Elementary Electrochemistry
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Experimental Calculation of Potentiometric Titrations

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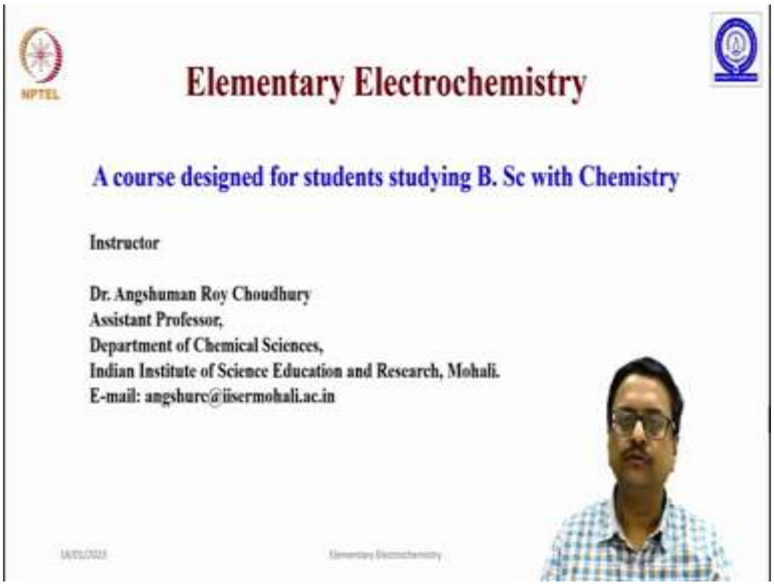

Welcome back to the course entitled Elementary Electrochemistry. In the previous few videos we have demonstrated the strong acid strong base, weak acid strong base and weak dibasic acid versus strong base titrations using potentiometric method using a pH meter. So, in this class now I am going to demonstrate or I am going to show you how to do the calculations.

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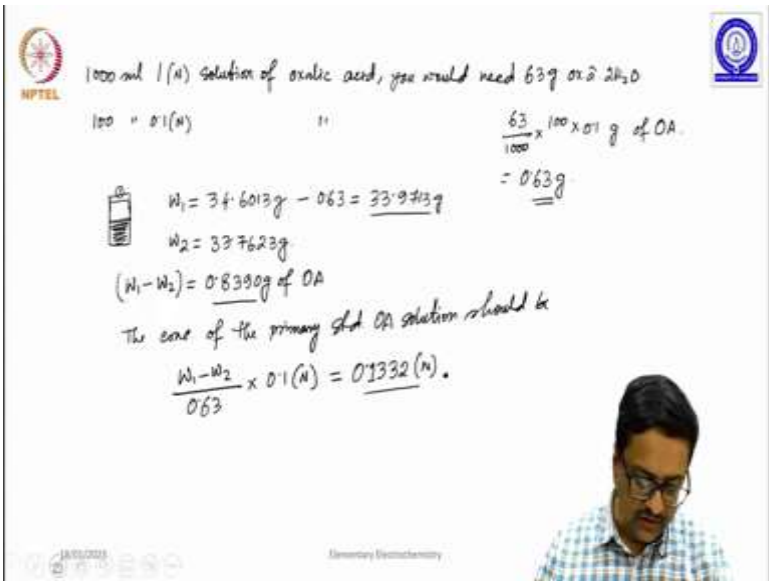

So, if you remember we made a standard oxalic acid solution and I assume that all of you know how to prepare the oxalic acid solution just for the records I am going to show it once again here because this is required for the calculations that I am going to do today. So, if you want to prepare 1000 ml 1 normal solution of oxalic acid, you would need 63 grams of oxalic acid 2 H2O.

And what we prepared is a 100 ml solution of 0.1 normal oxalic acid so for that we would need 63 by 1000 into 100 into 0.1 gram of oxalic acid dihydrate, which turns out to be 0.63 gram. So, now if you remember we used a weighing bottle to do the weighing of oxalic acid. So, when we took that weighing bottle with a lid and that contains some amount of oxalic acid and take the mass of that weighing bottle with oxalic acid that W1 we observed during the experiment is that W1 was 34.6013 gram.

