Elementary Electrochemistry
Professor Angshuman Roy Choudhury
Department of Chemical Sciences
Indian Institute of Science Education and Research, Mohali
Validation of Ostwald Dilution Law using HCl

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Welcome back to this experimental section of Elementary Electrochemistry course, and by now, we have demonstrated experiments related to potentiometric titration and conductometric titrations, and now we have got ready with another experiment where I am going to show you the variation of conductance with concentration.

And as we have discussed in the theory class, the variation of equivalent conductance with the square root of concentration was proposed by or explained by Kohlrausch. So we try to do an experiment and validate the proposal of Kohlrausch which he proposed regarding the conductance or the limiting conductance of strong electrolyte and weak electrolyte.

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So in for example, we are going to use HCl solution. This is 1 normal HCl solution to make various dilute solutions of HCl. So I will make 8 dilute solutions of HCl in those volumetric flasks and also I will use this 1 normal acetic acid solution and prepare several dilute solutions of acetic acid and then one by one, we will measure their conductance using these conductivity meter.

And then from the value of conductance, we will calculate equivalent conductance which is then related to the concentration because direct conductance versus concentration plot does not give us any significant information.

Whereas when we calculate their corresponding equivalent conductance, that is small lambda. So we will calculate lambda c for each of these solutions, and then plot those numbers and show how the variation happens.

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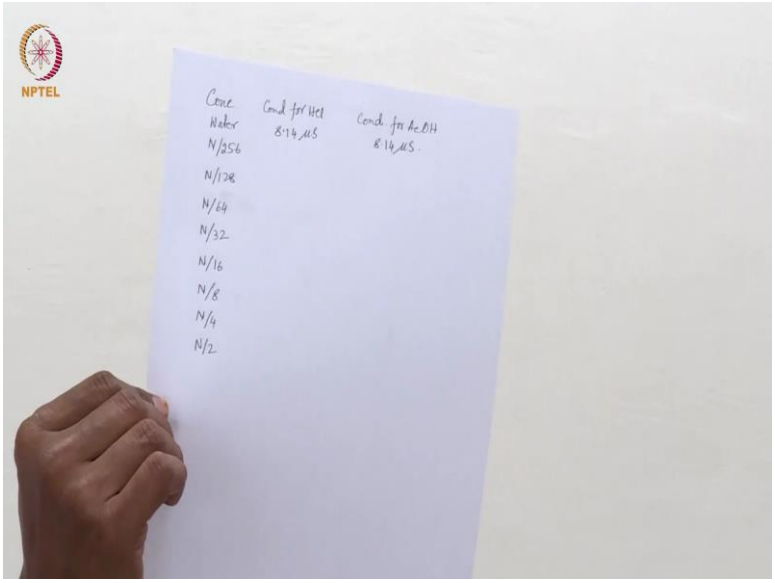

In this particular page, I am going to take the reading. You can see the dilution that I am going to do. I have already written down the conductance of the solution water which is slightly changing. It is like 1.17. When I noted it was 1.14. This value actually does not make any difference because when we add this acid solution whether it is acetic acid or HCl, we will see the conductance of that solution.

So what we are going to do is we are now going to prepare these dilute solutions from 1 normal solution. So when we have 1 normal acetic acid, we can dilute it to half then it will become N by 2.

Then that N by 2 solution will be again diluted to half which will become N by 4, then N by 8, N by 16, 32, 64, 128, and 256. So that means the topmost solution is the most dilute and the bottommost solution is the most concentrated.

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How are we going to prepare these dilute solutions? We are going to use a 50 ml pipette with a pipette pump here. So this 50 ml pipette we will pipette out 1 solution. We will start with 1 normal solution which we will take 50 ml, transfer it to a volumetric flask which is marked as N by 2.

In this volumetric flask, we will transfer 50 ml of 1 normal HCl and dilute it up to the mark and that solution will then become N by 2. Then we will pipette out 50 ml from here, put it in the next volumetric flask which is marked as N by 4, make it up to the mark so that will

become N by 4 solution. So like that from one to the second, second to the third, third to the fourth, like that we will make total 8 solutions.

