Electrochemical Technology in Pollution Control

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Lecture – 08
Conductometry 1

So, greetings to you. We will begin our next session on Electrochemical Methods. In the last class, we had seen electro gravimetric analysis a little bit and then we had defined several terms that is Ohms law and other things, what we had I had told you is regarding the electro gravimetric method they especially, it deals with the deposition of the electro element electrolytically from upon a suitable electrode.

So, filtration is thus avoided and some co deposition and other related methods related problems with respect to normal gravimetric. They have been avoided and then we also saw a little bit of Ohms law.

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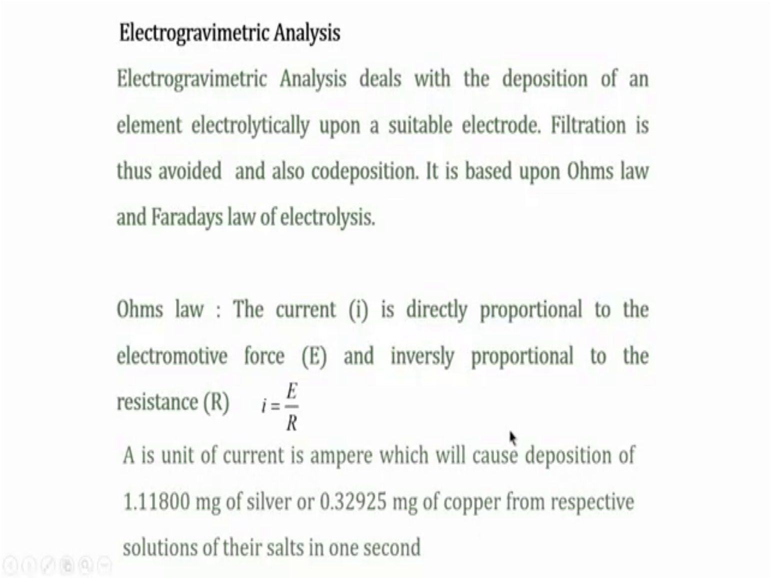

Electrogravimetric Analysis

Electrogravimetric Analysis deals with the deposition of an element electrolytically upon a suitable electrode. Filtration is thus avoided and also codeposition. It is based upon Ohms law and Faradays law of electrolysis.

Ohms law : The current (i) is directly proportional to the electromotive force (E) and inversly proportional to the resistance (R) $i = \frac{E}{R}$

A is unit of current is ampere which will cause deposition of 1.11800 mg of silver or 0.32925 mg of copper from respective solutions of their salts in one second

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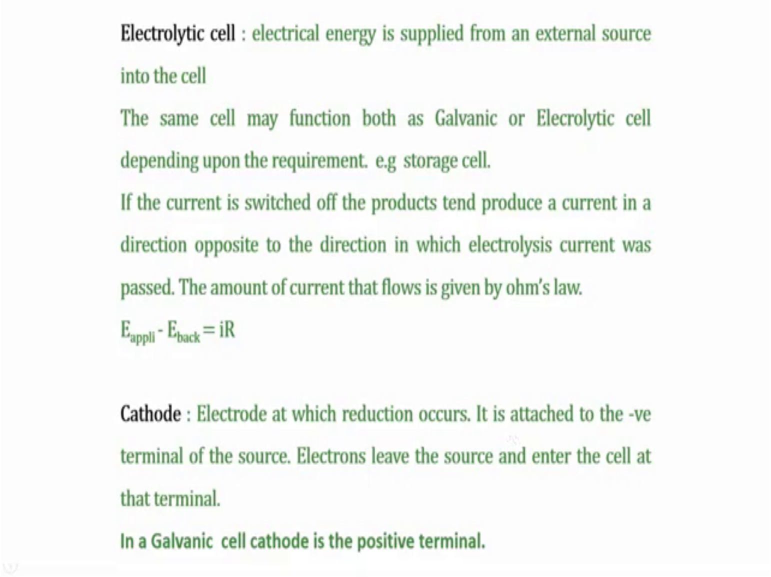

Electrolytic cell : electrical energy is supplied from an external source into the cell

The same cell may function both as Galvanic or Elecrolytic cell depending upon the requirement. e.g storage cell.

If the current is switched off the products tend produce a current in a direction opposite to the direction in which electrolysis current was passed. The amount of current that flows is given by ohm's law.

$E_{appli} - E_{back} = iR$

Cathode : Electrode at which reduction occurs. It is attached to the -ve terminal of the source. Electrons leave the source and enter the cell at that terminal.

In a Galvanic cell cathode is the positive terminal.

After the Ohms law, we saw this electrolytic cell regarding cathode.

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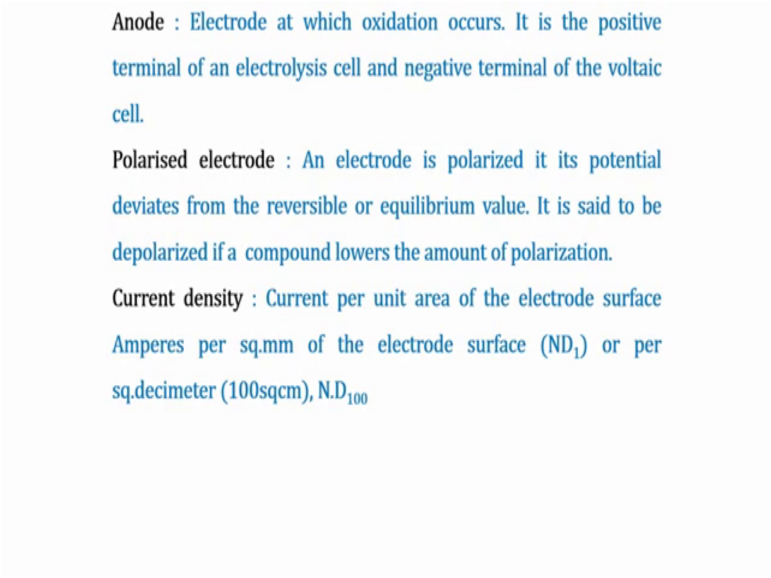

Anode : Electrode at which oxidation occurs. It is the positive terminal of an electrolysis cell and negative terminal of the voltaic cell.

Polarised electrode : An electrode is polarized it its potential deviates from the reversible or equilibrium value. It is said to be depolarized if a compound lowers the amount of polarization.

Current density : Current per unit area of the electrode surface Amperes per sq.mm of the electrode surface (ND_1) or per sq.decimeter (100sqcm), $N.D_{100}$

And then you know, we looked at what I what is an anode, what is a cathode and what are the polarized electrodes etcetera.

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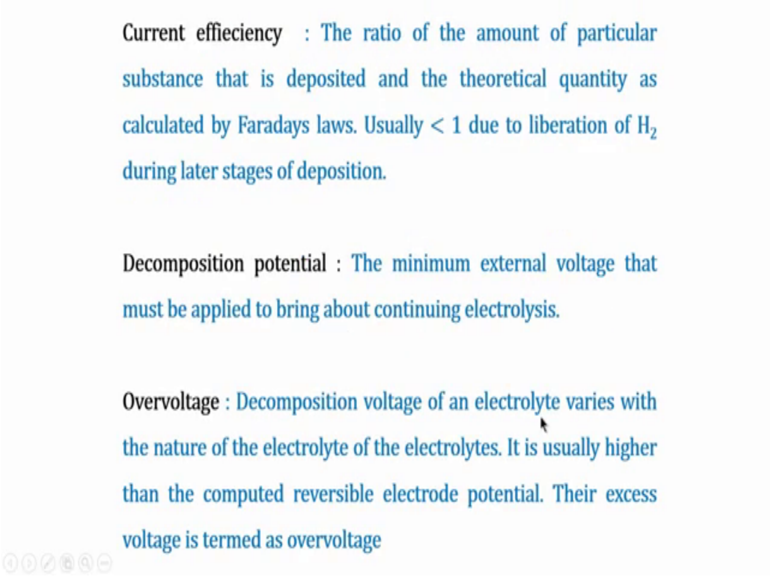

Current effieciency : The ratio of the amount of particular substance that is deposited and the theoretical quantity as calculated by Faradays laws. Usually < 1 due to liberation of H_2 during later stages of deposition.

Decomposition potential : The minimum external voltage that must be applied to bring about continuing electrolysis.

Overvoltage : Decomposition voltage of an electrolyte varies with the nature of the electrolyte of the electrolytes. It is usually higher than the computed reversible electrode potential. Their excess voltage is termed as overvoltage

And then we had looked at over voltage decomposition potential and all these definitions I had passed on to you.

