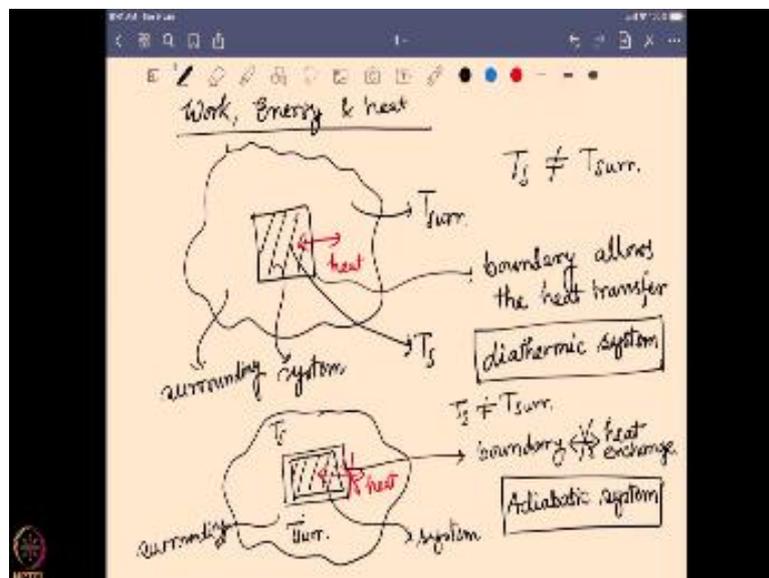


**Concepts of Chemistry for Engineering**  
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**Lecture 51**

**First Law of Thermodynamics – Diathermic and Adiabatic Systems, Exothermic & Endothermic Processes.**

Hello and welcome back to the discussion of thermodynamics. In the first segment, we discussed about some important properties that actually defines the thermodynamics system and they are, heat, work and energy. Now, in the second segment we like to look into what are the correlation and how we can connect them so that we can arrive to the first law of thermodynamics. So, lets begin.

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So far, we discussed about these three important factors work, energy and heat and now over here, we will define the system on the property, how this particular heat is getting exchanged with the system and surrounding and not. So, for that we will take a particular system which is present in a surrounding and the particular property is such that the temperature of the system and the temperature of the surrounding are not same.

So, if the temperatures of the systems are not same, they are going to exchange heat depending on which side has the higher temperature. The heat will flow from the higher temperature side to the lower temperature side. And over here, we are creating such a boundary that actually allows this heat transfer.

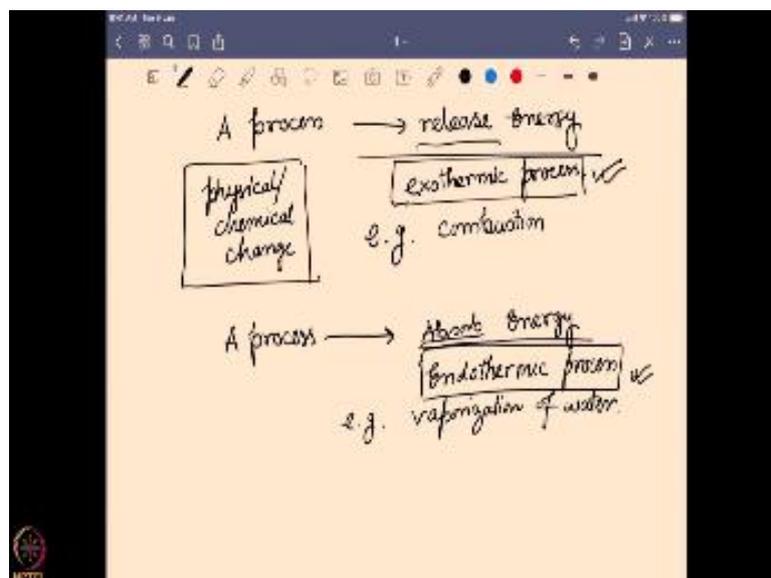
If we have such a system where the temperature of the surrounding and the system is different, and at the same time the boundary is such that it is allowing the heat to be exchanged, we say, this particular system as diathermic system. So again, what is a diathermic system? Diathermic system is a particular system which can exchange heat with the surrounding and the heat exchange happens because of the difference in the temperature.

Now say, we have a very similar system and a very similar surrounding, but now the temperature of the surrounding and the temperature of the system are still such that they are not the same. However, the difference is now that we have such a boundary that does not allow any heat exchange. So over here what will happen; that heat over here cannot get exchanged between the surrounding and the system even there is a temperature difference exist, and that particular system is known as adiabatic system.

