Chemical Reaction Engineering 1 (Homogeneous Reactors)
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Lecture No 40
Non-Isothermal Reactors (Graphical Design)

Yesterday we were about to derive the formulas and then ())(0:16) yes in graphical design also we need this formula okay some equations we have to derive and then we will go for graphical design okay but I have drawn some graphs okay.

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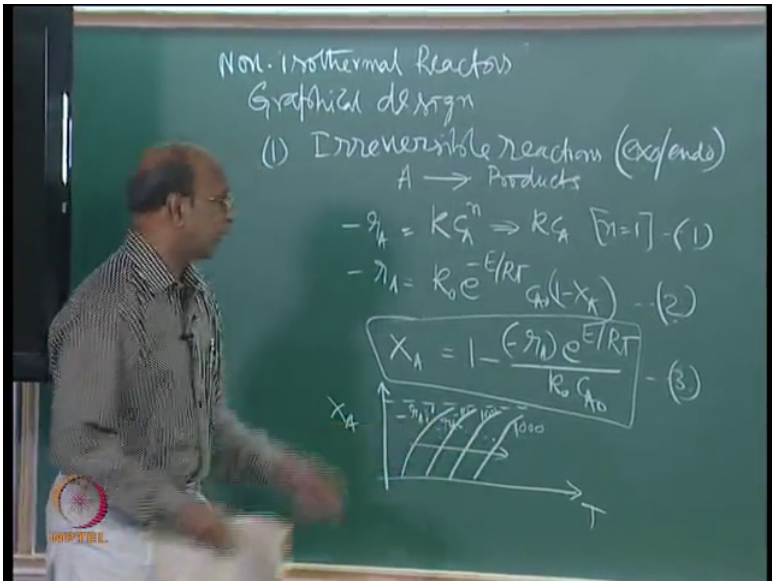

So in the last class we have given some graphs where we have to plot you know there are 3 variables in whatever way you want you can always try to ())(1:03) them changing XY YX And all that but logically there is only one way to draw logically where we are convenient with that kind of drawing so that only we plot but before doing that how do you get those graphs which I have given there? Right someone going like this someone increasing decreasing and all kind of things are there but how do you get those actual lines there that is what fist we will decide and for this we will take irreversible reaction first and in this case if that really doesn't matter whether you have first order reaction or sorry whether you have ()) (1:40) thermic reaction or endothermic reaction okay irreversible only temperature decreases with endothermic.

Temperature increases with exothermic okay and what the rate lines will be increasing only all the time so for irreversible reactions let us first take that I have a very simple thing like it is going to products it is reversible so products will not affect anything there so then minus r

A for this one is k C A to the power of N and of course as usual we are going to get k C A for n equal to 1 right, so now it is a non-isothermal reactor where I can write this equation minus r A equal to k 0 e power minus E by RT C A not 1 minus X A and we are also telling that there is no volume change okay this is the equation 1, equation 2. So this equation I would like to arrange in terms of X A and as a function of other 2 then you will get that by readjusting this equation you will get minus r A e power minus E by R T whole thing divided by k not C A not this is equation 3.

So this is one equation right so now I have 3 variables that is X A as a function of now minus r A and T all other things are constant what is k not? I think I do not have to derived that equation you know very simply you can write this equation, so k not is the frequency factor which I know and C A not initial I know and e and R (())(3:51) energy you have to measure before (())(3:53) okay is a 1st order reaction and for 2nd order reaction also you can write this but only thing is that will be more complicated, so that is why we are writing in the simplest form 1st order you are taking and now can I draw this graph?

Student: (())(4:07)

Professor: Which minus? No I think that is plus you check it that is plus only right yes so now like the graphs which are shown you the other day yesterday now I can plot X versus T or X versus R or R versus X All combinations are possible but most convenient way of drawing this one is in terms X And T so when I say when I have X A and T in x axis and y axis conversion is in y-axis okay, so now what is the parameter for us now? R is a parameter okay and anyway the maximum conversion because when plotting conversion it cannot be more than one, so that line can be shown something like this.

So now I have to calculate this X every time I have to substitute for a T that means I should know the range of temperature and that is the reason why thermodynamics when we are talking about Gibbs free energy and all that, so at that time I know definitely what is the corresponding temperature and then equilibrium conversions right, so then I will know the range of temperatures where I will get this that means equilibrium conversion if it is 60 percent that itself is X A equal to 1 for us because beyond that it cannot go unless otherwise of course you have a very large k values right, so but anyway.

Now I can assume minus r A as let us say 0 of (())(5:51) nothing will happen you know we should not use that then a small value for minus r A then calculate for various t then I will get

X versus T, so I will have lines like this going this is the kind of lines this is for each one r so how r is increasing or decreasing this way or increasing this way? Is this is r 1, r 2, r 3, r 4 so from the graph can you tell I mean because you have the idea as temperature increases the rate must…so this will be in the increasing order okay so this is minus r A 1, r A 2, et cetera okay yes or maybe I think you know this will be 1 r A equal to 1, this maybe 10, this may be 100, this maybe 1000 just to give you some physical feeling exothermic endothermic does not matter. Even endothermic as the temperature is increasing irreversible what will happen to rate?

