start our conductometry titration. So, what we first need to do is we need to take this solution away, we remove this KCL solution and keep it aside. We do not throw it because we can use it once again in the next time when we are going to do a calibration once again.

Now, we need to watch the electrode carefully because 0.01 molar KCL is reasonably concentrated solution, so one has to get rid of that KCL before doing any analysis. So, we are throwing away the washing and we should wash the beaker as well because we are going to use this beaker for our conductometric titration using 1 N approximately N by 100 HCL. So, in the previous experiment I have shown you how to prepare a primary standard oxalic acid solution.

So, in this experiment I am not demonstrating that, but I just want to mention that you will need a primary standard oxalic acid to standardize the NaOH solution which will be used to do the conductometric estimation of HCL. Just like your potentiometric titration we need to use approximately 10 times more concentrated NaOH solution for the titration just to reduce the change in volume that may take place during this titration experiment.

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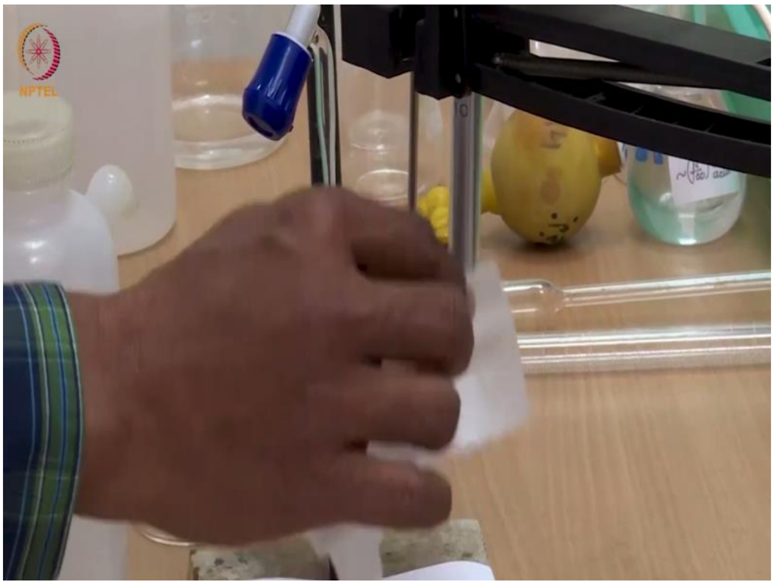

You see now I am going to clean the temperature sensor and also the outer part of the electrode carefully without touching or without spoiling the electrode with the tissue paper we should clean up any solvent, any solution of KCL that maybe sticking to the electrode and giving you some conductance value when we use HCL in our experiment. So, now the electrode is ready to use.

I am just going to dig this electrode in distill water and show you what is the conductance value of distill water that we would show and then to that we will add 10 ml of N by 100 HCL so that we can start the titration in this solution itself. Once again the amount of water added is just to dig the electrode otherwise we will not get a good reading. So, now you can see that I have just added some amount of water about 30 ml of water.

And the conductance value that you can see for this distill water is showing as 8.04 and you see the unit is micro-siemens, it was for KCL a milli-siemens you need that means the conductance of N by 100 KCL was about 1,000 times more than this water.

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So, now to this water I will add N by 100 HCL solutions which is here which we prepared the other day the same HCL solution I am going to use for this analysis. So, this is approximately N by 100 HCL, I am going to add this N by 100 HCL 10 ml to this beaker. So, I will be getting out this N by 100 HCL using a 10 ml pipette and carefully making it up to the mark which is marked here as 10 ml. You can see there is a mark here which tells that this volume is 10 ml.

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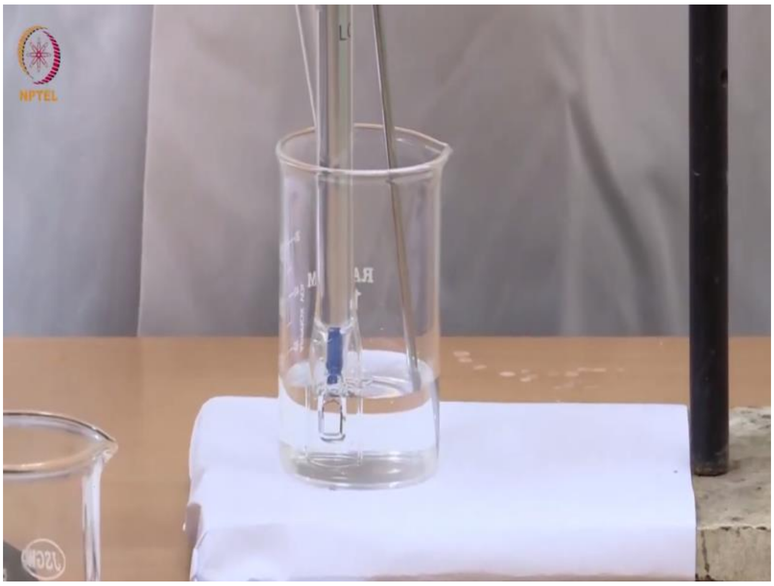

So, now I am adding this HCL to water which I have taken to emerge the electrode. You should notice in the reading that now the electrode is reading the concentration, reading the conductivity of the solution of HCL in water. I have to add completely as much as it goes and leaving the last drop here. So, now when I shake this solution well and homogenize this will then read the starting conductance of this particular titration.

