Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Engineering Thermodynamics

Lecture – 04
Energy and its various forms

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Let us start this lecture with a thought process.

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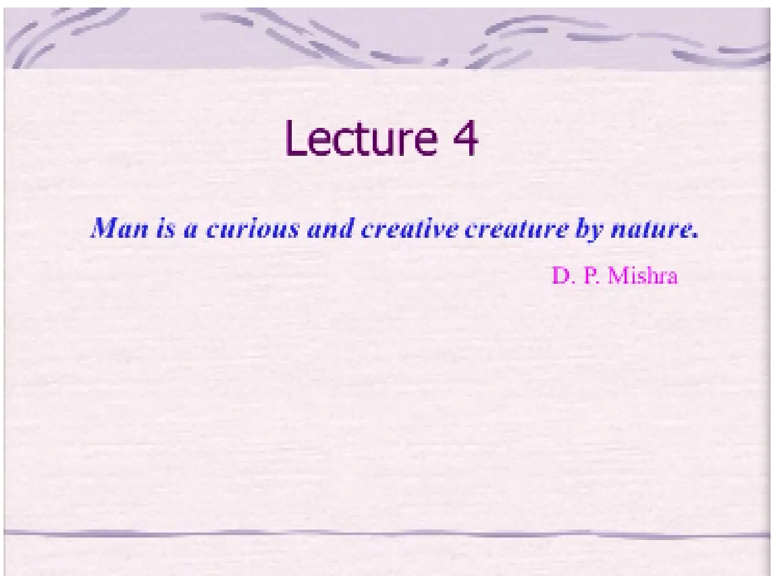

And remembering that man is a curious and creative created by nature, but of course with the modern life people do not have time to think. And let us recapitulate that what we learnt in the last lecture, in that we started with what you call the properties and we looked at when it can be exact differential, so that we can call a variable as a property. And later on we moved into the kinds of properties intensive property, and expensive properties and also the specific properties right we define and we took some examples which will be helpful for analyzing thermodynamic system.

Then we looked at the prices and what is the importance so also the how to measure object to catch up and some of the things and we should learn it you know how to measure. And today what we will be doing, we will be looking at various forms of energy. And let us ask a question what do you mean by energy.

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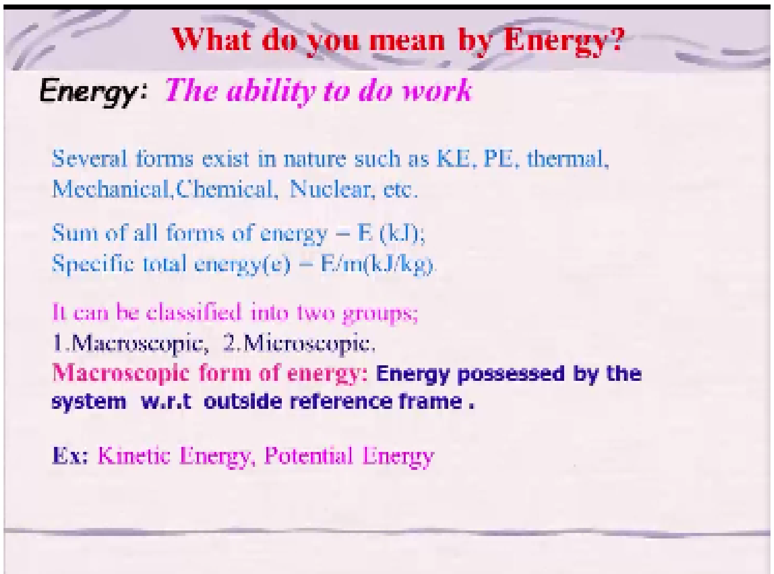

And all of you know that it is basically the ability to do the work and there are several forms of energy that exist in nature like your kinetic energy potential energy thermal energy, mechanical energy, chemical energy, nuclear and so on so forth right. Now this energy if you look at we will be dealing with, now it can be classified, you know into various forms, but the sum of all the forms of energy we can use a symbol known as e you can use any other symbol as a matter of fact.

But generally people use e that unit will be in SI kilo joules, it can be mega use you know kind of things or a huge simply depending upon the, you know like a amount of energy what we were dealing with. And specific total energy E/m kilo Joule per kg if you recall the energy is basically an extensive property whereas the specific total energy is what intensive property, am I right? because per unit mass. So as I told that this energy can be broadly classified into two categories one is macroscopic form of energy, other is microscopic form of energy.

And microscopic form of energy will be related to what, related to the molecules, atoms and their activities the exchange of activities whereas the macroscopic form of energy will be bordered by the system with respect to outsider for instance right. And that what we will be dealing with in this thermodynamic right, but however let us look at it also the other aspect of the microscopic energy will be discussing little bit. And the common form of microscopic form of energy are basically kinetic energy and potential energy.

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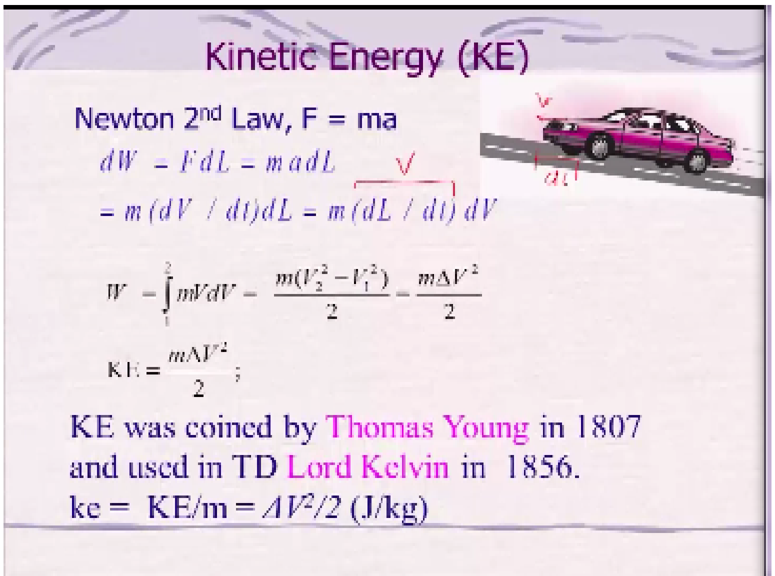

So let us look at kinetic energy and we will take an example let us say a car which is moving with a certain velocity V, it is moving with certain velocity V. And if it is moving with certain velocity it will be that means how it will be moving somebody should be applying a force am I right, otherwise it would not move right anything which is, you know that means the car has to displace something.

So we know according to the Newton's second law the force is basically is equal to mass into acceleration when it is velocity you know like it will be either at a constant speed, or it will be accelerating, or it will be deflated in place it can be anything. But let us say that force basically will be mass into acceleration and the work done will be nothing, but your force into change in length if it is basically doing there will be this even moving car will be moving certain distance let us say dL and then will be FdL and F is nothing but mass into acceleration.

And if you look at the acceleration is nothing but changing velocity with respect to time right dc/dt and if you look at this dl/dt if I just take this is nothing but your what right. So this is nothing but your what, this is that is nothing but your velocity itself. So usually mass into velocity into change in velocity between states 1 to 2 you can say and then you integrate keeping this mass, mass is not changing you know like.