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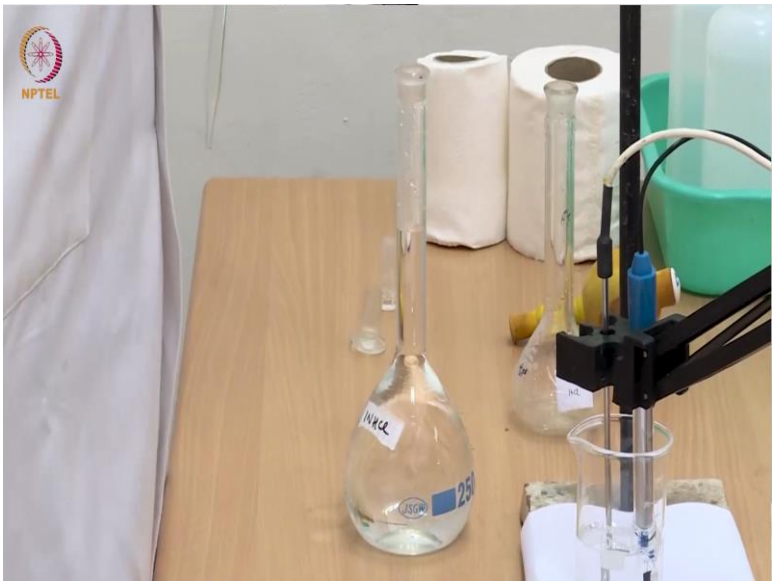

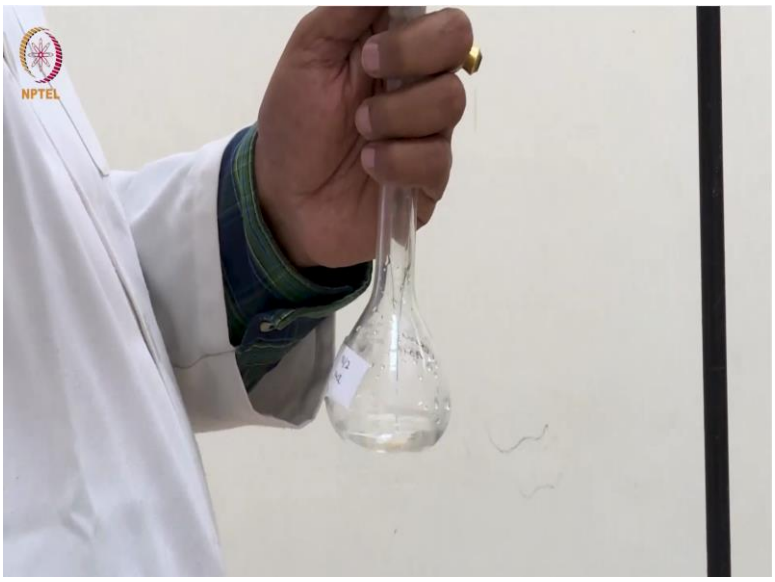

So let me start with this 1 normal HCl solution. This experiment will depend very much on the accuracy of this dilution because here if we make a mistake in dilution if we take little more or little less, the concentration will be different. As a result, the measured conductance will have a significant effect.

And then when we try to calculate the equivalent conductance where the concentration term will be used, then the equivalent conductance values will not match so well and we will not be able to draw the straight line or the curve that we are expecting to observe.

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So now I have transferred 50 ml of 1 normal HCl in this and carefully I will add water to dilute it, to 100 ml. Towards the end, one has to be very careful to make sure that there is no air gap or air bubble in the volumetric flask which will then result into a slight change, decrease in actual volume.

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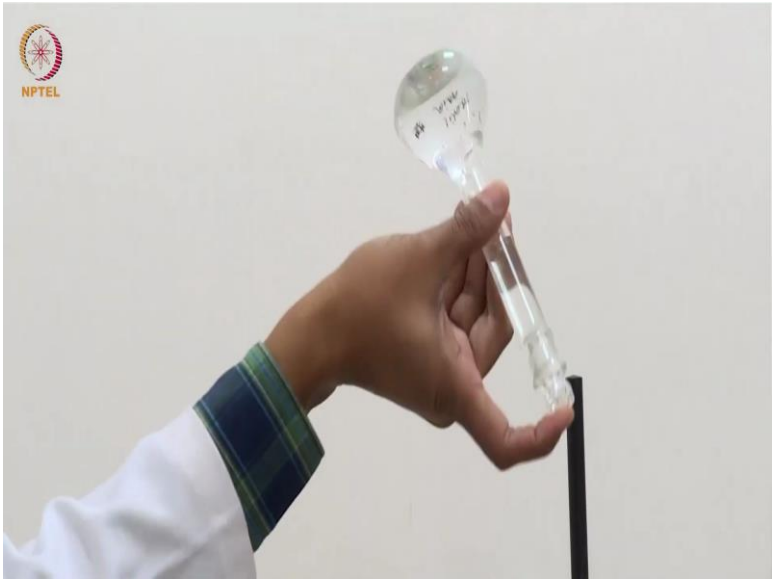

So after taking it up to the mark, we close it and shake well to homogenize. So now this solution is a homogeneous solution of N by 2 HCl. So with this N by 2 HCl, we will now prepare N by 4, and then from N by 4 we will make N by 8, and so on.

