Elementary Electrochemistry
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Introduction to Elementary Electrochemistry

Welcome to the course, elementary electrochemistry. This course is basically designed for students studying BSC with chemistry as one of the subjects. Electrochemistry is a subject taught mostly in first and second year of BSC. So this course is suitable for first and second year of BSC students who are studying chemistry as I already indicated. I am Doctor Angshuman Roy Choudhury, Assistant Professor in the Department of Chemical Sciences at IISER, Mohali. And I have been teaching this course in this institute for last few years.

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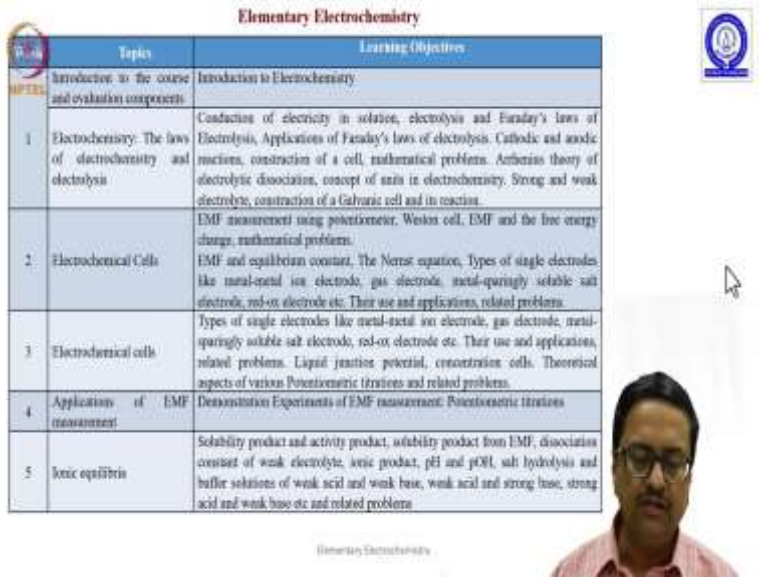

So, this course as you all know, that will have eight weeks total and this course will have about 20 hours of total lecture, which will include theory and experiments involving electrochemistry. So here on your screen, you can see the basic outline of this course. In the first week, we will have a brief introduction to electrochemistry, some basic aspects of electrochemical cells and how the electrolysis is conducted and based on that the first week, we will try to cover conduction of electricity in solution, electrolysis, Faraday's laws of electrolysis, applications of Faraday's laws of electrolysis, etc.

And we will talk about cathodic and anodic reaction, construction of cell, we will try to solve some mathematical problems. And we will also discuss about Arrhenius theory of electrolytic dissociation, concept of units in electrochemistry, strong and weak electrolyte, etc. In the next week, we will start talking about electrochemical cells, where we will discuss the application

of EMF measurement using polarimeter, we will discuss about Weston cell, Danniel cell etc. And we will try to derive equations related to EMF and free energy change of a given reaction and we will highlight some of the mathematical problems as well.

Then we will discuss about Nernst equation, EMF with equilibrium constant relationship, types of single electrodes, how to determine their standard electrode potential, etc., their applications and some mathematical problems. In the third week, we will talk about types of electrodes, single electrodes, different types of redox reactions and their use in practical life. We will talk about liquid junction potential, concentration cells and learn some aspects about their applications. And then we will discuss about the theoretical aspects of various Potentiometric titration and related problems.

In the fourth week, as I already indicated, this course will have a component of experiment. So, the fourth week, we will have demonstration experiments of EMF measurement. So, in that we will conduct some Potentiometric titrations; there will be laboratory sessions which will be video graphed and shown to you and we will then talk about the calculation, graph plotting etc. in the fourth week. In the following week, after four weeks, fifth week, we will talk about the solubility product.

So we will move to the ionic equilibria part. So, we will talk about solubility product, activity product, solubility product determination from EMF measurement, dissociation constant of weak electrolyte, all these along with buffer solutions, weak acid, weak base and strong acid; buffer solutions of weak acid and weak base, weak acid and strong base and strong acid and weak base, etc and the related problems.

