Elementary Electrochemistry
Professor Angshuman Roy Choudhury
Department of Chemical Sciences
Indian Institute of Science Education and Research Mohali
Potentiometric Titration of Strong Acid and Strong Base

(Refer Slide Time: 0:18)

Welcome back to this course entitled elementary electrochemistry. In the previous couple of videos, I have shown how to prepare a primary standard oxalic acid solution for standardization NaOH. And then we have shown you how to do standardization of NaOH, and I am going to share these readings with you later.

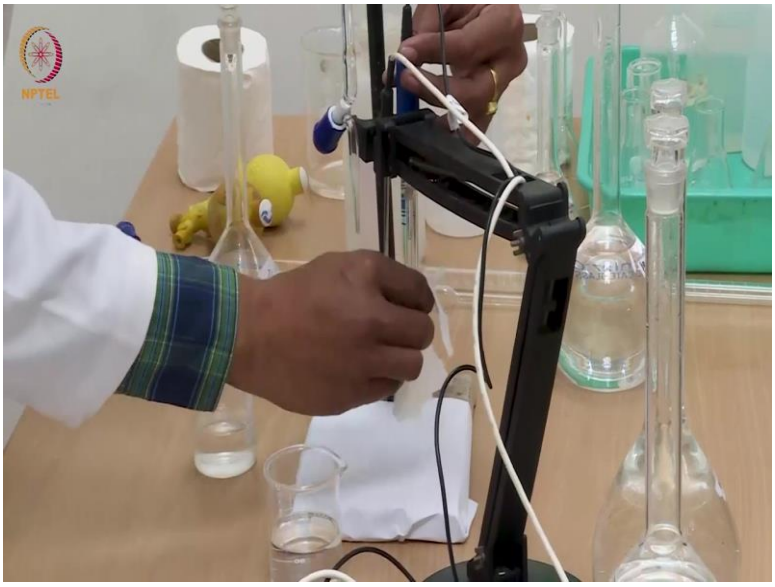
(Refer Slide Time: 0:40)