Then we carefully transferred a certain amount of oxalic acid to the volumetric flask daily two to three times till it reached a value which is close to 0.63 gram by subtraction. So, what we did is we simply subtracted 0.63 from that number and we were trying to achieve a number 33.9713 gram. So, we continued transforming oxalic acid till we reach that number. And then we took the final weight which was 33.7623 gram.

That means we have transferred W1 minus W2 that is equal to 0.8390 gram of oxalic acid instead of 0.63 gram, that means we are transferred little more than what was required but we know very accurately how much we have transferred. So, the concentration of the primary standard oxalic acid solution should be this W1 minus W2 divided by 0.63 into 0.1 normal. So, here when you replace W1 minus W2 by 0.8390 we end up getting that as 0.1332 normal.

So, here we wanted to make 0.1 normal but by adding little more we have increased the concentration by certain amount. But what we know is the exact strength that is what is the exact concentration of oxalic acid in this solution.

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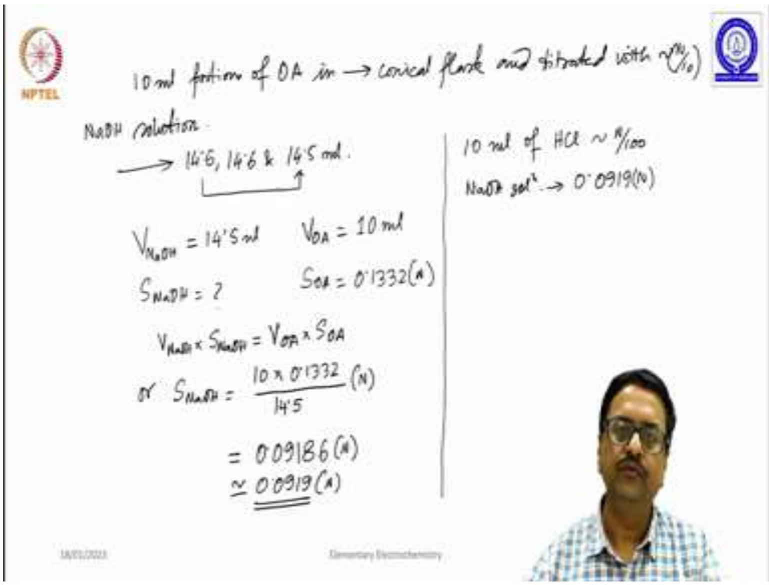

So, after that what we had done is we had taken 10 ml portions of oxalic acid in a conical flask and titrated with approximately N by 10 NaOH solution. So, during that titration when we had done the titration three times, we got the readings as 14.5, 14.6 and 14.5 ml in three consecutive titrations.

We will take these two readings as concurrent readings for NaOH and we will consider V NaOH as 14.5 ml, S NaOH is unknown, volume of oxalic acid we took using a whippet of 10 ml volume and strength of oxalic acid that we prepared is 0.1332 normal. So, then you can calculate using V NaOH into S NaOH equal to V oxalic acid into S oxalic acid or S NaOH equal to 10 into 0.1332 divided by 14.5 strength is in normality.

So, this number turns out to be 0.09186 normal which you can make it approximate to 0.0919 normal because our weighing is accurate up to fourth decimal place. So, this is the concentration of NaOH that we have used for this titration. So, now if you remember we have collected a large number of data points using the potentiometric titration where we have taken 10 ml of HCl solution of approximate strength N by 100 and then we titrated it with the NaOH solution of strength which we now determine to be as 0.0919 a normal which is approximately 10 times stronger.

And if you remember we have done that experiment using a micro (())(8:50) where one can measure very small quantity of NaOH dispersed so we could take multiple readings, we could take several readings with 0.02, 0.04 ml NaOH being discharged at a time and the pH noted. So, now I want to show you the data that we have recorded and how we did the data analysis.

