Infrared Spectroscopy for Pollution Monitoring

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Lecture-04
Atomic Structure I

So, we are starting our discussion on module II.

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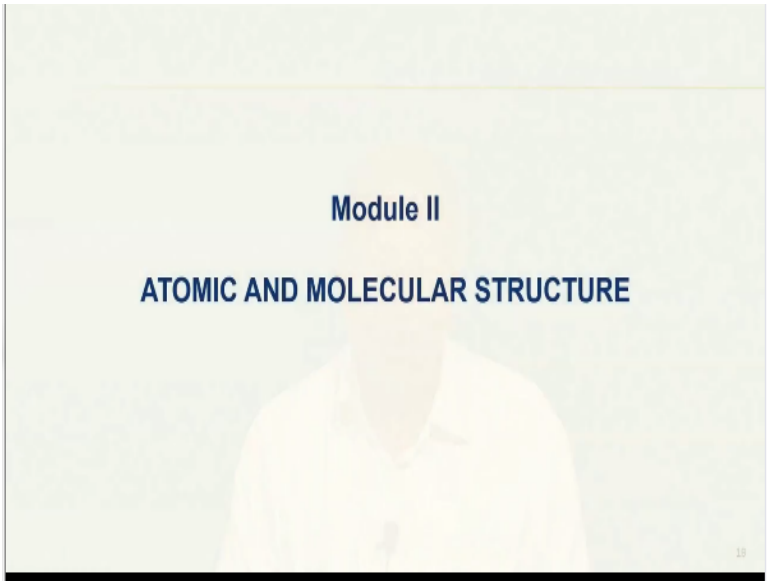

That is atomic and molecular structure it for those of you who are familiar with the atomic and molecular structure it maybe a repetition for many of you it maybe for others it maybe just a reminder of the things to come, I need not explain to you more about it. But you will go about our business of introducing you to the subject okay. Now a little bit of ancient history in India you know atom in Hindus scriptures**.**

This I have prepared for you for many of us think that we do not know much about in science in India. But the factor approve otherwise ancient Hindu scriptures recognize that matter is made up of very discrete particles known as kana, Anu and paramanath which are the rough equivalent of a molecule atom.

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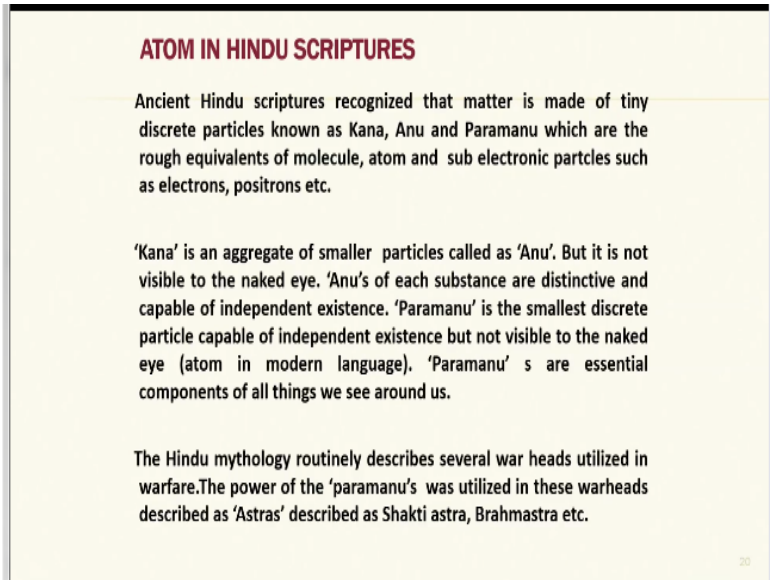

And sub electronic particles such as electrons, positrons etc. that means the awareness of the atomic particles and subatomic particles was there in India much before the actual advent of science through the renounce somewhere around 15th, 16th century in Europe okay. Now what is a kana it is a little bit of the bit of Sanskrit word, kana many of you may be familiar and for those who are not familiar kana is the aggregate of smaller particles called as Anu atoms.

But it is not visible to the naked eye kana, Anu is not visible to the naked eye but kana is visible to the naked eye. We can roughly describe it as they smallest particle that is visible and existing independently okay. So, that is a grain of jowar probably or wheat is this smallest particle you can see that is called as kana. Similarly a pinch of salt first nucleus of the salt when you are crystallizing probably that is also called as kana.