Student: (())(7:12)

Professor: Even endothermic? You are increasing the temperature, so should increase so that is why it is irreversible exo or endo does not matter okay only reversible you will have problem okay good, so this is very simple then we will see later how do we use this for our graphical design this is the 1st one.

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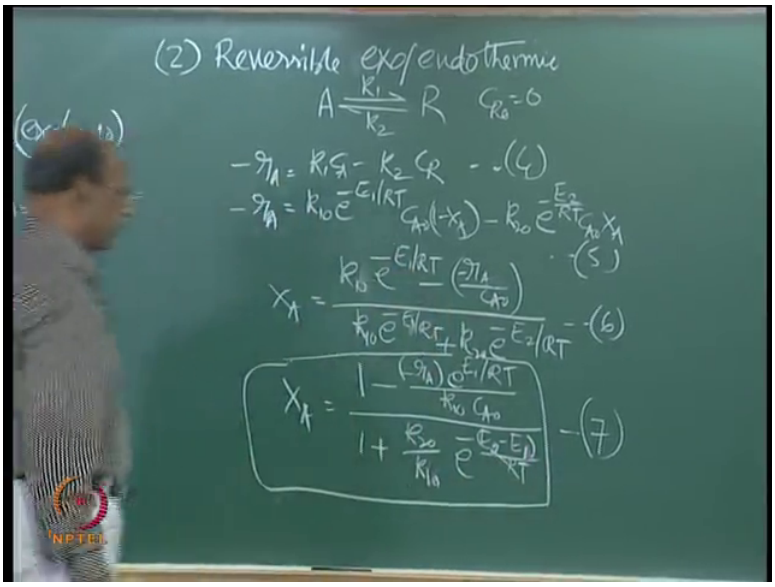

Then the 2nd case is I have reversible endothermic okay first I will write exo or endo because the equation is same only sign changes endothermic exo or endothermic. Now it is reversible simplest scheme which we can write without getting confusion with mathematics is the scheme where C R is not equal to 0 much simpler okay only C a not is there and for exothermic endothermic also know that e 1 e 2 depending on those 2 values you can find out which is endo which is exo (())(8:37) I will tell you little bit later right. So now what is the rate equation here minus r A equal to k 1 C A minus K 2 C R so this is equation number 4.

So this equation I can write in terms of its activation (())(8:58) or any equation this is k 10 e power minus E 1 by R T into C A not 1 minus X A for the 1st part. 2nd part k 20 that is the frequency factor e power minus…am I crossing my boundaries okay e power minus E 2 by R T into C A not X A, so this is equation 5 okay this is minus r A. So this also I would like to write in terms of X A this algebra you have to do on your own it is very simple it is L KG algebra separating X A and writing in terms of minus r A and temperature that is all, so if I do that then all this thing again I have to blackmail you saying that this may come in the surprise test otherwise you do not do it that is the problem so but anyway this X A can be written as k 10 e minus E1 by R T minus r A not by C A not and whole thing divided by k 10 e power minus E 1 by RT plus k 20 e 2 by RT okay.

So this is just separation and I can also write that in a much nicer way where X A yes 1 minus r A e power E 1 by RT this divided by k 10 C A not again this whole thing divided by 1 plus k 20 k 10 e power minus E 1 minus E 2 by RT yes so this is a nice form equation 6 thank you. Yesterday I made a mistake in writing that (())(12:06) equation yes that K 1 K 2 I have written small actually both of them are capital K 1 and K 2. Actually it should be K by K not but both are capitals the other side we have T and T not so that is corresponding to that K not and K I am sorry capital K right yes so please correct that (())(12:40) I think Rashmi or someone…where is Rashmi? There she is or Janvi I think they found out that it must be capital K 0 and capital K then only that limits will be satisfied otherwise… because normally our convention is small k are for rate constant and capital K are for equilibrium constant so that is why okay good. So this is the one and now…

Student: (())(13:08)

Professor: You are right E 2 minus E 1 otherwise I should have remove minus there. So now actually this E 1 minus E 2 is what?

Student: (())(13:43)

Professor: Heat of reaction, do you remember that reaction coordinate diagram I thing which I have told you some time back also okay. So I maybe I have to draw for some other people who do not want to member so that is why again I write once more so that they will remember I think maybe I will draw here as a small 1.

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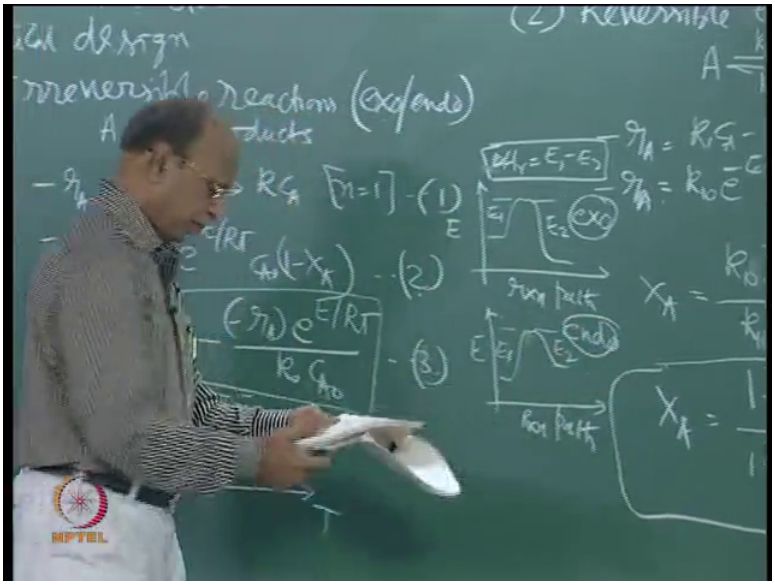

Yes what are the coordinates? Energy and…

Student: Reaction.

