Atomic and Molecular Physics
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Lecture – 01
Experimental observations and theoretical development in discovery of constituents of an atom

You are welcome to the course Atomic and Molecular Physics. So, in this course basically it is designed for undergraduate students of science and engineering.

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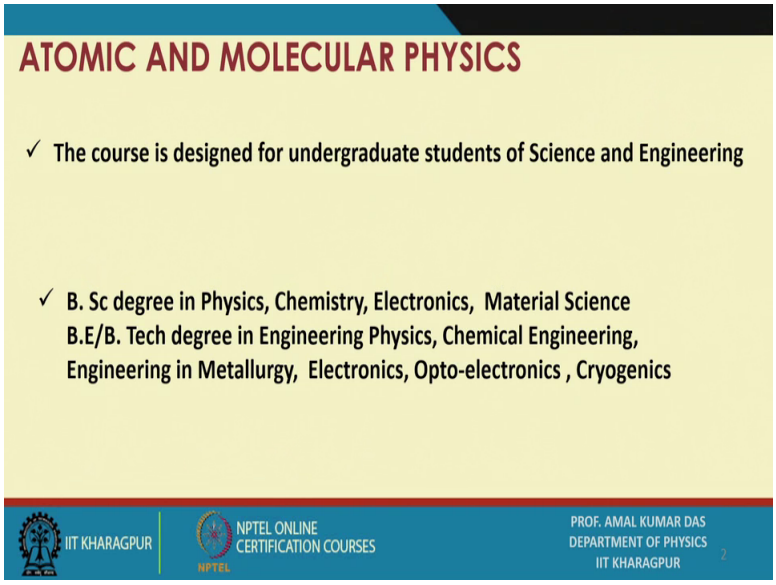

So, who are pursuing B.Sc degree in Physics, Chemistry, Electronics, Material Science and also BE or B.Tech degree in Engineering Physics, Chemical Engineering, Engineering in Metallurgy, Electronics, Opto-electronics, Cryogenics, for those student this course will be suitable.

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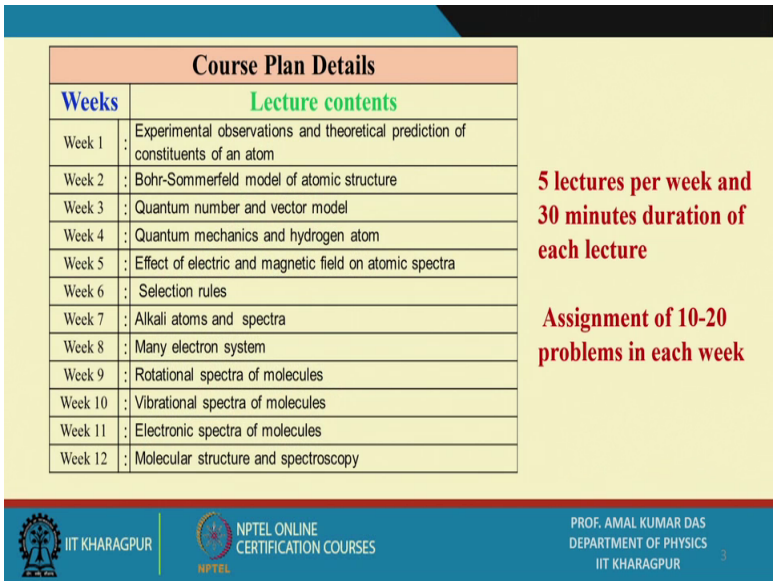

So, this course content basically. So, we have divided this content into 12 weeks. So, week wise I have given the list where you can see that in week 1, we will cover the experimental observation and theoretical prediction of constituents of an atom, basically historical background of the development of the subject that we will cover in week one. And in second week, we will discuss about Sommerfeld model of atomic structure and then we will go for quantum number and vector model, quantum mechanics and hydrogen atom then effect of electric and magnetic field on atomic spectra. So, that we will discuss then selection rule is basically transition of electron from one energy level to another energy level and corresponding spectral lines.

