**Atomic and Molecular Physics**
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**Lecture – 02**
**Experimental observations and theoretical development in discovery of constituents of an atom (Contd.)**

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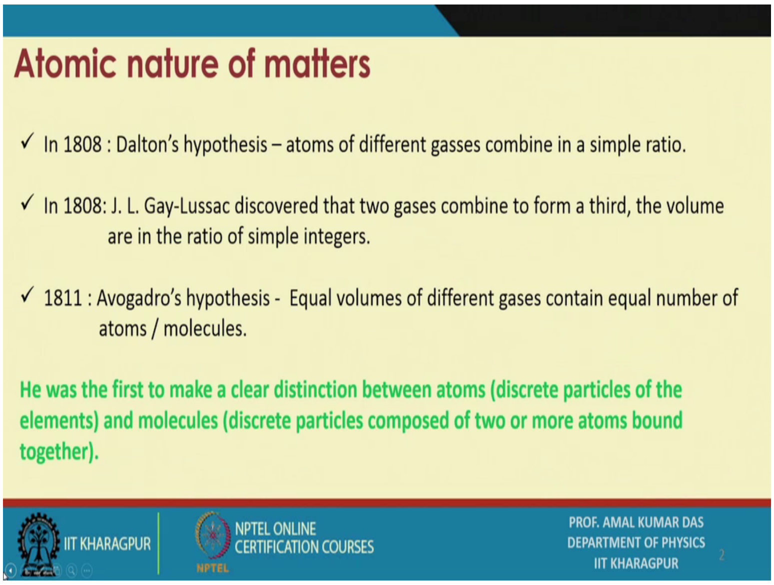


So, we will continue our class on atomic and molecular physics, see in first class we have seen the Daltons hypothesis which basically first tell about the atomic nature of the matter in 1808 and in 1808 this J.L Gay-Lussac discovered that 2 gases combine to form a third one, the volume are in the ratio of simple interior. So, basically in case of Daltons hypothesis the chemical combination that was tell in terms of the basically in terms of number of atomic weight, so that gives the sense of the combination in number and that also possible in terms of volume so that is the Gay-Lussac discovered.

So, then in 1811 Avogadro the hypothesis; this you know; this Avogadro number, so that is that is Avogadro hypothesis what is that the equal volumes are different gases contain equal number of atoms or molecules right, so and we and from this hypothesis Avogadro first time clearly mentioned or clearly distinguished between atoms and molecules, so atoms basically he described as a discrete particles of an element or an substance and molecules basically the discrete particles composed of 2 or more atoms bounded bound together ok.

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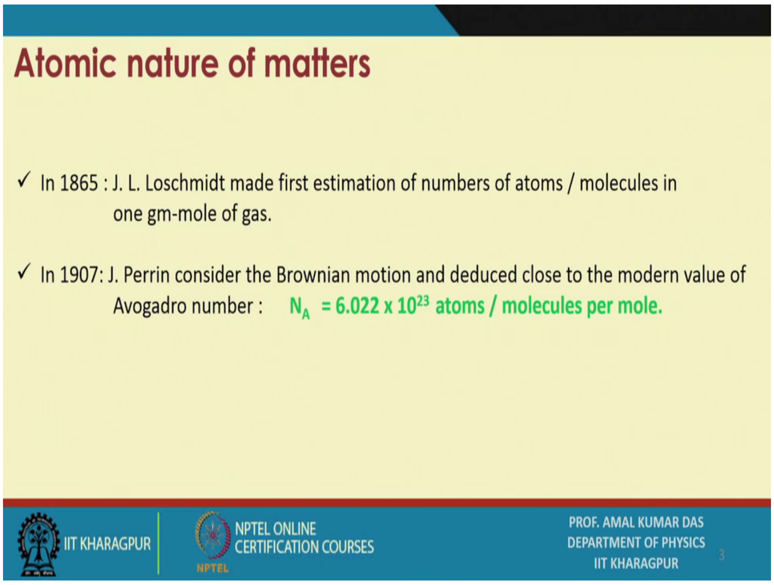


So, he is the first to make clear distinction between the atoms and molecules. So, in 1865 J.L. Loschmidt made first estimation of the number of atoms or molecules in 1 gram mole of gas. And he estimated he found some he found this number which is which is which was not very accurate because he was taken data from the he used this kinetic theory and then in 1907 J. Perrin considered the Brownian motion suspended particle in a in a liquid, Brownian motion suspension of particle motion of particles suspend in liquid or in a medium and deduce the number of molecules or atoms per mole and he reported the value of Avogadro which is called the Avogadro number that is close to the modern value of Avogadro number.