Professor: It is not reaction there is actually reaction path okay. So when we have this kind of may be this is (())(14:26) this is 1. Same thing reaction path versus E then I may have another one…not so much, correct. So what is this one? Yes this is E 1 E 2 please remember this this is a nice questioned to be asked in the interviews okay yes then this one will be E 1 E 2, so which is endothermic which is exothermic here? This is as this means E 1 minus E 2 this will be negative value so this is exo and I have to also write here delta H okay I will write here itself. In general Delta H r equal to E 1 minus E 2 right, so if E 2 plus is greater then this becomes negative then it is exothermic reaction and the other one is Endo, so this is exo yes this is the one right.

Student: (())(16:06)

Professor: E 1 minus is the top one is endo yes you are right okay sorry this is endo this is exo.

Student: (())(16:28)

Professor: No E 1 greater than E 2 yes what I wrote is right.

Student: (())(16:42)

Professor: This one you are telling.

Student: Yes.

Student: No sir E 1 minus E 2.

Professor: What is it that you are playing with me? I think I do not want to listen to you so I think I have written E 1 minus E 2 doesn't matter yes that is right yes do not play because I started listening to you that is very bad I thing I have to take my own decision I have everything here okay good yes so this is the one okay so now this one will be now accordingly the values of E 1 and E 2 this will be either exothermic or endothermic that is why as far as derivation is concerned I have written here exothermic or endothermic right. If delta H r is negative then we have exothermic and if Delta H r as positive we have endothermic okay. So now let us plot those graphs.

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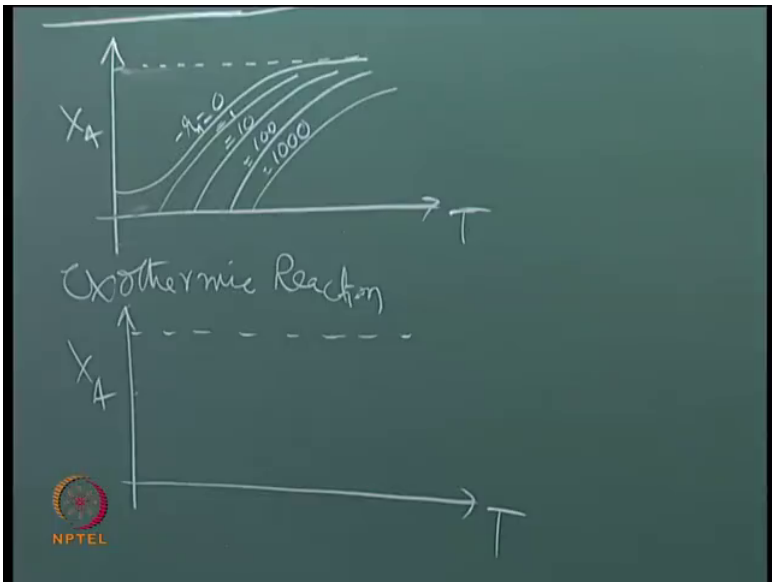

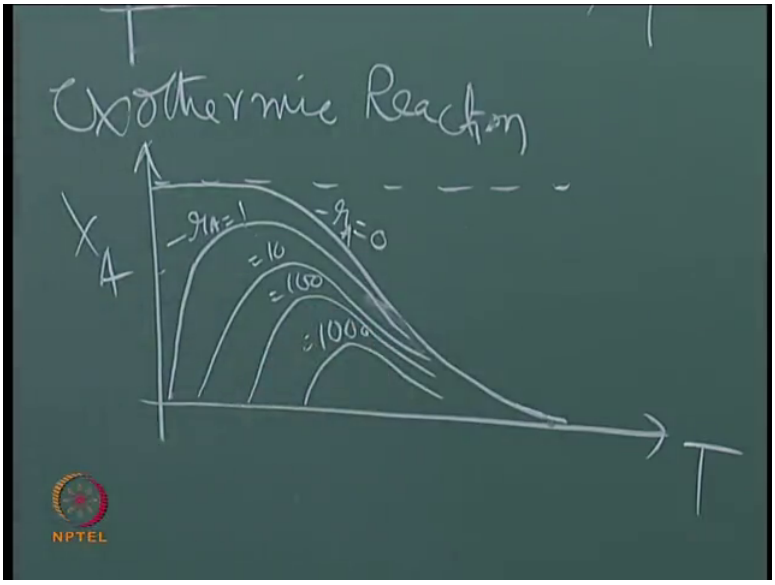

So now I will take endothermic case Delta H r is positive good, so what kind of graph I will get if I want to plot again same thing X A versus T, this is what the question which I asked you long time back in ())(18:07) exam yes tell me how do I draw that?