So, there are some rules all lines we cannot see so that we will we will try to explore and then alkali atom and atomic spectra then many electron system. So, this is up to 8 weeks. So, we will basically learn about the atomic structure and atomic spectra and then next 4 weeks, we will learn about the molecule. So, this is in week 9 rotational spectra of molecules, then vibrational spectra of molecules, next electronic spectra of molecules and then we will summarize this molecular structure and spectroscopy. So, these are the more or less course plan for atomic and molecular physics.

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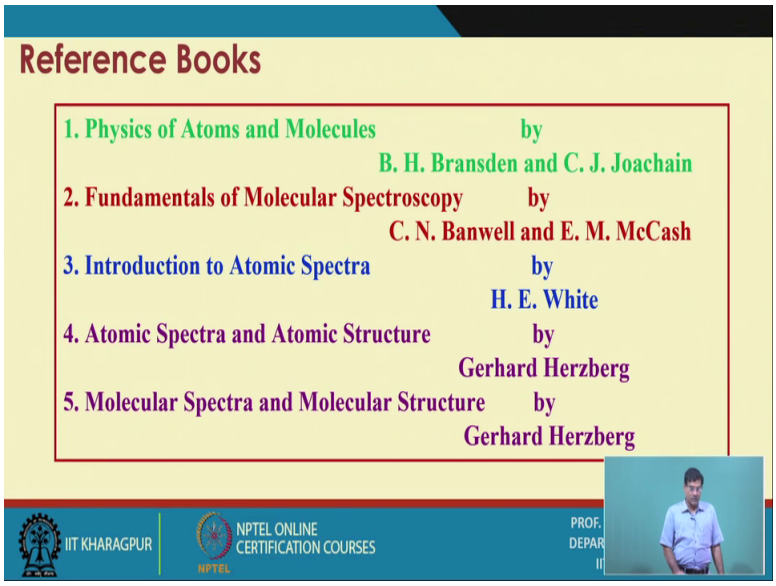

So, for this course I have given reference of 5 books. So, that first one I have given this Physics of Atoms and Molecules by Bransden and Joachain.

Next one Fundamental of Molecular Spectroscopy by Banwell and McCash, then Introduction to Atomic Spectra by White, next one next fourth and fifth one basically it is written by Gerhard Herzberg. So, one is Atomic Spectra and Atomic Structure and another is Molecular Spectra and Molecular Structure. So, these two books basically this atomic and molecular physics is described physically not much mathematics is used. So, for physical understanding this fourth and fifth that book or very useful.

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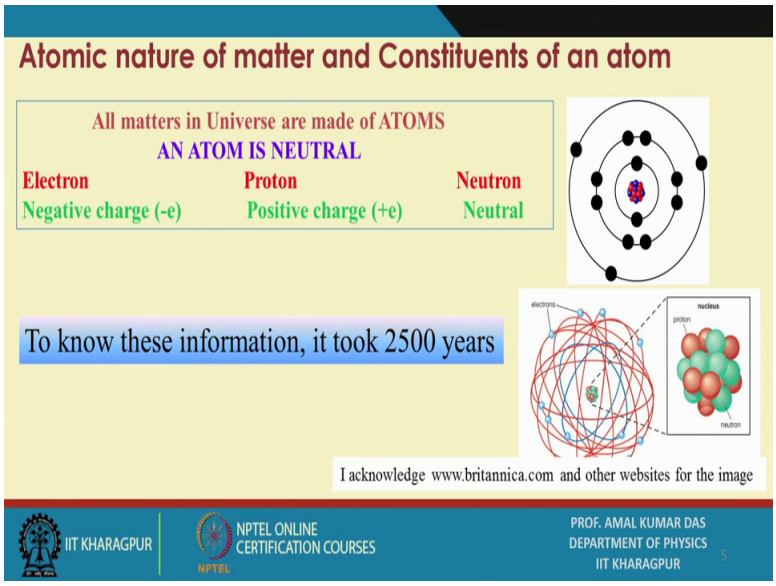

So, atomic nature of matter and constituents of an atom. So, now, we know about atomic structures and its constituents, but if you think just if you close your eye and go 2005 years ago, so what was the situation in that time. So, what I want to mean that that now we know all matter in universe made of atoms and atom is neutral and atomic constituents are electron proton neutron.

