Bio-electrochemistry

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Lecture – 03
Key Terms

Welcome back to the third lecture of the first week of Bio-electrochemistry. So, we concluded the previous lecture which was second lecture with a note that will be doing few numericals on relating charge to the quantity of reaction. In other words charge which is represented by coulombs which is the unit of charge and similarly will be relating current amperes to the rate of reactions.

So, before we do these kind of problems what I wish to do is I wish to explore few other basic concepts and once we are done with the basic concept we will deal with the problems. So, among the other basic concepts which are important, as of now we have talked about the current and the charge and the charge on a single electron and we talked about Faraday's constant which essentially when you are multiplying Avogadro's number which is total number of particles per mole multiplied by the charge in an single electron that is gives you the Faraday's constant and using Faraday's constant if you multiply Faraday's constant with the number of moles then you need know the quantity of charge that is pretty much if you recollect. This is where we ended the last class where this is the amount of charge and this is the number of moles n and this is the Faraday's constant.

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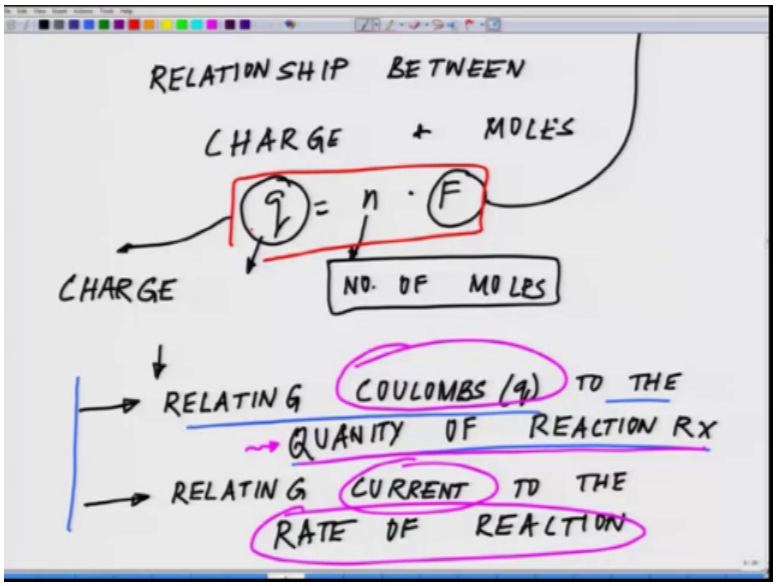

And we talked about that per unit flow of charge per unit time flow of charge from a specific point. So, there is a specific point per second the amount of charge which is falling or you can use any unit of time that denotes the current. And the difference, the potential difference between any two points represent the potential drop or is expressed in terms of voltage.

So, today what we will do, will resume this class which is our lecture 3.

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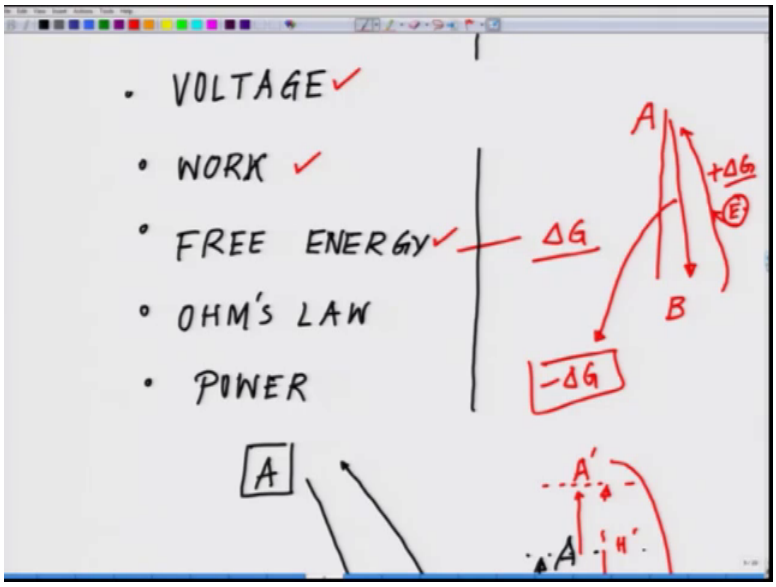