Student: ())(18:17)

Professor: So how do I draw it tell me.

Student: So as the conversion decreases.

Professor: Okay first what you have to do it is a reversible reaction that means r A equal to zero also possible right or equal to zero so that means I can substitute here r equal to 0 per reversible reaction then I will worry about Delta H r equal to positive or negative, so this term will be there for r equal to 0 this will vanish, so this will be 1 by all this okay, so now as r equal to 0 it is a function of only I mean r equal to 0 now calculate for different ())(19:05) what will be the x straight forward so then you will get what length equilibrium line or some other length you will get the equilibrium line. How the equilibrium goes?

Student: ())(19:20)

Professor: You are telling increase like this.

Student: ())(19:25)

Professor: You said increase or decrease?

Student: Increase.

Professor: You are telling increase like this like you know 10 kilometres like this and 1 micro-meter like this.

Student: Sir as t increases x decreases.

Professor: Yes tell me.

Student: Sir decrease the temperature.

Professor: Recently also I have plotted and even yesterday I plotted it is there see yesterday's notes.

Student: Yes it is there.

Professor: Where? Is it increasing or decreasing?

Student: Increasing.

Professor: See I can happily draw there without asking you but by asking you I thought some of you will think that is the reason why I am again asking many times same things. Yes Abdul now you tell, increasing and decreasing? Okay now you draw you tell me I will draw. Do not be afraid as all of us can make mistakes I also made many mistakes and you played with me also okay tell me.

Student: (())(20:35)

Professor: Very good, so it goes…no he has shown me as it goes like that is enough correct what he said is right, so this is and finally anyway this one will be yes and that maximum you know equilibrium yes that means under extreme conditions it can go to one also okay good so this is the one this is r equal to 0 not below that is right yes. So then if I take r equal to 1 for example r equal to 1. See as temperature is increasing what will happen to the rate? It is increasing here but you can actually calculate anyway I am going to give you an exercise also which you have to do on Excel and then you will know yourself okay, so depending on Delta H r value you have to calculate x versus T and then plot okay you take this value Delta H r one is positive one is negative, so then you will know actually you feel it when you are doing so that is the reason, yes.

Student: (())(21:48)

Professor: We just talked about that.

Student: (())(21:55)

Professor: No, this is okay I mean you can like …

Student: (())(22:00) even if below it is above.

Professor: So what?

Student: (())(22:11)

Professor: Can be there, it can be there. Absolute value only I have to find out whether positive or negative that is all once you subtract one from the other okay yes the total is negative, total is positive I said, yes Delta H r right, so that is why I think that is no problem. Yes you tell me the other one, r equal to 1 below that how it goes same shape

Student: (())(22:42)

Professor: Yes it is not exactly same shape, it goes something like this, something like this trying to reach, so this minus r A here equal to 1, 10, 100, 1000 like this okay this is for endothermic okay good, so exothermic here also I have to write reaction okay same again X A versus T okay, so this one first r equal to 0, same equation but I think depending on this values you will get yes, so it starts from almost to the top like this it goes okay good this is r equal to r A minus r A equal to 0. Now for very small r, r equal to 1 for example.

Student: (())(24:13)

Professor: Yes it increases and decreases because for exothermic reaction forward reaction till some point it will increase then backward reactions starts dominating, so it will come back again, so that is why it reaches a maximum and then goes like this not touching that if it touches then again 0 it cannot because this is a value for r so you also have another line like this, another line like this, another line like this, so this is minus r A equal to 1, 10, 100, 1000 good, so the actual optimisation problem is only with exothermic reaction that optimisation thing we will talk later, little bit later. Yes okay, so now how do I use this information for the graphical design okay, so who will take the simplest one for graphical design that is you take some general curves for graphical design okay, so this is the information we will discuss again later for as far as optimisation is concern how to use this this this and all that but now you take any of those general figures like this figure I will take 1st right.

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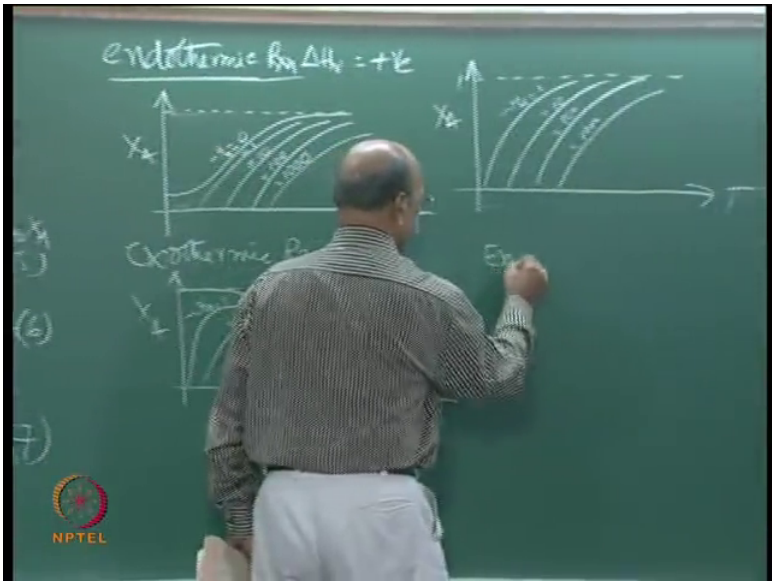