And each time when we try to do this dilution, we will have to wash this pipette thoroughly because always remember that this pipette will contain a solution of higher concentration and that is going to change the concentration of the lower concentrated solution significantly.

So every time one has to thoroughly wash this pipette with water and then only one should use it for rinsing purpose. You should rinse the pipette with the prepared solution and then take that solution for further dilution. So we will come back after we have made all the solutions in a minute.

Now we are ready with one set of solutions of HCl which we have diluted from 1 normal HCl and as I have shown you in the previous section of the video. I have first prepared N by 2 and from that we prepared N by 4 by half dilution, then by half dilution N by 8, N by 16, N by 32, N by 64, N by 128 and N by 256.

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So on my right, for yours on your screen on your left, it is the lowest concentration and on the other side, it is the highest concentration. So we will be measuring the conductance of these solutions starting with the most dilute solution and slowly going to the higher and higher concentration.

The reason behind this is that the most dilute solution will have the lowest conductance and then when we change from the dilute solution to a solution of double concentration, if you see 256 to 128 that is 1 by 256 to 1 by 128, the concentration is double. So the conductance will be significantly more.

So any leftover drop of the previous solution, if it is there by mistake in with the electrode will not become very significant in terms of conductance for the higher concentration solution.

So we should always measure from the lowest concentration to the highest concentration. And that is why I have shown you in my table that the table is from the highest (concen), the lowest concentration to the highest concentration. So let us start taking these solutions one by one.

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So now you can see that the conductance that I am reading here is the conductance of water. So I am now going to remove this beaker which contains water. I will throw and wipe it with a tissue paper so that there is no water in the beaker because I am going to use a very dilute solution of acetic acid which will give a very small value for conductance and a small amount of water in the electrode or in the beaker will probably change its conductance value. So we should make sure that the beaker and the electrode is perfectly dry.