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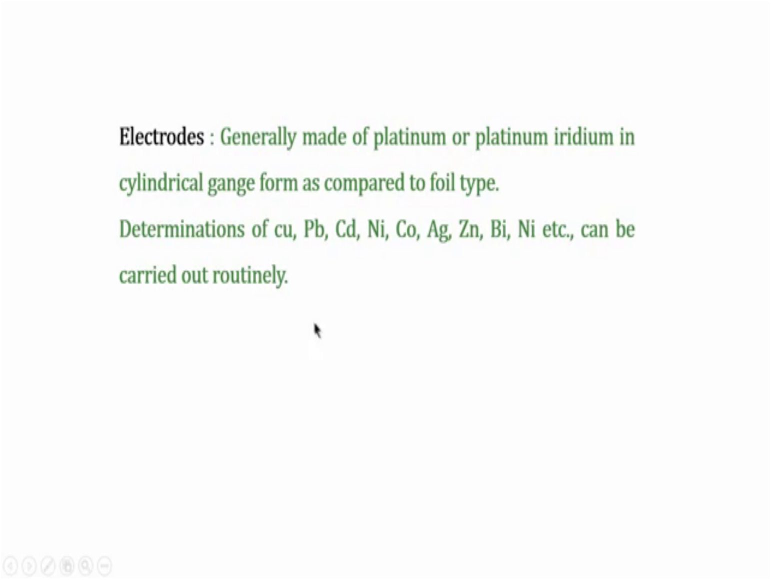

Electrodes : Generally made of platinum or platinum iridium in cylindrical gange form as compared to foil type.

Determinations of cu, Pb, Cd, Ni, Co, Ag, Zn, Bi, Ni etc., can be carried out routinely.

And then I had told you that electrodes can be made of all these platinum or platinum iridium, gauges etcetera and determination of copper, clad, cadmium, nickel; many of the metals can be carried out routinely.

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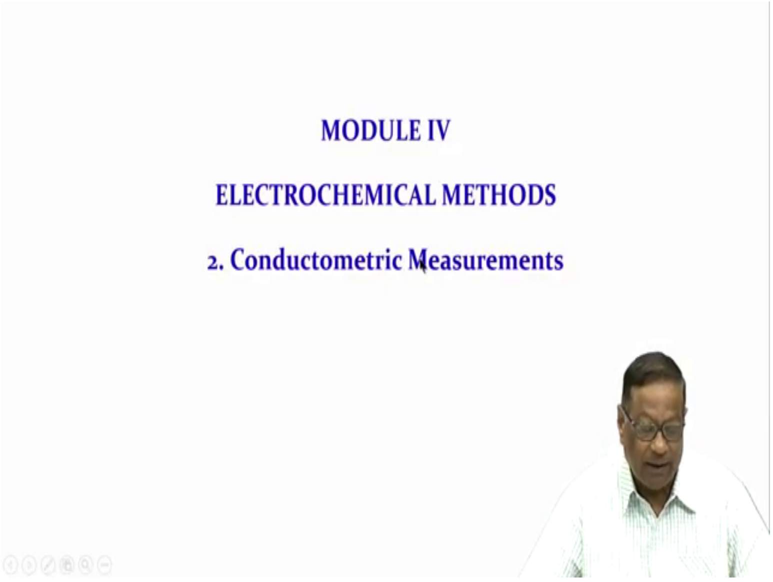

MODULE IV

ELECTROCHEMICAL METHODS

2. Conductometric Measurements

Now, we will go to the conduct next technique that is of electrochemical methods that is conductometric measurements.

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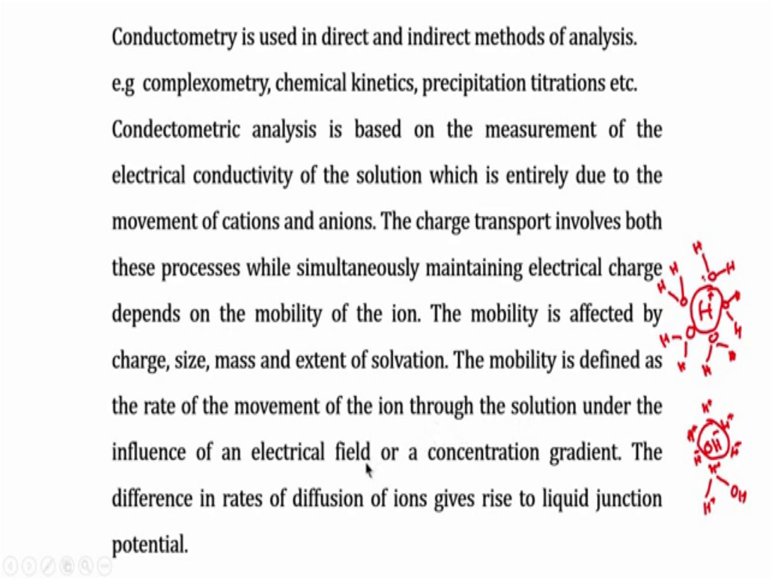

Conductometry is used in direct and indirect methods of analysis.

e.g complexometry, chemical kinetics, precipitation titrations etc.

Condectometric analysis is based on the measurement of the electrical conductivity of the solution which is entirely due to the movement of cations and anions. The charge transport involves both these processes while simultaneously maintaining electrical charge depends on the mobility of the ion. The mobility is affected by charge, size, mass and extent of solvation. The mobility is defined as the rate of the movement of the ion through the solution under the influence of an electrical field or a concentration gradient. The difference in rates of diffusion of ions gives rise to liquid junction potential.

So, what is conductometry? Conductometry is nothing, but the measurement of conductance that is current. So, conductometry is used in direct and indirect methods of analysis. For example, complexometry, chemical kinetics, precipitation titrations. Wherever there are ions involved and there is an appearance or disappearance of the ions, we can use conductance analysis.

So, in complexometry, normally ions will complex and then they will become a neutral charged or uncharged species; in chemical kinetics ions may be consumed or added in the chemical reactions. So there it can be used for chemical kinetics. In precipitation definitely, they precipitate is supposed to be neutral and ions will be removed. So, like that there are wherever there is appearance or disappearance of ions, conductometry can be used.

So, conductometric analysis is based on the measurement of the electrical conductivity of the solution that is directly entirely due to the movement of cations and anions. So, the charge transport involves both these processes while simultaneously maintaining electrical charge that depends on the mobility of the ion. So, different ions move towards cathode or anode at their own speed it is like running race where there are several participants all the cations will be moving towards the cathode and all the anions will be moving towards the anode.

So, the mobility of the cations and anions are not only the specific property of the ion, but it also depends upon several factors. For example, the mobility is affected by the charge whether it is monovalent, divalent, trivalent, etcetera or it can then it is it depends on the size of the ion. If the ion is very small then it will move very fast, if the size is bigger then it will move rather little sluggishly and then it depends upon the mass and the extent of solvation.

So, what is solvation? Solvation is nothing, but the water molecules surrounding the ion. For example, if I can draw hydrogen ion; this is the hydrogen ion and then the water is nothing, but oxygen, hydrogen and hydrogen. The ions are electrons are two electrons are here, they are attracted to the towards H plus. So, each hydrogen ion would be surrounded by number of solvent molecules like this water molecules here. Then I can write here one more and hydrogen, another hydrogen, so many water molecules I can write. So, these water molecules are usually associated with the cation.

Similarly anion also why because OH minus ions would be attracting H plus ions around it. If I have OH minus ions, then there will be H plus ions would be surrounding it all around. So, in general the H plus where do these H plus part come from? It comes from the water. So, the so, if I have a water molecule like this with oxygen at the apex hydrogen at the bottom like this with hydrogen ion, oxygen will be attaching all around the hydrogen and with OH minus ions hydrogen atoms of the water molecule will be attached around it.

So, the orientation will be something like this, this is not correct. So, this is H plus yeah another H plus this is OH. So, H 2 O molecules will be going around it. So, there is water of extra lot of solvation of the ions. So, the mobility is defined as the rate of the movement of the ion through the solution under the influence of an electric field or a concentration gradient.

So, we also have a concentration gradient; that means, any ion moving around towards and cathode or anode would be having competition from other ions present in the same solution. So, sometimes what happens all the cations will be moving towards the cathode and all the anions will be moving towards the anode under the influence of electric field. So, the there will be some competition among the cations to reach the cathode so, we call it flux. So, there will be some concentration gradient will be built up over a period of time and space near the cathode. So, the and the ions have to move through that gradient concentration gradient.