Today will be dealing with these few terms which is our voltage, then will be dealing with work or the work done these are all the basics you all have done, but we are just revising and we will talk about the free energy, then we will talk about the Ohm's law, followed by will talked about the power. Because if you realize whenever we talk about a battery or a cell or any kind of a energy storage device we talk about the power. What is the power? We talk about say milliampere hour. What does that mean? So, will be dealing with these basic terms today and before we move on to the galvanic cell which will be our next class and subsequently the Nernst equation.

So, to start off with voltage what really voltage means. So, I have already given you an idea that voltage is basically say for example, a charge has to flow from say point A.

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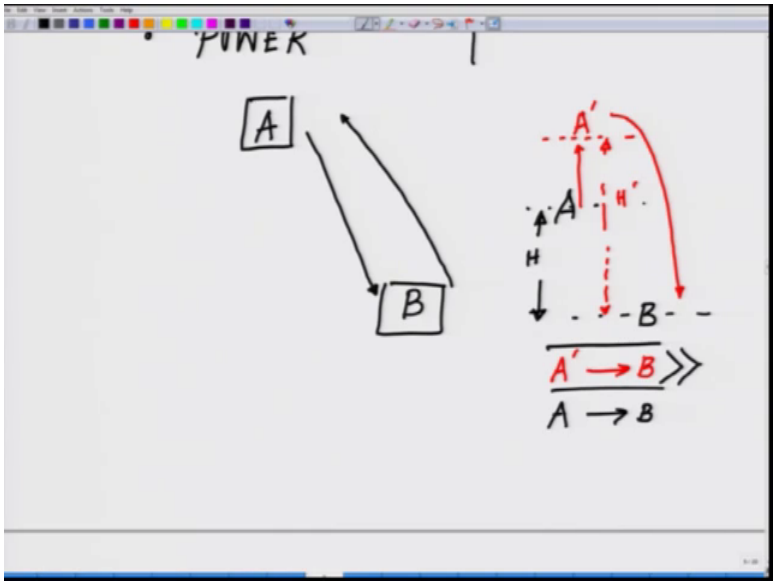

To point B whether this flow will be spontaneous or not or whether will be need to energy the difference or the potential difference between the two points. So, for example, you have think of a situation you have water here and you have to get the water down here. So, it will flow spontaneously. Now, the force with which it will flow can vary by raising the level of the water. Say for example, it is in this level and I raise it. So, for example, now this is point A, this is point B this is the level. So, this level is denoted in terms of height ok.

Now, if I raise this A even further up out here. So, then what will happen? This height will become H prime. So, for if the new as position is here from A to B there will be

more force which will be generated. In other word between A prime to B as compared to A to B, so automatically the force which will be will be far more in this situation. So, that is what essentially is in the layman language you have to understand the voltage difference between two points.

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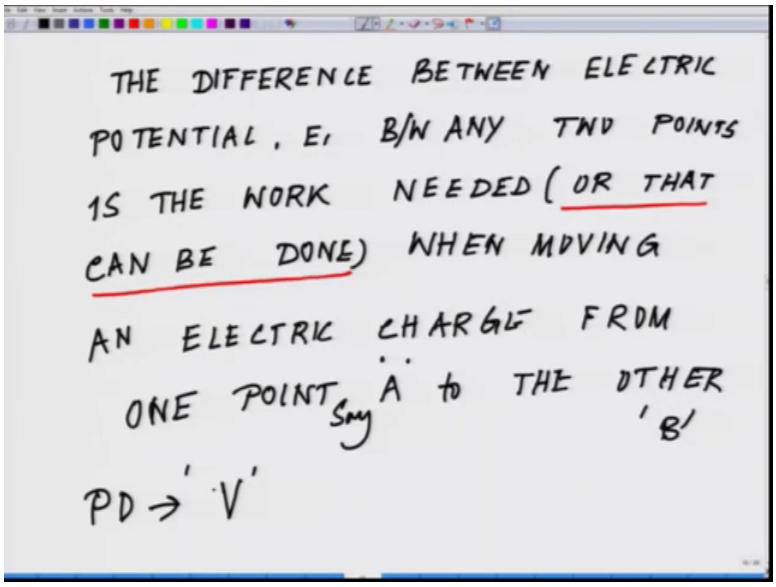