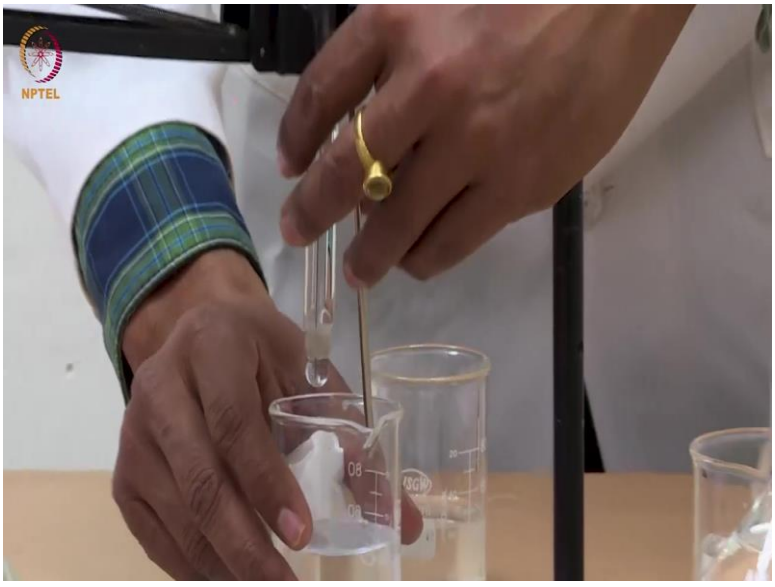

NPTEL


NPTEL


NPTEL


pH =+ 3.99 R3 a
mV =+ 172.4 * 23.6°



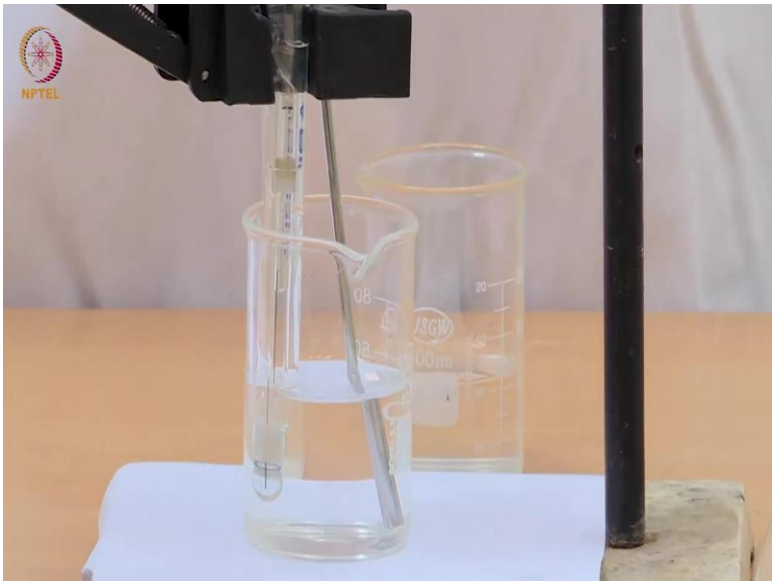


So, now we are here ready with the setup with a pH conductivity meter SpH cum conductivity meter which you can see in your screen, this pH conductivity meter has two options with a pH electrode which will measure the EMF change inside the solution and convert it into the corresponding value of pH is now connected and this pH conductivity meter when it is running in the PH mode, we need to do a calibration.

So, before starting this experiment, I have calibrated it with 3 buffer solutions pH 4, pH 7, and then one can check whether the calibration is correct or not with a pH 9 buffer. So, at the moment what we have in the beaker here is a pH 4 buffer and in the meter, you can read that it is showing 3.99 as pH. So, that is indicating that the pH meter is calibrated. So, just to make sure whether when everything is working fine, I want to check the pH of this pH 9 buffer how it reads using this pH meter.

So, I should take about 40 to 50 ml of the buffer solution. So, that the electrode completely dips inside this solution and before that, we should wipe out the electrode after removing it from pH 4 buffer. One should clear the electrode completely, so, that there is no solution of pH 4 sticking to it. And then we carefully insert the electrode in pH 9 buffer you can see that the reading on the meter was fluctuating when it was in air.

(Refer Slide Time: 03:08)