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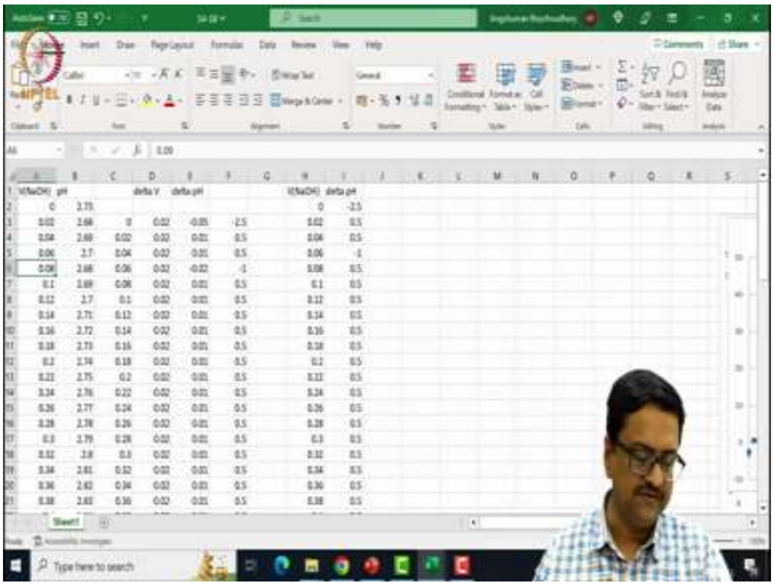
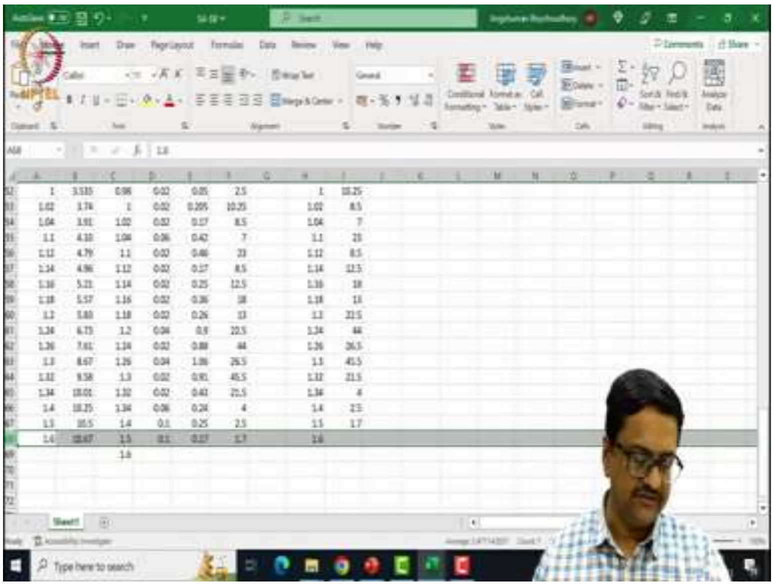