And an aggregate of kana is normal material what we are very familiar, but as far as our understanding is concern. The kana is the smallest particle that is capable of independent existence okay. So you should you look at it you will recognize that yes that this is this material, this is jowar, this is wheat, this is rice, this is sodium chloride like that the smallest particle that you can see from the visible eye should be kana.

And that kana is made up of Anu which is not visible to the eye, so Anu is of each substances are distinctive and capable of independent existence, kana is capable of independent existence. But

Anu of each substances are also distinctive but capable of independent existence but they are not visible okay. They are 2 small for our naked eye to be seen. So, what is Paramanu, Paramanu is the smallest discrete particle capable of independent existence.

But it is the part which is common to all, it is not visible to the naked eye that is it is Paramanu are essential components of all thing we see around us. You can say that you know like protons, electrons they are part and partial of every element as we understand them today. So, Paramanu like protons, neutrons and electron, positrons, mesons and so many of them are there around and they are capable of independent existence but still not visible to the eye.

But they are part of every material we see around us that is Paramanu. So, ancient Indian history is it comes and with the concept of the atom, structure of the atom. So the Hindu mythology routinely describes warheads, you know utilized in the warfare Ramayana and Mahabharatha we will come across where the wars were fought with several types of warheads described as Brahmasthra, Sakthiasthra and Nagaasthra and so many that possibilities.

And these warheads you know sort of represent the amount of energy that is energy release that is associated with their presence or with their application. For example Brahmasthra is suppose to release so much heat that it burns the whole world which is nothing but probably you know our atomic bombs and neutron bombs, hydrogen bombs and so many other bombs we already have them.

But India had them earlier and unfortunately that knowledge is lost as far as the current modern world is there but we do have the literature to support this sort of claims okay. Now we come to the modern definition of the atom and this modern definition of the atom is based on Dalton's theory that is around 1800. So 1802 to be very specific, so the modern theory of atomic structure is based on the Dalton's theory**.**

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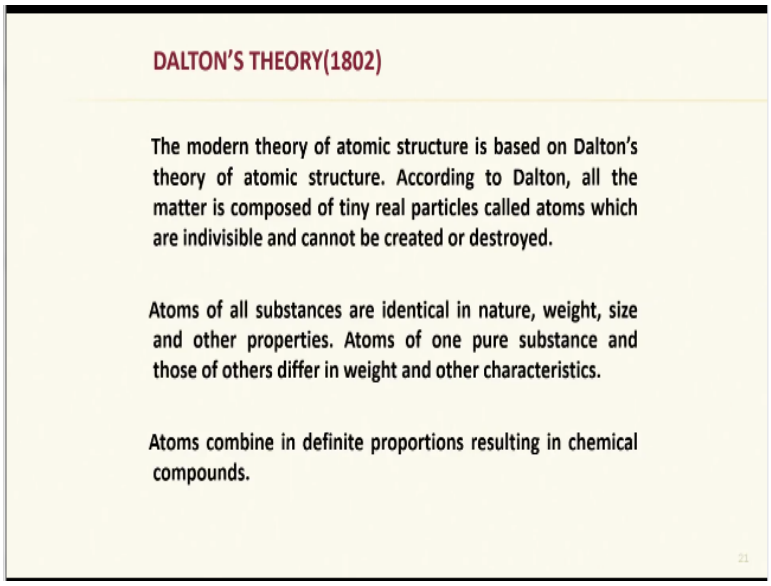

According to Dalton what he said all the matter is composed of tiny real particles they are called as atoms, he called them atoms okay. So, which are indivisible and cannot be created and cannot be destroyed that is one of the theory. Now a days we know that they can be created, they can be destroyed because in the nuclear energy things though we do create and destroy the atoms etc. but at that time probably it was appropriate.

And atoms of all substances are identical in nature, weight and other properties, that is another postulate he made. And then atoms of 1 pure substance and those of others differ in the weight and other characteristics okay. So atoms he also said atoms combine in definite proportions resulting in chemical compounds that means if you want to make sodium chloride you have to take 1 atom of sodium, 1 atom of chloride and then combine them to give you 1 molecule of sodium chloride or you can take 1 atom of hydrogen.