LABINDIA
pH/CON METER
pH =+ 9.15
mV =- 126.6 *
7 STU
8 VWX
9 YZ_
MEM CLEAR
4 JKL
5 MNO
6 PQR
CAL
1 ABC
2 DEF
3 GHI
SCAN


NPTEL
100 ml


NPTEL

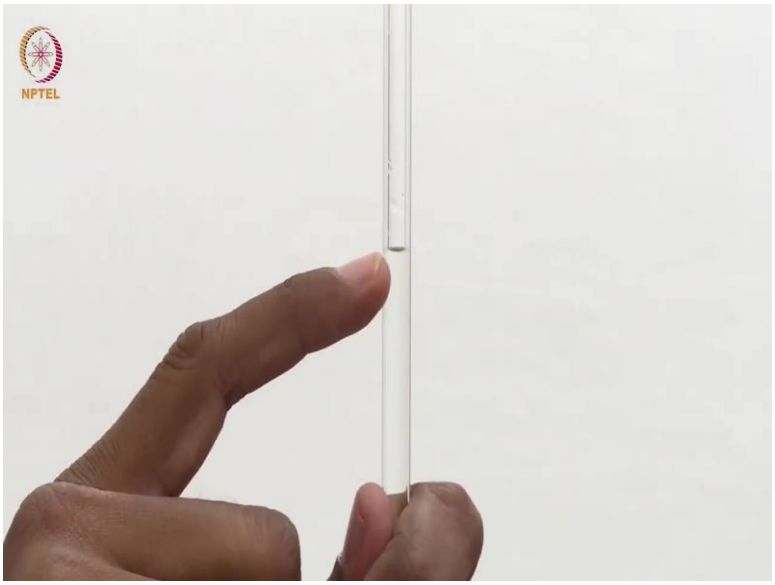

NPTEL
100 ml

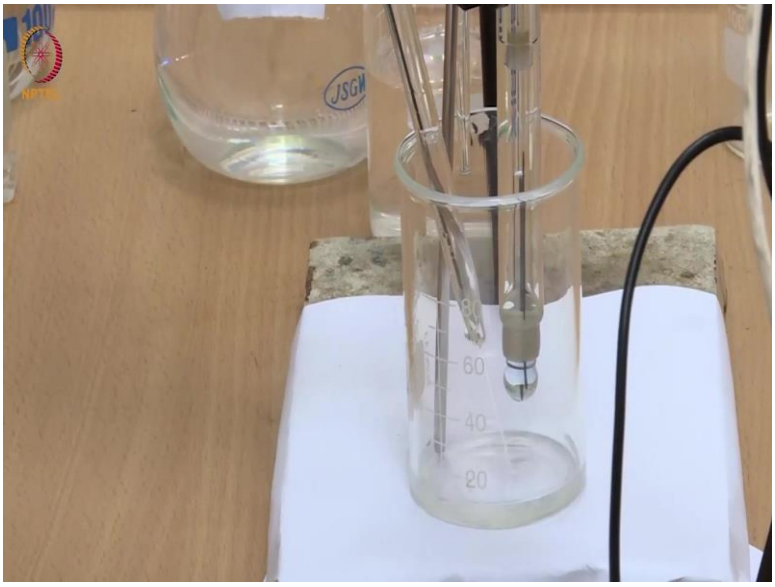
And now, it is going to stabilize and it shows a reading which is very close to 9 it may take a while to stabilize it to 9 or about 9.15 which it is showing. So with this, I think we should we are ready to start our experiment. So I am transferring back the pH 4 buffer which we do not need anymore. Now, we are ready for the estimation of one N approximately N by 100 HCL that we have here, we do not know the exact strength.

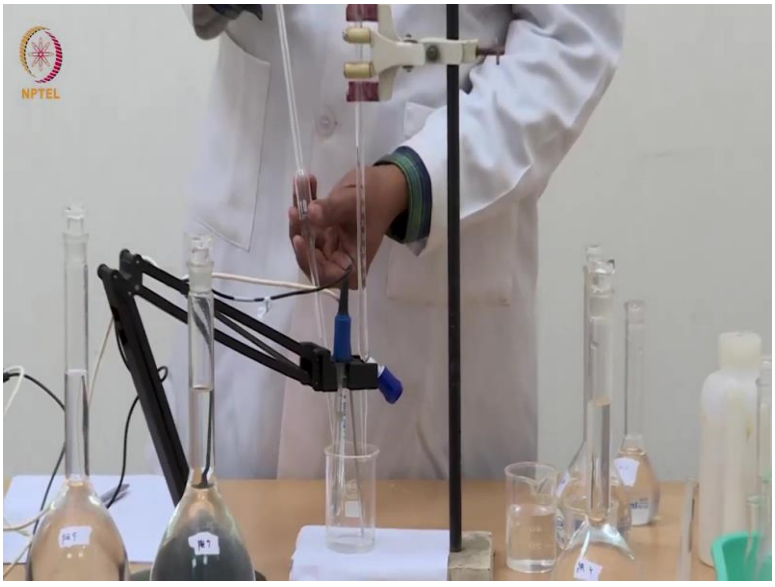
So, we will use these N by 100 solutions for the Potentiometric titration using N by 10 NaOH solution, you see that there is a 1 is to 10 ratios of HCl versus NaOH concentration. And we have discussed the reason for this in the class. Here what will happen is if you take 10 ml of N by 100 HCl and we will have to add little amount of water so that the electrode completely dips in water then it will show us the pH of that solution.

And then when we are titrating it with NaOH solution of about 10 times more concentration. So, for 10 ml of HCl, the total volume increase will be approximately about 1 ml to 1.2 ml and that will reduce the change in pH due to increase in volume of the solution. So, in front of me I have now a 10 ml burette which you can see here. This 10 ml burette is filled with N by 10 HCL it sorry N by 10 NaOH, this N by 10 NaOH, we will add dropwise to the solution of HCl, which will, I am now going to take using a pipette.