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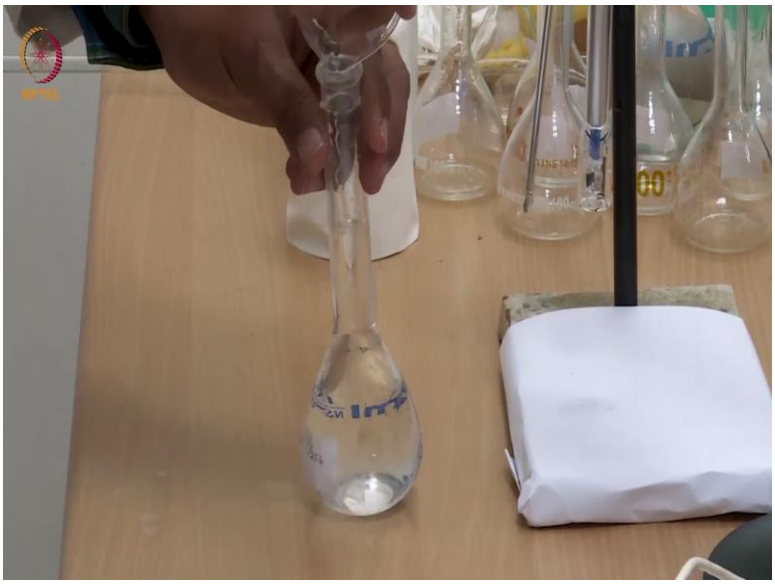
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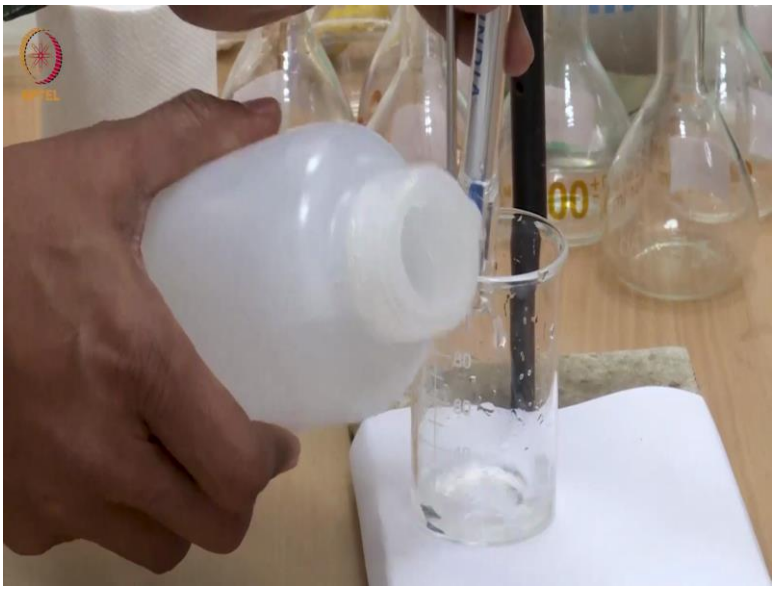
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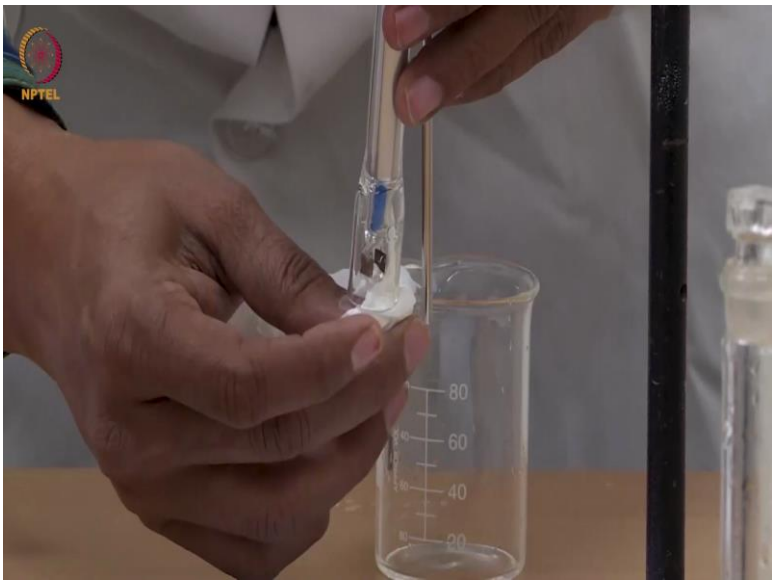

So now I am going to take the most dilute solution which is N by 256 concentration of acetic acid. Transferring a sufficient amount so that the conductivity cell, the electrode is dipped and what we see is that you get 1.7, 1.8, 1.9. So let it stabilize, we will take the reading for this. So we have n by 256 hydrochloric acid and the corresponding conductance that I am getting is 1.771 milli-siemens.

So if you see, look at if you remember the value that I had with water was running in micro-siemens and this one is in milli-siemen. So I will take this solution back. We will keep it back in the volumetric flask, wash the electrode once with a small amount of water. Wash the beaker again. Wipe the electrode to dryness as much as possible and also wipe the glassware completely so that there is no drop of the previous solution or water.

But as you can see that the concentration, the conductance value is running in milli-siemens. 1700 micro-siemens which is much more compared to 8 micro-siemens of water. So small drop of water will not change the conductance value significantly.

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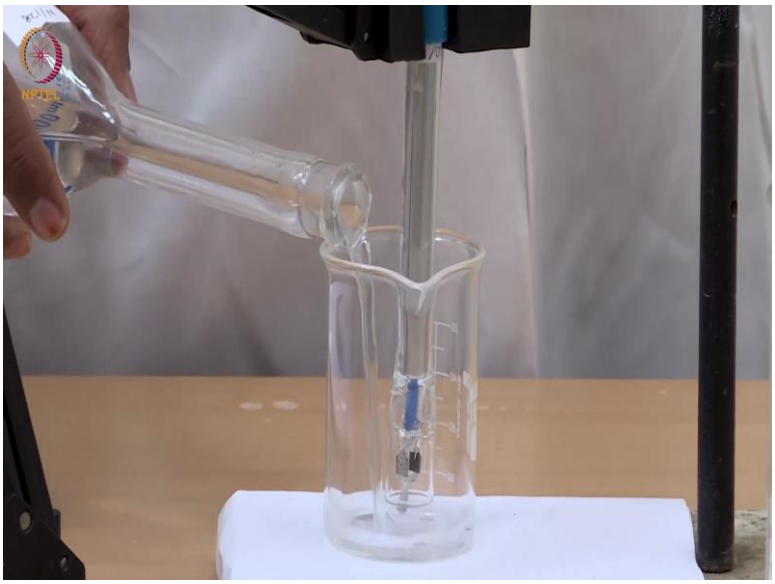