And if I technically to write it, it will be something this. The difference in electric potential E between any two points the difference between E which is basically the potential between E; between electric potential. So, we are exclusively talking about electric potential here E between any two points is the work needed or so. Be careful I will be underlining next sentence inside the bracket or needed or that can be done. So, let us highlight that part or underline that part that can be done when moving an electric charge from one point say point A say to the other. So, we consider say that as point B, say point B. So, potential difference is measured in volts. PD stands for potential difference.

So, now, if you talk about the work which will be done in moving a charge from A to B this could be quantified as work which is represent in Joules the unit of work is in Joules is equal to your E which is the potential difference represent in voltage volts multiplied by the q amount of charge which is in coulombs we have already talked about it, so the work done.

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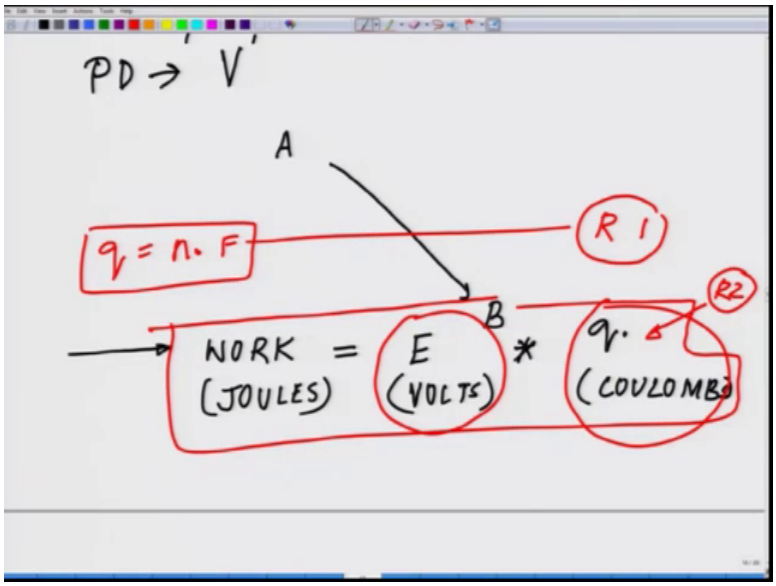

So, this is the second relation we are talking about if you remember the first relation we talked about just a recap.

So, q is equal to n F right. So, this was our relation 1. Now this is our relation 2, the second relation. Work is equal to the voltage or the potential difference between electric potential difference and the charge E q. So, this is our second relation what we have to remember. So, 1 Joule of energy we talk about 1 Joule of energy is gained or lost say.