(Refer Slide Time: 5:17)




60
40
20

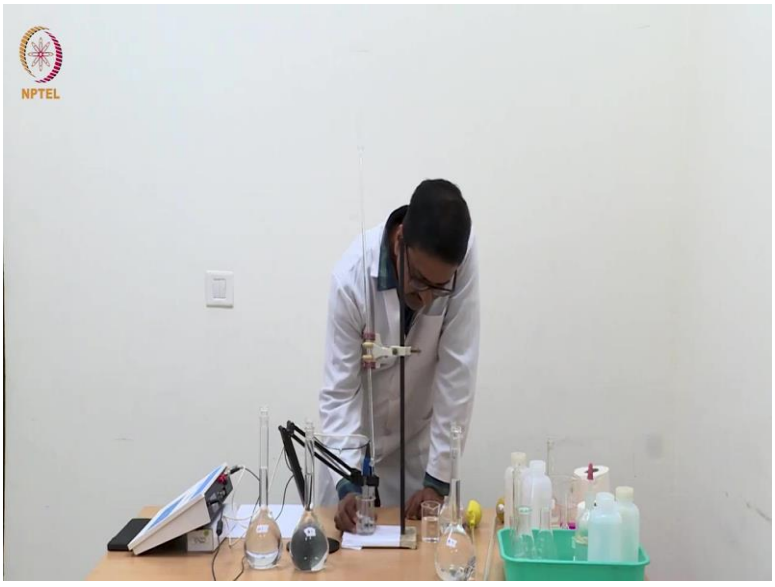



NPTEL


NPTEL


NPTEL
LABINDIA
pH/CON METER
pH =+ 2.73 R3 a
mV =+ 245.0 * 23.8°


LABINDIA



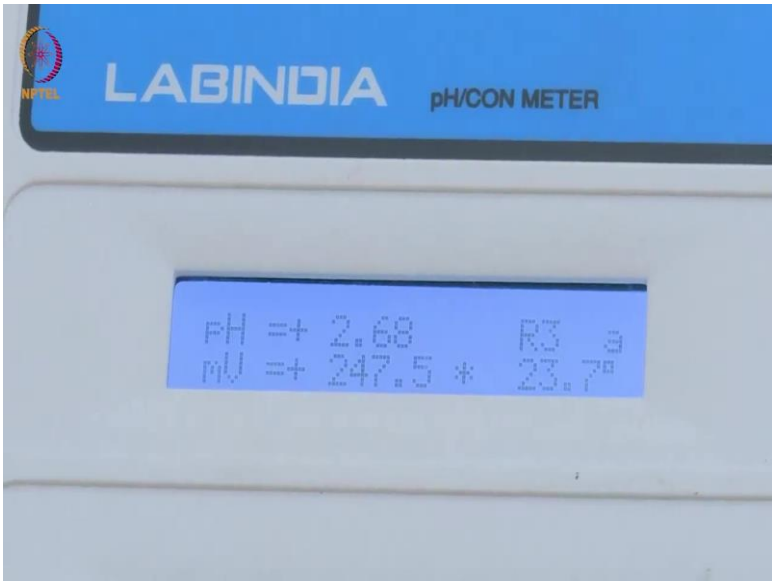
So, this time I am using a different pipette pump, which you can see here in my hand. So, we will use this different type of pipette pump to pipette out 10 ml of HCl. And we carefully take it only up to the mark which indicates 10 ml, we have a mark here in the pipette, as you may be able to see the mark is at this point here, which indicates that we have 10 ml solution in the pipette.

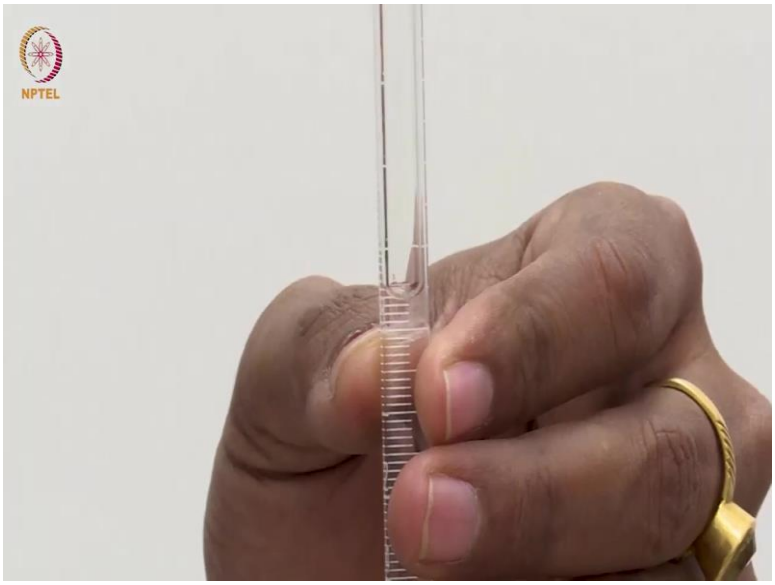
So, I will carefully transfer the entire solution to this beaker, in which we will do the estimation using the pH measurement method. Once again, we should just touch the bottom of this beaker with the tip of the pipette and whatever small amount of acid is left behind is supposed to be left behind. So, that does not is not included within the 10 ml that is calibrated for this pipette.