So that figure is just exaggerate and then try to draw here X A versus T, so did you have maximum is 1 there like this, this is rate minus r A equal to 1, 10, 100, 1000 like this okay, so what I have here is I just use only now the material balance equation I think you know without talking about any reactor but this is equation what I have used and now I have generated that information. Now to get this volume of the reactor now I have to use what? Another minus r A. Why we have various minus r A is there. No one told you this one in your B Tech or M Tech this design (())(26:51). I mean this part is really wonderful part in (()) (26:56) and most of few would have used only (())(26:58) book.

Student: (())(27:01)

Professor: Yes you avoid because you know if you learn you have to write in the exam.

Student: Reaction path

Professor: What do you mean by reaction path?

Student: (())(27:12)

Professor: Yes, it is not reaction path from energy balance you should now get the relationship between conversion and temperature if you have…no I told you that are simplest case adiabatic you will get a straight line resuming that Delta H r equal to constant, so if you plot that then that line will intersect all those rays okay. If you take for example adiabatic right but it need not be adiabatic all the time that means you may have some time the non-

adiabatic case where if you are talking about reactor you know plug flow reactor, along the length you have various temperatures and also you have various rates or conversion various rates and also various conversion but energy balance give this conversion versus temperature and the way I remove heat any shape of line I can get it is not straight line the way I get adiabatic case. Adiabatic is a special case right adiabatic is a special case so you conversion versus temperature line or you know that the extension…

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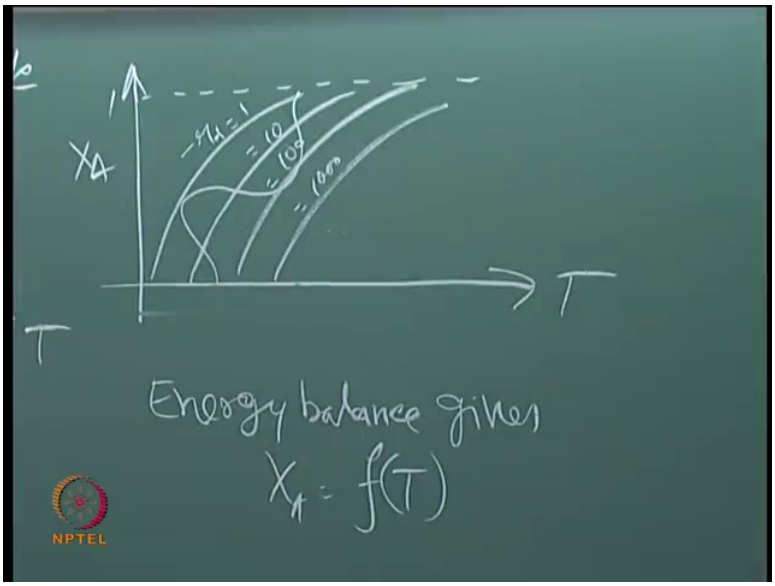

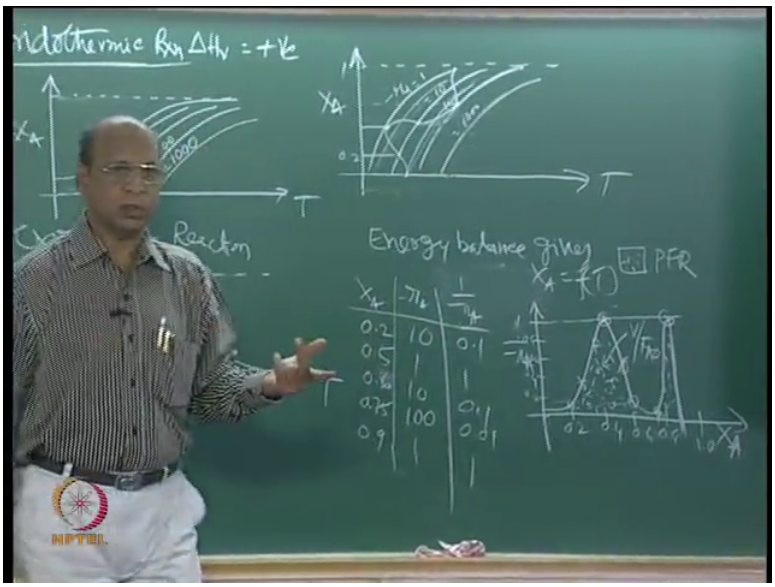

Okay I think I will also tell you here energy balance will give me… Energy balance gives X A as a function of temperature okay and of course you are taking here for simplicity Delta H r is constant and all that over that wide range, so this relationship if I have adiabatic case and

also Delta H is not varying with temperature not only Delta H r there is another thing also which varies with temperature in the energy balance.

Student: CP.