And another atom of hydrogen to give you 1 molecule of hydrogen gas. Similarly I can take 1 atom of hydrogen and 1 atom of chlorine to get hydrogen chloride molecule like that there are different combinations to be mixed in definite proportions, that is what Dalton said and which is true, he made the correct things as we understand them today okay.

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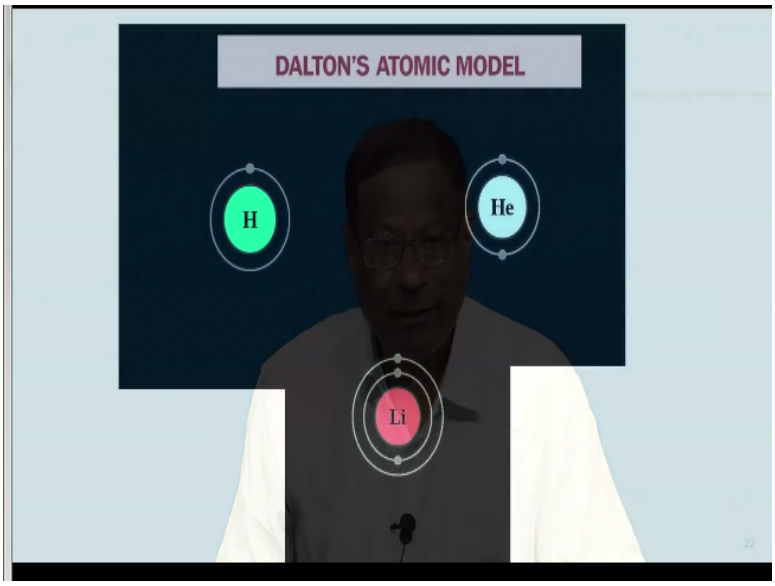

Now this is what Dalton's atomic model is looks like, now here I can see there is hydrogen, there is Helium and then there is Lithium. We have 1 hydrogen nucleus at the center around that there is 1 electron, Helium has got 2 electrons and Lithium has got 3 electrons okay simplest model probably.

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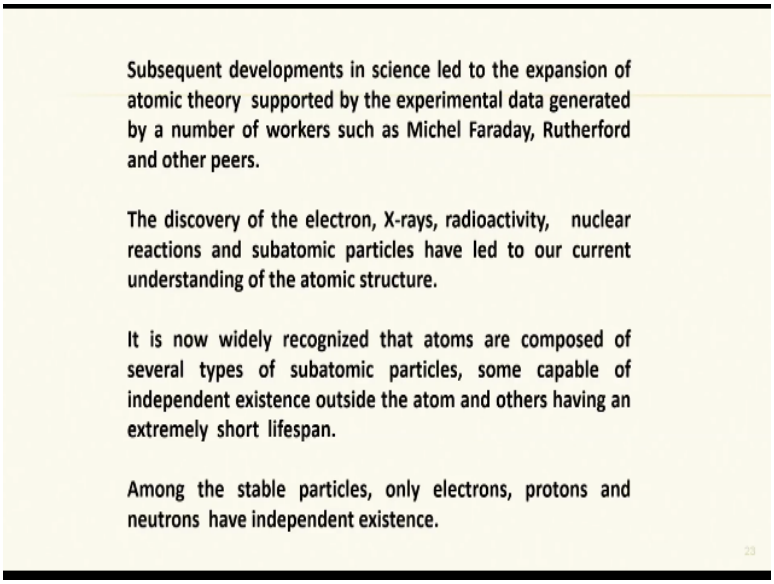

And subsequent developments in science have led to the expansion and atomic theory, expansion of the atomic theory that is supported by experimental data, lot of scientist were involved such as Michel Faraday, Rutherford and many other peers whom we respect. And who would have 1 Nobel prize every year by now if they were present now and they developed the theory of atomic structure.

And the discovery of electrons, X-rays, radioactivity, nuclear reactions and subatomic particles, all these things have led to the current understanding of our atomic structure. I am not going to teach you all the atomic structure theories but Dalton's was the first one maybe we will spend some time about some of his theory also. So, it is now widely recognized that atoms of composed of several types of subatomic particles okay.