Now, how this atomic nature of matter and constituents of an atom, so to know this information it took 2005 years. So, how it has taken how this was known to us, what is the historical background so that I will try to explain first?

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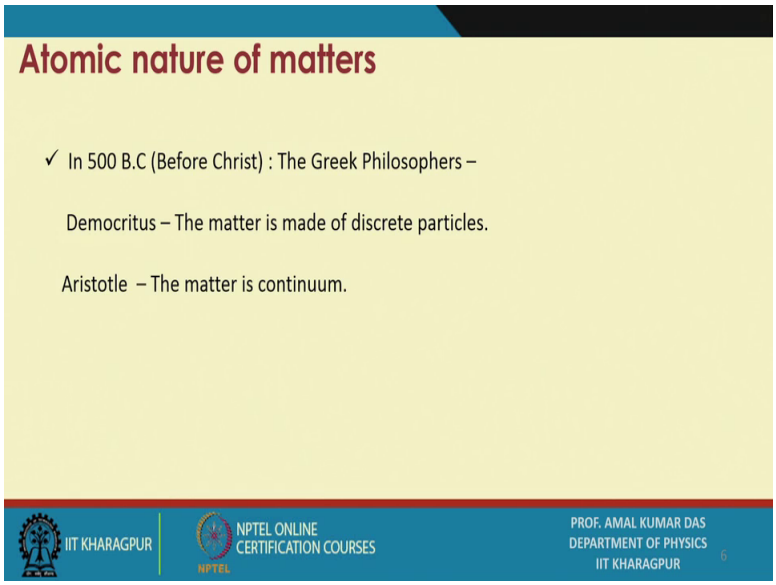

So, atomic nature of matter. So, in 500 BC before Christ means from now, it is around 2005 years ago.

So, this philosopher from Greek you know this in Greek where is there are many philosopher and Democritus and Aristotle they thought about the matter whether matter is made of discrete particles or the matter is continuum. So, that they started to think about the nature of matter and Democritus he was in favor of the discretenous of the matter means matter is made of discrete particle whereas, Aristotle he support the concept of the continuity of the matter. So, matter is continuum. So, that was the beginning of thinking about the nature of matter.

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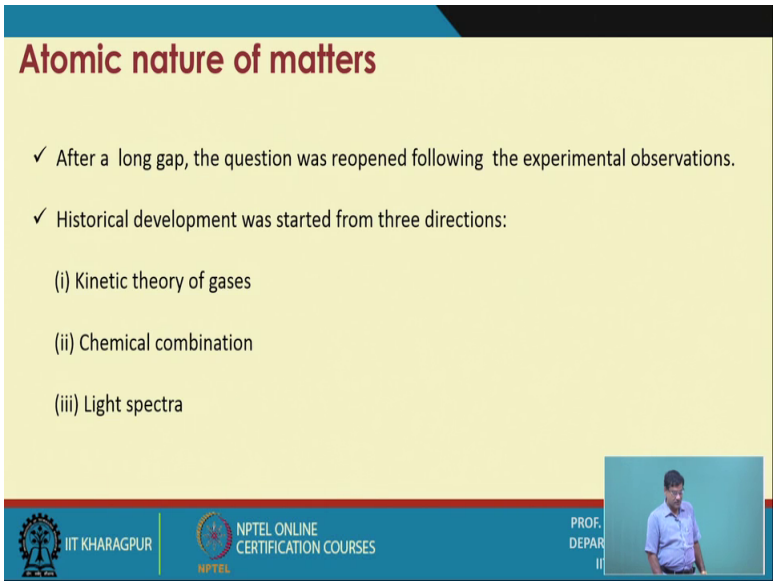

And after long gap the question was reopened following the experimental observation. So, that historical development was basically started from three directions, one is from one is kinetic theory of gases another is chemical composition or combination and other one is light spectra.