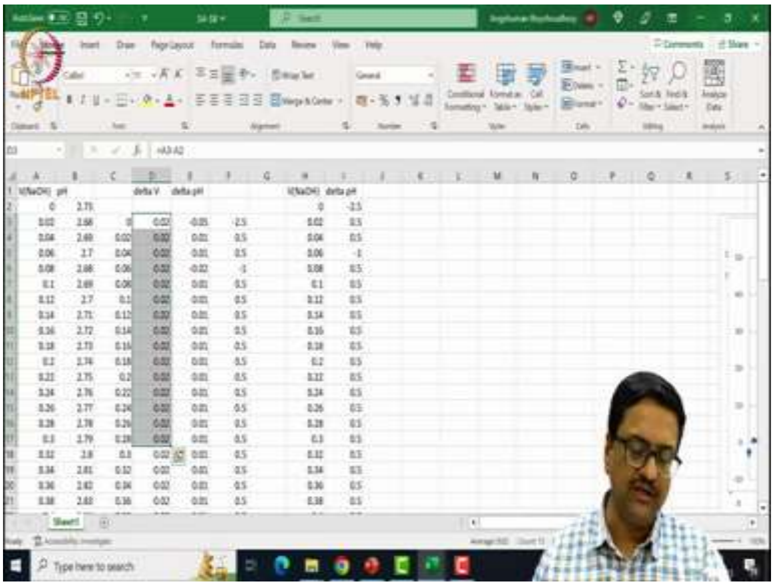
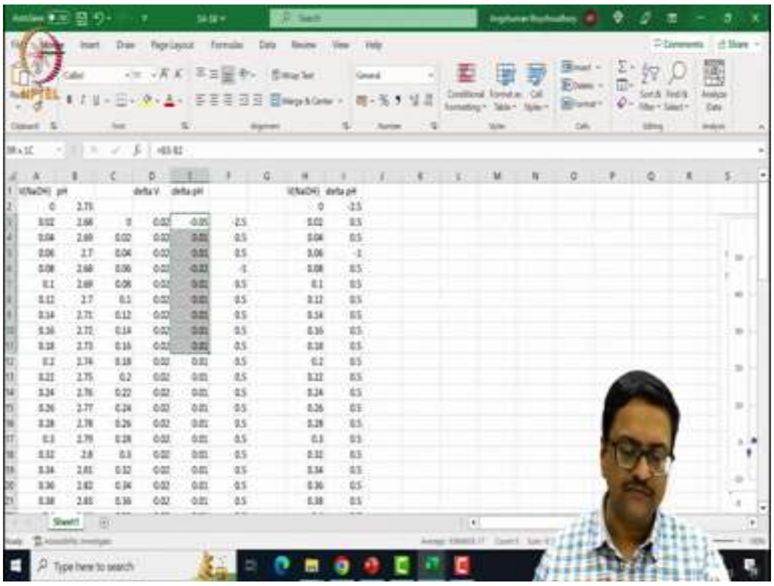
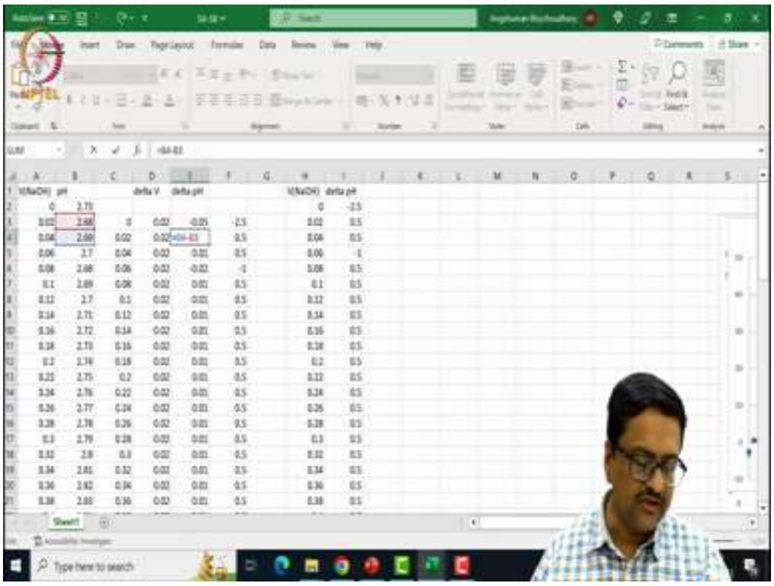