You remember that the water that I have added is actually reducing the conductance of this HCL solution, but since this is a method of titration and we are going to measure the change in conductance. So, the initial starting conductance with water will not matter. So, if we add little more water you will see there will be a change in conductance, but then that will be our starting conductance from which we will start adding NaOH.

And continuously measure the conductance value till we reach the end point. So, now as usual like the potentiometric titration you should take the reading at a very small interval in volume of NaOH. So, you need to write down the volume of NaOH versus the conductance value in milli-siemens. As you can see now after addition of 10 ml of HCL the conductance has changed to 1.249 milli-siemens.

It was earlier micro-siemens with water and now it has become 1,000 times more with the added amount of HCL. So, now we will start adding NaOH or starting reading without any NaOH is 1.250 milli-siemens.

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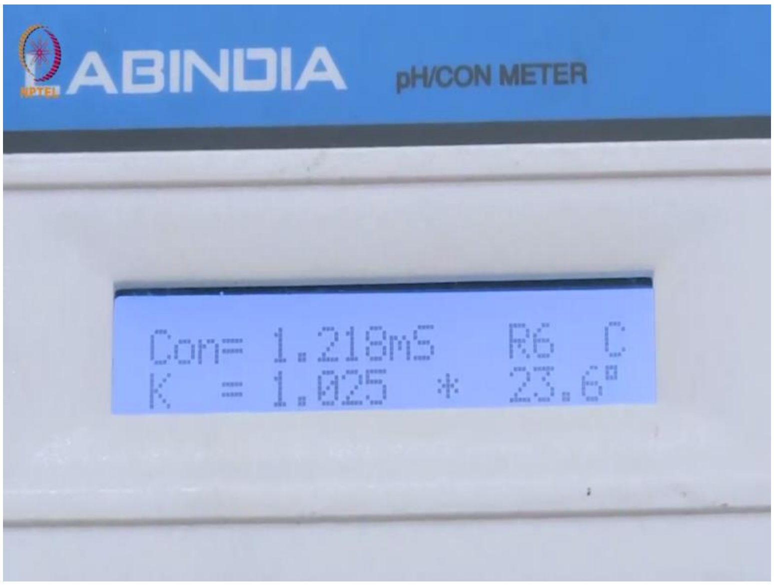

Now, I am going to use this 10 ml micro burette which I have filled with N by 10 NaOH and we will start adding small portions of N by 10 NaOH to this solution and mix the solution well, homogenize it and then take the reading of this changed conductance. So, now I am starting with addition of 0.04 ml of this NaOH solution. So, after adding 0.04 ml the conductance has changed to 1.218 milli-siemens.

So, we should continue this small amount of NaOH addition till we see any situation where the conductance again starts to increase. So, here what is happening is the H plus ions are getting reduced. The number of H plus ions is getting reduced as a result the conductivity of this solution decreases, the conductance of the solution decreases, because H plus ion conducts electricity significantly more than any other ions that you know and we have discussed about it in the theory why does that happen.

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So, now I have added another 0.04 ml I have reached 0.08 ml and the conductance has reduced to 1.189. So, like that I am going to continue addition of 0.04 ml each time.

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So, now I have reached a value of 0.2 ml and you see the reduced conductance is 1.087. So, like this again I will continue adding 0.04 ml and show you the reading after a few readings that I have already taken. So, now what you can see is that I have reached 0.4 ml of NaOH and the conductance has reduced in the level of micro-siemens, that is it is now giving you the reading in 937 which essentially means 0.937 milli-siemens.

That means the conductance has decreased significantly from the point where we started which was 1.25 milli-siemen and we have reached 0.936 milli-siemens. So, we will continue this addition till we see some increment in the conductance taking place. So, that will indicate the equivalence point has been reached.

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Now we have reached a value of 0.6 ml of NaOH added and the conductance that we see here is 0.778 milli-siemen or 778 micro-siemens that you can read from here. So, for our simplicity purpose we should always maintain the same unit although the instrument maybe showing in a different unit because it shows with 3 decimal places and then there is 3 significant figures and then after decimal you have one figure.

So, it gives you in terms of micro and milli it shows you only 4 digits. So, I am writing down the values in milli-siemen units. So, now we have added up to 0.8 ml and the conductance that we have reached is 0.632. So, what we see is we are still decreasing in conductance which indicates that the neutralization or the equivalence point has not been reached here. And we should continue addition of small amount, till we start seeing increase in the conductance, that will show that there is additional amount of NaOH, which is now, become will be responsible for the increase in conductance.

So, now you can see we have reached 1 ml of this reading which you can see from here in the burette reading you can see that we have reached 1 ml and with that 1 ml reading 1 ml of NaOH the conductance value is 0.484. So, as we assume HCL that was taken approximately N by 100 and NaOH that is taken is also approximately N by 100 we must determine the strength of this NaOH using a standard oxalic acid solution so that is the standardization process one should do to determine the correct strength of this NaOH.

