Bio-electrochemistry

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Lecture – 13
Concept of Concentration Cell- I

Welcome back to the lecture series in Bio-electrochemistry. So, today we are into the 3rd week and will be resuming with our 13th lecture and which is essentially the 3rd lecture of the 3rd week. So, as of now we have talked about the fundamental of electrochemistry in reasonable details which could help the biologists to appreciate how these things can be translated for Bio-electrical measurements.

So, today's lecture as well as next 2 lectures and the matter of fact these 3 lectures of the week, will talk a little bit more biology where we will be translating the most fundamental aspects, what we have learned so far in electrochemistry, in biological perspective. As of now, it must have appeared to you that we are talking a lot of chemistry out here except in the last couple of classes when we talked about the formal potential; where we talked about that standard electrode potential, standard redox potential which is measured at p h 0 kind of cannot be directly used for biological measurements.

Because plant and animal cells maintains a p h of 7 and depending on the hydrogen ion concentration, if there are hydrogen ion involved in any reaction. Then, the p h is going to shift; I mean the p h shifts. Then, you cannot assume that p h is 0; then, you have to calibrate your whole system with respect to p h 7.

So, that is where we kind of entered into the realm of biology. So, today what we will do; we will again start from the Nernst equation and we will derivatized it in the biological context with respect to the electrochemical context. So, let us assume our lecture.

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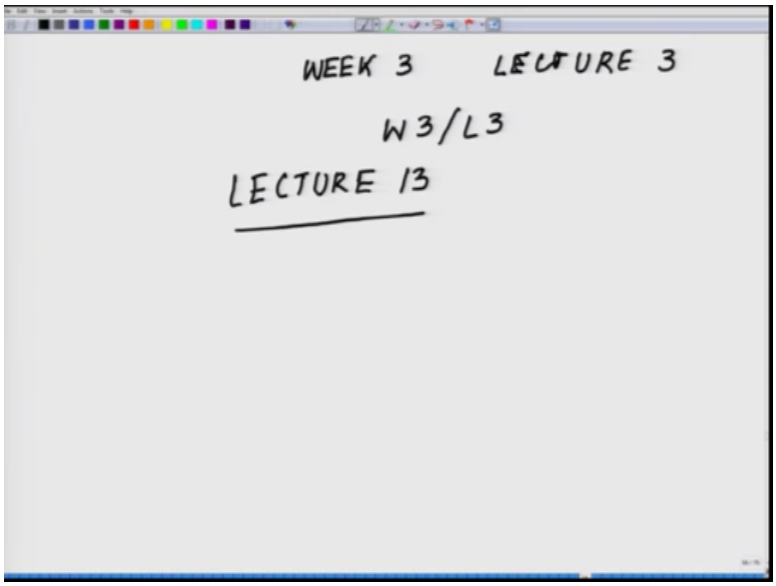

So, today we are into week 3, Lecture 3; W 3, L 3 and this is our essentially Lecture 13; 1 second, lecture 13. So, let us recollect back about the Nernst equation, when we write the Nernst equation.

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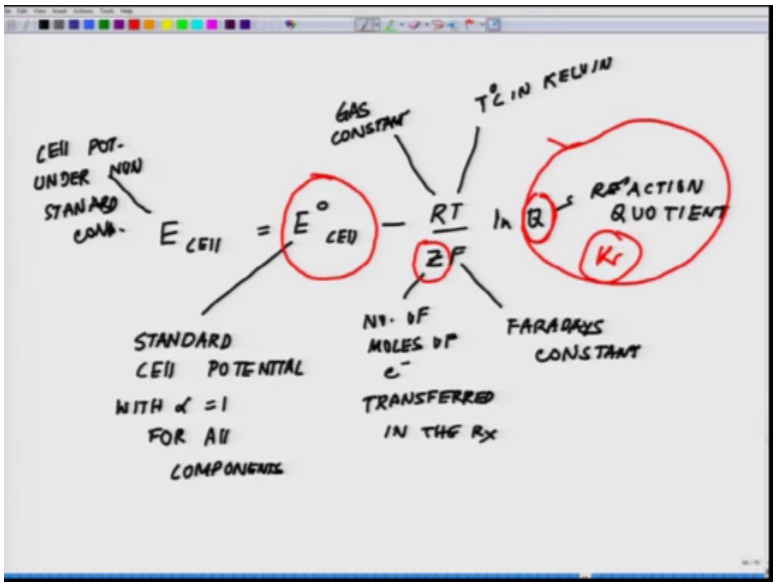

When we write the Nernst equations, this is E of the electrochemical cell is equal to E 0 of the cell, which is our standard cell potential. This is our standard cell potential with all the values as unity for all components. e cell is the cell potential under non standard

conditions; cell potential under non standard conditions, plus sorry, the minus RT ZF; where, R is your gas constant; T is the temperature in kelvin.