So, that is the modern value of Avogadro number is basically are 6.022 or sometimes it will tell 023 into 10 to the power 23 atoms or molecules per mole. So, with time it is clear about the nature of matter atomic nature of the matter, so matters is made of atom and atom is taken as a spherical ball kind of things, they are not breakable they are in motion, so that is the origin of temperature, pressure, viscosity, thermal conduction etcetera. And one thumb rule of any substance it contains Avogadro number of atoms or molecules so that is also nice development, so that was that was the sequence of understanding about the atomic nature of matters.

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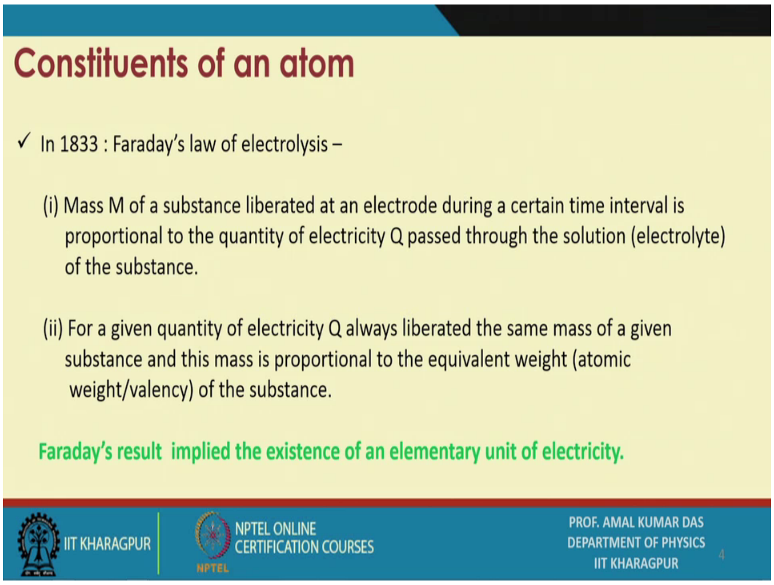


So, now I think now next question is the constituents of an atom, as I shown earlier that constraints of an atom basically we know now that electron, proton and neutron. So, how it was it was discovered so if we want to know that one so this first faradays laws of electrolytes, so that is that is the first law which tells about the about the existence of electricity or charge so that time it was not called charge it was called electricity.

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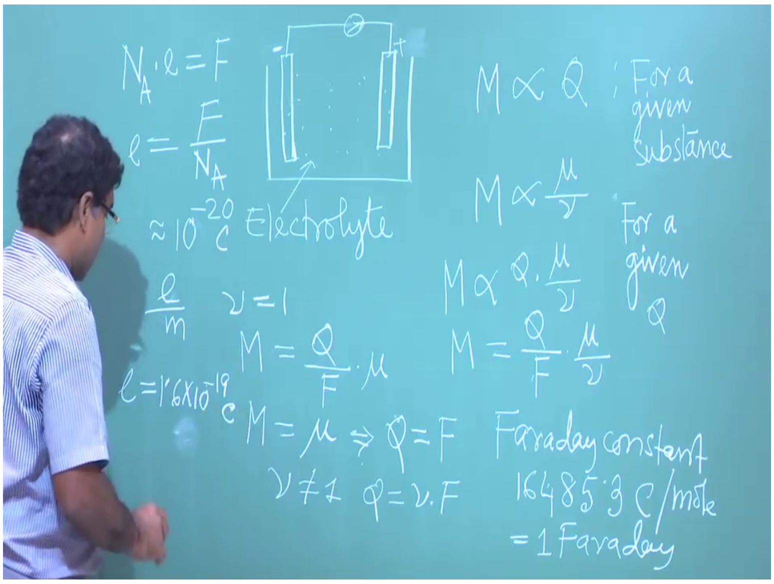


So, faradays law of electro lyse electrolysis so that is basically, if you take a if you take a container and in container you take the solution of some substance so that is basically called electrolyte there is a solution of a substance, now if you put 2 electrode ok. Now this electrode side is the negative electrode is the positive electrode this volt is applied between these 2 electrode and current is so current will flow through this electrolyte and it is found that if charge electricity that time it was called electricity is passes is passed through this electrolyte, then the mass of the substance is liberated on the electrode.