Professor: CP can also vary with temperature right because in that relationship you get definitely Delta H r and also definitely CP I also derive one equation just to give you a sample but this one as just simple analysis, so this relationship I can plot whatever way I can plot whatever way I wanted right so For example lime say that I have a relationship something like this, this is crazy you may (())(29:33) but still it is okay like this, it is really crazy okay but I can have that kind of crazy also because it only depends on how I am removing heat along the length of p of r this is p of r, this line is for p or r, so now I have drawn this. Now I have entire design information on that graph, can you identify that information? I have the entire design information on that graph. Have you thought about these? This is very beautiful one.

Student: (())(30:14) till (())(30:21)

Professor: That is not… indirectly you are solving that minus r A, temperature and corresponding rate that is what you know when you are plotting that each intersection will give you only that information, so that is why I may take for example here this is X A and correspondingly this is r A, so this is X A this is r A means 10 okay this X A maybe I mean just let me say that this is 0 to 1, so this may be 0.2 and this may be not this may be as it is exactly 10 correct it is cutting here then it is going here. There are many lines in between you can draw any number of lines you can take any number of r and any number of axis okay but here from this graph only I have few so I am just trying to draw that.

In fact there is another line also which goes here r equal to 5 for example, so then again you have to take this line and this line and of course when you are going systematically it conversion right so okay. Now just ignoring that now you have this point where I may say that okay that is equal to 0.5 what is the value 1 r equal to 1 and again it is coming to this point where this may be point 6 x equal to 0.6 and what is this value 10 okay so then next value somewhere here you should increase yes like that, so this one may be 0.7, 0.8, 0.9 to okay I think approximately I can say that this is touching here, touching here that may be 0.75 okay.

So then what is the value 100 and finally this may be around 0.9 right and what is the value again 1, so now I have to… I will remove this one function okay this is 1 by minus r A so if I simply plot 0.2 equal to 0.1 this is one this is again 0.1 this is again 0.01 and this is one, how do I plot them? I think where is Savita, so Savita what you asked yesterday I just want to give this one so that is why I have drawn that crazy line, so now I can plot 1 by minus r A versus X A I have that information right it is a plug flow reactor, so it is starting with 0.1 minus r A equal to point to one somewhere here what is the maximum value 1 okay, so this may be 0.2, 0.4, 0.6, 0.8 and then 1 okay, so now 0.1, 0.2 (())(34:00) this also 0.2, 0.4, 0.6 okay this is 0.2, 0.4, 0.6, 0.8 this is one okay so just approximately trying to draw that, so then for 0.2 it is 0.1, so somewhere here the point okay good.

So then what value, next one is 0.5, 0.5 is somewhere here and the one jumped here this is the one towards 0.6, 0.1. 0.1 means again 0.6 this is one, so it has come to this point okay then 0.75, 0.75 is somewhere here so this is again 0.01 still less okay then 0.1 again increase to 0.9 here this is one. How do I draw now? Of course here to start with may be somewhere here that means corresponding to x equal to 0 also I have to calculate that value okay or I have x equal to 0 how do I get from here. Yes x equal to 0 is this line that means there is another line which is also going through like that right, so that value also end understood or lost hope okay.

Lost hope because I have started putting values there if I have not put values generally probably you could have been in the class okay yes but anyway corresponding points we have to take and then plot and you will have yes some value here definitely, so you will have like this, like this, like this yes. So now what is the volume of the reactor? Because we have plotted for plug flow, so area under the curve all this area…this is really crazy place and if I take this is my conversion is 0.9 okay so this one equal to PFR.

So area under the curve will be v by F A not okay and this is really crazy as I told you okay this is really crazy but I just want to tell you but it can be really crazy also depending on the way you remove heat that depends on what is the functionality between X And T but nice (()) (37:02) will be adiabatic reactor where you will get a nice way of that 1 by minus r A versus X A you will get some other very nice way for this kind of increase in the rates because again if you go to this kind of increase in rates then you will have a different kind of I mean graph that means I am talking about minus 1 by R a versus X A graph.

But what you have learnt here is that the extra thing is that even with non-isothermal reactors the final area under the curve only will give me the…that cannot go wrong right but instead of integrating now I can find out those points correspondingly, the intersection points between r and then yes corresponding x right and I have drawn here how many points 1, 2, 3, 4, 5 only but you can draw any number of lines in between so that you will know again another point here maybe another point here another point here all that because between this and this Afzal how many lines I can draw?

Student: Infinity.

Professor: Infinity so that is why you can draw whatever you want and then get that for smooth curve so that you can join nicely right so that is the graphical procedure and now if I just want to know that for adiabatic case okay (())(38:27) PFR none of you asking me what do I do for CSTR okay that is what I told you I have to question and I have to answer but you do not. Sir I think is beautiful PFR now you tell me how do you do MFR okay anybody asked like that? Okay so now how do I do it for MFR? How do I do it for MFR? I think maybe these equations you have noted down I will remove this yes.