So, the difference in the rates of diffusion of the ions gives rise to liquid junction potential. So, there is a there lot of things are to be said towards a liquid junction potential, it is a highly researched area among the electro chemical scientists and we will talk about it as and when the time permits or at the appropriate time. For the time being, it would be nice if you understand that there will be some sort of competition for the cation to reach the cathode under the influence of other cations and solvent molecules because all cations have to pass through the solvent media to reach the cathode ok.

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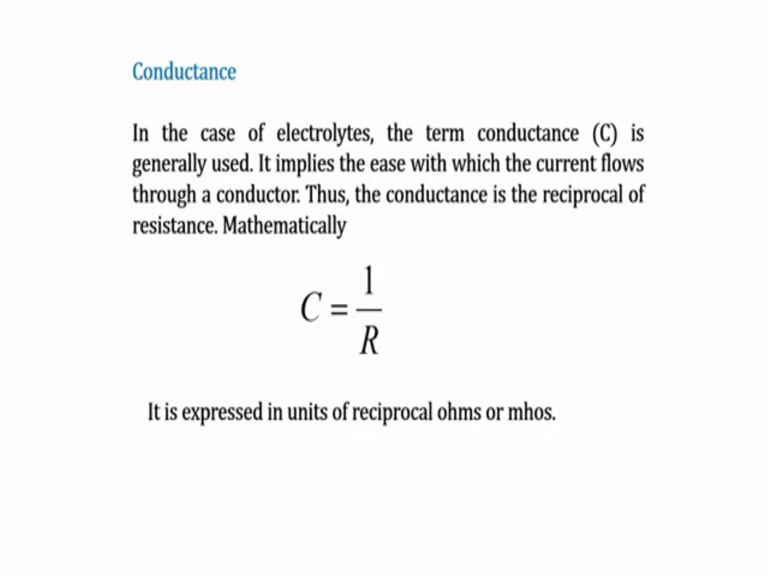

Conductance

In the case of electrolytes, the term conductance (C) is generally used. It implies the ease with which the current flows through a conductor. Thus, the conductance is the reciprocal of resistance. Mathematically

$$C = \frac{1}{R}$$

It is expressed in units of reciprocal ohms or mhos.

So, conductance in the case of electrolytes the term, we define a term called as conductance that is C that is used generally. It implies the ease with which the current flows through a conductor. Thus the conductance is the reciprocal of resistance. What is resistance? Resistance is the opposition for movement of the electrons and conductance is the ease of the movement of the electrons.

So; obviously, conductance is the reciprocal of the resistance. So, I can write mathematically something like this that is C is equal to 1 over R. So, C is equal to 1 over R where C is the concentration and R is the resistance. So, it is expressed in units of reciprocal Ohms or mhos ok.

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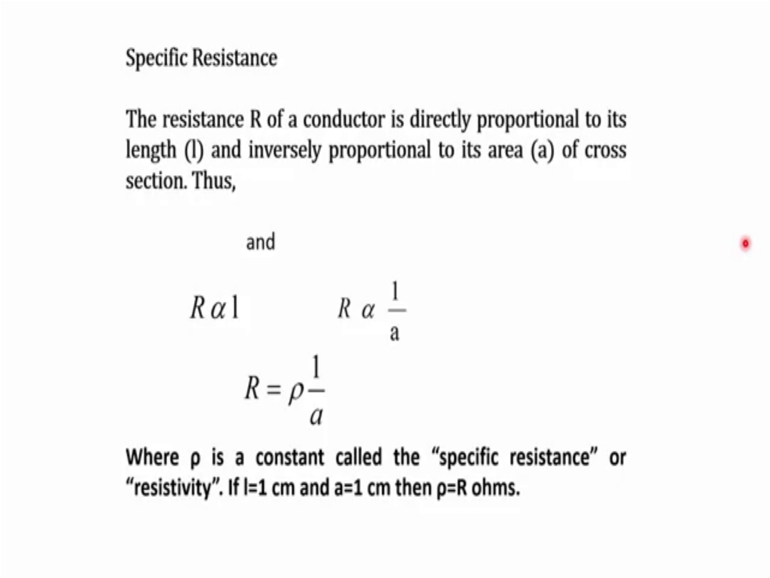

Specific Resistance

The resistance R of a conductor is directly proportional to its length (l) and inversely proportional to its area (a) of cross section. Thus,

and

$R\,\alpha\,l \qquad R\,\alpha\,\frac{1}{a}$

$$R = \rho\frac{l}{a}$$

Where ρ is a constant called the "specific resistance" or "resistivity". If l=1 cm and a=1 cm then ρ=R ohms.

So, if there is resistance, then we also can define what is a called as specific resistance. The resistance R of a conductor is directly proportional to it is length and inversely proportional to it is area of cross section.

So, what we are talking about here is we are talking about a wire which is a essentially a conductor of electrons that is a solid and the resistance any solid substance metal will offer resistance for whether it is metal or nonmetal either way. If it is a solid or liquid or something like that a wire will offer resistance because of the resistance it gets heated also that is another aspect which we will which is part of the phenomenon which everybody knows that we heat water with our electrical coils. So, there it gets heated because of the resistance.

So, the resistance of a conductor is directly proportional to it is actual length as well as cross section, how much of the volume is available for resisting the conductance. So, it is inversely proportional to it is area of cross section. So, we write R is proportional to l and R is proportional to area inversely proportional. So, R we can remove the proportionality constant R and write R is equal to rho into l by a, where rho is a constant called a specific resistance which should be typical a characteristic of all the elements which can conduct electricity.

So, for elements like copper and gold, it silver etcetera specific resistance will be very less for other metals it will be higher than that. So, a specific resistance is also called as the resistivity and if length is 1 centimeter and area is 1 centimeter, then rho R becomes ohm. This is 1, this is 1 nominate denominator and the numerator. If both of them become 1, R should be equal to 1 rho not 1.

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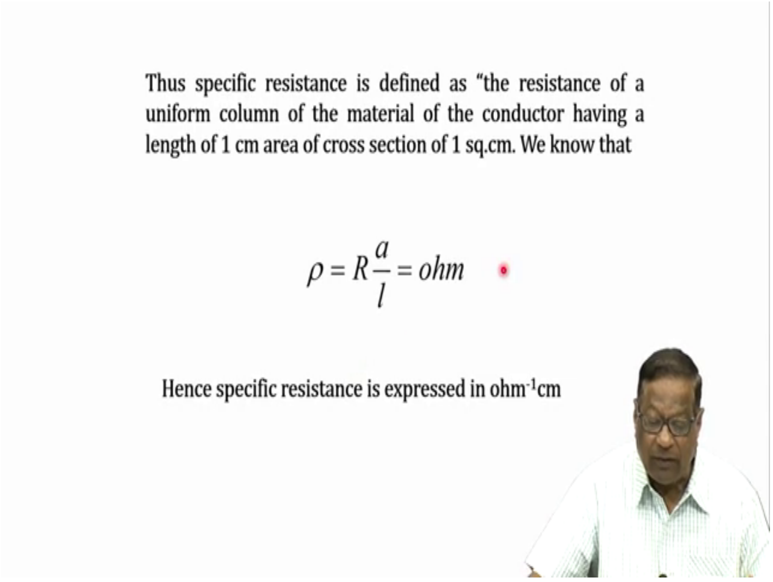

Thus specific resistance is defined as "the resistance of a uniform column of the material of the conductor having a length of 1 cm area of cross section of 1 sq.cm. We know that

$$\rho = R\frac{a}{l} = ohm$$

Hence specific resistance is expressed in ohm^{-1}cm

So, specific resistance is defined as the resistance of a uniform column of the material of the conductor having a length of 1 centimeter area of cross section and 1 square centimeter. We know that rho is equal to R into a by l that is in Ohms. So, specific resistance is expressed as Ohms per centimeter inverse that is the unit for Ohms.