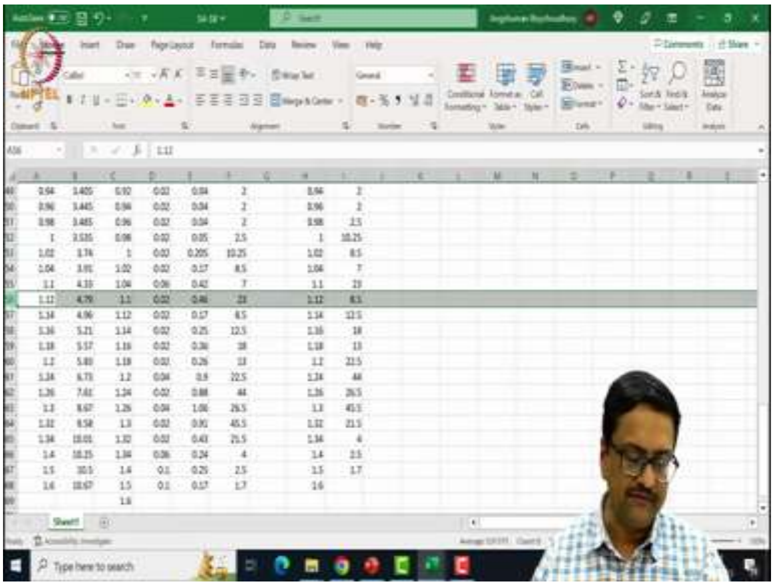


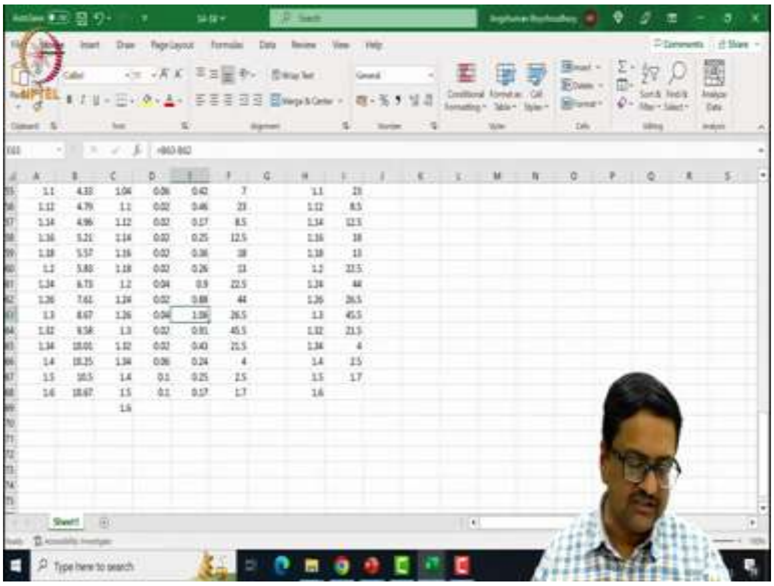


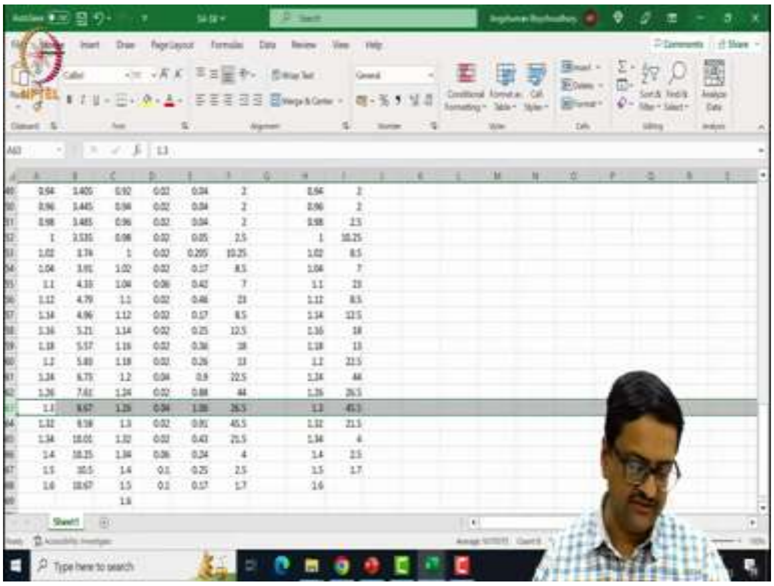

V(NaOH)
pH
delta V
delta pH
V(NaOH)
delta pH
Sheet1

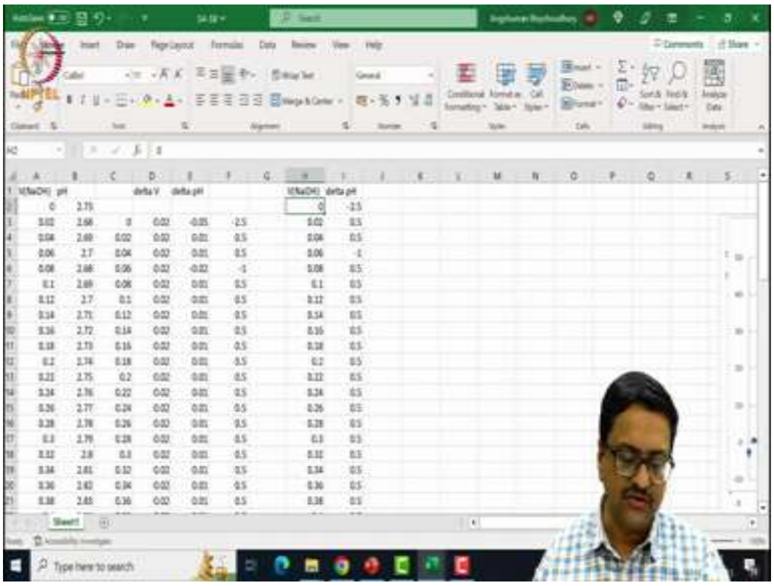

V(NaOH)
pH
delta V
delta pH
V(NaOH)
delta pH
Sheet1


V(NaOH)
pH
delta V
delta pH
V(NaOH)
delta pH
Sheet1









What you are seeing here in this screen is the volume of NaOH that is marked 0 and we started at 2.73 value of pH. And then we continued adding small, small fractions 0.02, 0.06, 0.08 that means every time we are adding 0.02 ml of NaOH and we noted down the corresponding value for the pH. And if you remember we have done it till the pH reached 10.67.

So, we have about 68 readings if you look at this excel sheet I have 68th row that means we have 67 readings except the first one. So, then what we have done is that we have calculated delta V which is for all of them it is 0.02 because we have always used 0.02 ml change and then we calculated the value of delta pH as well.