So, a adiabatic system and diathermic system, what is the difference? The difference is that adiabatic system cannot exchange heat between the system and the surrounding; the boundary does not allowe it. It is more of a such a boundary that is actually insulating any heat exchange. Whereas in a diathermic system, such heat exchange is allowed, that is the biggest difference between the diathermic system and adiabatic system.

So far, we are discussing about this heat, energy and work, but now we are also going to discuss about some of the changes happening in the system that is actually triggering such a change in the, either of these properties heat exchange and energy exchange or the work.

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So, for that, we are going to define the system in two different parts. First, a particular process happening in a system in such a way that it actually released energy. So, system is getting energy from the system itself, so that particular system is known as exothermic system or exothermic process. So, this is a particular process where energy is getting released from the system through some physical or chemical change.

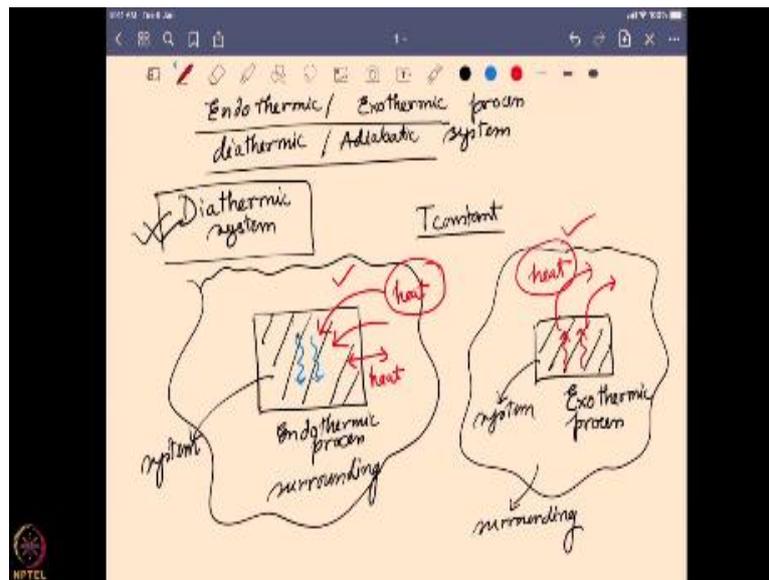
So, a physical or chemical change is actually the reason behind this particular change, so that heat is actually coming out or energy is actually coming out. One of the good examples is combustion, when we burn something. Say, if we take a piece of coal and then add some heat to it and then it continues to burn on its own in the presence of oxygen and release a huge amount of energy.

So that is we can call an exothermic process, so that is very much important. Now say a very similar process, but in this system now what is happening? It is actually absorbed energy; instead of releasing it is actually taking energy inside the system. Some of the energy is actually getting lost. In this kind of system, if it is happening, the process is known as endothermic process, where energy is actually getting lost.

So now, this particular process, one of the good example is a physical process; for an example, vaporization of water. So, when water starts vaporizing, you can feel that energy is actually getting out of the system such a way that the whole system where the vibration is happening it is getting cold, so that is a good example of an endothermic process.

So those processes; now we have defined endothermic and exothermic that is nothing but whether the energy is released or energy is getting absorbed in a process and differing to that, we can define a system exothermic and endothermic. Now, we will try to find out what happens when this endothermic and exothermic process is happening in a diathermic system and an adiabatic system. And then, how we can follow this particular process? Now, let us go to that.

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So now, we know, we have endothermic and also exothermic process. And we want to find out these processes, when it is happening in a diathermic or adiabatic system. What happens over there? And why we are interested in that, because that is how we can actually follow what is the change happening in a system, physical or chemical, it is endothermic or exothermic?

And we can follow that by controlling the system, whether it is a diathermic and adiabatic? Now get to the example of that. First, say we have a diathermic system, so that means heat exchange is allowed. So now, I have a particular system which is diathermic, so it can exchange heat with the surrounding. And now, consider we are having an endothermic process, so you are having an endothermic process, that means, energy is getting absorbed.

So, if the energy is getting absorbed over here, how the surrounding is going to respond, because now they are able to exchange heat in between them. And over here, what will happen? Because the energy is getting absorbed in the system, so the heat will come out of the surrounding and go into the system. And because over here, I am actually allowing the system to get actually equilibrated with the surrounding, the overall temperature of the system will remain same in the beginning and after the process is done.