Means mass of some that substance is deposited on the electrode, so the mass of that substance deposited from the electrode if it is M this mass it is the M so that is proportional to the electricity Q. So, if current passes basically electricity passes for a certain time T so that means this if current passes through these through this electrode through this electrolyte for a time T, so this mass deposited on the deposited on the on the electrode so that is basically proportional to the electricity proportional to the current and proportion to the time so that is basically the charge.

So, mass deposited on the electrode that is proportional to the charge if we if charge flows more and more so mass deposited on the electrode will be higher and higher. And for a particular for the given substance for a given substance that that first one was for a given substance basically and second one is so this is for a given substance and for a given electricity for a given Q electricity that means if same amount of charge or electricity passes through the passes through the electrolytes.

So, this mass for different substance this mass is proportional to the proportional to the equivalent weight of the substance equivalent weight of the substance what is equivalent weight so that is basically the atomic weight divided by the valency atomic weight divided by valency, so for monovalent the valence is 1 so this equivalent weight is basically equal to the atomic weight. So, this M is proportional to the equivalent weight say mu by nu, so mu is atomic weight or molecular weight and nu is the valency, so basically it is for a if the substance is constant for a particular substance M is proportional to Q and now for a particular for a given Q for a particular amount of charge of electricity, that means for different substance this mass is proportional to the to the equivalent weight so that is atomic mass by valency.

So, in general then we can write M is proportional to Q mu by nu, so it is now is this is general it is not for a particular substance it is not for a particular charge it is in general, so now this proportionality constant l equal to it is constant mu by nu, so mass deposited on the electrode or mass liberated during the electrolysis so that is that depends on the atomic weight valency and amount of charge passes through the electrolysis.

So, from here so that is the basically faradays laws of electric electrolysis and from here if you take mono valent substance nu equal to 1, then you can write M equal to Q by F and mu and if so if you consider that for mono valent the amount of substance deposited on the electrode so if it is if m equal to mu if it is equal to the atomic weight, so then you can tell you can write that Q is equal to F. So, F is nothing but the is the charge is the charge right or electricity so F is called faraday constant, and it is value so it is basically amount of charge or electricity which passes through the electrolyte for mono valent substance, then the mass deposited on the electrode that is basically 1 it is the mass is basically 1 atomic weight or atomic weight, so it is the 1 gram mole mass of 1 gram mole. So, for any mono valent substance solution or electrolyze taken of that substance so F amount of charge or electricity passing through this electrolyte always gives for 1 gram mole amount of material deposited on the on the electrolyte ok.

Now, if nu equal to 2 then you can say if nu equal to 2 if nu equal to 2 not 1, then mu equal to m in that case Q will be equal to F into see in that case if nu is not equal to 1, then your Q will be equal to Q will be equal to nu into F ok. So, as I told this F is faraday constant this has constant value see it is value is basically 1, it is value is a what is this value I think I have no I have written.

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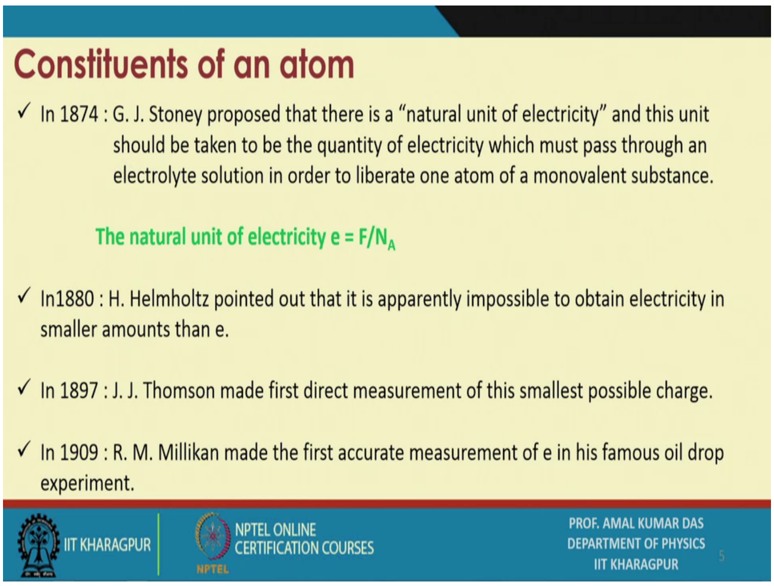