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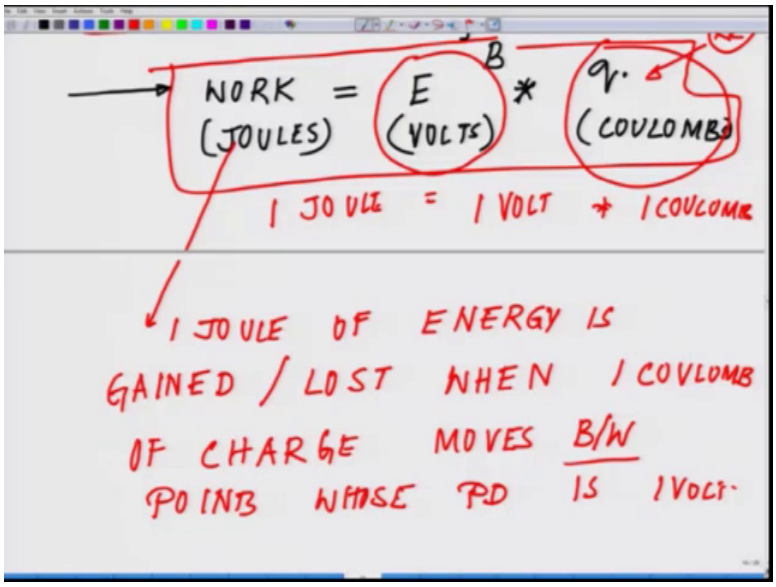

For example here, 1 Joule of energy is gained or lost when 1 coulomb of charge moves between points whose potential difference is 1 volt in other word. So, this is 1 Joule when is equal to when it is 1 volt multiplied by gained or lost when 1 coulomb of charge. So, if you put everything unity this is what you are going to get. So, this is the second fundamental concept what you needed to remember.

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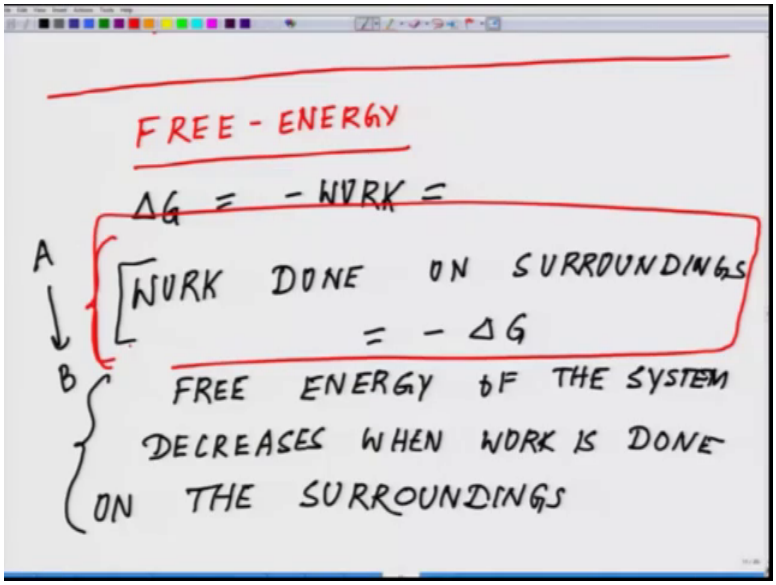

Now, having said this, now will introduce the concept of free energy. I told you that there will be few concepts. So, we talked about now if you will see what all we are going to talk today. We talked about the voltage, we talked about the work, now will talked about talk about the free energy which is represent by delta G.

So, those of you remember about the delta G concept if you remember. So, we always talked about the delta G is a situation, if delta G is negative it means the work will happen is spontaneously. Say for example, from here this is at a higher height and this is at a lower height what will fall spontaneously. You do not need to do any work you drop the water, water will fall down. Now see for example, from ground floor you have to carry the water all the way to the first floor, second floor, third floor, fourth floor. So, in order to do that you have to you will be needing energy you have to put energy into the system. So, you have to really do hard work you have to carry all the buckets and all the way go up.

Now, those kind of situations are the where very very positive delta G it means you have to give energy to make it happen whereas, contrary to that when we talk about negative delta G this is a situation when it is an spontaneous process; that means, this reaction will be spontaneous. So, between A and B, point A and B there will be a spontaneous flow and you do not need any extra energy or as a matter of fact any energy for that reaction to happen.