Some are capable of independence, some are capable now incapable of independence of existence. But some outside the atom there could be there and others maybe having existence only inside the atoms. So, the others are having extremely short lifespan, by short lifespan we mean say it is less than 1 second no, we mean to say it is less than 10 raise to -5, -6, -16 seconds, they are short lifespan we are talking about okay.

So, among this stable particles only electrons, protons and neutrons have independent existence, so all these things we see in our day today life are there are scientific laboratories, physical laboratories where you can infer the existence of electrons, protons and neutrons independently okay. So but they are present as the combined forming atoms etc. which I have already shown that Hydrogen, Helium and Lithium figures okay.

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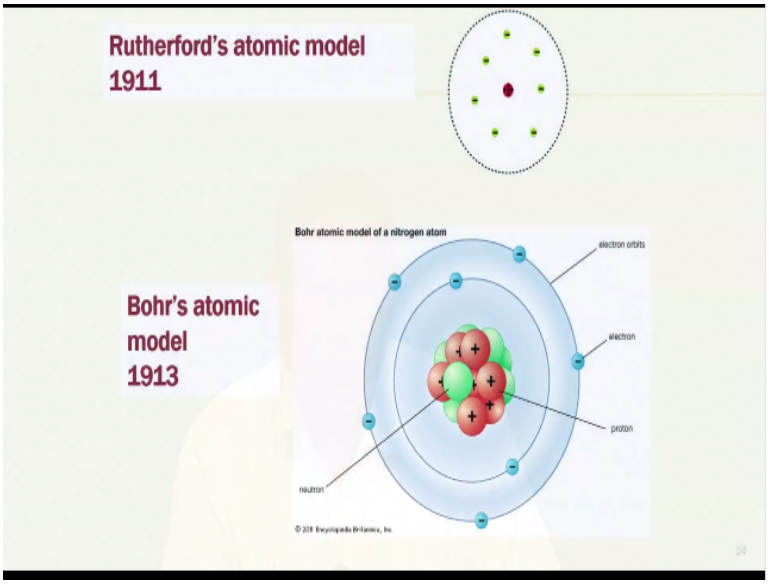

Now we come to the more 100 years down the line that is Rutherford's atomic model. So, in Rutherford's atomic model we can see that I am not going to explain to you all the theory etc., but you can take a look at what he might has said. For those of you who are interested I can refer to you couple of books on atomic structures, if you write to me or if you let me know you need to understand I will suggest you the books and literature which will help you understand the atomic structure as we understand today.

But Rutherford's was the next very descent development, what he said is that the atom is composed of nucleus and electrons going round and round about it okay. Now you can see that in Rutherford's model the electrons are going round and round they are I have not shown the animated picture but you can see that they are all (()) (13:39) okay that means the total atom as a structure is fairly stable.

Now the next model that is Bohr's atomic model improved upon that, then what he said is there are positive protons at the center and then negative electrons surround it. But they are all going round and round in fixed paths otherwise a big, heavy positive charged particle should keep on attracting the small electron negative element that is electrons into it subsequently. So there must be moving with enough force, so that the centrifugal force is enough to keep them in circulation okay.

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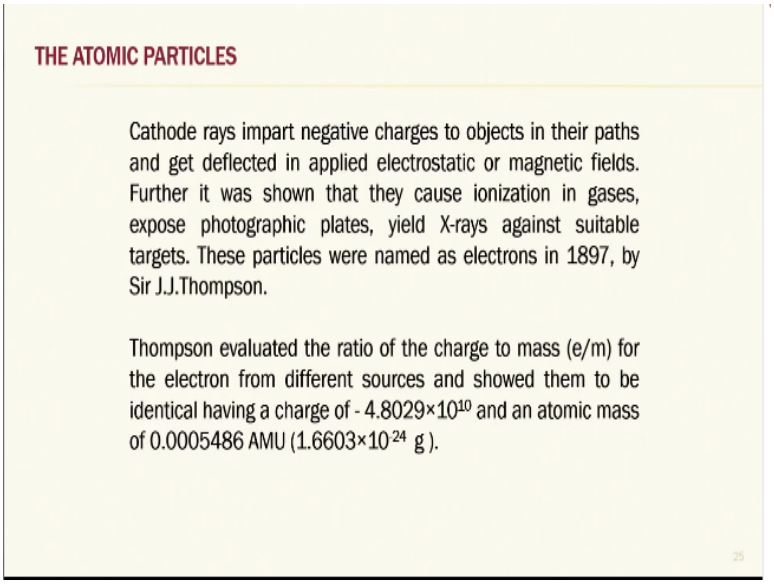