Temperature in kelvin; Z is the number of moles of electron transferred in the reaction. Number of moles of electron transferred in the reaction. F is the Faradays constant or faraday constant and the last term is the Q which is your reaction quotient.

So now, in this expression the critical point is, there are 2 unique critical points. One is you have to know the standard cell potential. You have to measure the standard cell potential using standard hydrogen electrode; with respect to standard hydrogen electrode where you assume that standard hydrogen electrode has a potential of 0 with respect to 0, you measure it.

Second the varying part is of course, the number of electron that is depending on what kind of reactant or analyte is involved. The third part is this part, reaction quotient and if you recollect the previous class, we talked about how you can calculate the K and here we I am representing by Q which can be also I can call it as K also. But I just avoided.

So, you represent it, you measure the value of Q which essentially is the real life amount of the reactant and the product. And based on that one can say certain things about how the reaction is going to proceed. Based on that one can say that whether if E 0 is positive or E 0 is 0 and likewise and so on and so forth. You can make certain predictions.

But, what I am going to highlight here is that. So as of now, whenever we talked about cells, we talked about say for example, you have a electrode A.

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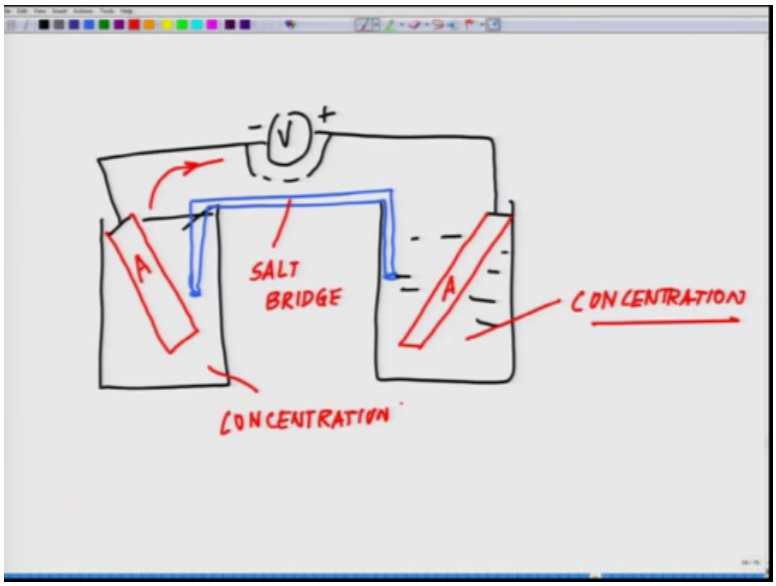

Electrode B. Electrode A is something like this; you have electrode B which is, this is the B electrode. It is connected to a voltmeter you are measuring or you can directly connect it and bypass it and this is the negative terminal; this is a positive terminal. And here you are having a salt bridge connecting them. This is how as of now we have talked about. So, this is your salt bridge, say we have talked about you know silver, talked about cadmium electrode likewise so on and so forth.

Now, in all these situations, we have assumed that both the electrodes are different. Now think of a situation if I say that I have the same electrode on both sides. Will the current flow; this direction or this direction whichever direction does not matter. Will the current flow across it, how it can flow? Now if you look at this reaction.