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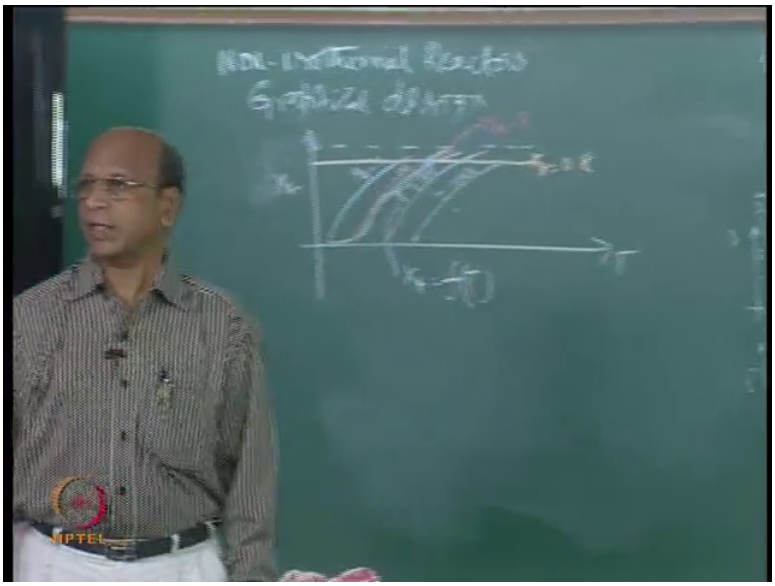

Let me say that I have the same X A versus T graph yes, so r is increasing anyway in fashion this is r A equal to 1, 10, 100, 1000 like that okay tell me.

Student: (())(39:34) till (())(39:39)

Professor: Yes how do I find out that?

Student: (())(39:41)

Professor: What is the problem I am asking? Is it volume of the reactor? You have to find out volume of the reactor the area under the curve, so that means what you should know?

Student: (())(39:56)

Professor: How many times I have repeated this if you know the volume what you can find out?

Student: Conversion

Professor: If you know the conversion what you can find out?

Student: Volume.

Professor: So that means what I am asking here? Volume okay that means you should know conversion definitely you should know conversion. Let us say I have 80 percent conversion? So that means I can draw that line 80 percent conversion line there okay yes right. So it is exactly the same thing you know even if this graph is crazy so it is going like this you know this is X A as a function of T now you see this graph is starting at only 1 point which is yes this point are you able to see that point? Right yes so this line and of course I have put 10 there but it may be 8 line 8 this is also of course this turn is also cutting here okay I think I will also plot and nicely we will have different colours here.

So my x versus T graph is like this okay and I have another nice color yes this is X A equal to 0.8, so now you see this line this line that means you know this is okay this red line this is minus r A equal to 8 that is 8 minus r A line and this is X A line equal to 0.8 and this line it is going and cutting here, so that means this is the point another color that is the point okay because in mixed flow reactor there will be only one point I think you know one rate corresponding to 1 conversion. Conversion be fixed already now you can also get correspondingly what is the temperature from this graph. So all the outlet conditions you have now. Like you know X A that is the line which you have drawn and you know minus r A now where it is cutting right and also you know corresponding temperature so that is how you do.

Even for recycle reactor also, so recycle reactor what you have to do is you will draw a line something in between like this I mean if it is a straight line need not be straight so it can be

like this but you know that conversion is not 0 in a recycle reactor when it is entering reactor that part you have to remember but whereas there and here x equal to 0 right the entry x equal to 0, so that is why you can now also extend this one for recycle reactor right even batch reactor I mean all reactors whenever you have temperature versus conversion relationship and you have this information this kind of graph.

We have done it for simplest case like you know we are going to minus r first order reaction right but you can plot these graphs and also all those graphs for any kind of rate but only thing is you have to separate x-ray and then you have to write that in terms of minus r A and T temperature, so plot this way because this is the most convenient way of getting the information for the design okay understood. I thing not that happy I do not know why because you lost somewhere please tell me if you have not understood Devang lost somewhere? Yes Abhijeet.

Student: (())(44:18)

Professor: No. That is any curve that is that means any kind of heat exchange I have. See I told you that this X A as a function of temperature that relationship you get only from the energy balance right, so that energy balance when you are writing may be probably I have to write that and then tell you okay I will write that and then tell you may be that still there may be some people who may not be understanding that okay, so now I will write for yes adiabatic reaction okay I think this equation is not required okay Abhijeet may not be following but any other people also not able to follow how do you get that line? Devang you are also not able to follow? Okay so then what did I tell? I mean what is the meaning of writing there energy balance gives x as a function of temperature what is the meaning of that? No meaning yes may be you tell that you know if there is no meaning you can write there is no meaning.

Student: (())(45:34) till (())(45:41)

Professor: That is all and what kind of relationship you can expect? You tell me what kind of relationship you can expect?

Student: (())(45:51)

Professor: You cannot expect any kind of special kind of relationship okay but only for adiabatic is you can expect sprightly.