Then it will be the kind of work done is basically $m\Delta V^2/2$ and that is nothing but your kinetic energy right. And this what is the reference for this with reference with respect to the road right is not it. So that means all the displacement whatever we are doing the velocity is acceleration we are having reference to the road right. So this kinetic energy was coined for the first time by Thomas Young in 1807 and later on it was used by Lord Kelvin in thermodynamics around 1856, of course the kinetic energy per unit mass will be nothing but your $\Delta V^2/2$ it is Joule per kg and this is a specific kinetic energy right.

So let me take another example right you might have observed lot of construction work is going on in our campus am I right okay. So I think few years back I observed a person he is standing on the ground and there is a one floor kind of thing right, and there is another person standing okay one laborer and he is showing the stone not stone the bridge rather, bridge towards the person who is standing on the first floor okay.

And he catching, so what is happening that brick you know so a person will be throwing a brick and another person will be catching. So that means it will be throwing with certain velocity that means happen kinetic energy therefore it is moving yes or no am I right okay. So then want you to keep their right are that person that means this kinetic energy what will happen when that person will catch are about to catch what will happen to that energy that means velocity will coming to the zero almost right.

So what will be that energy kinetic energy will it be kinetic energy will be there when the person is about to catch or already caught no, no so what is that energy where the energy has gone potential energy right. And that what is the frame of reference, frame of reference is a coordinate system in the floor and then you talk about it. Now you know this is asking in this campus during winter season right, and if work allow laborer who is doing this job which was quite risky. Suppose that person will lose his concentration who is trying to catch it which is coming with a velocity right and allow mass what will happen to him we will be in hospital, am I right.

Now question arises I am posing the question to you people as an engineer can you think of something so that that kind of risky wanted okay there comes into picture the thermodynamics how to analyze and what is the way of doing that? That means you need to be sensitive to the people's needs so that you can devise a proper device says that you know the problem of people can be solved. So that is the engineering aspect one as to team so a sensitive person can be a good engineer am I right.

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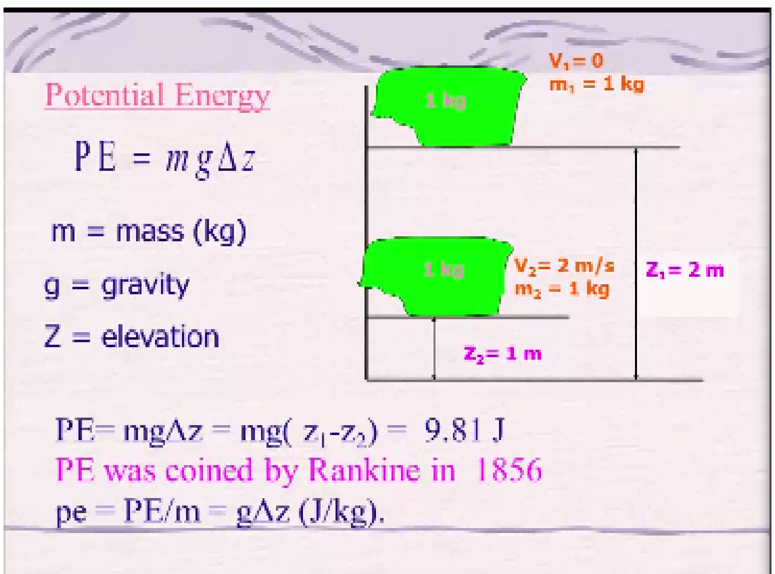

So coming back to that potential energy you know you have always talked about potential energy you might have seen in this place there is a lot of trees are there right, and some of you might be in the southern part of the country right, where these coconut trees are very tall trees, coconut trees are very tall, earlier days nowadays IB bit become small okay. Now let us say that the coconut is attached to the tree what will be potential energy at a very high let us say may be 4 meter kind of thing or maybe 5 meter right, what is the potential energy?

Potential energy I am talking about, because we are discussing about potential energy, what will be will this zero because it is attached but let us say by due to times somebody look at it, then it is falling what will happen it will be gaining but just after getting that it will be having a potential energy which is equal to the height whatever it is there am I right. So and then after that when it will fall down it will be gaining kinetic energy that means potential energy is converted into kinetic energy.

So if you look at there is a mass which is having a velocity V1 and mass of 1 kg it is falling down and you know and reaching the gate 2 with a velocity V2 and M2 is your 1 kg of the same mass. So we need to find out potential energy, so potential energy basically mass into G that is the acceleration due to gravity, and change in elevation right. And that will give you the potential energy and the potential energy if say in this example that mass is 1 kg and PE is 9.81 m/s^2 and z1-z2 is nothing but 1 meter it will be something 9.81 joule you can get from this example what I have presented here.

So the potential energy was basically coined much latter by Rankine and William Rankine who was a pioneer in one of the tell was in thermodynamics and of course the specific potential energy is nothing but your potential energy per unit mass that is equal to the Z into ΔJ what is change in elevation basically.

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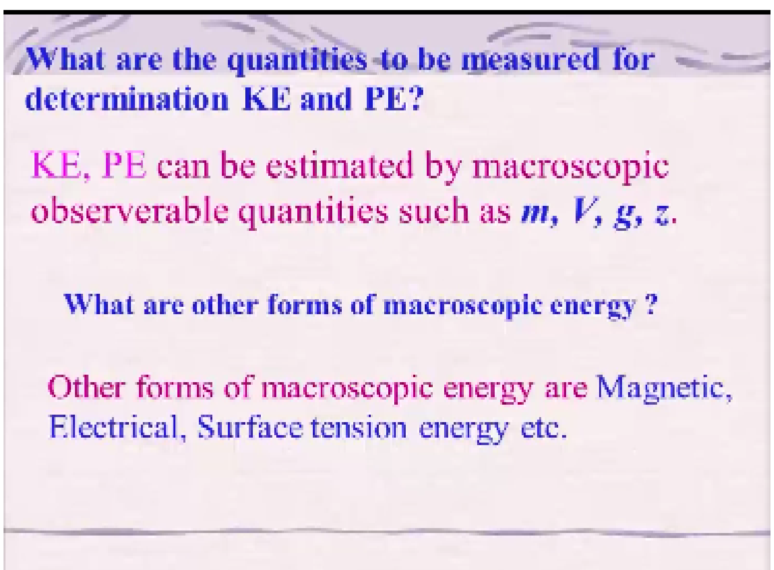

So if you look at these are the kind of energy what we will be dealing with kinetic energy and potential energy, potential energy will be also various kind you know if not the potential energy what I have just now discussed with this due to the gravitational effect that might be magnetic effect, there might be you know other effect right kind of things. So potential energy will be various kinds of things, and these quantities you know what are the quantities involved in this we have seen is basically mass, velocity, and acceleration kind of things right.

And these are observable quantities you can observe, you can measure it very easily right. And it is the other energy when you talk about it is very easy to quantify because you know the properties associated with and observable quantities, so that you can you know measure it. So what are the other forms of microscopic energy any idea, these are all very commonly you will people will be knowing, but what are the other I have already talked about you know like what I told electrical energy like, you know magnetic, surface tension, and several other you know kind of things will be various other forms of microscopic energy one can think of that.