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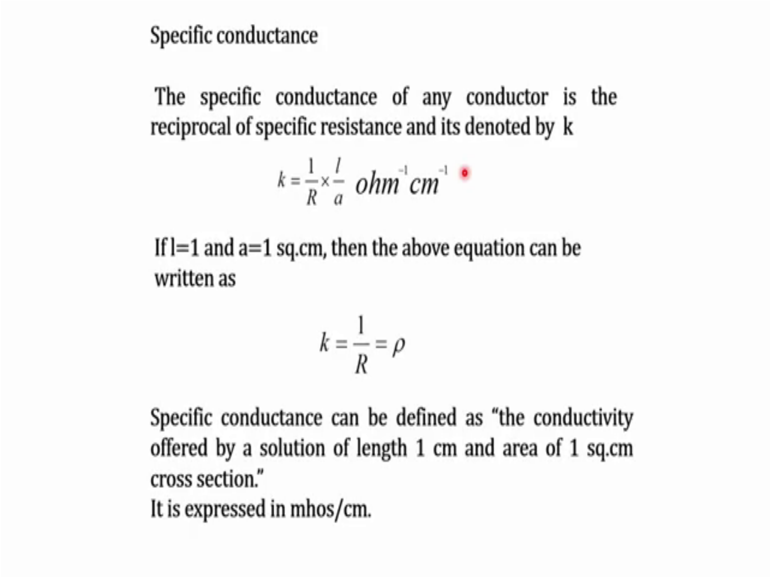

Specific conductance

The specific conductance of any conductor is the reciprocal of specific resistance and its denoted by k

$$k = \frac{1}{R} \times \frac{l}{a} \; ohm^{-1} cm^{-1}$$

If l=1 and a=1 sq.cm, then the above equation can be written as

$$k = \frac{1}{R} = \rho$$

Specific conductance can be defined as "the conductivity offered by a solution of length 1 cm and area of 1 sq.cm cross section."
It is expressed in mhos/cm.

So, then we can define what is known as specific conductance. The specific conductance of any conductor is the reciprocal of the specific resistance. It is very simple, what I we know what is resistance and inverse of resistance is nothing, but the specific conductance.

So, how do we determine the denote the conductance? Unit is k. So, we write k is equal to 1 over resistance into l by a that is length divided by area that is Ohms inverse centimeters inverse should be the units for the conductance. So, if again as usual if l is equal to 1 and a is equal to 1 k should be equal to 1 over R that is rho, specific conductance can be defined as the conductivity offered by a solution of by length 1 centimeter and area of 1 centimeter cross section. It is expressed in not in ohms, but in mhos ok. This is a very convenient term instead we write reverse of Ohms is mhos. So, just to indicate that conductance is the reverse of resistance. So, mhos per centimeter is the unit for conductance.

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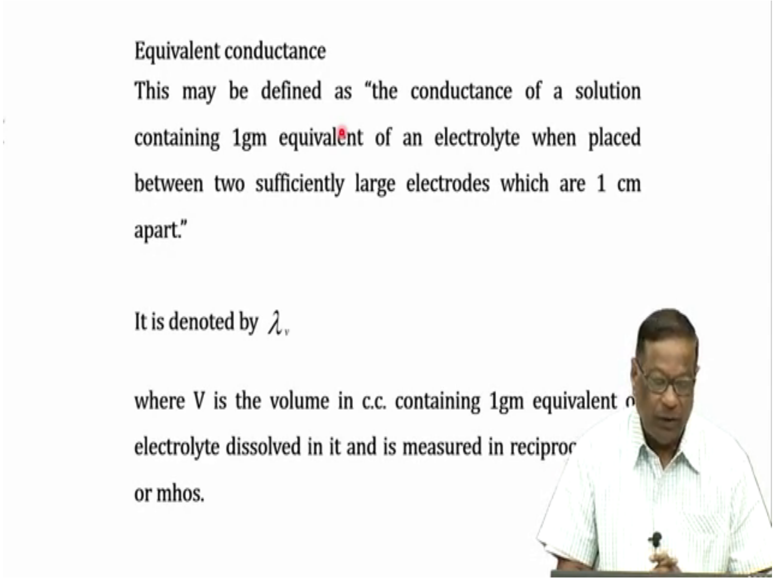

Equivalent conductance

This may be defined as "the conductance of a solution containing 1gm equivalent of an electrolyte when placed between two sufficiently large electrodes which are 1 cm apart."

It is denoted by λ_v

where V is the volume in c.c. containing 1gm equivalent o

electrolyte dissolved in it and is measured in reciproc

or mhos.

So, we may also define, what is the conductance of a solution containing 1 gram equivalent of the electrolyte. So, now, what all I taught you about the basic concepts of chemistry will become very useful because I am going to talk about many of those technical terms now.

So, 1 gram equivalent of any salt if I dissolve that is a electro called as electrolyte when placed between two sufficiently large electrodes which are 1 centimeter apart, 1 centimeter apart and they should be and in between there should be solution. So, the specific equivalent conductance is denoted by lambda V where V is the volume in milliliters containing 1 gram equivalent of the electrolyte resolved in that and it is measured in reciprocal Ohms or mhos.

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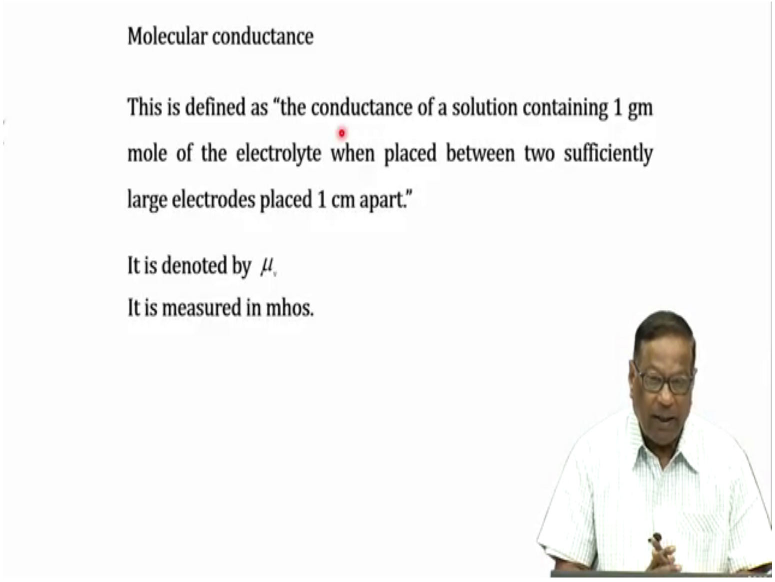

Molecular conductance

This is defined as "the conductance of a solution containing 1 gm mole of the electrolyte when placed between two sufficiently large electrodes placed 1 cm apart."

It is denoted by μ_v

It is measured in mhos.

Then I can also define what is known as molecular conductance, this is defined as the conductance of a solution containing 1 gram mole of the electrolyte when placed between two sufficiently large electrodes once a placed 1 centimeter apart. So, that is molar conductance that is denoted by mu v and it is measured in mhos.

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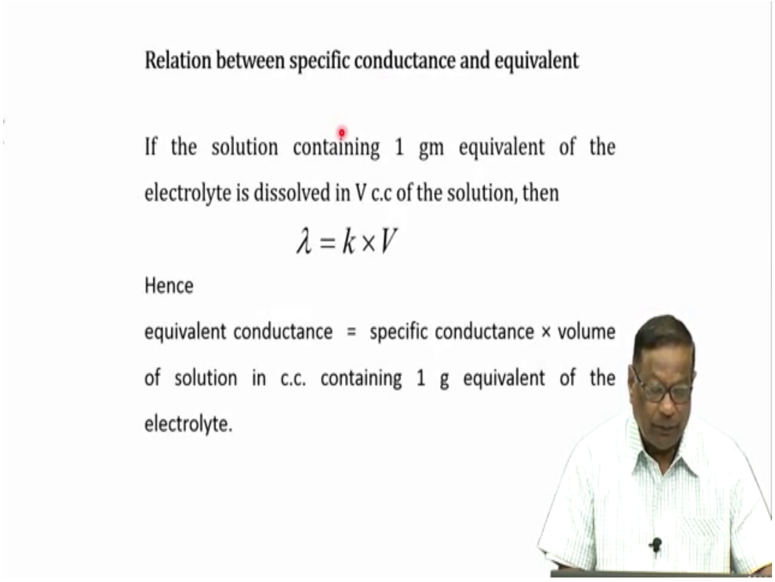

Relation between specific conductance and equivalent

If the solution containing 1 gm equivalent of the electrolyte is dissolved in V c.c of the solution, then

$$\lambda = k \times V$$

Hence

equivalent conductance = specific conductance × volume of solution in c.c. containing 1 g equivalent of the electrolyte.

So, they we can derive some sort of a relationship between the specific conductance and equivalent conductance. And if the solution containing 1 gram equivalent of the electrolyte is dissolved V c c; V ml of the solution, then lambda should be equal to k into V. So, equivalent conductance should be equal to specific conductance into volume of the solution in ml containing 1 gram equivalent of the electrolyte. These are all basic definitions nothing to we are not deriving any equation yet.