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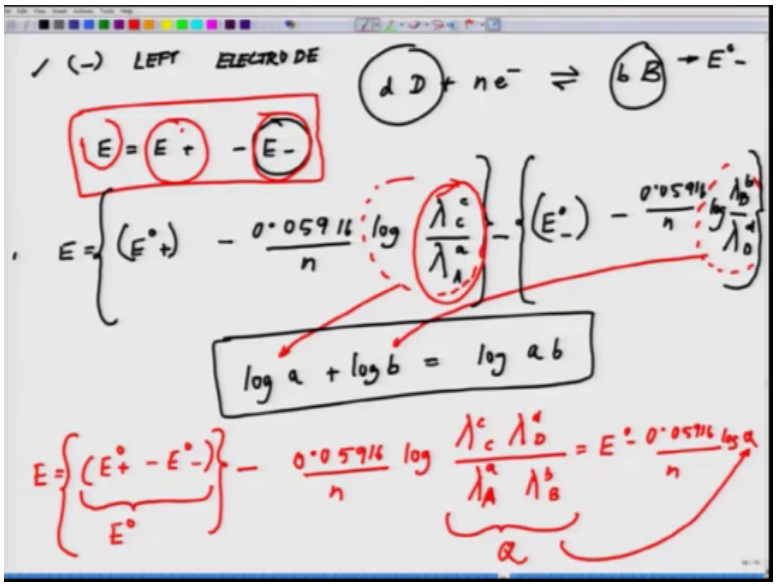

Like say for example, this reaction. This is how we measure. This is potential and this is positive; this is the negative and this is how we make the left electrode, right electrode.

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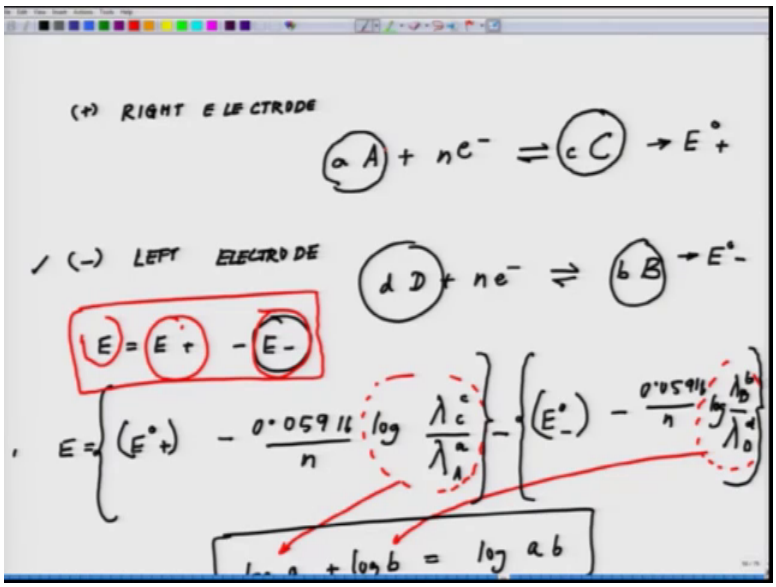

Now, if I say that instead of the left electrode, what do you see is in. If everything is same, if both the electrode reactions are same; Will the current flow across it or not? Because this has a connotation in biological system, that's why I am kind of coming to this. Well looking at the reaction now, looking at the expression now, out here; coming back, I give you a hypothetical situation, think of it.

Now, this one is say now, I just replace it by see I say this is A and I remove this cadmium thing; make it electrode A and I replace this B as electrode A. Both are electrode A. How one can vary? Could it flow? So, near here I am telling, it can flow provided; provided the concentration here. concentration of the electrolyte or concentration of the reactant analyte varies; why is it so?

Because, if you see the expression; what the expression says? Expression is here, expression is left to right; look at the expression. This is the expression from left to right. Now if that is the case then, by varying the concentration; if you vary the concentration so automatically the numerator and denominator is going to change. By varying the concentration, you actually can allow the current to flow. These kind of cells are called your Concentration cells.

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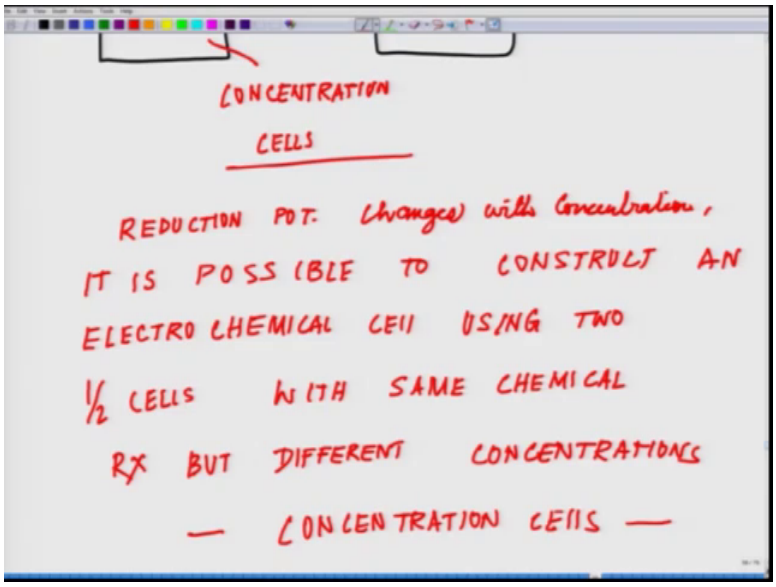