So we will be dealing mostly with the macroscopic forms of energy in the thermodynamic right, but however I will just try to give you the flavor of the various microscopic forms of energy we will be discussing now.

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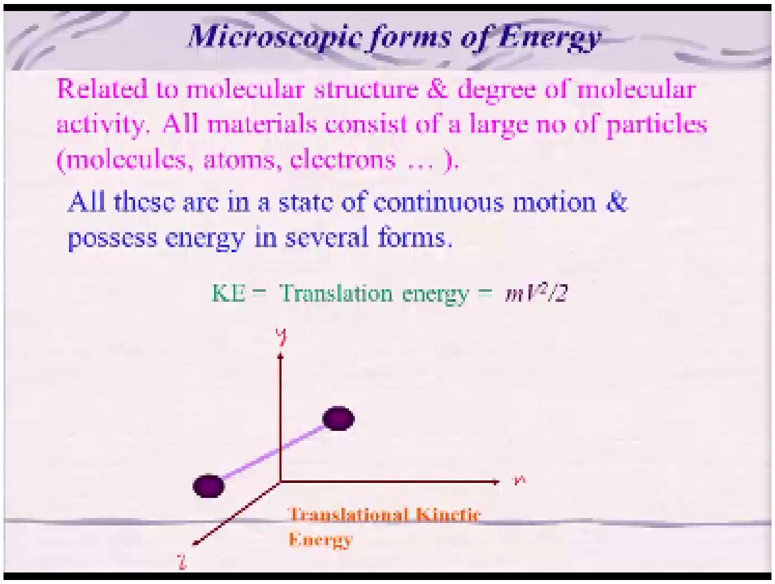

So this is as I told related to the molecular structure like how it is you know let us say whether it is a monoatomic a diatomic or polyatomic or triatomic molecule and what are the you know if interaction with themselves like basically degree of the molecular activities will be you know important for this energy right. And the all the material will be consists of large number of you know particles what we call molecules, atoms, ions, electrons and other things and all you know will be basically having producing some energy.

And those energy is known as microscopic form of energy. So all these particles are in all the time in motion right they will be in a continuous motion and producing some sum of energy. So this thing we these forms of energy is basically can be opting of places that is a what you call a molecule right if it is there is having let us say this is having X directions right let us say this is X direction this is Y direction, this is Z direction and this can translate this molecule can move from one either in X direction, or Y direction, or Z direction right.

And this is whenever it is moving with you know particular directions are kind of things so you know it can be known as the translation energy, because it is moving and as it is moving it will be possessing certain kinetic energy and this kinetic energy is basically known as the microscopic form of energy. For example I am considering a molecule and then molecule having mass m and it is moving with a velocity V keep in mind that this you do not think this is not that you know the each molecule will be moving with the same velocity.

For example if I take a cylinder is it which molecule will be moving at same velocity no, may be mass is same we provided the molecule it same, the nitrogen gas cylinder right. And the motion also will be very random it will be colliding he said, so it may go and you know bump into the wall or it may be go and collide with another molecule. Of course if it is in a no reaction is taking place right kind of thing.

So therefore this will we have different address consider for a single molecule therefore I am writing this, otherwise it will be each molecule having different velocities may be mass system if the molecule the gas is there.

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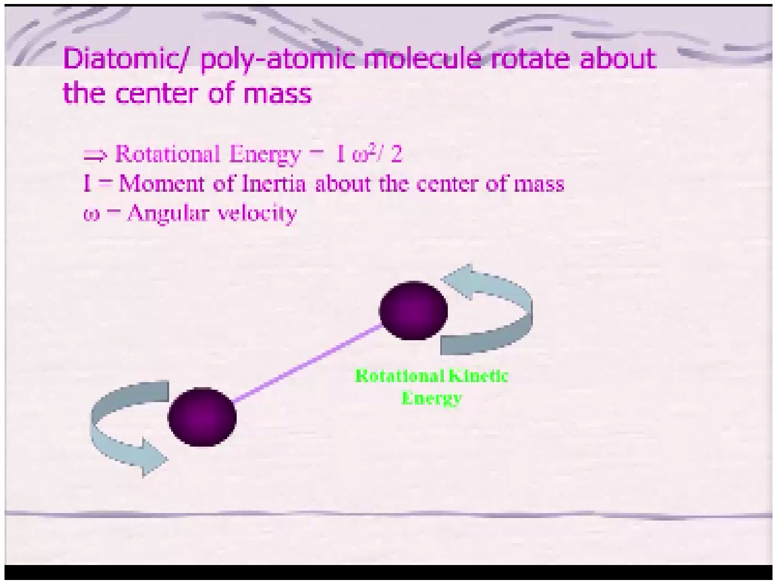

So and if you consider there might be diatomic or polyatomic molecule which can rotate less molecule can translate, it can rotate right and rotate about center of mass. So therefore that will be basically rotational energy you can think of momentum is equal to $I\omega^2/2$ and I is the moment of inertia about the center of mass and it is rotating with the certain angular velocities. So you can calculate for each molecule then you think up about whatever the number of molecule it will be having in a system then it is very complex you know and you will have to look at.

So that is basically the rotational if you look at this another rotation the kinetic energy that means molecule early having kinetic energy, molecule will be having rotational energy.

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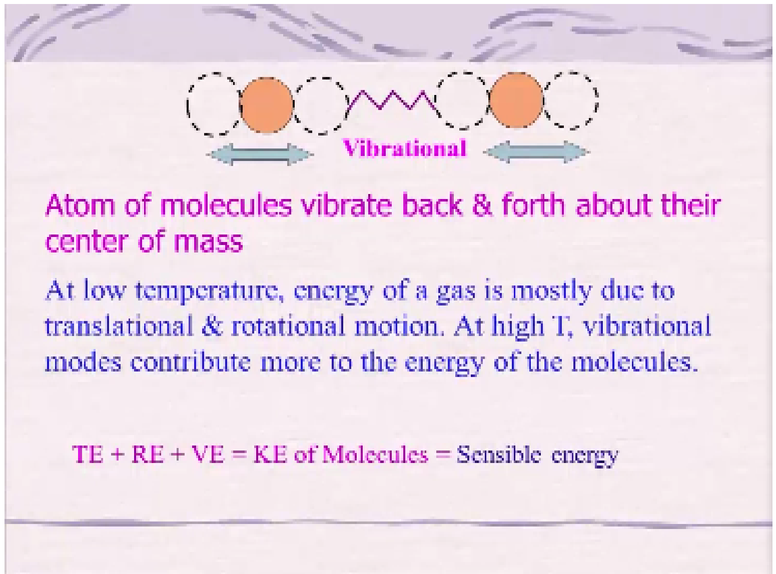

And the molecule can also vibrate within certain mean position with this certain mean position it will be vibrating right, if it is vibrating that is known as vibrational energy in a microscopic form that means particularly at low temperature like energy of gas is mostly due to the translational and rotational right. But high temperature vibrational mode contributes more to the energy of the molecule because if you look at microscopy energy it will be sum of all rotational and kinetic energy and vibrational energy.