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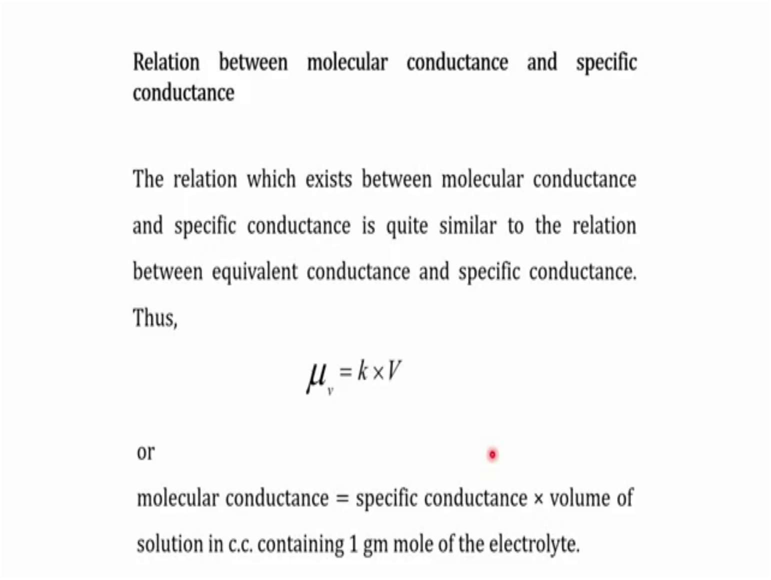

Relation between molecular conductance and specific conductance

The relation which exists between molecular conductance and specific conductance is quite similar to the relation between equivalent conductance and specific conductance. Thus,

$$\mu_v = k \times V$$

or

molecular conductance = specific conductance × volume of solution in c.c. containing 1 gm mole of the electrolyte.

So, only thing required of you is to understand how we are defining each and every parameter. So, this is the relationship between molar molecular conductance and specific conductance. So, here it is quite similar to the equivalent conductance and specific conductance we write mu v is equal to k into V or in words if I have to describe what is molecular conductance it is nothing, but specific conductance multiplied by the volume of the solution in milliliters containing 1 gram mole of the substance that is molar conductance.

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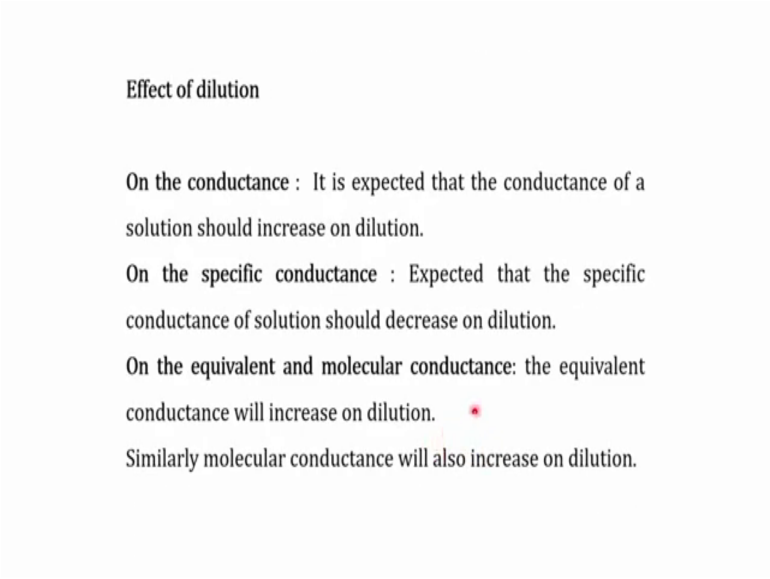

Effect of dilution

On the conductance : It is expected that the conductance of a solution should increase on dilution.

On the specific conductance : Expected that the specific conductance of solution should decrease on dilution.

On the equivalent and molecular conductance: the equivalent conductance will increase on dilution.

Similarly molecular conductance will also increase on dilution.

Then we also have to think about the effect of dilution on the conductance. So, it is expected that the conductance of a solution should increase on dilution; this is understandable. Now for example, if the if you take water pure water, then what happens? I have only pure water and very few ions. What is the number of ions in water? Pure water contains 10 raise to minus 7 moles 10 raise to minus 7 H plus ions and 10 raise to minus 7 of anions in 1 gram equivalent, there should be 18 molecule in 18 grams that will be concentration of cations and anions will be 10 raised to 14 minus 14.

So, if the solution is very pure there are not many ions. So, I put only one small ion and then that can move very freely. So, the effect of conductance normally on the specific conductance is expected that specific conductance should decrease on dilution and on the equivalent and molecular conductance the equivalent conductance will increase on dilution. Similarly molar molecular conductance also will increase on dilution.

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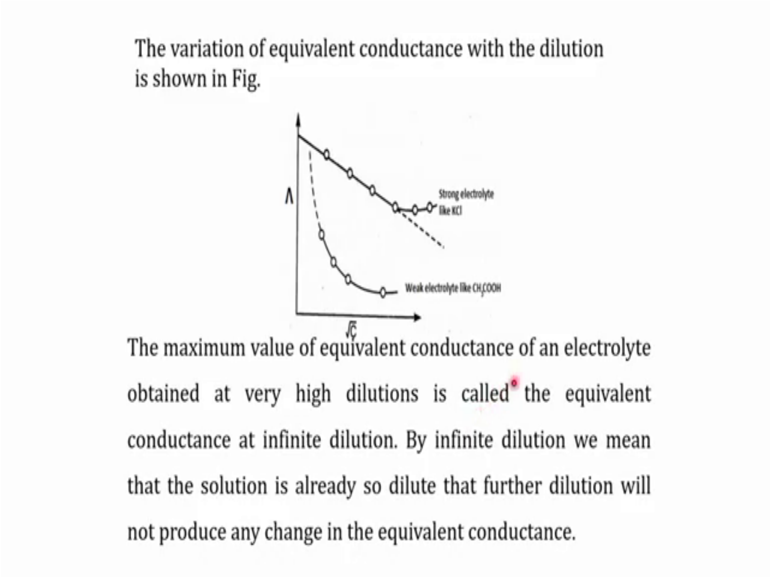

The variation of equivalent conductance with the dilution is shown in Fig.

The maximum value of equivalent conductance of an electrolyte obtained at very high dilutions is called the equivalent conductance at infinite dilution. By infinite dilution we mean that the solution is already so dilute that further dilution will not produce any change in the equivalent conductance.

So, the variation of the equivalent conductance with dilution, we are showing here in this figure. So, you can see this is the conductance, this is the concentration. So, if I have a weak electrolyte like acetic acid, the equivalent conductance will keep on coming down and then if it is a strong electrolyte, then it will be very predictable upon dilution. But near the very dilute solutions, it will be increasing much faster, at higher concentrations it will be almost predictable linear, but increase the concentration decrease the concentration more and more the electrons will be the ions will be able to move faster. So, a strong electrolyte like potassium chloride that will increase the conductance.

So, the maximum value of the equivalent conductance of an electrolyte obtained at very high dilution is called as the equivalent conductance at infinite dilution. So, how much it can increase basically that is what we are looking at. So, at infinite dilution whatever is the conductance you get that would be the equivalent conductance of a of the electrolyte. So, by infinite dilution, what do we mean by infinite dilution? We cannot have infinite dilution, it does not mean anything.

So, what we exactly mean is that the solution is already so dilute that further dilution will not produce any change in the equivalent conductance. This is how practical definition of an infinite dilution comes about, it is the dilution after which the equivalent conductance will not increase if you dilute it more; that is almost infinite dilution.

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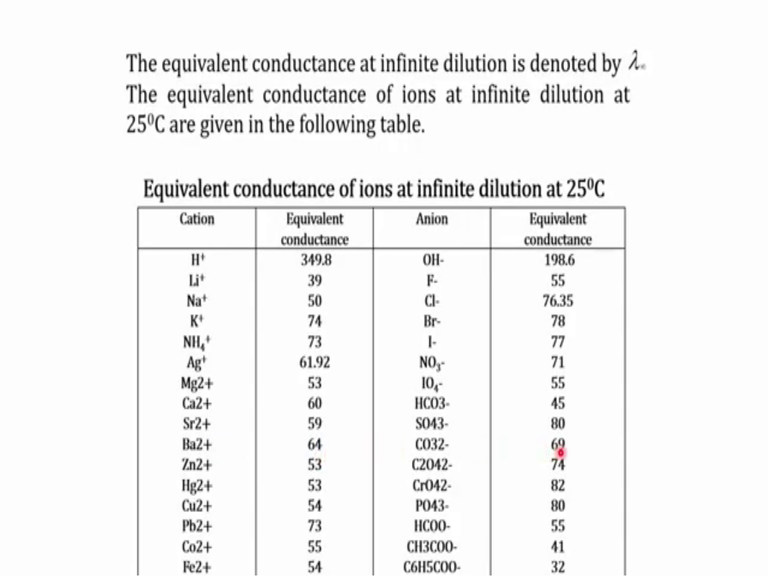

The equivalent conductance at infinite dilution is denoted by λ_∞
The equivalent conductance of ions at infinite dilution at 25^0C are given in the following table.