So, today we are going to talk about Concentration Cells. What are Concentration Cells? Concentration Cells are basically because the reduction potential change with concentration. So, reduction potential changes with concentration and electrochemical cell using 2 half cells with the same chemical reaction, but with different concentration, such cells are called Concentration Cells.

So, let me repeat again, because the reduction potential change with concentration; it is possible to construct an electro chemical cell using two 1 by 2 cells with same chemical

Reaction. Reaction is same; but different concentrations and such cells are called concentration cells.

So, today our journey will be from concentration cells to the bio-electrochemistry of nerve and ion channels; that is what we are going to proceed. So, now, talking about a concentration cell, let us think of an example; where, you have a cell like you know silver.

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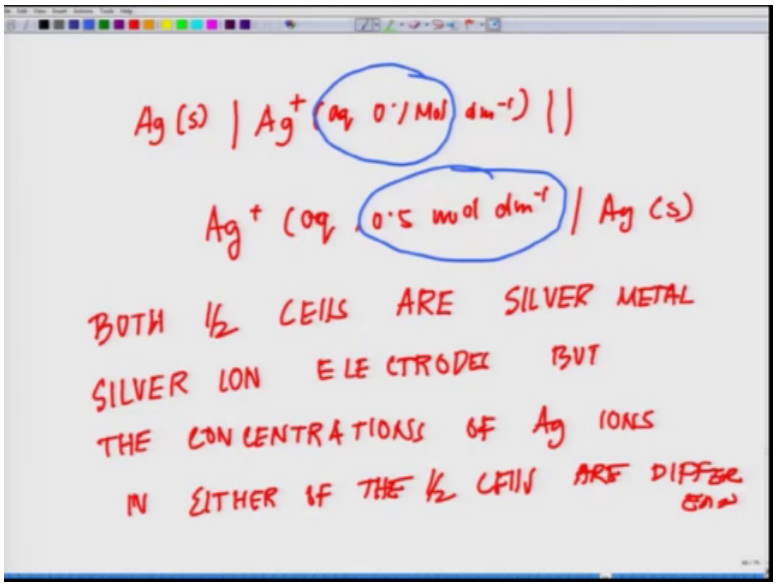

Solid silver. I am just putting by the notations. Ag plus which is on the salt in the aqueous phase which has 0.1 molar of 1.

Now, on the other side, what you have? Silver again, Ag plus aqueous, but 0.5 mole Ag solid. Now both half cells are silver metal, silver ion electrode. Both 1 by 2 cells shown above are silver metal silver ion electrodes. But the concentration of silver ion in both or in either of the half cells is different.

concentration of silver ions in either of the half cells are different; as you can see clearly here, you have this is the difference out there.

Now, if we see the left and the right reaction, as we always say that we have to first of all understand the reactions.

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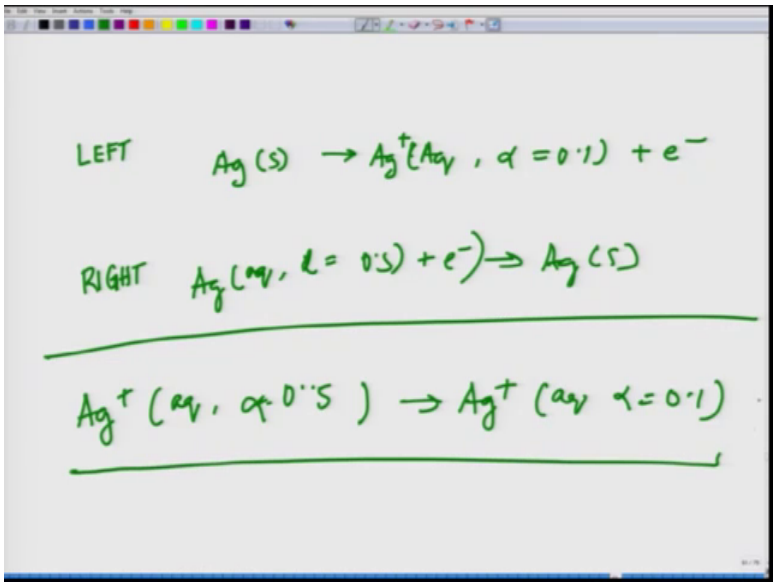