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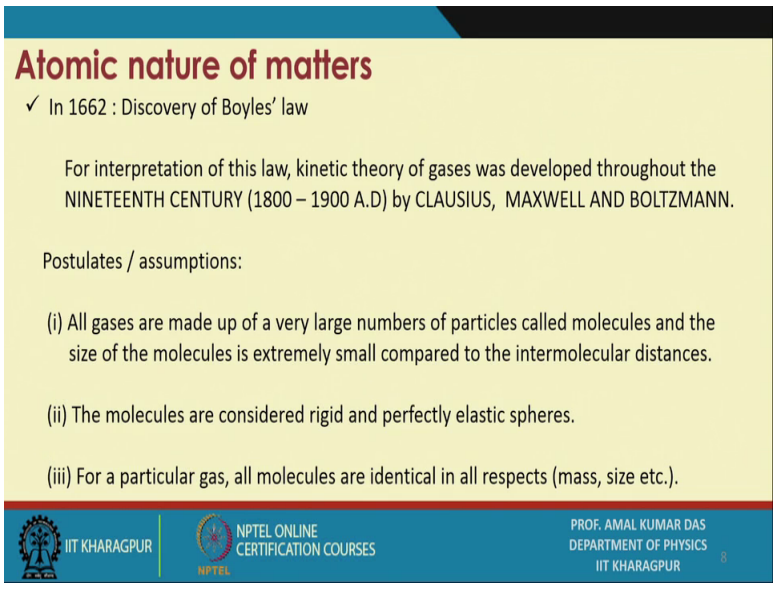

So, this in 1662, this in this year the discovery Boyle's discovery of Boyle's law, so you know Boyle's law that volume and pressure they are inversely proportional at a particular

temperature right. So, that was the basically experimental observation, but why it happens that was not known this explanation of this result was not known.

So, it took long time to understand why such type of relation followed by gas. So, for interpretation of this law kinetic theory of gas was developed throughout the 19th century by Clausius, Maxwell and Boltzmann. So, the postulates or assumptions for kinetic theory of gases was basically that all gases are made of a very large number of particles all molecules and the size of the molecule is extremely small compared to the inter molecular distances right. So, that was one first assumption. Second assumption was the molecule are considered rigid and perfectly elastic spheres. Third assumption was for a particular gas all molecules are identical in all respects means its mass, its size are same. So, that was considered that the postulates that is the assumption.

So, considering this assumption then some mathematical derivation a relation was established and that mathematical relation will agrees with the experimental result. So, jelly for anything theoretical calculation, we take model and build up the theory expression equation etcetera and then if that theory that expression equation if it fit with the experimental result then we tell that the assumption whatever we made for this model they are correct. So, that is the normal procedure.

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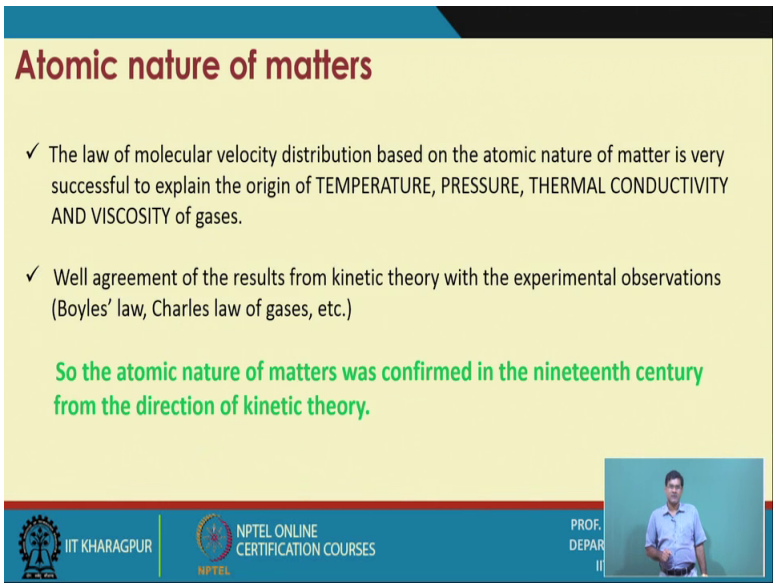

So, in kinetic theory of gases in kinetic theory of gases basically, concept of molecule, concept of discrete nature of matter was considered and theory was developed and that

theory basically you know this the law of velocity distribution which sometimes you tell Maxwell's velocity distribution of gas molecules. So, that distribution velocity distribution that was very successful to explain not only the Boyle's law or Charles law it was success it was successful to explain the origin of temperature pressure thermal conductivity and viscosity of the gases.