And so what we call this total energy that means you know total basically translational, rotational and vibrational energy we call it basically kinetic energy of the molecule because it is motion all the time motion. And that we call it as a sensible energy, why you call it sensible energy because we can measure it, we can measure in terms of let us say temperature and other things right, so therefore we call it in a sensible energy.

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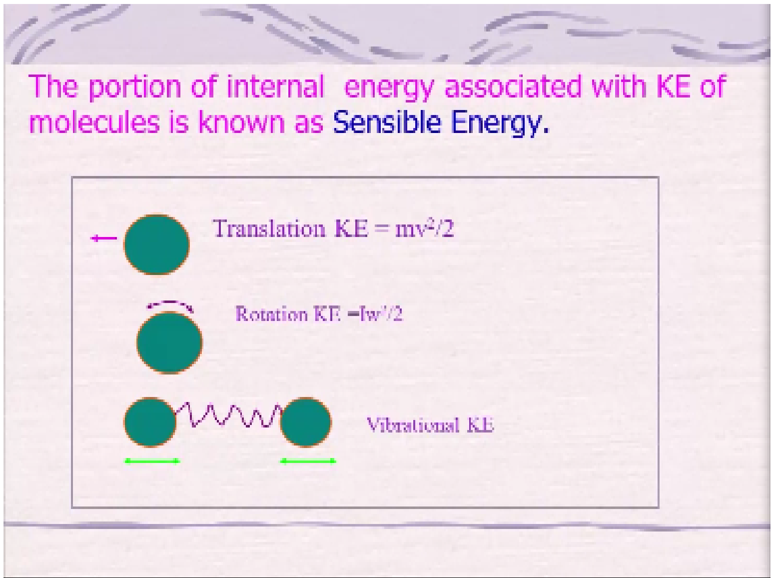

But however the portion of internal energy associated with the kinetic energy of molecules is known as sensible it will be more definition what we are given, because these are all internal energy this one form because due to the motion, you know it will be this energy is coming therefore we call it as a you know kinetic energy of the molecules. And if you just sum it up write a translational energy and rotational kinetic, vibrational kinetic that is nothing but your sensible energy and we call also in case of sensible enthalpy right we will be dealing with that.

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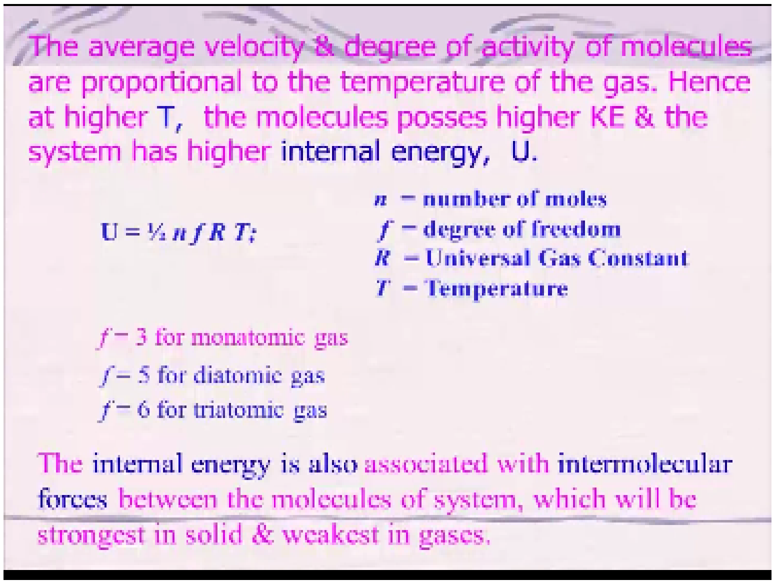

And the average velocity and degree of activity molecules are basically as I told earlier that proportional to the temperature the gas right, because you know like you temperature is higher what will happen to the molecules, molecules will be moving at a higher velocity am I right yes or no right. It is similar to you, suppose you are very much agitated your energy level will be high am I right okay yes or no.

So that means you know you are by you know becomes hot so that you know your mind become hot so that your agitation level increases. So similarly also the molecules right and the gas, and at higher temperature molecule possess higher kinetic energy and system has is higher internal energy that means at the highest temperature you know because the molecule will be having a higher energy level kinetic energy and vibrational then your translational and rotational will be very distinct and so also vibrational.

So then you will get a higher internal energy, so if you look at this things you will be knowing and like we can sum it up like half U=1/2 nfRT where n is the number of moles and F is the degree of freedom like and R is a reversal gas function and T is the temperature and this one can derive from the kinetic theory of gases right, you must have exposed to in your plus two time and if you look at the F the degree of freedom for monoatomic gases will be three right, it will be only the translational right this is in the three direction.

And wherever for the diatomic, the F will be basically 5 provided it is not very high temperature right and for triatomic it is a 6 two rotational for the diatomic apart from the three translational and for diatomic be rotational we are assuming that you know vibrational form of energy you know not there right that is the assumption and that will be true only at a very moderate combustion like something.

The internal energy is also associated with the intermolecular forces between, you know molecules of the system right there will be if you look at there is a you know in case of both the solid or liquid or the you know gas there will be forces between the molecules for selects a nitrogen gas resources if I take water, water molecule will be having a force they are not, they try to stay together you know unlike the first gas and then that intermolecular forces you know which because of some forces and that intermolecular forces is basically will be strongest in case of solid and weakest in case of gas.

Therefore that is the reason why you know solid fluid can save the highest rate am I right, because of maybe pressure is applied the space it can take a step it is together, you know that will be to get in the lattice structure to the day.

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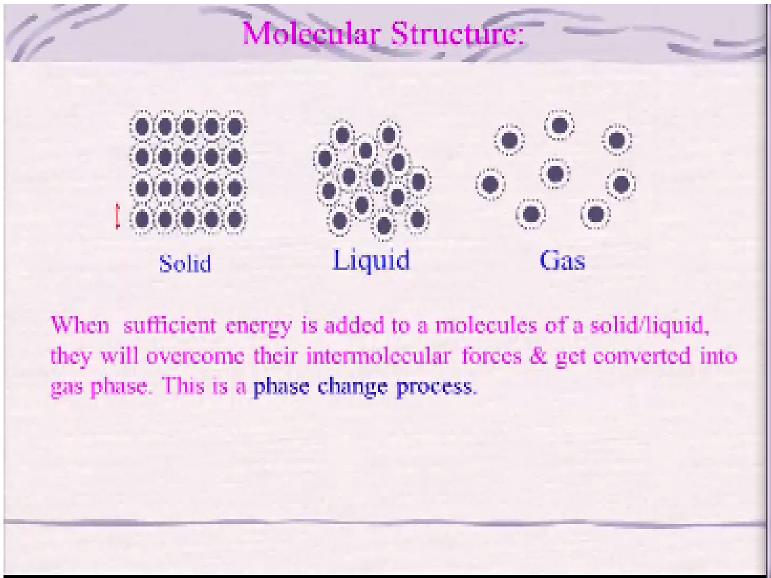

So if you look at that is exactly the point I was trying to make is here that we as a solid upward this is shown two-dimensional, but actually to three dimension that means perpendicular to this will be having. And people have made some kind of a system like where this molecule can vibrate right if you look at the molecule can vibrate like this and within the mean position and where the liquid it will be together but not really in a particular lattice structure.