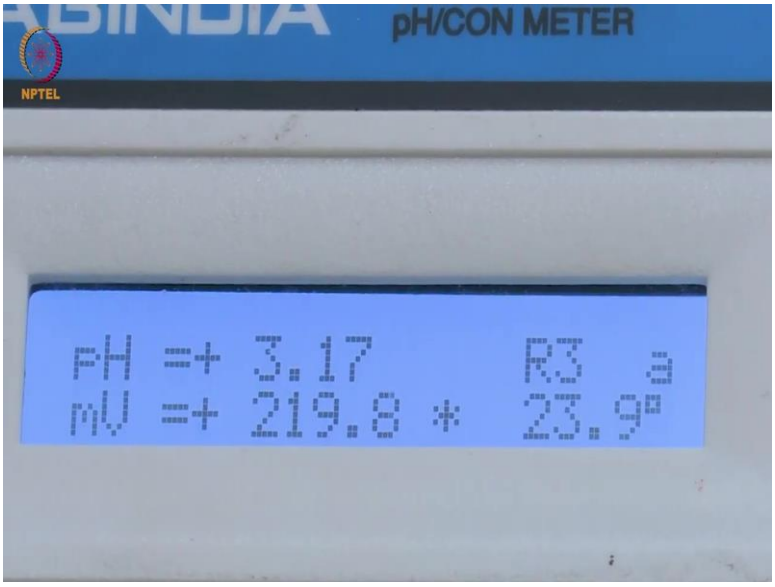
So, now, what you can see is that the electrode cannot be dipped in such a small amount of liquid. So, what we need is we need to add some amount of water making sure that the electrode completely dipped. And we get the reading of pH as shown here, which you can see is so, without the addition of any NaOH our reading of pH is 2.73. Now, what we need to do is we need to very carefully add very small amounts of NaOH from the burette.

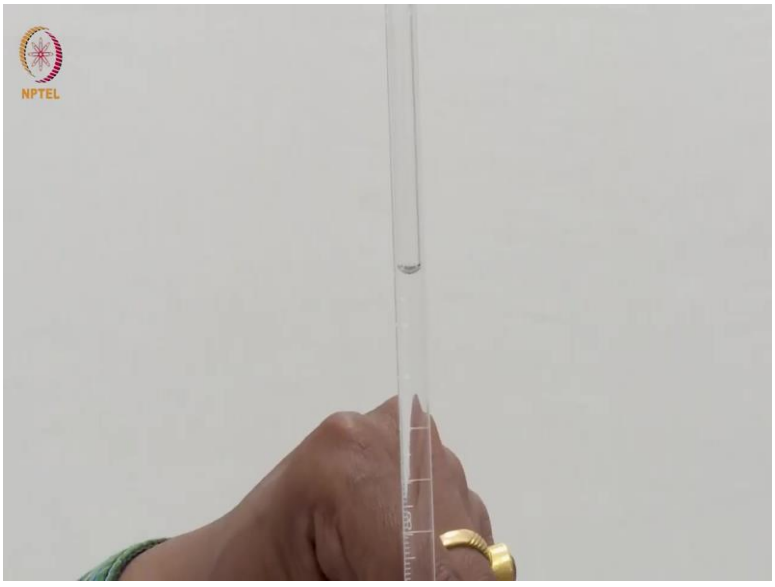
And as I indicated this particular burette which is a 10 ML burette can for very small quantities like 0.01 which can show point 0.02 ml of reading or it can transfer 0.02 ML you can measure. So, after addition of 0.02 ML that is just about two drops, you can see that there is a small change in the pH from noting down this reading as 0.2 and reading is 2.68. So, like that, I should be adding small quantities every time about 0.2 ml each time and shake it well.