So, during this endothermic process, the temperature of the system is going to get constant, because the surrounding system is actually allowing the heat to get transferred and make sure the temperature remains constant. Now say, I am having a very similar system in a surrounding,

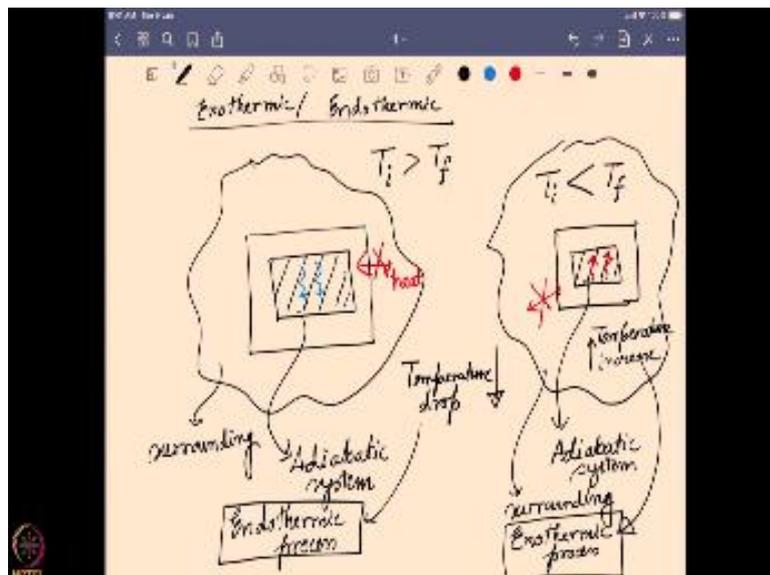
but the only difference now is that I am actually doing a process which is exothermic in nature, it is an exothermic process happening.

If an exothermic process happens over there, what will happen? Previously, actually what we notice, some energy is getting absorbed. Now, some energy is getting released, and when the energy is getting released and the boundary is allowing me to exchange that in the form of heat, so the heat will now come out of the system and the surrounding will absorb the excess heat it is coming out and make sure the temperature remained constant.

So, in all this process, the temperature remains constant, either endothermic or exothermic, if I am talking about a diathermic system, where the heat exchange is allowed. So, the temperature remains constant, but we can follow what is actually happening over here by following what is happening to the heat.

If it is getting from the surrounding towards the system or if it is coming out of the system to the surrounding and by that we can easily define whether it is endothermic process or an exothermic process by following the amount of heat and the direction where it is moving. So that is how thermodynamics can help us understanding whether an endothermic or exothermic process is happening in a system when we are talking about a diathermic process.

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Now, if we go to the next one, now say, we are going to look into the same processes, that exothermic and endothermic process again, but instead of a diathermic system now, I am going to do that in an adiabatic system. So, I have the system but now I have insulated it. So, I am

talking about an adiabatic system. So, this is now an adiabatic system, this is surrounding and as we have discussed earlier, what is the adiabatic system, which cannot exchange heat.

So now what happens? If I am doing an endothermic process, in endothermic process what happens, the energy is actually getting absorbed. Now over here the endothermic process is happening and I am not allowing any heat coming from the surrounding towards the system, so the temperature of the system cannot be constant, it is going to change. So initially, if my temperature is temperature initial and after the endothermic process, if my temperature is temperature final, what we can expect?

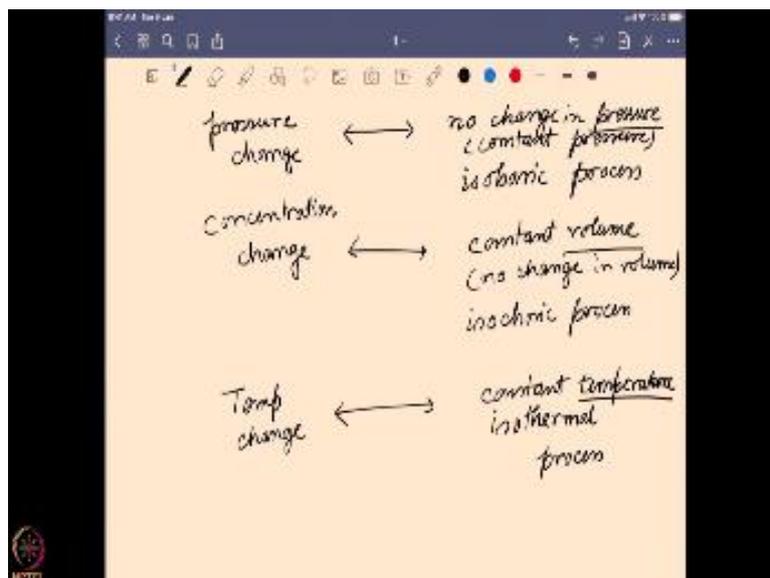
Because the energy is getting absorbed, the temperature is going to get down. So, the final temperature will be lower compared to the initial temperature, so I would see a temperature drop during this process, if it is an endothermic process. Now imagine, I am doing the same process again at a very identical system, which is again still adiabatic system, and this adiabatic system means that, with the surrounding, it cannot exchange any heat.