But it will be you know like because of bounded by the molecule, but where as a gas the molecules be far apart each other and they may collide with each other, but it will be there will be some forces existing between what you call molecules in the gas as well. So when the sufficient energy basically added to the molecules of solid or the liquid what will happen this intermolecular forces, you know will be reduced and it became you know like overcome this thing.

And it became converted to gases right are solid also can get into the liquid phase and this you know measure phase change passes to us because you are having some you know amount of energy so that the more they can overcome the molecules can overcome the molecular forces and this internal energy because you are you know every canvas energy associated efficient watches he is known as the Latin energy like you must be knowing like if I heat.

The water you know and then and putted a thermometer there and then what will happen there in the beginning the water temperature will rise from the ambient to settle degree Celsius right let us say something 99 kind of few and then after that it will get a beverage after that there is no change in temperature right and but however you are doing here and that it will be helpful to converting this liquid into it is vapor let us say for example water then gas heat that energy what we are supplying you known as latently method.

And this is a one form of what you call microscopic energy and if you just you know look at the overall picture you know solid can be converted into the gas.

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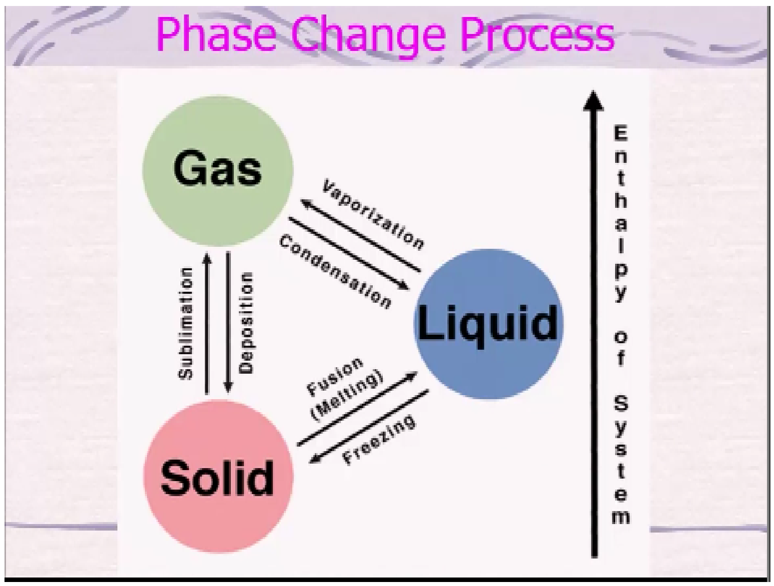

Whenever in a heat you supply that is basically known as the sublimation and gas can be converted back into solid provided you extract the heat the energy from the gas and the when you give what you call the heat energy to the solid it will be melted out to the liquid and we call it melting and when the liquid you know from the liquid heat is being extracted with all get the fish freezing right kind of things we know like you know nowadays very hot you get this ice you know water is converted by this waterfall freezing process similar liquid can be vaporized into the gas by adding this energy and the question.

Specifically and so also the gas to liquid15 process is known as condensation if you look at if you go in this way that with enthalpy of the system increases you know like an upward direction as you go to the solid to the gas if you just you know internal energy will be so also you know other time so and if you look at there will be a molecular bond between these forces if you look at the solids as a result it will be solid liquid and gas and of course as a plasma which we have not discussed right these are the various functional pages and but beside this.

You know if you look at the you know in a molecule there will be some atom they will be joined together having some bond energy and then that energy associated with the atomic bond you know in a molecule we call it as a chemical energy and during the reaction what will be happening that this bond is being broken and then you will be you know like again new one will reform and some chemical energy will be released or it can be you know if it is you know release then we call it as it exothermic reaction.

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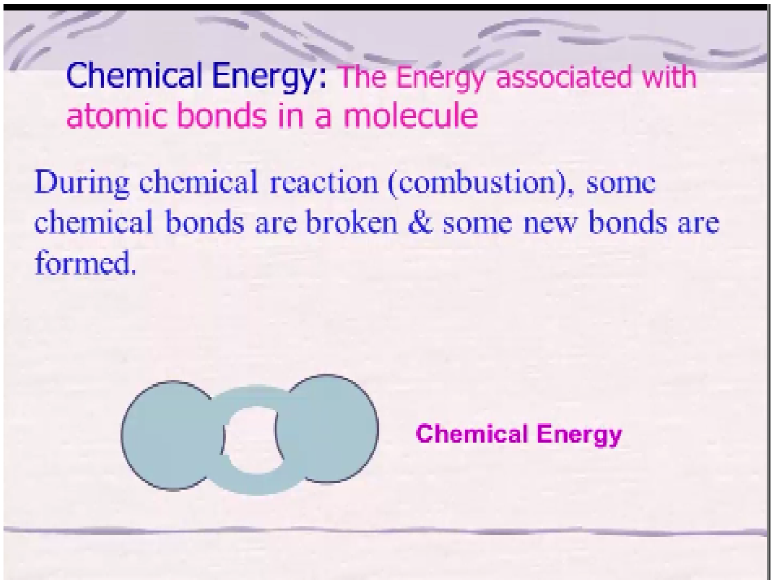

Because it will be giving heat and if it is being observed is known as endothermic reaction and during chemical reaction this you know once new bonds are being you know form and while the whole bond has been broken so these are basically known as chemical energy which way and there is a nuclear energy you know which is associated with the nuclear bond of atom right and which is the.

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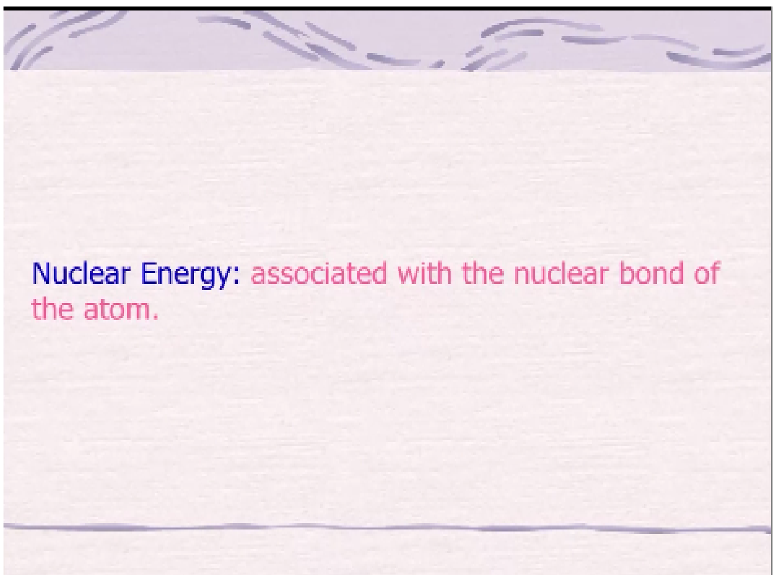

Twice much higher level that means the in the nucleus itself there will be various particle and all together there same and if you bombard it and then black large amount of energy being released of course there is a known as nuclear fusion and there is also nuclear fusion that where the you know these things will be coming together and then you will have to be large amount of amount of heat if you look at nuclear or to confuse and Oscar's in the star or in the Sun where you give a large amount of energy and a very high temperature if you look at something maybe 100^0 under big million difficulty F is required to have this kind of reaction.