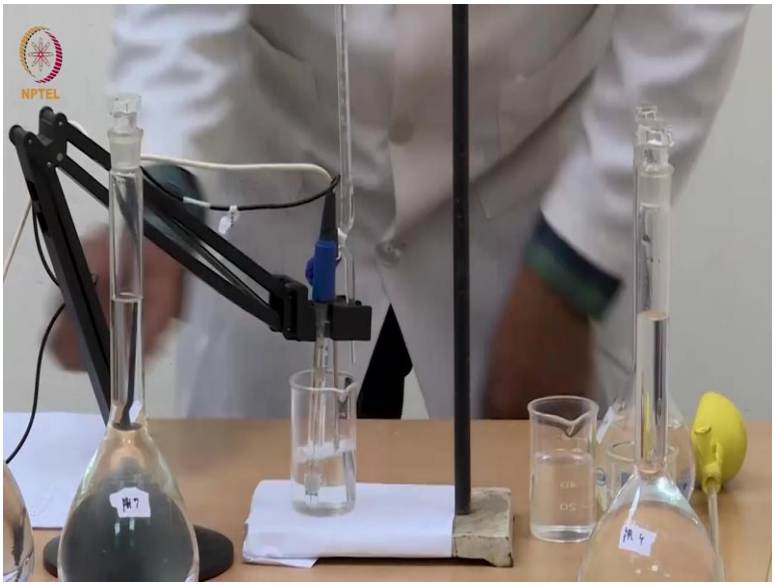
(Refer Slide Time: 9:20)


LABINDIA
pH/CON METER
pH =+ 2.68
mV =+ 247.5 *




pH/CON METER
pH =+ 3.17
mV =+ 219.8 *





So, that we reach the equilibrium and the stable pH is red. So, it is with 0.4 ML the rating is 2.69 you must appreciate that this pH is not changing because this is strong acid which is completely dissociated in solution and hence the pH does not change with addition of NaOH significantly from the burette. So, I am going to continue this edition of NaOH very little at a time and every time I have added 0.2 ML, which means now I have added 0.6 ml and reading still 2.69.

So, like that, I should continue doing this addition for a long time 0.2 ml at each step till I see a sudden jump in pH now, I have kept adding to 2 drops each and continued taking the reading and I have reached a rating of 0.6 which you can see from here with 0.6 I am getting a pH of 2.96 which now means that the H plus ion is considerable is consumed and the pH

has increased a little and if we continue like this, there will be a point when there will be a sudden jump in pH.

Now, I will again add up to 0.8. So, now, you can see by slow addition of 0.02 ml each time, I have now reached the reading of 0.8 ml which you can see here. So, with 0.8 ml of NaOH addition we have reached a pH of 3.97 which you can see in the inset. Now, I will add up to 0.9 now, I have reached a point when where I have already added about 0.9 ml using this 10 ML micro burette which is reading here it is between 8 and 9 which you can probably see in your screen. And the pH that we have reached is 3.33.

(Refer Slide Time: 12:52)


NPTEL
LABINDIA


NPTEL


NPTEL
LABINDIA


NPTEL
LABINDIA
pH =+ 4.23 RS a
mV =+ 158.7 * 23.9°


NPTEL
LABINDIA
pH =+ 4.33 RS a
mV =+ 153.0 * 23.9°


NPTEL
LABINDIA
pH =+ 4.34 RS a
mV =+ 152.6 * 23.9°


LABINDIA


LABINDIA

So, what we can see is the pH is slowly increasing stepwise but not increasing very sharply. So, now I should add a little more and see at what volume of NaOH the pH suddenly starts to jump up. Now, you can see that we have reached a point about 1 ml in this 10 ML burette and the pH that we have reached is 3.57. So, that indicates we are very close to the equivalence point we have to be very very careful at this point.

And we should again continue adding 0.02 ML at a time and try to get the end point very accurately. So, now I am continuing addition by 0.02 ML at a time. And we have reached 3.91 and like that if we just add up to suppose now I have added 1.10 ml and the pH has jumped up to 4.33 with 1.12 the reading has come to 4.79. 1.14, the reading is 4.96 with 1.16 it has come to 5.21 with 1.18 it has come to 5.50 maybe 5.51 when it stabilizes it takes a while to stabilize.