Equivalent conductance of ions at infinite dilution at 25^0C

Cation	Equivalent conductance	Anion	Equivalent conductance
H^+	349.8	OH-	198.6
Li^+	39	F-	55
Na^+	50	Cl-	76.35
K^+	74	Br-	78
NH_4^+	73	I-	77
Ag^+	61.92	NO_3-	71
Mg2+	53	IO_4-	55
Ca2+	60	HCO3-	45
Sr2+	59	SO43-	80
Ba2+	64	CO32-	69
Zn2+	53	C2O42-	74
Hg2+	53	CrO42-	82
Cu2+	54	PO43-	80
Pb2+	73	HCOO-	55
Co2+	55	CH3COO-	41
Fe2+	54	C6H5COO-	32

So, here is the as a stable for you to understand what is equivalent conductance at infinite dilution that we denote it by lambda infinity here, it is here lambda infinity. The equivalent conductance of ions at infinite dilution are always measured at particular temperature. So, we write 25 degree centigrade here, this is only useful for comparison.

So, what do we have here, H plus what is the equivalent conductance 349.8 and OH minus is approximately half of that 198.6 ok. Then lithium is 39, fluoride is 55, sodium is 50, chloride is 76.35. The first column is cation, then equivalent conductance, then anion, then we have the equivalent conductance for anions. You can see that there is not much difference between the equivalent conductance of ions whether it is the anion or cation except for this H plus and OH minus.

So, if they are all acidic solutions containing H plus will show very high equivalent conductance and the alkaline solutions also will show high, but it would not be as much as the acidic solutions; equivalent conductance will be approximately half of that may be slightly less than half. But all other things are known to the plus or minus 1 unit that is 39, sodium is 50, calcium is 60, barium is 64, CO 3 is 69 all within that range less than 100, very few are there above 100 except hydrogen and hydroxyl ions.

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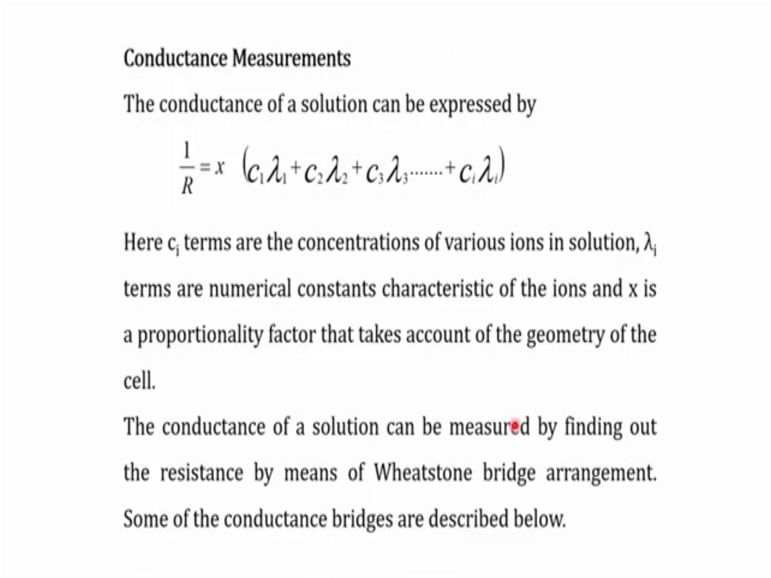

Conductance Measurements

The conductance of a solution can be expressed by

$$\frac{1}{R} = x \left(c_1\lambda_1 + c_2\lambda_2 + c_3\lambda_3 \ldots\ldots + c_i\lambda_i\right)$$

Here c_i terms are the concentrations of various ions in solution, λ_i terms are numerical constants characteristic of the ions and x is a proportionality factor that takes account of the geometry of the cell.

The conductance of a solution can be measured by finding out the resistance by means of Wheatstone bridge arrangement. Some of the conductance bridges are described below.

So, the conductance of a solution if it contains many ions, then how do we explain how do we write express? So, what do we do is the conductance is nothing, but one our resistance that we know. So, it is the product of c 1 lambda 1 that is ions ok. So, ions and equivalent conductance of the first ion, second ion, third ion, forth ion and nth ion.

So, the c i terms are the concentrations of various ions in solution c 1, c 2, c 3 etcetera and lambda 1, lambda 2, lambda 3 are the numerical constants of the characteristics of the ions and x is the proportionality factor that takes into account the geometry of the cell that is very important. So, geometry of the cell is dependent upon how we are constructing our measurement unit, our electrochemical cell whether they are exactly 1 centimeter apart whether they are exactly 1 square centimeter cell or 5 square centimeter cell etcetera, calculation part will come later. So, the conductance of a solution can be measured by finding out the resistance. How do we do that? We do it with Wheatstone bridge arrangement and some of the conductance bridges are; I am showing you here.

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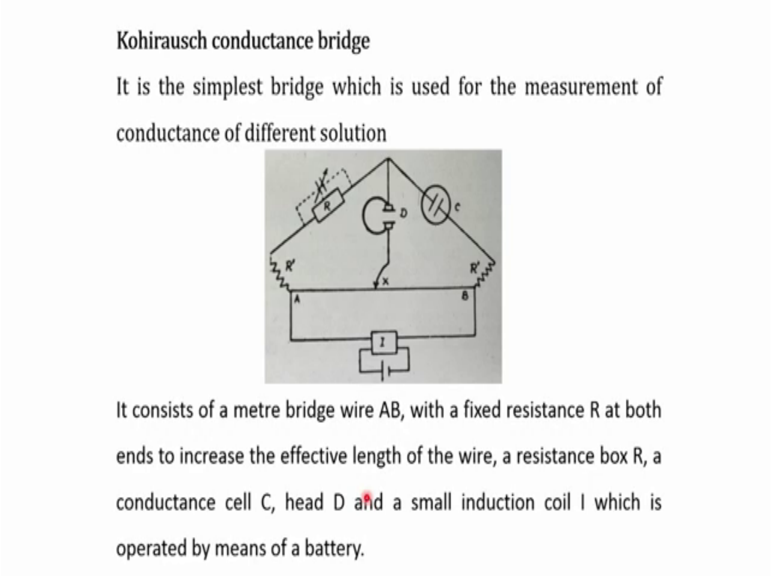

Kohirausch conductance bridge

It is the simplest bridge which is used for the measurement of conductance of different solution

It consists of a metre bridge wire AB, with a fixed resistance R at both ends to increase the effective length of the wire, a resistance box R, a conductance cell C, head D and a small induction coil I which is operated by means of a battery.

This is known as kohirausch conductance bridge. Here I have a wire and then this is the wire A to B and then I have a resistance so, 1 and 2, here the bridge circuit. So, here the bridge is completed. If the it this is the simplest bridge which is used for the measurement of conductance of different solutions.

It consists of a near 1 meter bridge wire, this is A B with a fixed resistance that a for any metal wire the resistance is fixed and that wire is fixed at both ends to increase the effective length of the wire. And it has got a resistance box R, this is our resistance box. I can increase or decrease the resistance and then a conductance cell that is C this is our conductance cell with two electrodes separated that is how normally a cell is drawn represented. And it has got a head D here and a small induction coil I which is operated by means of a battery. This is a simple conductance bridge.