What is happening at the left and the right hand side? So, the left hand side the reaction is Ag Solid Ag plus it is an aqueous 1 plus electron. Similarly on the right hand side, it is Ag aqueous, the concentration of 0.5 plus electron giving you Ag solid.

So, the overall reaction, if you add both of them, the reaction is something like this. Ag plus aqueous 0.5, Ag plus aqueous concentration 0.1.

So, this is how it kind of looks like and if you put the Nernst equation in place for this. So, the Nernst equation will be.

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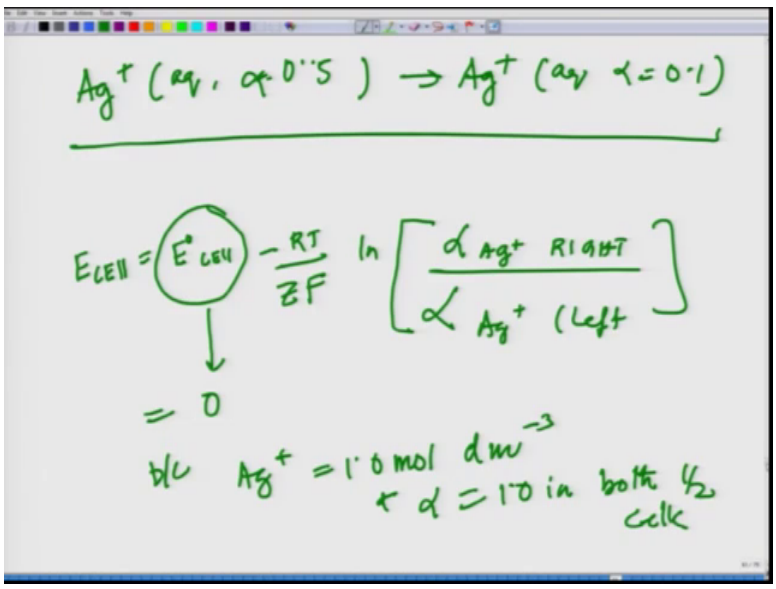

E of cell is equal to E standard reduction potential minus RT ZF will be Ag on the right divided by Ag plus of the left. Now E 0 of the cell will be 0; because under standard condition. Because this value will become 0; because under standard condition Ag plus is equal to 3 and alpha is equal to 1.4 in both half cells.

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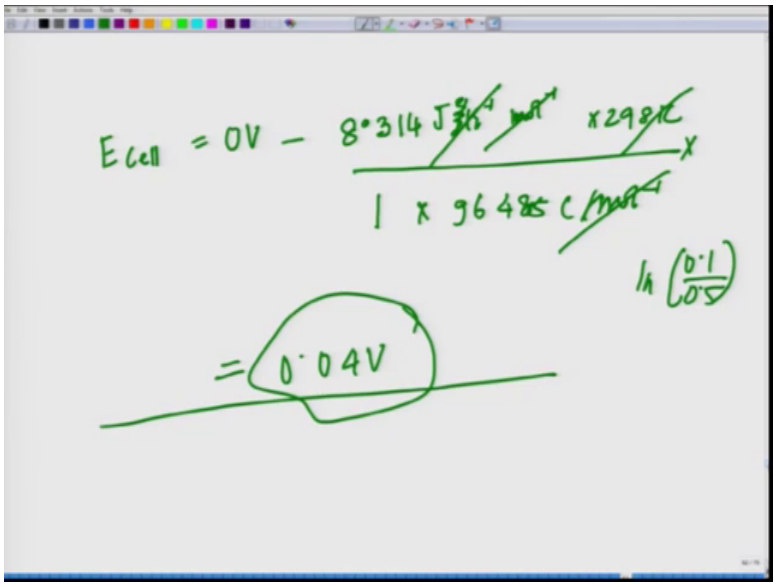

Now, if this is the case; then, your E cell is equal to 0 volt minus, now putting the values 8 point which is the gas constant 314 joules per Kelvin per mole. One second, mole multiplied by 298 Kelvin which is your 25 degree centigrade. One electron transfer which is your Z multiplied by faradays constant which is 96 485 coulombs mole to the power minus 1. Where, this mole and this mole get cancelled. This kelvin and this kelvin get cancelled. And then, multiplied by your log 0.1 divided by 0.5.