And as I told that this theory was able to explain the experimental observations like Boyle's law, Charles law of gases. So, the atomic nature of matter was confirmed in the 19th century from the direction of kinetic theory.

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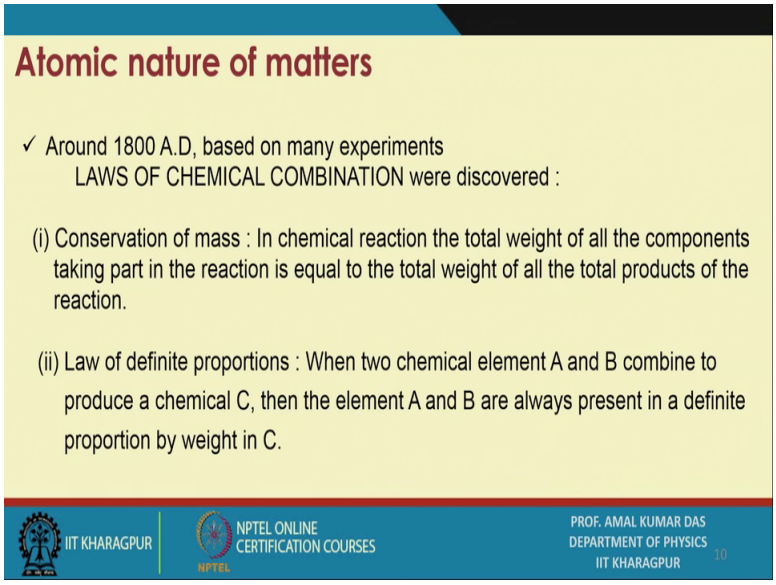

So, that is this is one direction from other direction also this similar type of conclusion was made. So, that was the next another one is from chemical combination say around 1800 AD, based on many experiments laws of chemical combination was discovered what are the those laws that is conservation of mass means, in chemical reaction the total weight of all components taking part in the reaction is equal to the total weight of all product of the reaction.

So, before reaction what about the component individual components, so they react and then after reaction we get product, so mass of the components before reaction total mass is equal to the total mass of the product after reaction. So, that was one experimental observation which value now we tell this laws of chemical combination.

Second one was law of definite proportions laws of definite proportions. So, in chemical reaction the total weight of all components, total weight of all components taking part in the reaction is equal to the total weight of all sorry, that was the basically conservation of mass, but laws of definite proportion that definite proportion that definite proportion that that is basically when two chemicals or elements A and B combine to produce a chemical C. So, before reaction individual element A and B when they combine they after reaction they produce A chemical C. So, then the element A and B are always present in a definite proportion by weight in C. So, chemical A chemical B they react and they form they produce C.

Now the element A and B they are present in C that is there in, A and B they in any proportion in any amount is not allowed to form the product. So, they have to combine in a definite proportion to get the product C or in product A and B are in definite proportion it is not arbitrary. So, that was the law of definite proportions.

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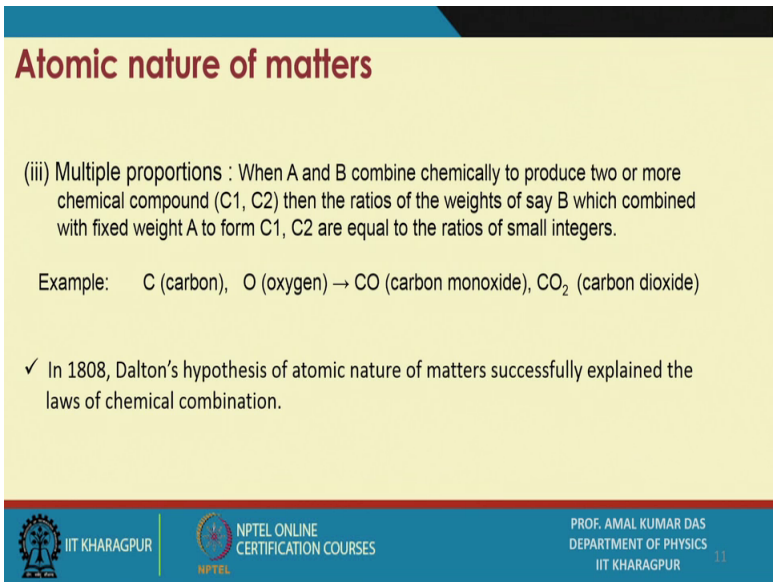