So, here I have value 96485.3 coulomb per mole and this is called basically this faraday constant this is the in terms of coulomb so this is equal to till this 1 faraday also gone. See if you pass 1 faraday charge or electricity through the electrolyte, so you will get 1 gram mole mass deposited on the electrode. So, if valance is higher if say 2, if 2 then you need 2 F amount of electricity charge to release to get deposited on the on the electrode of 1 gram mole substance, so from here from here basically some hints we get about the existence of a of a element elementary unit of electricity.

So, this in electrolysis so some charge are flowing electricity is passing through it so that how it is happening, so it is the so these atoms have atom the sum charge or electricity across with the atom charged atom and motion of the charged atom it is motion of the charged atom towards the electrode and after reaching to the electrode, so this mass of that atom is liberated or deposited on the electrons. So, this kind of implication one can get from this faradays laws of electrolysis, so next in 1874 G.J Stoney proposed that there is a natural unit of electricity and this unit should be taken to be the quantity of electricity which must pass through an electrolyte solution in order to liberate 1 atom not atomic rate 1 atom of a monovalent substance.

So, what is telling there must be some natural unit of electricity some smaller or smallest value of electricity and if you pass this unit this amount of charge this unit amount of charge through the electrolyte then there are then the then the 1 atom should deposit on the should deposit or will deposit on the electrolyze or is will libert liberate 1 atom of a monovalent substance ok.

So, here basically one charge attached with 1 atom so this kind of proposal made by the Stoney and later on if so according to study if so then 1 dumble of substance it contains a Avogadro number of how many atoms the Avogadro number of atoms and each if each atom is having a if a unit smallest unit of charge right smallest unit of charge ok. So, any number of atoms which is deposited which is deposited which is deposited on the on the electrode, if you pass current or electricity of 1 faraday F faraday. So, this n a number of atoms each atom contains a unit of charge smallest unit of charge and so then this for 1 gram mole, so total charge will be this and that should be equal to the 1 faraday because if you that already is known from faradays law of electrolyte electrolysis.

So, that if you pass 1 faraday electricity through the electrolyte, then 1 gram mole for mono valent 1 gram mole of mass will deposit it on the on the electrode. And 1 gram mole of substance it contains Avogadro number of number of atoms, so from here from here one can estimate this that unit natural unit of electricity that is E equal to F by N A. So, that time it was estimated it was estimated and the value it was value as was calculated that is around 10 to the power 20 coulomb so that it was not so accurate.

Because it was not so accurate because of the N A value Avogadro number value during that time there is Avogadro number value whatever available for kinetic theory that was not accurate value, so that is why that error was there side but in principle it was calculated the unit natural unit of charge the smallest unit of charge that is E and I think this name of this electricity it was that time it was called that this amount of charge that is called electron, the name was given electron first time that word was used to a space about the amount of charge it was named was electron.

Later on actually it was changed actually we later on this name elect name of that smallest unit of charge that was given electron among not amount of charge, but at that time that electron was used to express the amount of charge. So then in 1880 Helmholtz pointed out that it is apparently impossible to obtain electricity in smaller amounts than E ok, so means that is the smallest that is the smallest unit of charge we cannot get smaller value than this so that was the prediction or of hypothesis or assumption so but in 1987 J.J. Thomson made first direct measurement of this smallest possible charge, but that was not very accurate and basically it is a from J.J. Thomson experiment we get the specific charge that the charge E by N and but in 1909 R.M. Millikan made the first accurate measurement of e in his famous experiment you know that oil drop experiment.