This is on a natural log, what we are doing. So, what you are essentially getting is 0.04 volt. So, the value of itself or concentration cell is equally quite small, as you could see that. You know you are obtaining a value of 0.04 volt, but what is important here is when the current is drawn from the cell the cell potential decreases as the reaction proceeds. The concentration in the 2 half cells tend to equalize when the concentration are in same in both half cells and the reaction comes to a K equilibrium where E cell becomes 0.

The principle what is important here which is underlying the concentration cell is particularly important.

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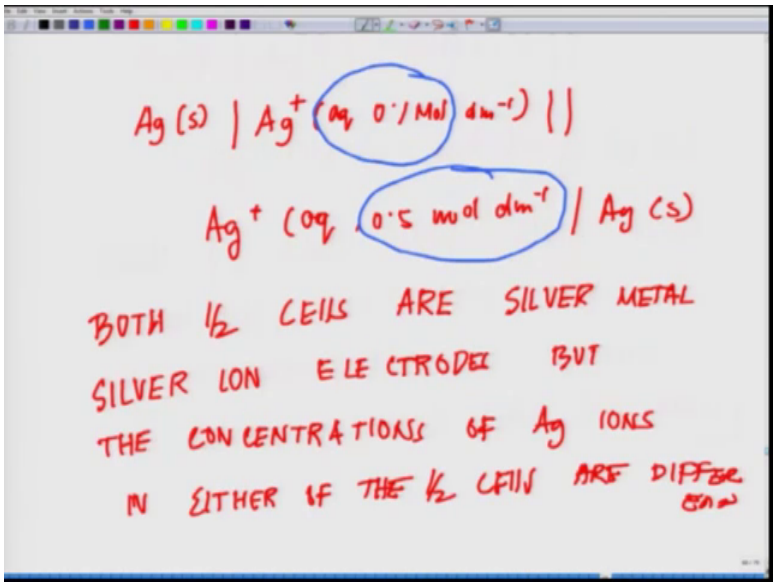

So, what I wanted to highlight at such concentration cells can be developed with the same electrode.

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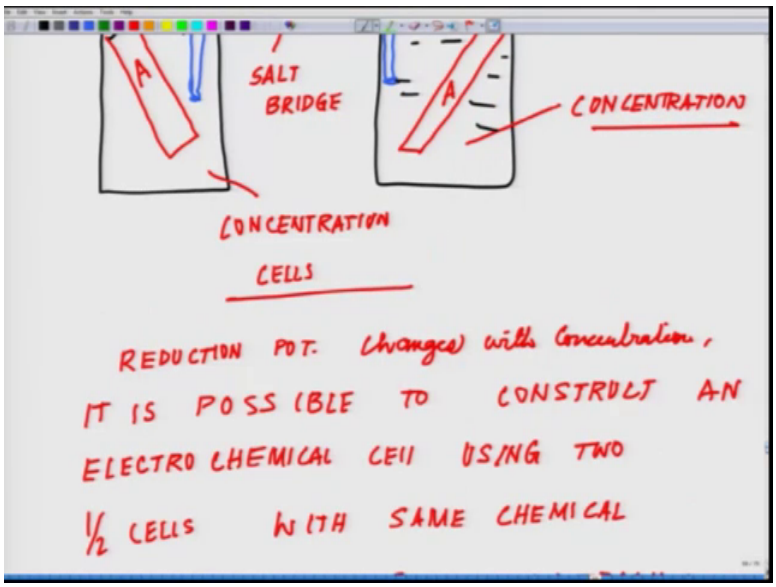

And that is 1 derivatization from the Nernst equation. Now from here, we will gear up, will close in here; will gear up for the biological system where this relevance of concentration cell comes into play.

Thank you.