Instrument as a place to start but generally it is not successful we have not done that Q what you can fuse until now but however the fission reaction is vintage β we you will some uranium kind of things and it gives large amount of energy standard.

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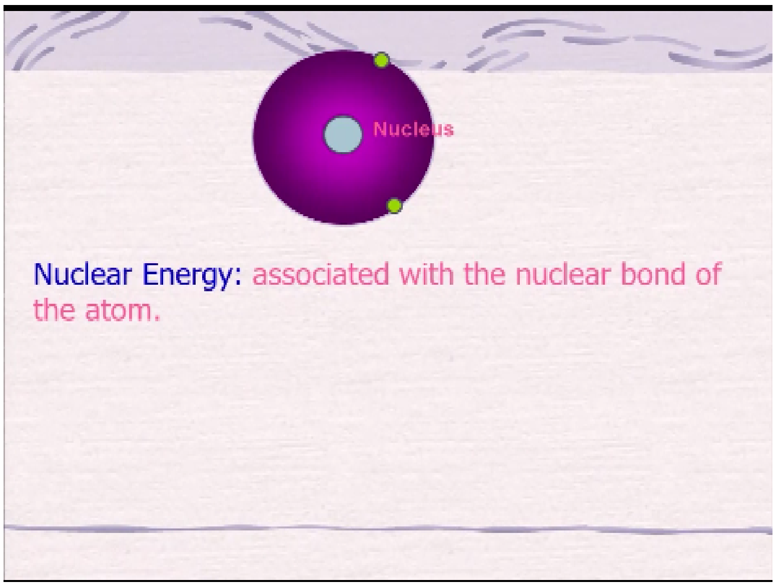

Of your chemical bond if for example let me to you know what you can use 1 kg of uranium and then subjectiveness nuclear fission reaction let us say u -235 kind of thing which can give you something 6.7 X 10^{10} kilo joules which is a very use amount and if you look at that amount which will be prevalent to something 3,000 of the coal when it is burned you know whatever the heat will be generated during the burning of these 1000s tons of coal you know can be obtained just by 1/1 by you know reactor.

And by just using the 1kg of uranium you know is a bit much but however the nuclear energy is having lot of particular in our country where is a popular and one has to be very careful about the nuclear energy and I must tell you that it is very difficult to handle any accident occurs and because of nuclear radiation and unfortunately lot of nuclear wastes are coming to our country to my knowledge I mean whatever I watch one has to very careful otherwise it is a very difficult place to live and then of course some of all microscopic form of energy whatever we have discussed till now.

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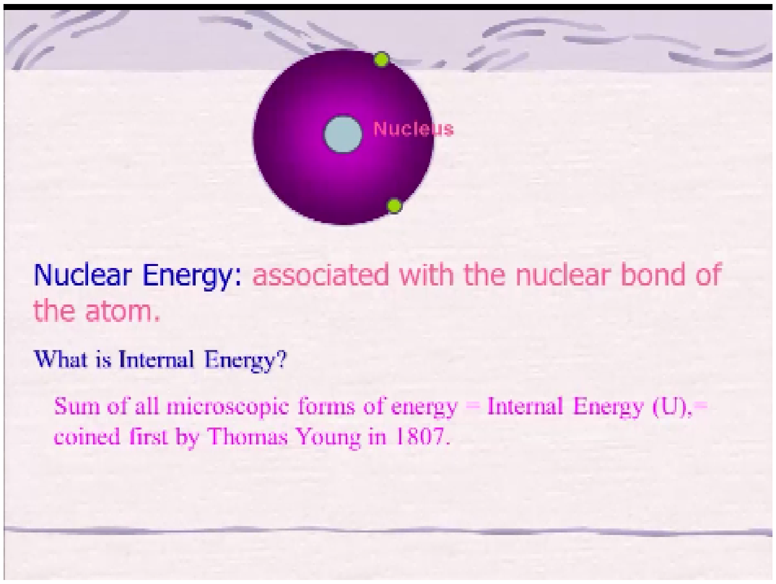

Is basically internal energy which is owned by the FAMAS zone in 1807 and internal energy is basically sensible Latin chemical nuclear energy right that is the best organized form of energy okay these are all disorganized is not organized am I right? So therefore if you look at the main objective of the thermodynamics if you look at from the application point of view that to convert this disorganized form of energy into organized form of image okay so that we can utilize this you know whatever the Latin are the nature is basically.

Let me put other way around that nature I have restore some energy and we could utilize for our purposes and the microwave phenomena is quite difficult to measure directly because it is very difficult you can have a model and say look at it like this but you cannot really measure and the total energy.

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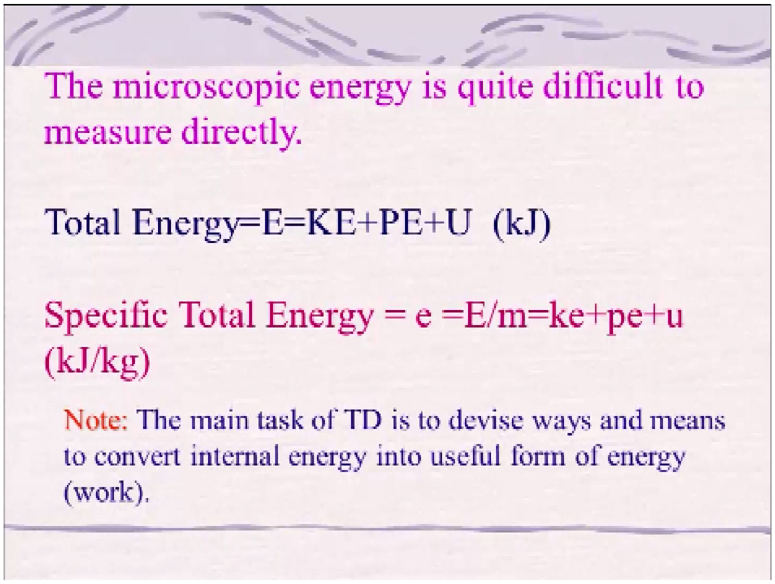

What we will be talking about is not only the internal energy but the what you call the potential energy and kinetic energy and potential energy need not to be confined to only gravitational potential energy due to gravity but it can be due to other things so the specific total energy as I told it is in a total energy per unit mass and as I told that main task of thermodynamics is to devise ways and means to convert this internal energy into useful form of energy that we call it as a walk.