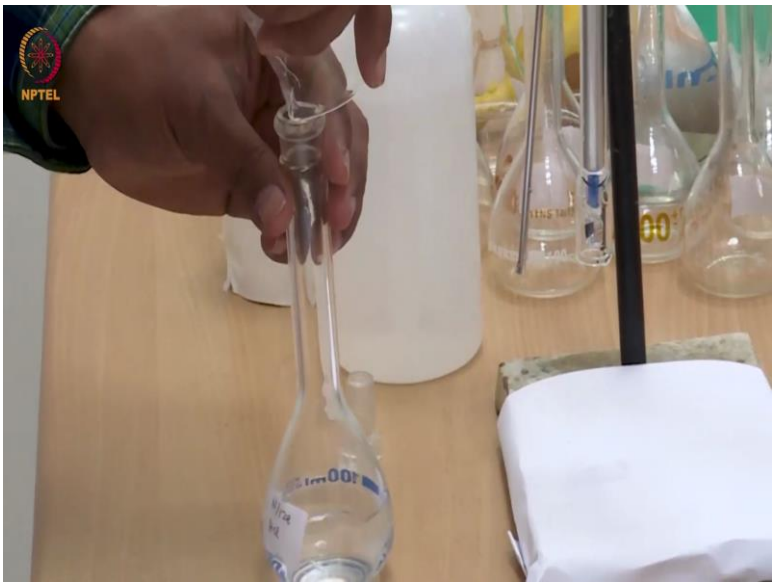

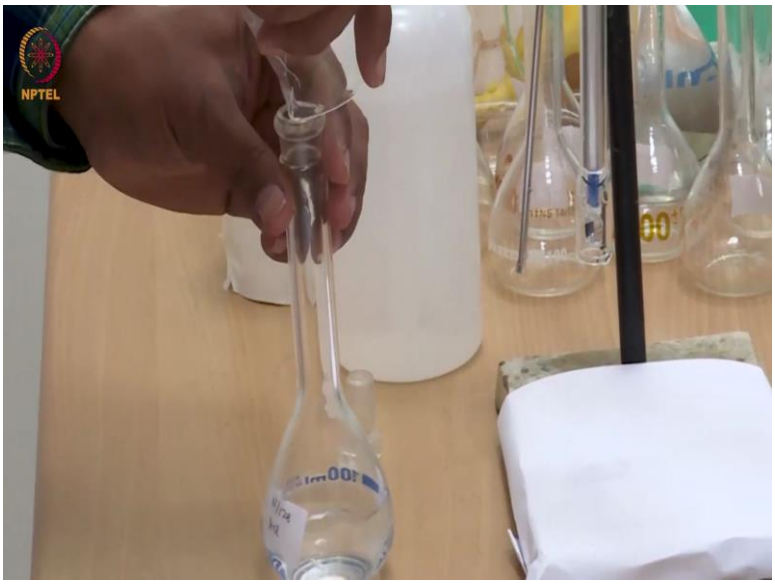

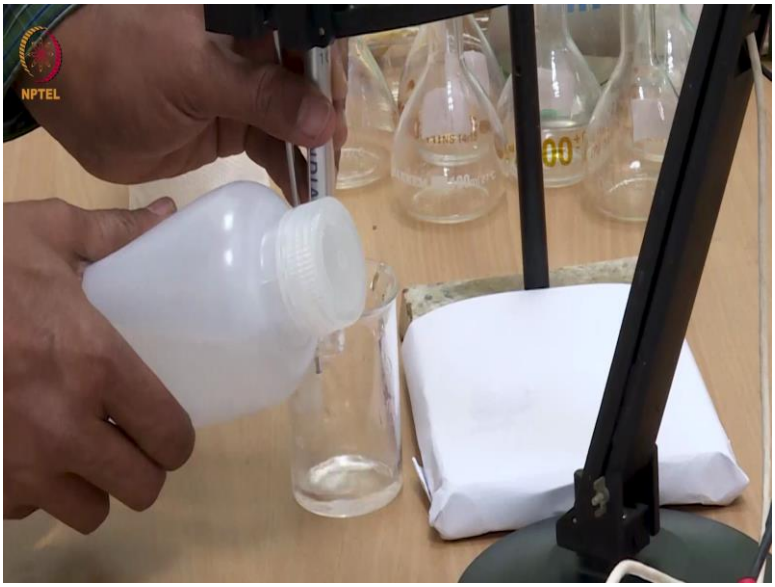

So now I am pouring this N by 128 HCl solution. So this is a double concentration. So you should see a significant increase in conductance of measured using the electrode. So with 1 by 128 normal HCl, the reading is coming as 3.74, 3.740 milli-siemens.

So we will do the same process again. Keep this solution back. Wash the electrode carefully with water. Wipe it out and use for the next solution of higher concentration.

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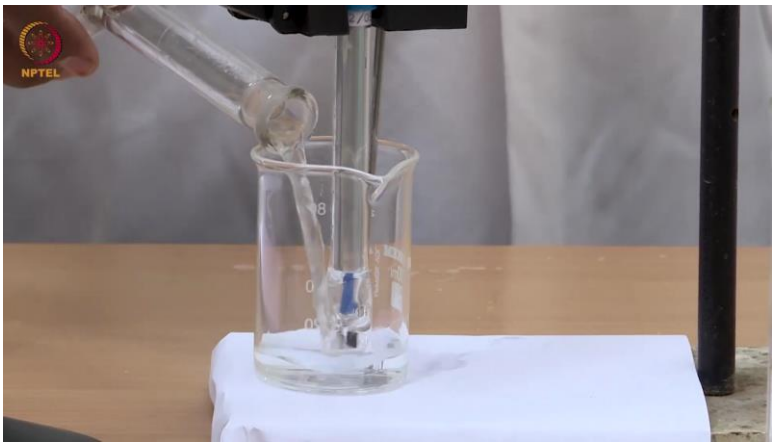

Now I am going to use this N by 64 HCl solution and then get its conductance value. So with N by 64 HCl, we are getting a reading of 7.727 milli-siemens. So with continuous doubling of concentration, we are getting nearly double the conductance value.

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Now I am going to use this N by 32 HCl solution and get the reading. So every time you can see that when we are cleaning and taking it back, the reading is going back to about 8 to 9 micro-siemens and now I have added N by 32 HCL. It should read maybe nearly double of what we had seen before. It was 7.7 and now it is about 16.5, 15.8 and it is stabilizing at 15.86.

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Now I am going to use this N by 16 HCL. I am slowly increasing the concentration as you can see and the conductance value is also significantly increasing. Every time it is becoming nearly double. So N by 16, the reading is 28.56, 28.57 like that.

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Now I am going to add this N by 8 HCL which is significantly concentrated solution. So we have to be now careful to see with what kind of conductance value it gives and if it gives something more than 50 or about 60, then we will not go beyond this because here this reading will become difficult.

It will not be able to give a reading of 100 milli-siemens or more. So we are getting 60.29. So we will try and see whether it can read more than 100. So we will try the next solution as well.

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As I am now reaching higher concentration, this cleaning has to be done very carefully so that no drop of previous concentrated solution stays here because every drop of that solution may result in a change in the conductance in terms of 1 or 2 milli-siemens.

Now, I am going to use this N by 4 HCl and see whether the instrument is able to read beyond 100 milli-siemens or not. 124.7 milli-siemens is now the conductance measured for N by 4 HCl. I think we will not go beyond this.

So we will use these 7 solutions and we will have to then calculate the corresponding equivalent conductance values using the actual concentration of the solution and the conductance values that we have measured.

And then from there, we will plot the lambda c versus concentrate, square root of concentration, and we will try to extrapolate and find out the lambda 0 value for HCL using that plot. So I will show you this plot in the theory discussion after these experiments are over.

So in the next part of the experiment, I will come back with solutions of acetic acid, dilute solutions of acetic acid in the same range and then we will note down the readings of those dilute solutions of acetic acid using this conductivity meter.

And then we will be able to compare the plot of lambda c versus square root of concentration for a strong acid and a weak acid, acetic acid. So we meet again in the next part of this experiment. Thank you.