Now, coming back how it is being represented. So, this is, will be talking about the free energy, free energy. So, free energy in terms of thermodynamics is determined by is basically delta G is equal to minus work or in other word work done on surroundings is equal to minus delta G. This is when we talked about A to B this is basically work done on surroundings and we represented it as minus G the negative sign in equation indicates that the free energy of a system decreased when the work is done on the surrounding. So, free energy of the system decreases when work is done on the surroundings. So, this is the case of minus delta G.

Now there is the next relation of free energy what we will be dealing now is delta G is equal to minus n F E.

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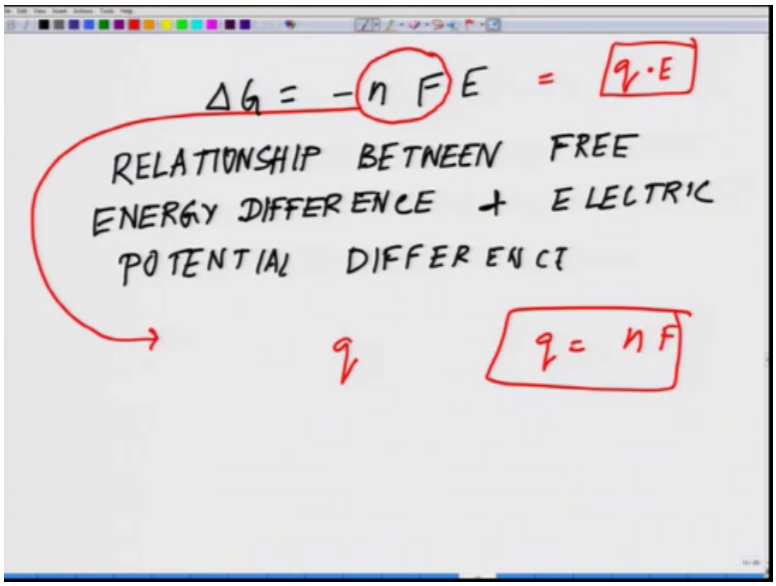

Now, if you look at this relation, this is the relationship between, relationship between free energy difference, free energy difference and electric potential difference.

In other words if you look at this n F if you look at this term n F. You remember that this term was the term which was q, q is equal to n F the total amount of charge which is this is the term I wanted to show you what we talked about the Faraday's constant. If you remember in the very early classes here is that relation. So, if you remember this relation now coming back to this one what we talked about this n F is basically is the charge and this also could be written as q E and q E you remember this is this relation just one step earlier, what we talked about work done this system q E. So, delta G is equal to minus n F E. So, this is another relation which is very important for us to realize and all these applications will comes.

Next we will move on to the most fundamental it which is the Ohm's Law.

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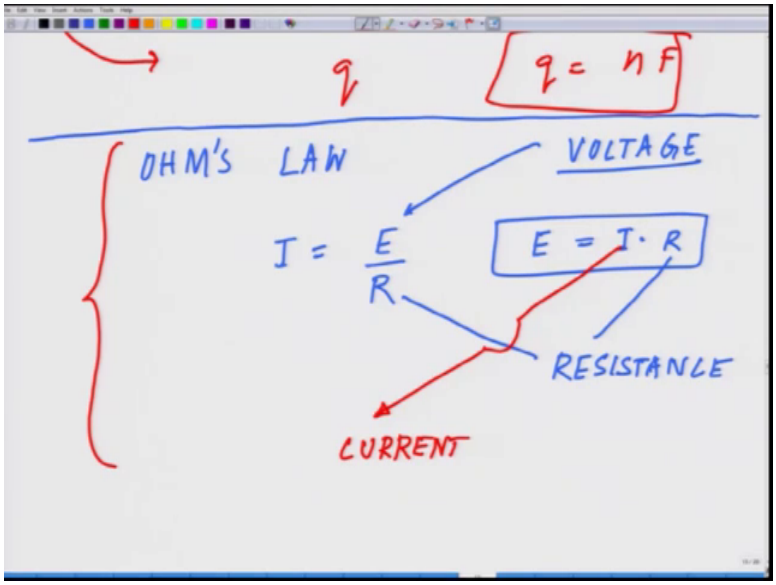

Ohm's law states that I is equal to E upon R or in other word if you replace some people write E as V which is voltage or potential difference. So, basically V is equal to I R or E is equal to I R or E is equal to I R, where R is the resistance and I is the current. This is the third relation what you will have to remember, that the relation between current, voltage and resistance.