So, then after calculating delta pH that delta pH means if you look at it delta pH means pH of reading 2 minus pH of reading 1. Again in the next row it is pH of reading 3 minus pH of reading 2. So, like that in Excel we have calculated delta pH. You see that delta pH is very small or about 0.1 till a point and then it increases slowly, reaches a maximum value at 1.12 ml which is 46.46 and then it continues and again goes and reaches the value 0.88 and then at this point about 1 and then again it reduces 2.17.

So, what we see that this reading here indicates probably the end point of the reaction the neutralization point. So, when we try to plot this these values of delta pH versus V NaOH what we get is a plot if you try to plot this V versus delta pH what we get is a plot that I am going to show in this, the next slide.

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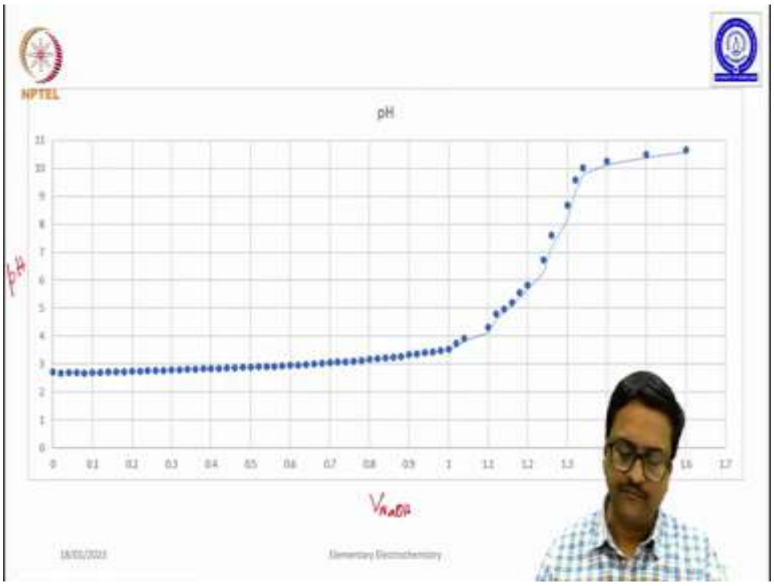