So, the atomic particles, cathode rays impart negative charges to objects in their paths and get reflected in the applied electrostatic and magnetic field. So this is how we infer the existence of protons, neutrons, X-rays etc. So further it was shown that the cathode rays cause ionization in gases and then expose to photographic plates these yield X-rays against suitable targets, these particles were named as electrons in 1897.

That is when I showed you the Rutherford's model the electrons were already known that is why I had shown you this straight away the Rutherford's model before coming into the discovery of the atomic particles. But these particles named as electrons they were discovered by Sir J.J. Thompson where he leading experimentalist and most celebrated atomic scientist. And Thompson evaluated the ratio of the charge to the mass ratio this is his real contribution.

So what he said is the electron from different sources he obtained in the cathode rays and he showed that all of them are identical. That means if all of them are identical it means they are all the same particle but they come from different elements. So, these particles are the common components of all elements that is the conclusion. So what did he do, he said okay let me measure the mass of these particles, let me measure the charge of these particles and then see how they compare.

So, he showed them to be identical having a charge of -4.8029*10 raise to -10 and an atomic mass of 0.0005486 atomic mass units or if you want to convert them into the grams it is 1.6603*10 raise to -24 grams. These kind of numbers were generated in 1897 for common man it is difficult to imagine these numbers even now is not it 2018 it is difficult to remember these numbers now. But these numbers were generated in 1897 you should remember that okay. So, another particle that was discovered was proton and look at the slide now.

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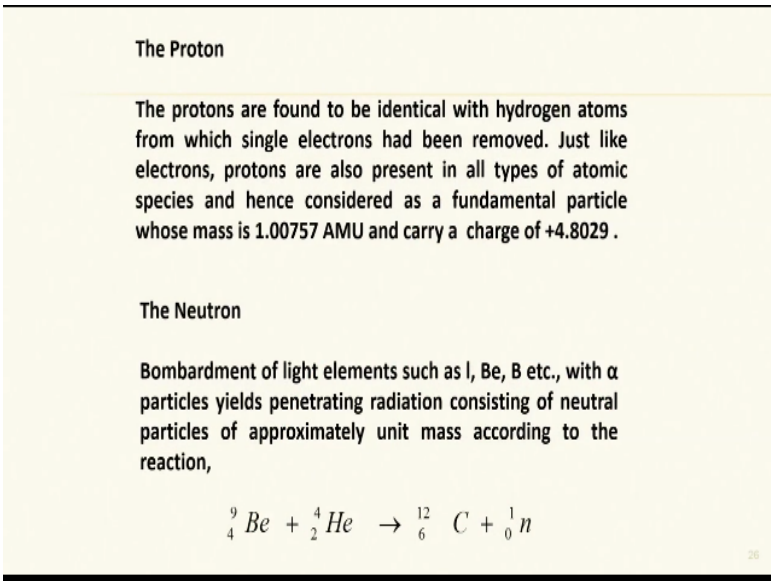

The protons were also found to be identical with hydrogen atoms okay. So the hydrogen atoms once you remove the single electron what remains is the proton. Because the hydrogen has got 1 proton and 1 electron nothing else, so you remove the electron what remains is proton you can call it H+ or hydrogen proton or simply proton whatever it is. So, just like electrons protons are also found to be present in all types of atomic species.

And hence considered as a fundamental particles whose mass is 1.00757 atomic mass units and carry a charge of 4.8029 positive charge. That means if you take protons and neutrons the proton is quite heavy because in atomic mass unit look at this 1.00757 AMU and what is that of electron 0.0005486 correct. So, electron is having very small weight compare to 1.00757 atomic mass units.

So, obviously if you take a ratio it works out approximately about 1640, that means a proton is 1640 times more heavier than the electron okay. Then there were other particles that were found out and 1 is neutron, so neutron the bombardment of light elements such as Beryllium, Boron etc. it alpha particles they yield penetrating radiation consisting of neutron particles approximate mass unit is according to the reaction.