So, heat exchange is off the table. So over here, it is actually we are doing now an exothermic process, we are doing an exothermic process, where we are actually releasing energy. Now, because the energy is released, but I cannot exchange heat with the system and surrounding, the excess energy cannot come out of the system, so what will happen?

Even over here, if we follow the temperature, temperature initial and temperature final, now the temperature final will be higher in magnitude. Because over here, now the temperature will increase, so we will see it spike in the temperature, it will increase for an exothermic process. Whereas, a temperature will decrease in the case of an endothermic process. In exothermic process the temperature will increase.

So, that is what happening in adiabatic system. Again, if we have a adiabatic system and if we want to follow what is happening in the system, we can easily follow with respect to the what is happening in the temperature. So, over here, either through the follow, what is happening on the heat, and either we can follow, what is happening with the temperature, we can define whether it is exothermic or endothermic process; no matter what whether it is a diathermic or an adiabatic system.

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Over here, I give you the example of it, where we are actually looking with respect to the change in the temperature, but the same can be done with respect to a pressure change or with respect to a concentration change. So, those kinds of changes, we can also follow and see what is happening in that particular system with respect to a physical or chemical change.

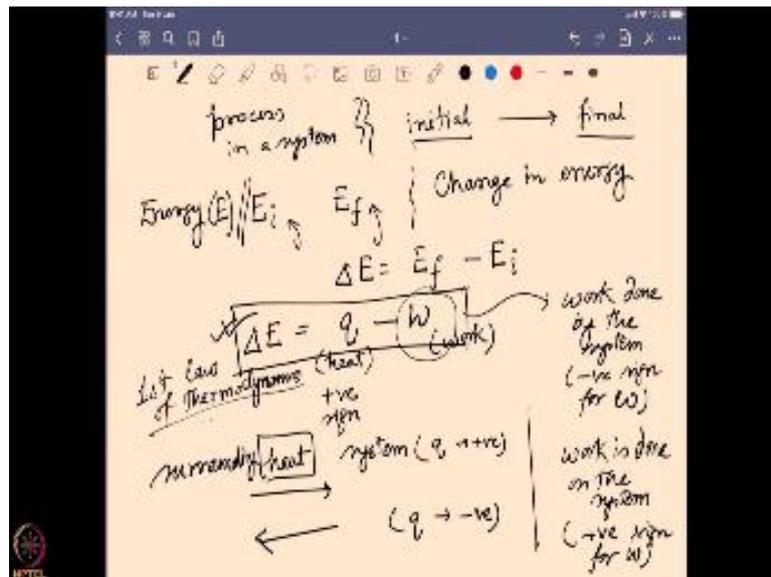
And it may happen that we actually can do this system in such a way that there is no change in pressure. We are doing this reaction or a process such a way there is no change in pressure that means, we are doing it at a particular constant pressure system. If we can do that, this is known as isobaric system or isobaric process.

Same thing can happen that there is a constant volume, there is no change in the volume during this process and that will be known as isochoric process. As we have discussed earlier in a diathermic system where we allowed the temperature to be changed in such a way that the heat exchange is playing role and we are able to do that system at a constant temperature and that system or that process is known as isothermal process.

You can easily see that a change in a particular system can be followed by the change of this particular parameters – temperature, volume, pressure and we can play with the system such a way that we can do it at a constant pressure, temperature or volume and allow some other properties to change in the form of energy heat and work. And at the same time, we can also do the system at a constant pressure, constant volume or constant temperature.

With respect to that, we can easily follow what is actually happening in a system? What is the process is actually taking over there? And by that we can actually know, what is happening with respect to the energy, the work and the heat. And now, we are in the process of the last part of this particular segment, what is the connection between energy, work and heat? So, that we define in the particular way.