(Refer Slide Time: 17:55)


NPTEL
LABINDIA
pH =+ 5.09
mV =+ 068.9 *
24.0°


NPTEL
LABINDIA
pH =+ 5.04
mV =+ 066.4 *
24.0°


NPTEL
LABINDIA
pH =+ 5.06
mV =+ 065.4 *
24.0°


NPTEL
LABINDIA
pH =+ 6.10
mV =+ 051.8 *
24.0°


NPTEL
LABINDIA
pH =+ 6.71
mV =+ 016.6 *
24.0°


NPTEL
LABINDIA
pH =+ 6.73
mV =+ 015.7 *
24.0°

So, we should take the reading when it stabilizes the pH. Maybe 5.57 then we add again 0.02 ml and reach 1.2 ML the pH comes out comes about 5.7476. So, it takes a while to stabilize. So, with addition of 1.2 ML the pH is 5.83. So, now with 1.24 ML the pH has come almost to the neutral pH of water it is about 6.73.

So, I am expecting with one more drop that is another 0.02 ML this pH will jump beyond the neutral pH and it will become alkaline and as I have indicated in the lecture that we should continue admission of NaOH little beyond the equivalence point. So, that we can achieve a flat region once again as there was a flat region at the beginning when we were adding innovate in the early stage.

(Refer Slide Time: 20:54)


NPTEL


NPTEL
LABINDIA
pH =+ 8.55
mV =- 091.2 *
RJ a
24.1°


NPTEL
LABINDIA
pH =+ 8.64
mV =- 097.0 *
RJ a
24.1°


NPTEL
LABINDIA


NPTEL
LABINDIA


NPTEL
LABINDIA

So, now, what you can see is with addition of 1.30 ML the pH has jumped up to 8.64 as you can see in your screen, which essentially means, we have crossed the equivalence point we will need about 3 to 4 points beyond this for a good pH curve that I have shown you in the class by hand drawing with this experiment we can achieve that kind of curves as well we experimental curve can we achieve.

So, with the addition of 1.32 ml of NaOH we have reached a pH of 9.58 we need a few more such readings till we reach a flat region. So, with 1.34 ml of NaOH we have reached pH of 10.01 we need one or two more readings, since we have reached the point where we have crossed the equivalence point and we have reached a pH of more than 10. So, now I have added 0.06 ml of NaOH to reach 1.4 ml and with 1.4 ML we see that pH has changed only from 10 to 10.25.

(Refer Slide Time: 24:48)


NPTEL
LABINDIA
pH =+10.50 R3 a
mV =- 206.6 * 24.1°


NPTEL
LABINDIA
pH =+10.51 R3 a
mV =- 207.2 * 24.1°


NPTEL
LABINDIA
pH =+10.68 R3 a
mV =- 216.9 * 24.2°

So, what you can see that in the beginning the pH was not changing towards the equivalent point the pH was changing slowly near the equivalence point the pH changed drastically close to 7 and then it has reached 8, 9 and 10 And now, with addition of more amount of NaOH, the pH is not increasing significantly as it was doing when the equivalence point was reaching.

So, now, I am adding 0.1 ml that is reaching 1.5 ml. So, by addition of another 0.1 ml we have reached 1.5 ml and you see that the pH has only increased by 2.25 and reached 10.5. So, now, what we see is the increase in pH is again very small 0.25 for every about 0.1 ml addition. So, we will take the last reading as 1.6 ml and then try to plot the entire reading using a graph paper and then determined the concentration of this HCL using the calibration or using the standardization process that we have done using oxalic acid.

So, now, I have added 1.6 ml and the pH that we see it has increased only by 0.18 from 10.5 to 10.67, 10.68, 10.67 like that. So, this is our last reading of this experiment, where you can now see the last burette reading is shown here it is 1.6. So, what we have achieved here is we have done a titration of 10 ml of N by 100 HCL using N by 10 NaOH, which is technically 10 times stronger.

So, for 10 ML, we would have required about 1 ml and probably the NaOH is not exactly N by 10 which we will know from our calculation of standardization. And then we will be able to determine the concentration of HCl after we plot these data using a graph paper and then plot the data in terms of delta pH verses volume of NaOH where we will see a sudden jump in that plot. So from that jump we will be able to calculate the concentration of HCl using this

pH or Potentiometric titration. So thank you very much for attending. We will continue similar experiments using acetic acid in the next class. Thank you.