Here I have written their nuclear reaction 4 charged 9 mass whatever I am writing at the top is the mass whatever I am writing at the bottom is the charge. So, Beryllium+Helium goes to 12C6

that is carbon atom of 12 atomic mass and 6 atomic charge okay +it release it is 1 neutron of 0 charge and 1 atomic mass. So, the proton and neutron are differing from each other only by the number of charges that are present neutron has no charge and proton has got 1 charge, 1 atomic mass unit, 1 charge.

So by convention what we say is the charge of proton is 1, the charge of electron is -1, charge of neutron is 0. So, we continue discussion, so cathode rays this I have already shown know, next one I should show you yes.

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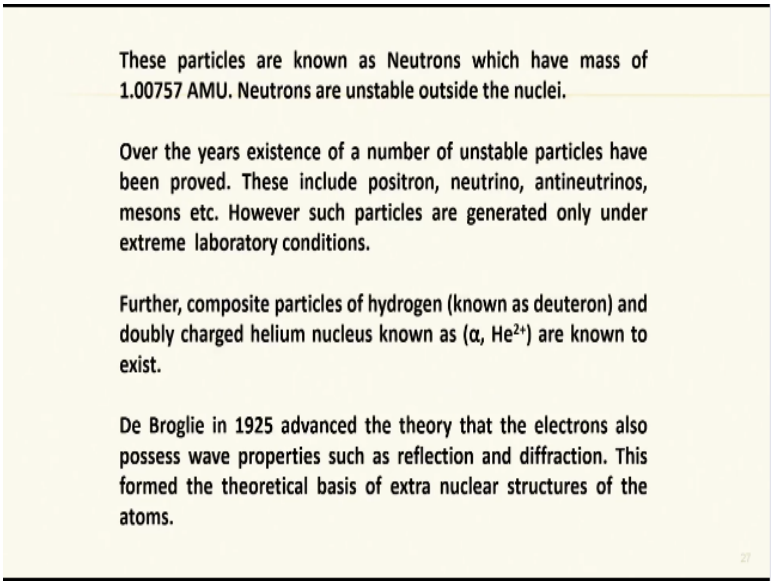

So, that neutrons produced by the reaction of Beryllium with Helium to give you carbon and neutron are known as neutrons. They have a mass of 1.00757 AMU, so neutrons are unstable outside the nuclei that we should remember okay, outside the nuclei on their own neutrons are not there they are all heavy energy particles and they keep on running the around until they hit something and then get absorbed.

So, over the years existence of number of other unstable particles have been improved these include positrons, neutrinos, anti-neutrinos, mesons etc., these are all unstable particles okay. So, however such particles are generated only under extreme laboratory conditions and the composite particles of hydrogen known as neutron and we charged Helium nucleus known as alpha He2+ are known to exist.

Then somewhere around 1925 De Broglie advanced the theory that the electrons also posses wave properties such as reflection and diffraction. So you see basically electrons if they are very small particles we throw them they move like a ball, but if it is very small particle it gets it moves like this you know it may not go like a ball and straightforward but it may show some vibration.

And this kind of observation on small electrons if they are going in some fashion which is not a straight line, but as a wave then they should also exhibit the properties of the wave is it know what are the properties of the wave it must have an amplification, it must have number of cycles. The number of cycles should be uniform and all those things are involved now a days we know that all electrons and many other things are like part of our electromagnetic radiation, which I have got amplification which I have got number of cycles etc., and all those things we know.

But in 1925 that was the time when these things were postulated okay, now this formed De Broglie's discovery formed the theoretical basis of extra nuclear structures of the atoms that is very important. So, extra nuclear structure of the atoms are you know we understand even the nucleus is composed of different things is not just a electrons outside the atom, outside the neutrons and neutrons at the center no.

We also know that the nucleus of an atom itself is different that can contain lot of things we will study them little bit. Now Rodger's experiments on the bombardment of a target with cathode rays yielded a highly penetrating radiation of short wavelength which we called X-rays. So, the discovery of X-rays was also a very important milestone in the development of science and such radiation is due to the energy release when an inner electron.