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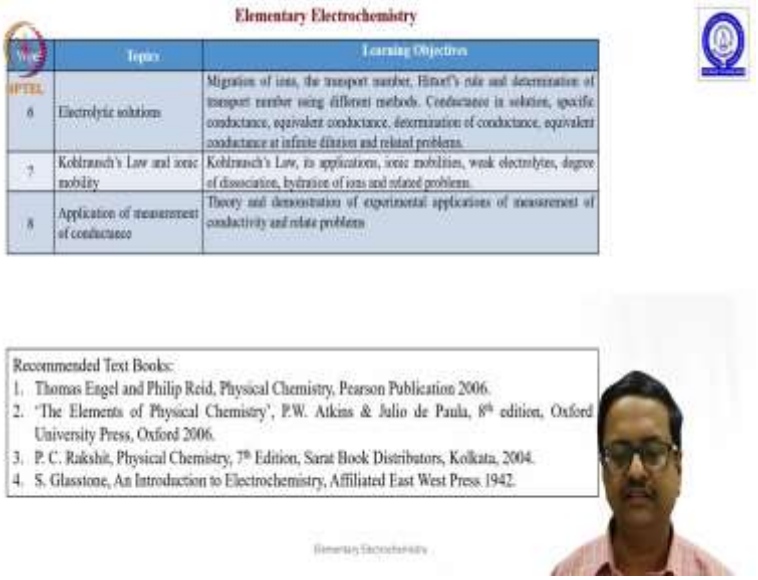

In the week six, we will move to electrolytic solutions, where we will talk about the conduction of electricity through an electrolytic solution. We will discuss about migration of ions, the transport number, Hittorf's rule and determination of transport number using different methods. We will talk about the conductance in solutions, specific conductance, equivalent conductance, their definitions and unit and determination of conductance, equivalent conductance at infinite dilution, and we will also discuss some of the related problems.

In the seventh week, we will talk about Kohlrausch's law of ionic mobility, its applications, weak electrolytes, degree of dissociation, hydration of ions and related problems. And we will also start discussing about the use of conductance measurement in practical problems. So, in the last week, the eighth week, we will talk about the application of conductance measurement, we will demonstrate again some of the experiments where the conductance measurement will be used to determine some of the physical parameters.

So, those experiments will again be demonstrated through a laboratory practical method. And we will also teach or discuss about how those experiments can be conducted and the corresponding calculation will be done. So, this course will have eight weeks of total content and each week as you are aware, we will have eight assignments worth about 15 to 20 marks which will be mostly based on multiple choice questions.

And at the end of the semester, there will be a written exam. Remember, it will be a written exam not a multiple choice based exam. It will be a written exam, hardcopy, you will have to

appear in the exam at some venue and answer the questions in pen and paper mode, classical mode of writing exams and we will get those copies graded at IISER, Mohali. In this course, there will be a tutor from my laboratory. So, that tutor will interact with you during this course, through the portal provided by NPTEL.

So, you are free to ask questions in that portal and it will be the tutor and myself who will be looking at the portal on a regular basis and we will try to answer your queries in the portal. And as far as we are told that there will be a few live sessions as well when I will be present or my tutor will be present to answer your queries or discuss some mathematical problems. So, this is the course outline that I wanted you to first know. Here are some textbooks that I have prescribed here.

You can see at the bottom of the screen, some of the standard textbooks that you should buy or try to get from some library and follow for this course.

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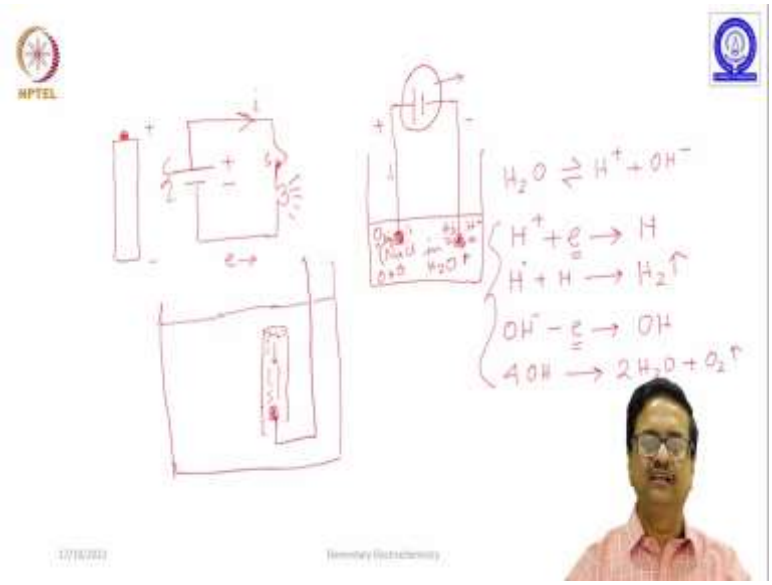

When you have studied in your classroom, you might have a little bit studied about the electrochemistry in the sense that when you have a battery, normally when we see a battery in our house, it looks like this. Is not it? The upper end is the positive terminal and the lower end is the negative terminal. So, when we write a battery in a given electrochemical circuit, we write the positive end as a longer line and the negative end as a shorter line, indicated like this.