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So, say, there is a process happening in a system, and the system is changing in such a way, it goes from a initial state to a final state. So, I am changing the system from one particular state to a different state. When I start that is called the initial state, and where I end up, at the end of this process, we call that the final state.

And if I measure the energy of the initial state and if I measure the energy at the final state, I have a very good idea, what is happening with respect to energy. This is the initial, this is the final and we say, what is the change in energy and the change in energy, we defined it in the form of  $\Delta E$ , which is nothing but  $E_f - E_i$ .

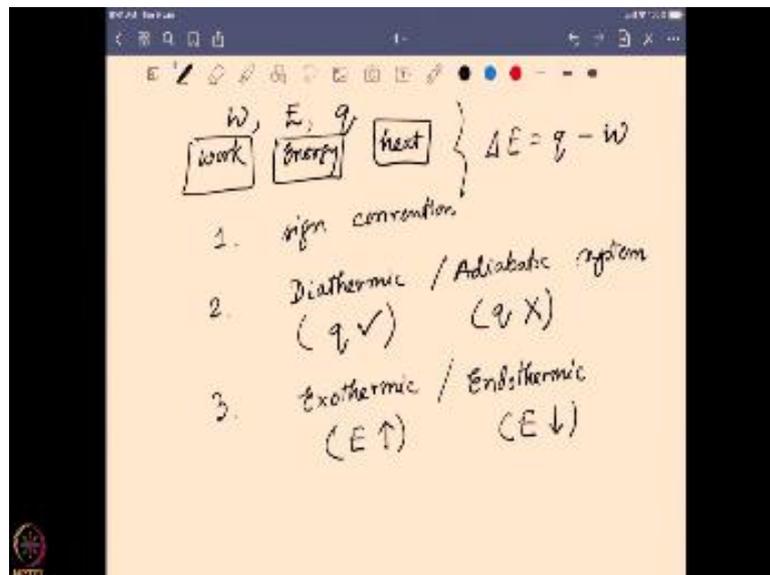
And this change of energy is connected with the heat exchange happening between the system and surrounding and the work possible with respect to the system. Over here the sign of this heat and the work is very critical. Over here I put the heat as a positive sign that says that the heat is actually coming from the surrounding towards the system.

So, there is an inward flow of the heat from the surrounding to the system, and then we define heat as a positive entity. If it is the other way round, if the heat is going from system to the surrounding, if it is lost from the system, then our heat will be negative.

About the work, if it is work done by the system, that means, the system itself is doing work and by that it is losing its energy, because energy is nothing but capacity of doing work and if the system is doing work on its own, it is losing the energy. That is why we put a negative sign for work. If the work is actually done by the system and if work is done on the system, then we say, if we are doing work on the system, we are actually increasing the energy of the system and there will consider a positive sign of work.

But over here, we calculated the system such a way that the energy is changing through a process, such a way that heat is coming from the surrounding into the system and some work has been done by the system itself and that is how the energy change is connected. And this particular equation is known as the first law of thermodynamics.

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So, in this particular segment, we will wrap it up, we discussed about how work, energy and heat, these three particular terms are connected to each other and from there we actually find out that it is the first law of thermodynamics. We discussed about the sign convention, if the heat is lost from the system to the surrounding it is a negative sign, if it is gained, the surrounding is sending the heat towards this system, this heat is coming into the system, that is a positive sign.

The work is done by the system, it is a negative sign, work is done on the system, it is a positive sign. We have also discussed about diathermic and adiabatic systems, which are nothing but, in diathermic system heat exchange is allowed, in adiabatic system heat exchange is not allowed. We also talk about exothermic and endothermic process. In exothermic process energy is released, in endothermic process energy is absorbed.

And then we also talk about how we can do exothermic or endothermic processes in either diathermic and adiabatic system and follow what is the fate of it. In diathermic process the temperature remained constant, that means, it will be isothermal system and we can follow the system with respect to the change of heat.

In adiabatic system, we are not allowed to change any heat, but we can follow with respect to the changing temperature. Similar systems can be also taken care with respect to pressure and volume, where we can get isobaric or isochoric system. So, with respect to that, now we will conclude this section of the discussion of thermodynamics, where we are able to come into the conclusion, what is the first law of thermodynamics? In the next segment,

We will talk about an another very critical term, enthalpy, which can be derived from the first law of thermodynamics. So, we will talk about that particular term, will understand what is the physical parameter, what is the physical significance of it, and how it can allow us to understand the thermodynamics of a system better. Thank you.