We are about the equivalence point now. We have taken 10 ml of HCL and that 10 ml of HCL would consume about ml of NaOH. So, in next few additions of 0.04 ml of NaOH we should be starting to see there is an increment in the conductivity value which will then indicate the end of the titration and the equivalence point can be determined using the tangent method.

So, now I have added one more portion of 0.04 ml and you see that the conductance value is still decreasing, it has now come to 0.44945 like that which means now we are close to this equivalence point. One has to operate the burette very carefully so that you only open a little and let one drop of NaOH fall which corresponds to 0.04 ml of NaOH.

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Now what we have done we have kept on adding 0.04 ml and now we have reached 1.3 ml which you can see here, it is here 1.3 ml at that point we start seeing that there is an increase in conductance value which is here 0.384. The earlier reading was 0.354. So, now we see that there is increase in conductance happening which means that now the equivalence point has been crossed.

All the HCL has been consumed and the conductance that we are seeing here is due to all the ions including the additional amount of NaOH that we are adding. So, to end this titration to be able to draw a straight line after the equivalence point is reached we would need 3 or 4 points after equivalence maybe 5 points. So, for that we will add 0.1 ml at each step and record 5 conductance values which will be continuously increasing.

So, this identification of the equivalence point during the titration is important so that after the equivalence point is reached you can increase your step width from 0.04 to 0.1 ml and get 5 or 6 readings after the equivalence point so that you can draw a straight line through those points. So, now I have got 2 more readings 1.4 ml and 1.5 ml and I see there is a constant jump on the value of conductance from 0.385 it has gone to 0.429 and then it is 0.476.

So, it is constantly increasing. To be able to draw a good straight line as I indicated I need some more points. Now I am going to 1.7 ml and we see that the increased conductance has now become 0.573 that is 573 micro-siemens or 0.573 milli-siemens. We will take 2 more readings at 1.8, 1.9 maybe up to 2 ml 3 readings will be sufficient. Because you know here the slope of the straight line will be much less compared to the slope that we expect to observe before the end point, because before the end point the concentration of H plus was reducing as the result the conductance of that solution was reducing very fast.

So, the slope of the line before the equivalence is steep and the slope of the line after the equivalence is not that steep. So, we need a few points to get the correct slope. Of course, you should remember that all these experiments has its own experimental errors and that also involves human error as well. So, now we have reached 1.8 ml and we see the conductance value has increased to 0.621.

So, if you just try to compare these readings at 0 ml it was 1.25 and when we reached 0.12 that is about 1.1 ml it reduced from 1.2 to 1.1 and continuously it kept reducing very fast, but now the increase is slower. So, we can see this change when we plot it carefully. So, now I have added the drop which completes 2 ml and this will be our final reading of this experiment.

And then we will have to compile all the readings and plot, so that we will discuss in a separate class.

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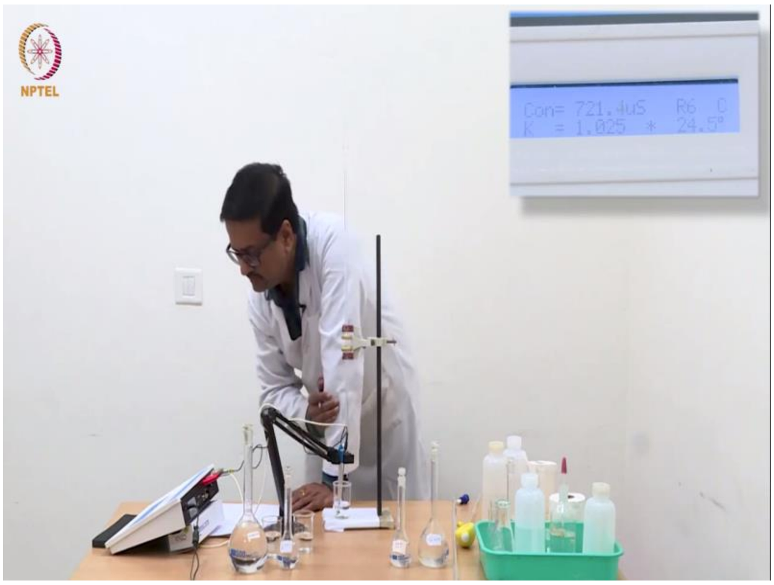

So, now our reading for 2.0 ml is 0.721 micro-siemens, sorry 721 micro-siemens or 0.721 milli-siemens. So, with this we will finish taking the readings of this experiment and we will use a standard graph paper to plot it, I will discuss how one can plot this numbers efficiently and get a very good end point through the theory lecture that will be followed after this experiment demonstration. So, in the next experiment we will continue doing this conductometric titration experiment with a weak acid and strong base.

And we will see how that those readings will be slightly different and then we will see that when we plot, there will be a significant difference in the change in conductance with the volume of NaOH added, in cases of strong acid and weak acid. So, let me conclude that we have completed the first experiment of conductometric titration using strong acid and strong base. Thank you.