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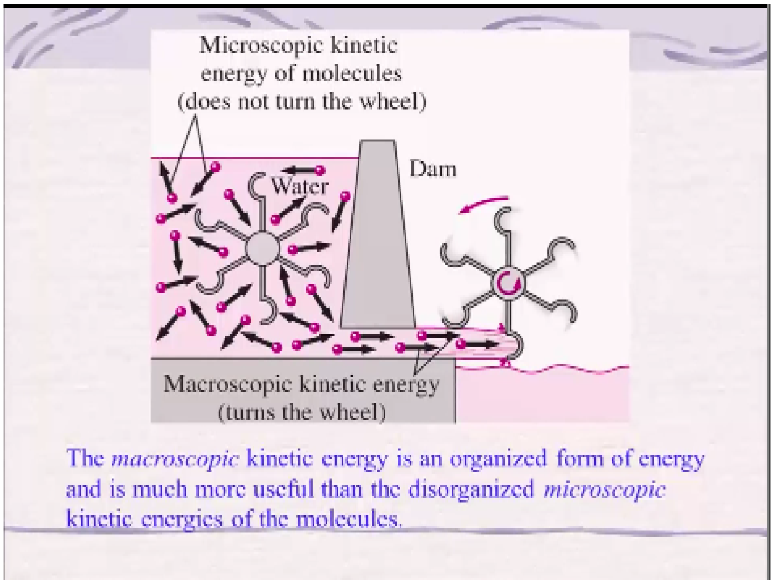

And let us look at like why we call it as a basically unorganized form of energy right so if you look at there is a we you know and this is a dam like dam is basically a you know there is water being stored and putting this then putting your damn eye and this will be having a certain amount of this thing stocked and then water is allowed to flow through this and it will be known as you know Pelton wheel and the water will be coming with certain velocity very high velocities here because he is having potential energy right.

Because of high and then this is converted into kinetic and is very high and when it is kinetic energy that you know impede into this end of the turbine you can think of and you will get the energy will be rotate and you load it and then you get the mechanical energy which we can use for our power generation and everything but however if I place this what is called turbine blade and then we call it a basically Pelton wheel here right and can it give the NEPA work then is it possible so I am getting here the work done and they put some power and generating right mechanical power and then will convert into electrical okay.

Using density now the same will I will put it here on the upstream of the dam can I get some work done yes or no certainly no right because although the energy there is having potential energy right it is having molecules are moving and then it is interacting you know like having this thing but it is these molecules are coming and impinging into this wheels but these are not finished it is occurring at a random manner but yet it is in an organized manner like it will be all this thing will be going indirection and go on impinging into the vertical turbine place am I right? So therefore the microscopic kinetic energy will form of energy because we have converted into capisco kinetic energy.

And which is much more useful than the disorganized microscopic and because easier also microscopic and is a movie both are kinetic this is kinetic energy and these are also kinetic energy but one is microscopic one are the reason naturally form so objective of basically thermodynamics is to convert this microscopic form of energy or unorganized form of energy into organic form so that is true with a country album am I right? Yes or no you must be knowing the history right we are invaded by various heat India was a populate country earlier also today also right.

See the few people came with a very organized man as they put we know where our land and rule over this am I right? So because we are not organized similarly today the market forces are what you call invading our cultural heritage spoiling so because we are not organized therefore we could not really resist the cultural invasion what we have been affected today so therefore it is very important to learn you know like that we will have to be organized right that is why we are having are which is organized.

So that they can you known nullify the invaders intention to come to this line and then maybe create some problem so therefore it is important to be organized in your case for example the education the objective of education is what you people are being educated are being exposed to the what you call teaching and learning for last 20 years right or maybe little left okay so what is the meaning is that your mind is you know will be regulating all the time so you should have to develop your concentration level and get trained so that you will be organized in your mind to deliver some kind of work.

So now as I told that energy is always you know associate with the environment and whenever we are trying to harness the energy so it is important that we should take care of environment and there is a global concern.

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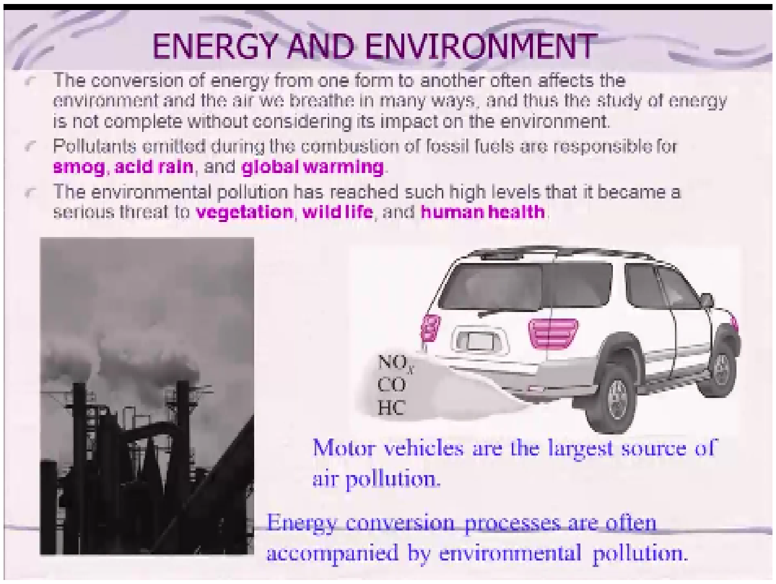

For the what you call environment today and what is there in earlier death or not it was there but we never you know looking at that that previously because people we are not using the technologies that blatantly but today we are using for our own comfort but we are spoiling and from the energy devices the pollutants emitted from the during the combustion of fossil fuels are you know like global warming and the smog and acid rain we are getting you might be aware that you know in particularly a Liquated.

People were asked to go and you know have a good enjoyable shower in the first rain today people are actually do not do that why you will be in trouble your skin will be in trouble okay right so because of accident smoke and unfortunately our country more most of the cities are really with the environmental problems because we are not taking care of it and we should as a country of citizenship citizens we should take care of that and then and thermodynamic comes into picture the imminent pollution are you know a very high level across the globe and India is one of them.

And in the name of development and quality of life we are you know using energy blatantly and then also spoiling too you know like motor vehicles are the largest source of air pollution and we need to device you know better energy devices with the help of thermodynamics that we can provide better Edmund mental friendly you know gadget for our youth and therefore the energy conversion processes are you know often accompanied by environmental pollution kind of things we need to take care of.

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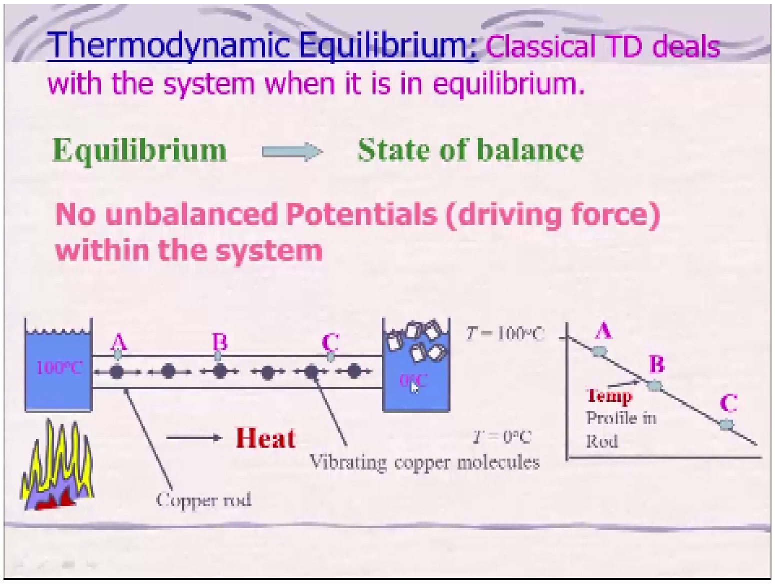

So when we talk about this you know kind of thermodynamic system we always dealing with a system which will be in equilibrium right and because we are dealing with classical thermodynamics right as I told we are not interested in the microscopic we of the things in molecules and interact or not we are basically looking at the glass ware macroscopic aspect of that so therefore and our this thing will be equilibrium space and when will be in equilibrium you know the equilibrium means basically state of balance right if the state of balance is there we need to see like.