And third one is multiple proportions multiple proportions. When A and B combine chemically to produce two or more chemical compounds say C 1 and C 2 then the ratios of the weights, ratios of the weights of say B which combine with a fixed weigh a to form C 1 and C 2 are equal to the ratios of small integers ok.

So, what does it mean? Say example if you take carbon say it is A and oxygen it is B. So, when they combine, it can form the product can be carbon monoxide CO or carbon

dioxide CO 2. So, C that is fixed one is a basically, so combine with combine with B form the two product. So, this B, the weight of B that is basically weight of B combined with A. So, that ratio of B ratio of B is ratio of B is basically varies small integers. So, again this again it is telling that that is called multiple proportion, one is fixed and another is if it is another is another combine to the fixed one and form different products and in different products the amount of B, amount of B in which ratio there is, so that is telling the their ratio is in ease of simple is small integer. So, this was the experimental observation chemical combination.

So, how to explain them, how to explain them, that basically that was done by Dalton's say in 1808. 1808 Dalton's hypothesis of atomic nature of matters successfully explained the laws of chemical combination.

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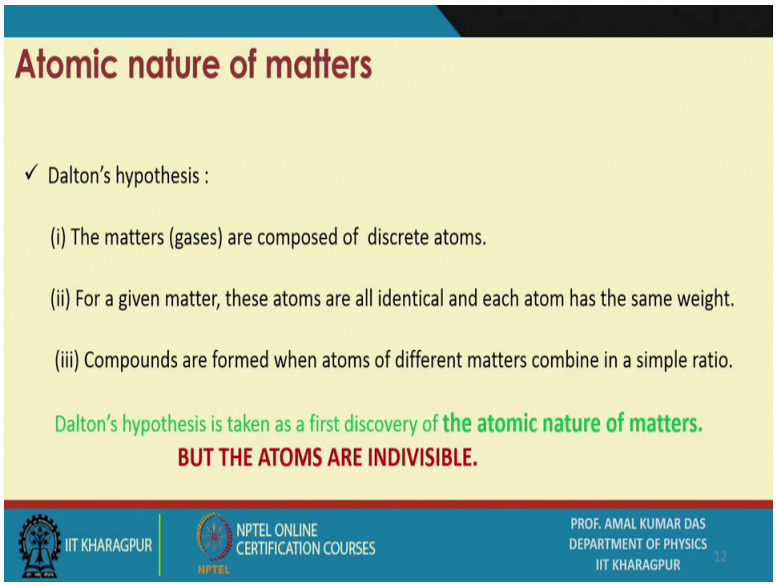

So, you know; what is Dalton's hypothesis. So, Dalton's hypothesis is basically the matter are composed of discrete atoms. So, that was the first hypothesis. Second one for a given matter these atoms are all identical and each atom has the same weight. Third one was compounds are formed when atoms of different matters combine in a simple ratio. So, this is three hypothesis Dalton's hypothesis and clearly from this hypothesis you can see it is telling about the atomic nature of matter. And in the matter how this discrete particle how this atoms combine with the other matters other substance.

And, so from this combination from this combination basically we tell that this is the first attempt of Dalton to tell clearly that the matter is made of atoms and these atoms are indivisible it is it cannot be divided it is not breakable it cannot. So, this is the smallest unit as if. So, these atoms are invisible indivisible. So, this was the first discovery in science jelly this we taken as a first discovery of atomic nature of matter. Matter is made of atoms. That time it was still Dalton did not know about the about the constituent of an atom. So, we consider this atom is the smallest particle and it is indivisible.

So, I will stop this lecture here and then I will continue the next part in next class.

Thank you.