So, whenever you see an electrical circuit, a DC circuit, this means this is plus and this is minus end of a battery. What happens if you connect this battery through a circuit and

connect it to a bulb with a switch S, when you close the switch, the current flows. As a result, the bulb glows. So, what is happening is that there is some chemical energy which is stored inside this battery, is now being used up and that chemical reaction which is happening at these two electrodes, the positive electrode is the anode and the negative electrode, the cathode, the negative point.

So, the current flows in this direction, while the electron flows in the other direction and the bulb glows. Similarly, if you have a battery and you take a solution of common salt in water, what will happen? You connect these two electrodes there. So, I have already used the term called electrode, the tip at which you are dipping and making the electrical conductivity with water is the electrode. So, this is your positive and this is your negative end.

So, in this case what happens? Here, this solution of sodium chloride in water or just a tap water which will be conducting electricity, in this will break water into H plus and OH minus ions. What will happen? The H plus ions will move towards the negative electrode, the cation will move to this negative electrode, towards the cathode, take up electron and form the hydrogen atom and two such hydrogen atoms will join to form the hydrogen gas. So, you will start seeing bubbles of hydrogen gas coming out of it.

Similarly, the OH minus ions will go here and release its electrons and become OH radical. 4 such OH radicals will combine to give you 2 H2O plus O2 which will count. As a result, we will see the oxygen gas is coming out and hydrogen gas is coming out. So, this is your very well known electrochemistry experiment that you might have done in your childhood, using a battery and somewhere, and what you see is that these chemical reactions are simultaneously happening in the solution and it is breaking water into hydrogen and oxygen.

So, if one can trap this hydrogen and collect in a container, so, suppose you put a very tiny glass bottle filled with water and then insert the electrode in that bottle which is filled with water. So, suppose I am tying that bottle which is filled with water and then you have inserted the electrode here and you have water at this level, what will happen is hydrogen gas will come up and it will fill in this region and push the water level down.

So, one can collect the evolved hydrogen at this point and one can see if you bring a burning matchstick close to this bottle after taking it out, this hydrogen will suddenly burst and catch fire and get ignited.

If you are trying to do this experiment at home, be very careful because hydrogen is highly susceptible to fire and once you do it under controlled condition only. So, these aspects you probably have studied in your 10 plus 2. So, we will discuss about these reactions in detail in the next class. So, this is one thing that one has to understand, what is happening and you see this current that is flowing is actually consuming the electrical energy stored in this battery. And that electrical energy is stored because we have a particular chemical reaction happening inside that battery to release that electrical energy and you are able to do this electrolysis.

See, today's date we all use different electronic devices and those electronic devices have batteries. Starting from your mobile phone to a wristwatch to a laptop or a computer, everywhere you get to see different kinds of batteries. And what are those batteries? Batteries are the storage of electricity. And when we try to take out that stored electricity, a certain chemical reaction happens inside the battery, which releases the energy as electrical energy. So, chemical energy gets converted to electrical energy.

And when the battery is drained, the entire chemical energy is consumed and it cannot run the device or your mobile phone or the laptop computer or some other device, there is a way to do a charging, right? Every day you put your mobile phone for charging and that charging means you are regenerating the chemical energy inside the battery. So, the reaction that is happening inside the battery can be a reversible reaction, some of the batteries you may encounter are not reversible process.

So once the battery is drained, you cannot recharge those batteries. So, there are two types of batteries, one are rechargeable batteries and others are not rechargeable batteries. So, in non-rechargeable batteries the chemical reaction inside is irreversible. Whereas in the rechargeable batteries the chemical reaction that is happening inside the battery is a reversible process. One can do a large number of cycles of charging and discharging using those batteries and on today's date, this is a big industry to develop small but more cyclable batteries and small but more powerful batteries which can store more energy so that one can operate a car using a battery.

So, that is where the application of electrochemistry comes in very handy. Starting with some basic knowledge, one can develop a carrier in electrochemistry and the battery world which is always a growing field of research, because as you know, the natural resources of energy, the petroleum and coal are continuously reducing. And we are now slowly moving towards an

era when everything will be operated using a battery. But then the battery has to be charged using a source of energy.

So, people are working on lots of different types of solar cells so that you can utilize the solar energy or windmills, wind energy to convert it into the chemical energy stored in a battery. And then eventually that chemical energy is used to operate different devices, even a motorbike or a car. So in the next class, we will start talking about various laws of electrolysis, the Faraday's laws of electrolysis, how the release of these ions are related to their corresponding molecular weight and the amount of electricity transferred during their discharge process, that is h plus ion getting discharged to hydrogen atom, OH minus ion getting discharged to hydroxyl radical.

So, governing these aspects there are a few laws proposed by Faraday several 100 years ago. So, those, Faraday's laws of electrolysis will be discussed in the first class and from there we will continue to talk about aspects of electrochemistry in this course. So, I would like to stop here as the first lecture, and we will continue from here in the next class. Thank you.