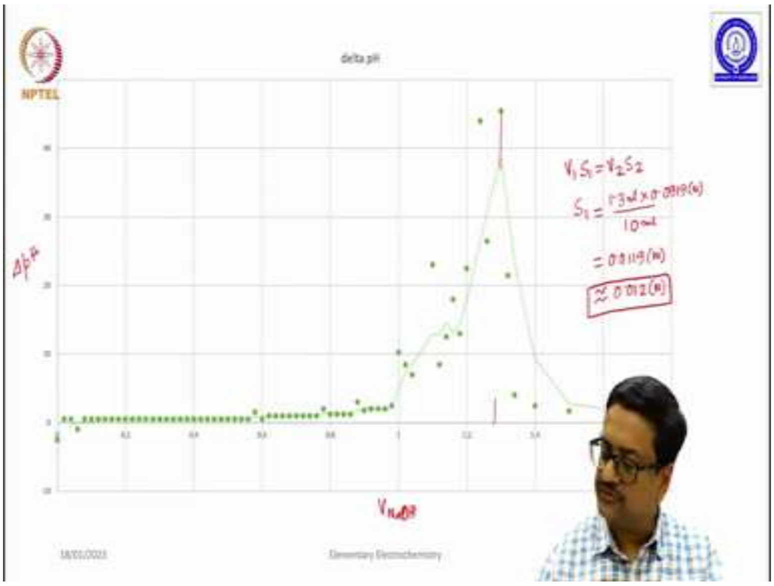

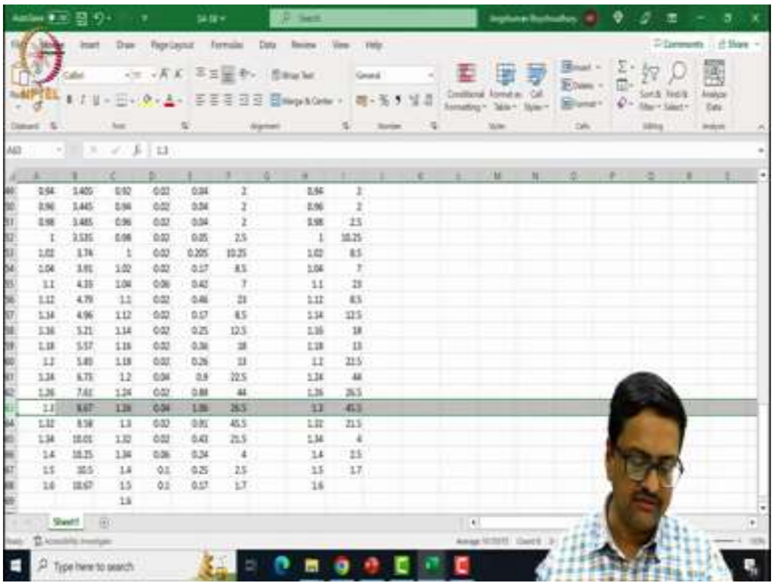

So, you are going to get a plot like this when we have plotted in Y axis the pH and in X axis the volume of NaOH. So, you get an a slightly S type of curve and when we plot delta pH versus V NaOH we see that there is a jump here. So, that particular reading which we have identified is zero point, so here it is delta pH versus V NaOH.

So, that means the reading that we have seen in the Excel file with the maximum value of delta pH is your end point, this 1.3 is your end point. So, using this value as end point one can do the calculation of the strength of HCl in this particular experiment using the same V1 S1 equal to V2 S2 formula and here S 1 is the strength of HCl that is not known, we have taken 10 ml of HCl at the beginning to start with.

Volume of NaOH that was used is 1.3 ml into the concentration of NaOH that was observed is 0.0919 normality. Therefore, the therefore, the concentration of this HCl solution turns out to be 0.0119 normal which can be equated to 0.012 normal. So, this is how one can determine the concentration of HCl using a potentiometric titration which experimentally we have demonstrated and here I am showing you the calculation of that experiment. Now I will just show you the readings and the results of the next experiment that we had done.