An electron going around the nucleus it is released and other electron when 1 electron is knocked off the electron from another orbit falls into that hole. So, that radiation corresponding to that energy change is known as X-rays okay. So, when the inner electron is released other electrons drop into the vacant plots and X-rays are generated. So, therefore an atom is believe to consist of 2 parts namely that is a positively charged nucleus which is small in size.

So, what is the size of the nucleus it is about 10 raise to -12 grams centimeter size you know we are talking about the size and we can talk about the radius or diameter. So, it is about 10 raise to -12 centimeter and comparatively heavy because we have seen that both neutrons and protons are quite heavy particles in terms of atomic mass units which I have shown you in the slide earlier. So, an extra nuclear arrangement another part of the nucleus of the atom is the extra nuclear arrangement of the electrons going round and round loosely arranged.

And they are not rigid particles fixed in a particular place, no but the electrons keep on moving around the nucleus just like our planets keep on moving around the sun. That is the best analogy so far anybody has provided regarding the structure of the atom. So, all our planets keep on moving around the sun we are also stable on the earth, moon is stable, earth is stable and then the mercury, venus, mars and so many other bodies which are satellites of the sun planets etc.

They are stable that is the analogy we normally accept and these are loosely electrons are loosely arranged around the nucleus in a space of about 10 raise to -8 centimeter and diffusing character. Now just imagine nucleus is 10 raise to -12 centimeter. And the size of the area of the size where electrons are around the nucleus is 10 raise to -8 centimeter that means the total area occupied by the electrons around the nucleus is 10000 times larger than the actual size of the nucleus.

Nucleus is 10 raise to -12 and 10 rise to -11 is where 10 times more, 10 raise to -10 is 100 times, 10 raise to -9 is 1000 times and 10 raise to -8 is 10000 times larger area around the nucleus. That is that is where all the electrons are hanging around but they are all bound to the electrons okay but they are bound to the same nucleus and they cannot escape. Electrons cannot escape from the nucleus nor will they fall into the nucleus because they are all going round and round.

And that is Bohr's theory okay, so the nucleus the further understanding of the nucleus and chemical properties come from our studies on the nucleus. Nucleus governs the physical properties of the element.

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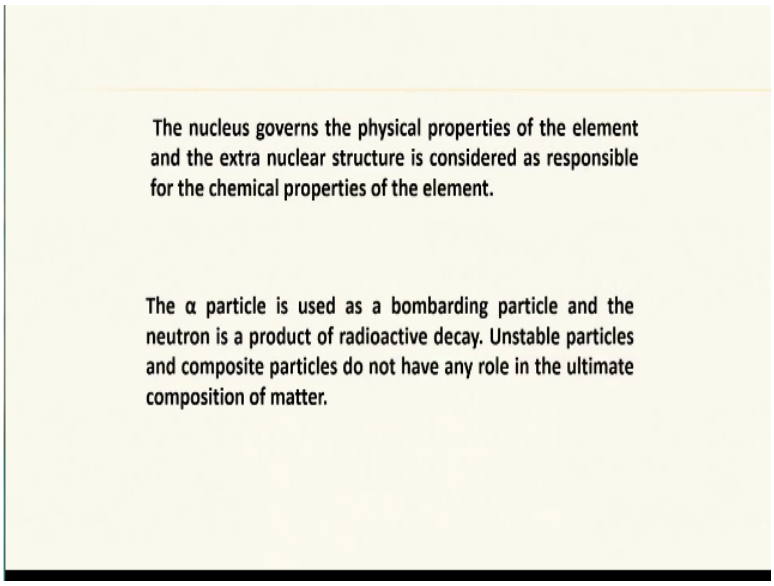

And the extra nuclear structure is considered as responsible for the chemical properties of the element okay. So, the alpha particle is used as a bombarding particle and neutron is a product of radioactive decay that we know unstable particles and composite particles do not have any role in the ultimate composition of the matters. That means unstable particles and composite particles they are part of the atoms.

But they have no role in the in shaping the properties of metals or elements and they are there they will be produced under special circumstances, they are all part of the system sort of a dormant we can see okay. So, that is our understating of the nucleus and our time next class we will know a little bit more about the Bohr, Rutherford theory etc., and that is the modern atomic theorem okay. So, thank you very much, I hope this much of information has been useful to you.