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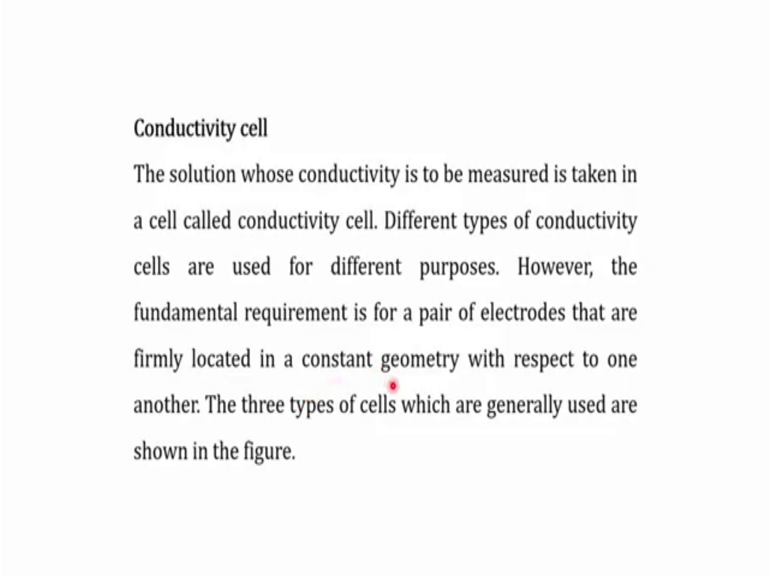

Conductivity cell

The solution whose conductivity is to be measured is taken in a cell called conductivity cell. Different types of conductivity cells are used for different purposes. However, the fundamental requirement is for a pair of electrodes that are firmly located in a constant geometry with respect to one another. The three types of cells which are generally used are shown in the figure.

So, a what is a conductivity cell? The solution whose conductivity is to be measured is taken in a cell called as conductivity cell, different types of conductivity cells are used for different purposes. However, the fundamental requirement is for having a pair of electrodes that are firmly located and connected to wires outside in a fixed geometry. It can be square or triangle or circular or whatever it is and with respect to one another.

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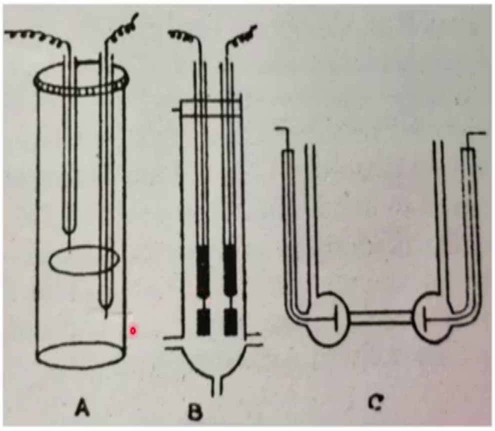

And 3 types of cells which are generally used are shown here. You can see here I have a single wire here, another wire here in a weaker connected to wire outside. This will lead to Wheatstone bridge. So, this is one type, here I have another type an electrode made of a small made into a thin sheet like this and then here I have the electrode made into a circular shape or any other shape and connected with a salt bridge. So, different types of conductance are there ABC.

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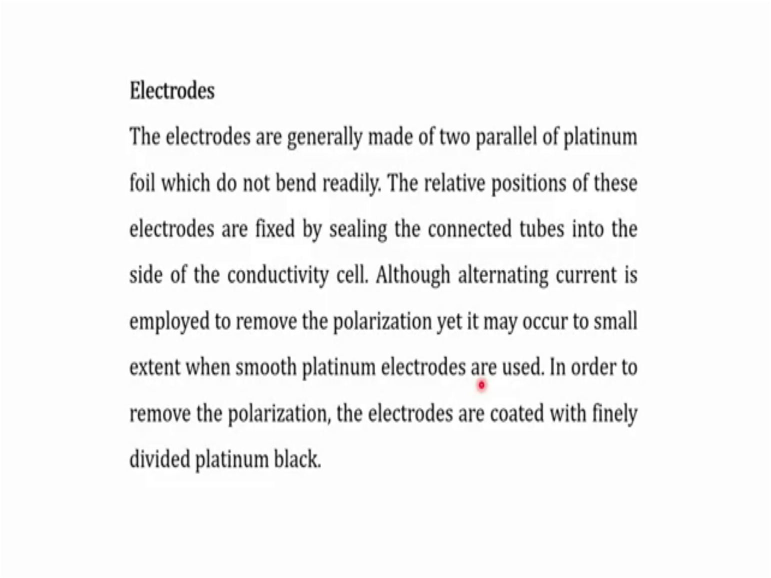

Electrodes

The electrodes are generally made of two parallel of platinum foil which do not bend readily. The relative positions of these electrodes are fixed by sealing the connected tubes into the side of the conductivity cell. Although alternating current is employed to remove the polarization yet it may occur to small extent when smooth platinum electrodes are used. In order to remove the polarization, the electrodes are coated with finely divided platinum black.

And now, we talked about the electrodes used in conductivity measurements. We have here, the electrodes are generally made of two parallel plates of platinum foil. What is a foil? Foil is a squarish plate, you have heard of aluminum foils. So, in the supermarket etcetera, if you go they will pack your food or whatever you buy into an aluminum foil.

Similarly platinum files are available it would not be so thin, but it will be slightly thicker and they so that they do not bend easily. So, the relative positions of these electrodes are fixed by sealing the connecting tubes that we have already seen in the previous slide into the side of the conductivity cell, here we have seen. So, they are all bound at the back.

And although alternating current is employed to remove the polarization, yet it may occur to some extent; polarization cannot be avoided completely when smooth platinum electrodes are used. So, in order to reduce the polarization, the electrodes are coated with finely divided platinum black powder ok. So, what we have as electrodes are basically two platinum electrophiles coated with platinum powder, black platinum powder.

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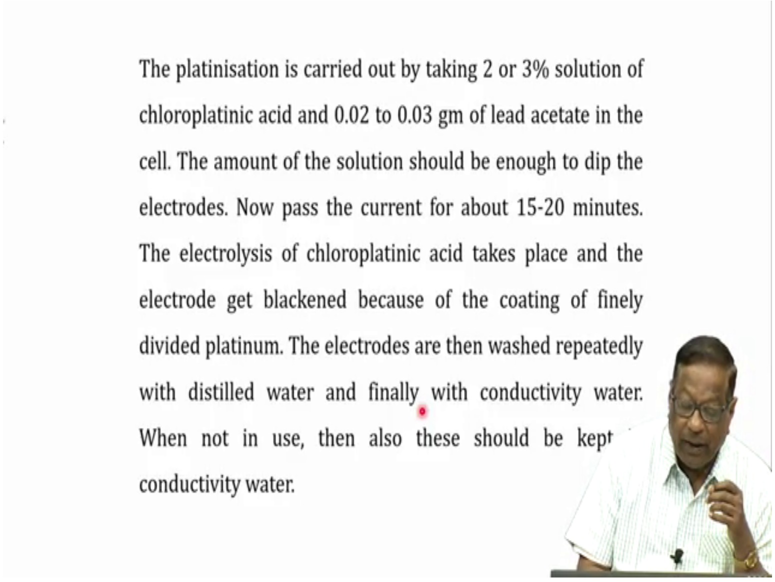

The platinisation is carried out by taking 2 or 3% solution of chloroplatinic acid and 0.02 to 0.03 gm of lead acetate in the cell. The amount of the solution should be enough to dip the electrodes. Now pass the current for about 15-20 minutes. The electrolysis of chloroplatinic acid takes place and the electrode get blackened because of the coating of finely divided platinum. The electrodes are then washed repeatedly with distilled water and finally with conductivity water. When not in use, then also these should be kept conductivity water.

So platinisation, how do I do that job? That process is known as platinisation and platinisation is carried out by taking 2 or 3 percent of the solution of chloroplatinic acid and 0.02 to 0.03 gram that is approximately 30 milligram of lead acetate in the cell. The amount of the solution should be enough just to dip the electrodes.

I take a solution of chloroplatinic acid and add a little bit of lead into that lead acetate. And current will be passed for about 15 to 20 minutes the electrolysis of the chloroplatinic acid will take place. So, what it will produce? H plus and chloroplatinic anion. So, the electrode anions will move towards the anode and cations will move towards the cathode. So, platinum ions will move towards the cathode that is on the platinum foil, they get deposited as a black powder. So, that is how we prepare them. Then they we can wash the electrodes repeatedly with distilled water and finally, with conductivity water. When not in use, these should be kept in conductivity water. What is the conductivity water? It should be it is the water with minimum conductance.