In that experiment he directly measured the value of value of e value of the smallest amount of charge so that value was received at a 1.6 into 10 to the power minus 19 coulomb, so far whatever I have discussed that this so one constituent of atom is the electron and what is the amount of that that what is the smallest unit of this of the charge of this electricity that contain that electron, so that was that was experimentally measured by J.J. Thomson and Millikan so next we will see about the how this Thomson measured the specific charge in his experiment, so for this basically so we have 2 tasks.

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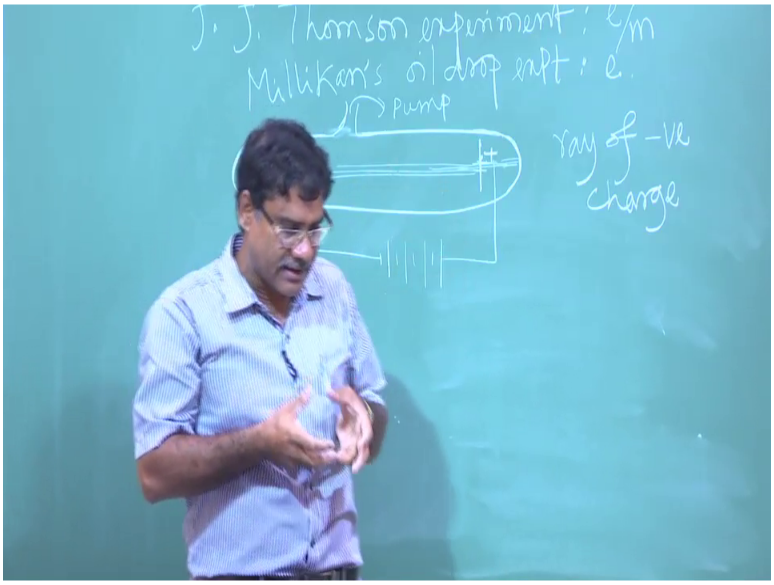


Now, we have 2 tasks now basically this J.J. Thomson experiment which measured the E by M specific charge and then Millikan oil drop experiment, so it gives the measurement of E. So, I would like to discuss about the experiment so it is a very interesting and during that time that experiment was done, so for Thomson experiment this discharge tube was used discharged tube was used what was that the discharge tube is a closure nearly glass tube people taken and 1 electrode here another electrode is here ok.

So, positive charge was highly as a maybe high voltage or they applied very high voltage or they applied between these 2 electrode, so this is called this is basically called cathode and this is called anode. Now if pressures of this tube is decreased means it if it is evacuated if it is evacuated means pumping that should be pumping arrangement pump is attached pump is attached with this tube and pump out the gas from the inside and we use gas inside this first evacuate and then we also control the gas so you can get take any gas hydrogen gas or other gas argon gas, so inside gas is in a very low pressure.

So it is a low pressure is maintained, now if we apply very high voltage between these 2 cathode or anode then it is found that if it is take hole is there if hole is there here so it is found that there is a ray passing through it and hit on this edge and sometimes if you use fluorescent material coated coat on this edge or you can tell that if you put a screen here, so you will see that some rays is passing through this anode.

So, these rays is basically called the cathode rays basically cathode rays, so that that was German physicist basically Goldstein he discovered that that cathode ray and So this cathode ray was used for Thomson experiment using the discharge tube ok.

Now, in cathode ray and it was known and I think Goldstein is discovered this cathode ray I think it is around 1870 or 80 that that I think around 80 yeah exactly I do not mean remember, but anyway and after that there are the some there are some study on this on this about the nature of this ray and from that earlier study it was so it was clear that these cathode ray is basically the it is the ray of the negative charge cathode, ray is basically ray of negative charge negative charge and yeah and also it was known that this ray is independent of the of the material of the electrode means cathode or anode as well as it is independent of the nature of the gas used in that tube.

So, this was known from earlier study so and this type of ray was this ray was used by the Thomson on experiment. So, in Thomson experiment so this ray was used and then, apply the electric field and magnetic field see the deviation of this ray and it was measure the deviation was measured, so that I will discuss in next class next class so I will stop here.

Thank you.