So, now just have a little recap.

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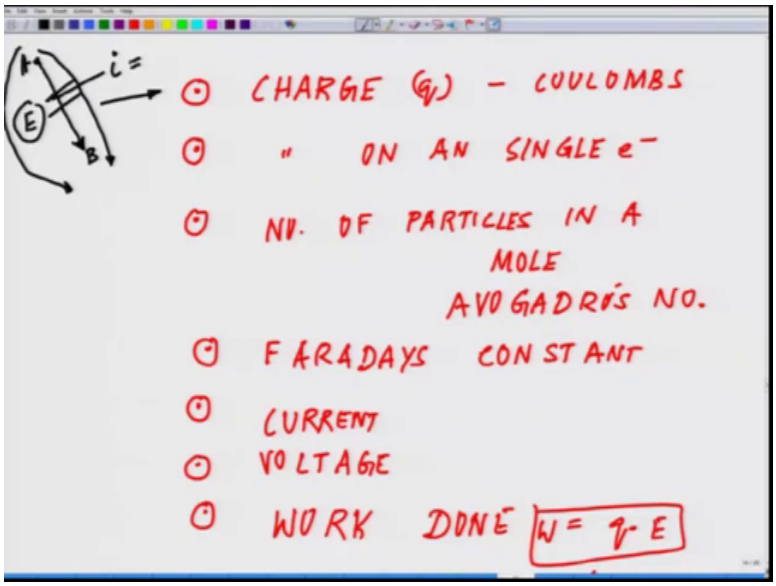

What all we covered? We initially talked about charge, charge q in coulombs, then we talked about charge on an single electron, then we talked about number of particles in a mole which is Avogadro's number, then we talked about Faraday's constant, then we talked about the current, next we talk about the voltage. So, you are slowly moving. If you realize it we talked about the voltage.

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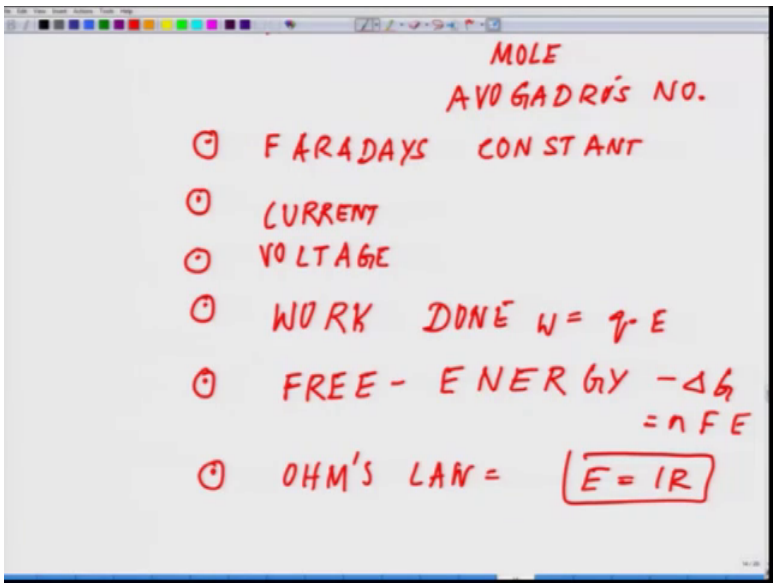

Then we talked about the work done, the relationship between work, voltage and charge. Then we talked about free energy change which is represented by delta G, if you n F E

and we talked about work done as W is equal to q multiplied by E and then we are now talk, just now about Ohm's Law which is E is equal to I R where E is the voltage and now, we will talk about another relation which is power.