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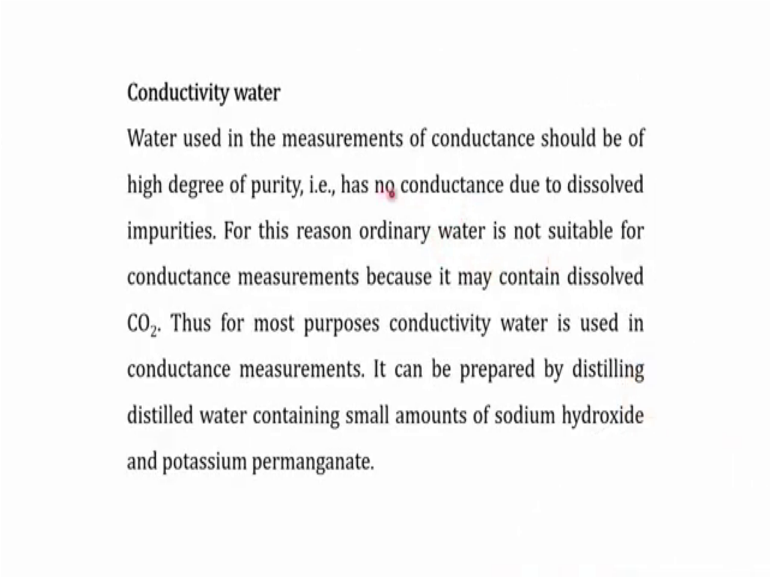

Conductivity water

Water used in the measurements of conductance should be of high degree of purity, i.e., has no conductance due to dissolved impurities. For this reason ordinary water is not suitable for conductance measurements because it may contain dissolved CO_2. Thus for most purposes conductivity water is used in conductance measurements. It can be prepared by distilling distilled water containing small amounts of sodium hydroxide and potassium permanganate.

So, what is conductivity water? it should be of very high purity; that means, it has no conductance due to dissolved impurities only pure water. For this reason ordinary water is not suitable, you cannot store a conductance electrode in the in a normal tap water or well water or sea water or any of the waters. So, because it may contain dissolved CO 2. Apart from these salts it should not have CO 2 also, why? Think about it, I will give you 2 seconds, CO 2 should not be there in the water where we store the conductivity electrodes ok.

The reason is CO 2 will dissolve in water producing carbonic acid that is H CO 3 H 2 CO 3 which can analyze as H plus and H CO 3 minus ions. So, again there is conductance is introduced. So, for most purposes conductivity water is used in conductance measurements without dissolved carbon dioxide, it can be prepared by distilling water containing small amounts of sodium hydroxide and potassium permanganate. You take water this add a little bit of potassium permanganate, a drop of sodium hydroxide distill it whatever you collect would be approximately conductivity water ok.

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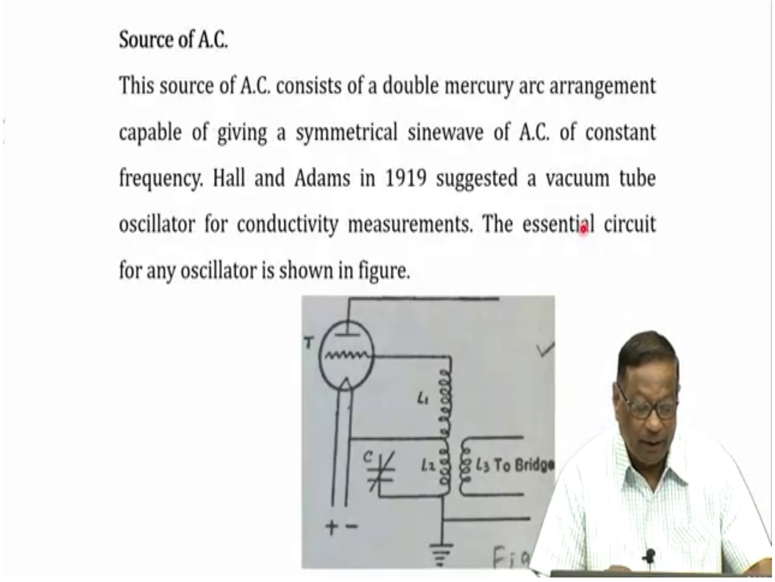

Source of A.C.

This source of A.C. consists of a double mercury arc arrangement capable of giving a symmetrical sinewave of A.C. of constant frequency. Hall and Adams in 1919 suggested a vacuum tube oscillator for conductivity measurements. The essential circuit for any oscillator is shown in figure.

So, we to conduct conductivity experiments, we need a source of conductance A.C. So, this source of A.C consists of a double mercury arc arrangement capable of giving a symmetrical sign wave of A.C of constant frequency Hall and Adams in 1919 suggested a vacuum tube oscillator for conductivity measurements. The essential circuit is shown here in so, very simple circuit these are all connect coils and vacuum tube this is known as vacuum tube oscillator if you have all these electrical units.

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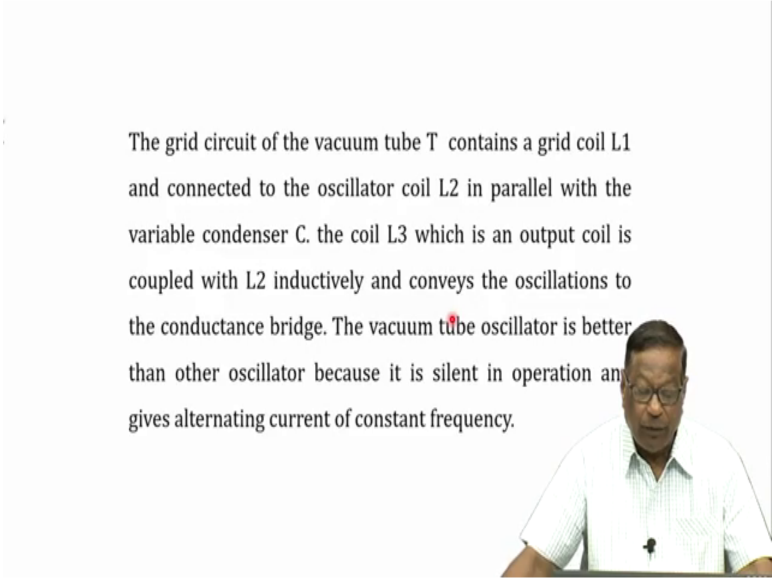

The grid circuit of the vacuum tube T contains a grid coil L1 and connected to the oscillator coil L2 in parallel with the variable condenser C. the coil L3 which is an output coil is coupled with L2 inductively and conveys the oscillations to the conductance bridge. The vacuum tube oscillator is better than other oscillator because it is silent in operation an gives alternating current of constant frequency.

So, the grid circuit of the vacuum tube contains a grid coil off grid coil L 1, I have written here and there is an L 1, L 2, it is a L 3 these are all grid coils. So, that is in parallelly connected to the variable condenser C, the coil L 3 which is an output of coil is coupled with L 2 inductively and conveys the oscillations to the conductance bridge. So, the vacuum tube oscillator is better than other oscillators because it is silent in operation and gives the alternating current of constant frequency.

So, this such units, you do not have to struggle to make it; they are available across the shelf in the scientific shops. All you have to do is go and say you want a A.C source supply. I am only teaching you the principle of that.

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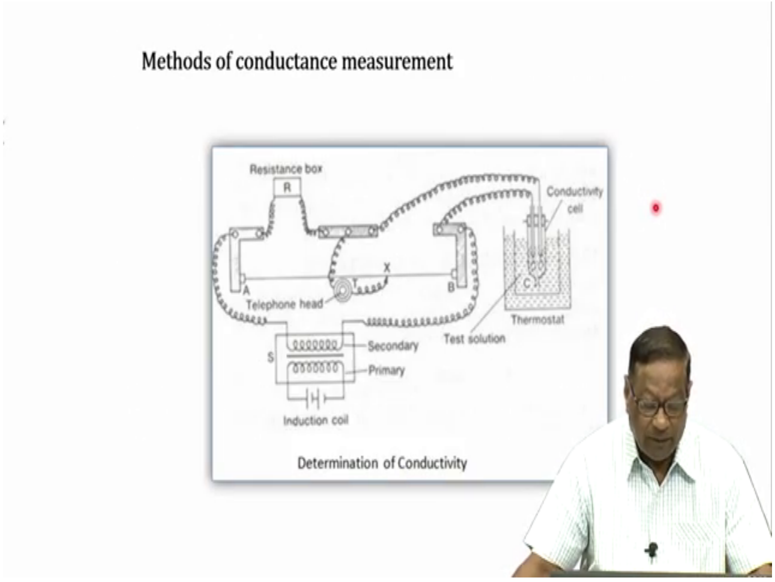

Methods of conductance measurement

Determination of Conductivity

We will continue our class with the determination of conductance measurement in the next class and see how we can apply it towards the chemical analysis. And at this stage I can only tell you that a conductance unit conductance measurement is part and parcel of every laboratory worth it is name the in pollution control.

Thank you.