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This is the data table of weak acid versus strong based titration. If you remember with acetic acid the starting reading was high 3.74 compared to that of HCl and we continued adding small amounts and noted down those values which are shown here on the screen that you can see. And for this again I have done the similar calculation that I have described for the strong acid strong base case.

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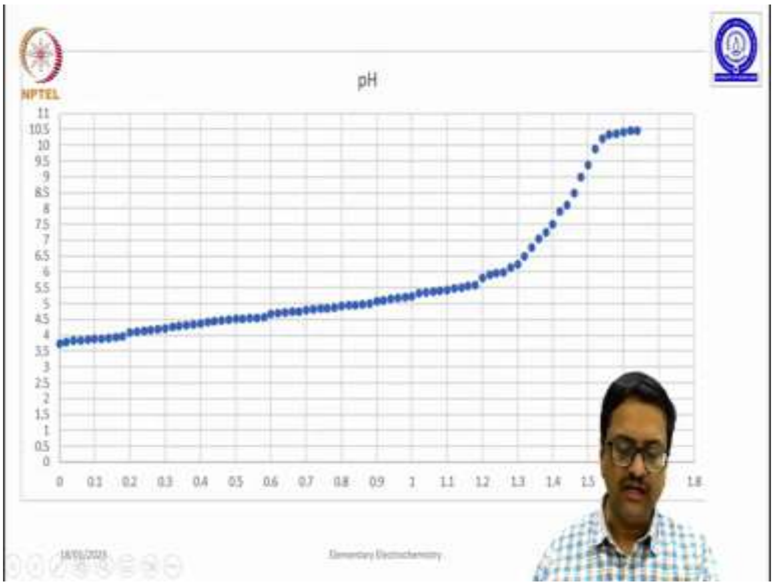

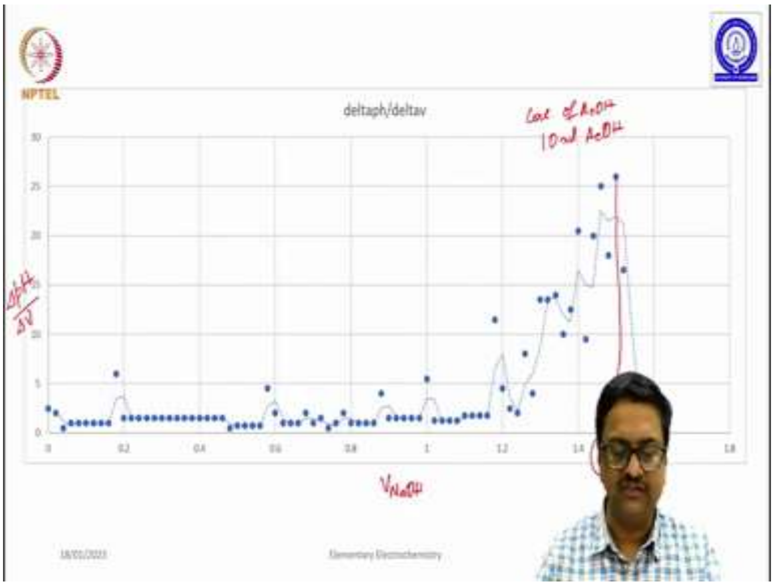

And when I plotted those data I get this kind of curve and when I have plotted the corresponding delta pH I think this plot is delta pH by delta V versus V NaOH. We see that the value reaches maximum at this point which turns out to be about 1.5 ml if you go back and look at the table and do the calculation you will see that it comes at 1.5 ml. So, using the same method you can calculate the concentration of acetic acid for which we had taken 10 ml of AcOH. And for that we required 1.5 ml of NaOH of strength 0.0919 normal NaOH.

So, I am not going to do the calculation here for you, you will do the calculation and find out the number because that is very simple. The main aim of this experimental demonstration was to show you that how one can use potentiometric titrations for acid based titration one can follow the pH and change in PH to get the end point of acid-based titration without an indicator.

Hope you have enjoyed this experimental session. So, from the next week we will discuss the theories of conductance and there the remaining part of the syllabus will be covered in next four weeks. Thank you.