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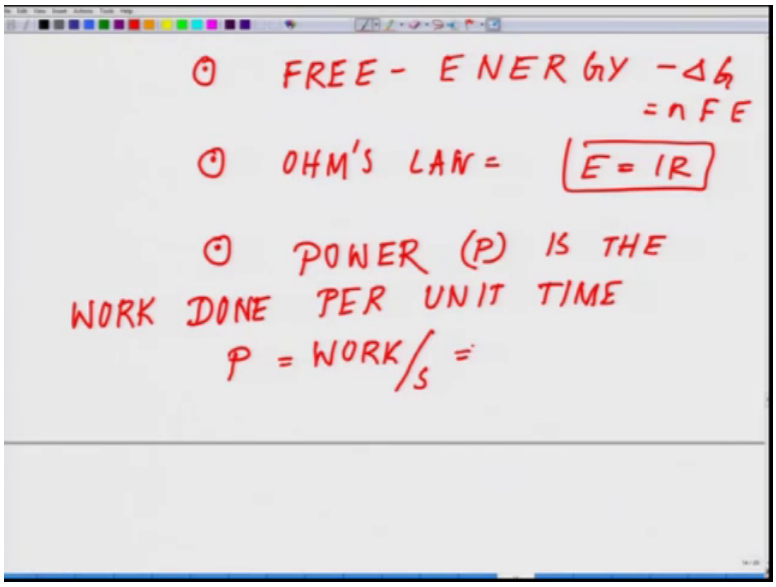

What is power? Power is power represented by P is the work done per unit time, is the work done per unit time. In other word W which is the work done and seconds which is per unit time is representing power. So, in other word we can represent this as P is equal to work upon S which is the time.

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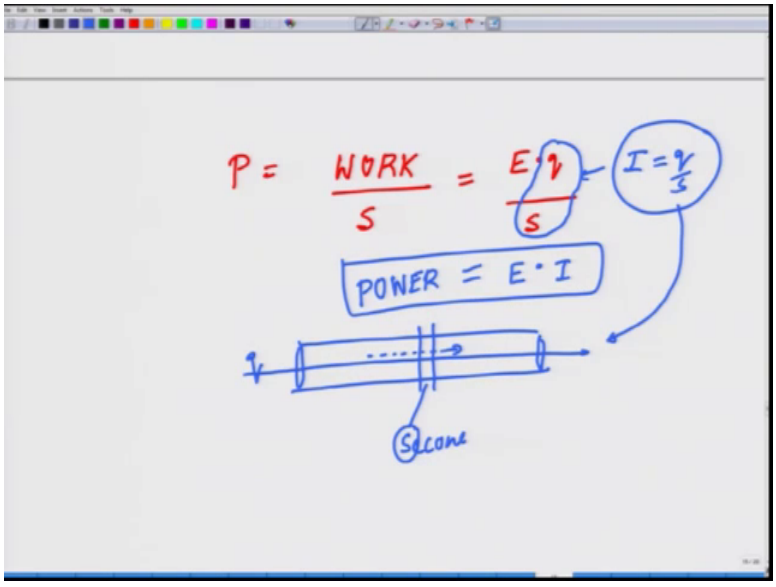

So, work could be represented as E q, you remember just few minutes back we talked about this work is E q. So, it is E q divided by the seconds and now look at it carefully if you pull out this relation flow.

So, say for example, here is where and charged particle is moving which is having a charge q per unit time which is per second at this point, it is traveling through like this. So, that represent is what we call as current. So, q upon S, so then power becomes a product of voltage multiplied by current is equal to, is equal to E I because q by S is current and we can write it as I and here is the diagrammatic view.