Whenever the system will be interacting with the surrounding it will be attending equilibrium right and then we will find it out what are the changes as after so in the passive that means the equilibrium means the unbalanced potential that means the driving force you know should be 0 right there would not be any driving force within the system then only we can look at it that means in the beginning there will be in equilibrium then whenever there is interaction there will be system will be interacting surrounding we need to lighten their equilibrium then we will be talking about the change that.

We will be doing in this kind of thing and when we will say that equilibrium okay let us understand what do you mean by equilibrium okay we will take this example there is a copper rod right and there is a 2 bar 1 is at under digital to the boiling water right temperature remain constant am I right or wrong okay because either temperature ratio if I go on giving it right unless the last drop up what are we there in this it will not be okay and similarly we will talk about the another bath we call it as a ice bath right.

They give it Excelsior and kind of and this is a copper rod we have connected with the boat - you know that we and what will happen here that means this is at high temperature this is the boiling water bath which is at under digital sphere the ice water bath will give additional ships what will happen to the heat it will be flowing from higher temperatures to the flow established because of gradient am I right or wrong now when you do that so will it reach equilibrium let us say after one hour what will happen to the temperature in the copper rod copper is a good conductor of heat.

So also electricity right so here we are concerned about it so what will happen to that will it attain equilibrium or not yes after one hour or after two hour maybe in the beginning it would not right but later on it will be if I give sufficient time do you agree with me or not how many o people agree with me but that means few people are not agree right few people are not agree with that it will not reach equilibrium okay so what I am considering this I want to call this copper is our system copper rod with our system okay that means whatever the diameter lens which is having that is our system boundary surface system.

Also since our system boundaries so let us look at what is happening that means if you look at here you know this is a temperature and after you know these things like the temperature at point a will be here it comes closer to the hundred digital sphere and B it will be in between and C is corresponding to the lowest temperature because it is Lois is a zero difficulties here right but that means if you look at the system itself what is happening the system the temperatures get into their because the temperature at a is not equal to temperature at C is equal to not equal to C am I right?

Then only it will be equilibrium there is only there is a gradient again the temperature is changing get me the heat as the temperature as a will be much higher than the temperature be there is the Jersey so heat will be flowing all the time it will show that means it is not reaches what you can equilibrium however it is it is a steady state am I right? Now you understand what do you mean by steady state and what do you mean by equilibrium or are you getting on my point what I am trying to say I -so now what I will do I take this copper rod and insulate it and allow it to homogenize.

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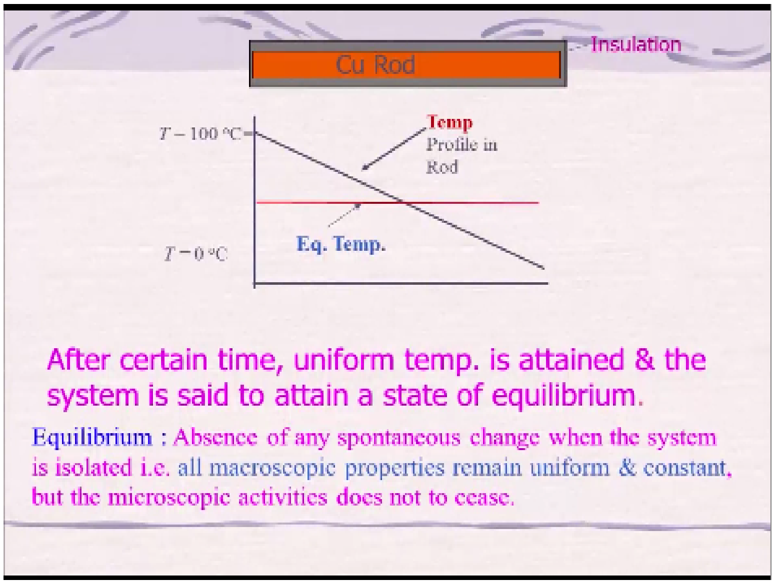

That means the temperature you know you will become like this some average temperature ranges and uniform temperature happens and system is fair to attain the equilibrium right then only that means I need to isolate it otherwise no so that is basically what you call as a recess equilibrium but unless I isolate means basically isolated from the surrounding and also the East ocean you know bath and the Kolbe are they those are basically surrounding for it am I right? So that means equilibrium means absence of any spontaneous thing when the system is isolated right.

In other words all the macroscopic properties remain uniform and constantly because if you look at the temperature is remaining constant across this whole range it is not changing right it is not changing with respect to time as well when it is insulated but however the microscopic activities go on the molecules will be by bracing in this case copper rod the molecules will be vibrating but because of temperature you know but however there it will be temperature will be same right so the macroscopically it will be you know uniform chemical property so when a system.

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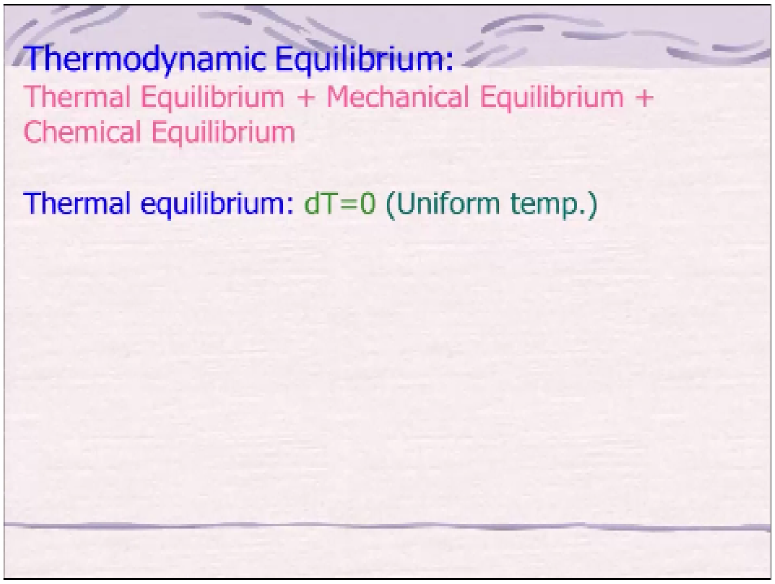

You know you mean basically thermodynamic equilibrium because we will be talking about equilibrium all the time and then looking at it so we can say that a system he attains a thermodynamic equilibrium only when it will attain the thermal equilibrium mechanical equilibrium and chemical equilibrium and there is another one which is basically phase equilibrium we will be discussing about all those things that means in the next lecture right and I will stop.

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