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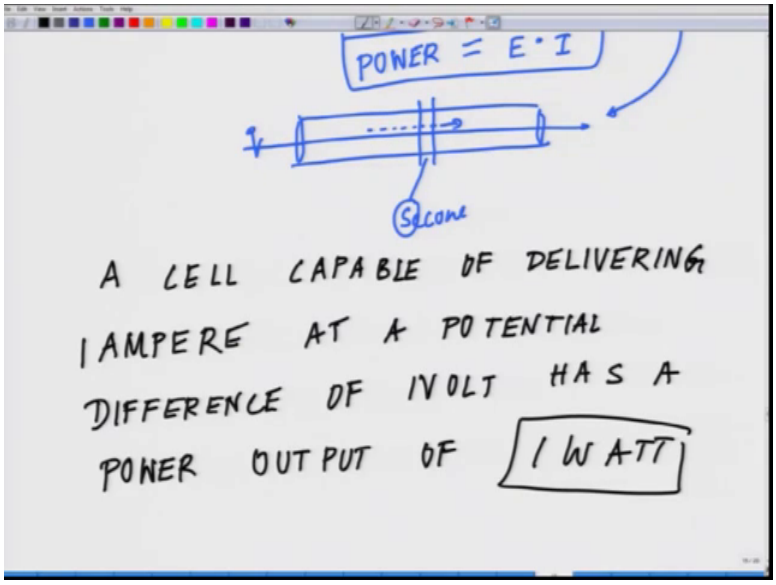

So, a cell, if we talk about a cell now a cell is capable of delivering 1 ampere. Now again put everything in unity you will realize it 1 ampere at potential difference of 1 volt has a power output of 1 watt. Now, this is the new term wattage whenever we talk about a bulb we say wattage right.

So, these are the basic fundamentals what one needs to understand to explore how a system generates it is power. So, if you look at it. So, where we started now here, we talked about the last one which is the power. So, now, these fundamental ideas I want you people to kind of you know regurgitate which what is a charge why a charge should move from one point to another say point A to point B, because they will only move when there is a potential difference electric potential difference for a charged particle to move.

So, the amount of charge moving from A to B is basically the amount of reaction which has occurred. Now, the rate at which charge moves or the current is essentially the rate of reaction. So, if you recollect where we ended the last class I told you if I go back. So, relating coulombs charge to the quantity of reaction or in other word the amount of reaction which has happened similarly relating current to the rate of reaction. So, these two fundamental things are of extreme value and a complete understanding of this basic concept is what I expect you people to once and for all these are the just the basic concepts. If you know these concept you can derive anything, but then one really had to appreciate and understand these concepts very clearly.

So, again though I am taking lot of time here because I want the basic fundamentals to be very very clear why a reaction will have a delta G negative and why a reaction will have a delta G positive. This you should be able to like almost close your eyes and you can tell this is it whether the reaction is going to take place without energy or with energy. Any reaction can happen provided, you know whether that is spontaneous process delta G will be negative or delta G will be positive and if delta G is negative then what we talk about you remember, free energy work done on surrounding, this is important.

So, these axioms are very important for you to understand surrounding it means it will be a spontaneous process delta G will be negative. And we talked about work, so it is basically a charge q moving through a potential difference between two points. So, in this case the charge is say for example, water is flowing. So, water itself is the charge. And the height is a potential difference. So, if you think of the water is falling from say fourth floor to the ground floor. So, there is a potential difference and the rate at which charge is flowing through a specific point per unit time that is your current, you remember q divided by s seconds charge flowing per unit time. That is all I expect you. If you understand these concepts, solving problems, so this was our which is essentially current.

So, basically your power which is work done per unit second is represented as voltage E multiplied by current which is the amperage and this is represented as 1 watt. So, this relation, this definition a cell capable of delivering 1 ampere at a potential difference of 1 volt has a power output of 1 watt. So, please and please remember these basic concepts because these basic concepts will be extremely helpful for us to solve most of the

problems what will be dealing in this basic fundamental electrochemistry or bio-electrochemistry.

From here, we will move on to our next class where we will talk about the galvanic cells and we will talk about the work functions and we will talk about the Nernst equation and equilibrium constants.

Thank you.