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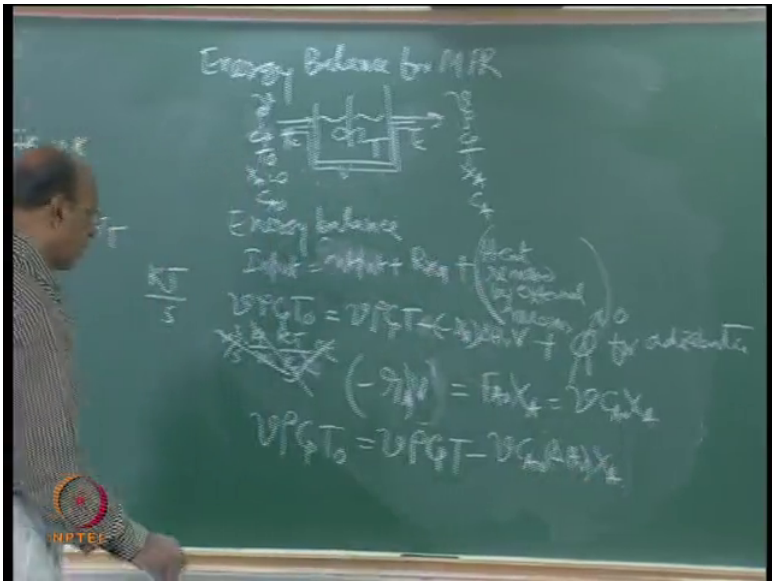

So that is why I just want to give now that adiabatic you know the energy balance and for the simplest reactor mixed flow then you will know that energy balance or MFR okay so let me give you this yes this is the one and here I have volume, volumetric flow rate, volumetric flow rate constant instant all that we are assuming and also I have here the density is rho that also is required and one-way of writing and I have CP and T not here also I have rho is any way constant and then CP T but okay X A. This is 0 X A not equal to 0 and of course I can also get C A not and all that also here C A not I can write here C A also I can write there.

So if I want to write this equation you can also write in terms of F A not of F A, F A means molar fluorine okay but now we are writing in terms of volumetric flow rate V is the volumetric flow rate okay good, so now energy balance, energy balance what we have is input equal to output plus energy generated are consumed due to reaction okay. If it is exothermic reaction it is generated if it is endothermic reaction absorbed okay yeah plus it is sturdy state only it is not unsteady state yes plus we have heat removed by external means so that means I may have here jacket and some amount of heat is…this is T okay T C also T C that means you have the heat capacity of this fluid so high, the temperature increase in that I am practically not seeing.

Assumption, it is simply an assumption okay it may be there may be 1 degree increase okay so but as an engineering, as an engineer first I want to simplify the problem understand and then the remaining things I can follow later, so that is one this is what than when I am writing this I can write here this heat input is okay first of all heat input should be what are the units I have to balance it is kilojoules per type okay that is what is the heat. So this is V rho C P T

not that is what is entering here equal to V rho C P T not that is what is entering here equal to V rho C P T right that is coming out and reaction if I take I have exothermic reaction then this becomes negative so that mean you know I should have written input because that also becomes input inside so that is why okay I write here plus or minus minus R A into Delta H r what are the units of that?

Student: (())(50:01)

Professor: Into volume and what are the units of this? This this matrix cube power second and this one is the kg per metric cube and C P is kilojoules per

Student: (())(50:27)

Professor: Yes this is where you make the mistake you know that depends on this flow rate okay if it is KG per metric cube this will be expressed per kg. C P you can expressed based on your molecule weight either based on mole or kg so that is why please be careful in the examination you will make that mistake that is why better write that but in this case it is kg per degree Kelvin or maybe degrees centigrade I will put here okay. So then I have degrees centigrade, so now this is cancelled this is cancelled this is cancelled I have kg per second kg per second, so that is the balance what you are making plus I have this external means as simply Q where Q equal to U a Delta T. What is a? All this heat transfer area okay.

What is U? The heat transfer coefficient between this liquid and overall heat (())(51:32) okay that U a and Delta T is this because everywhere have the same temperature T because here you have T right everywhere you have temperature this is P minus T C everywhere and that is why we assume that we have a fluid where it can observe any amount of heat without increasing its temperature that means this C P must be very high. Yes Rahul.

Student: (())(52:04)

Professor: Yes that means you know I have to right here negative the center quantity as negative if I have exothermic that means that will become input here okay.

Student: (())(52:19)

Professor: Yes I thing that is fine no problem yes that is fine depending on Delta H r value I thought you will write that okay so now this is the equation, now what we are saying is if I take that this is 0 what I have? Adiabatic system there is no heat removal for adiabatic. Rho

and C P we are assuming that they are not changing with temperature because I think all these are assumptions otherwise unnecessarily the equation will be so complicated I told you will forget about actually what we were discussing and worried about a big equation that is the reason why we are simplifying to understand the concepts okay good, so now if I separate this and yes I have another equation here this is delta H r and what is that we need? We need a relationship between conversion and temperature but is it? This is the material balance equation but is it relating conversion versus temperature?

Student: (())(53:27)

Professor: Yes so now I have the material balance equation where minus R A into V equal to F A not XA. F A not I can also write in terms of V by C A not yes V in to C A not because I not used F A that is why I am writing their okay so now I can substitute that here so what you get here V rho C P T not equal to V rho C P T not equal to V rho C P T. Then I have we here for minus r A delta V I have V minus V C A not yes V C A not X A Delta H r into X A right. So this equation I can now write T minus T okay

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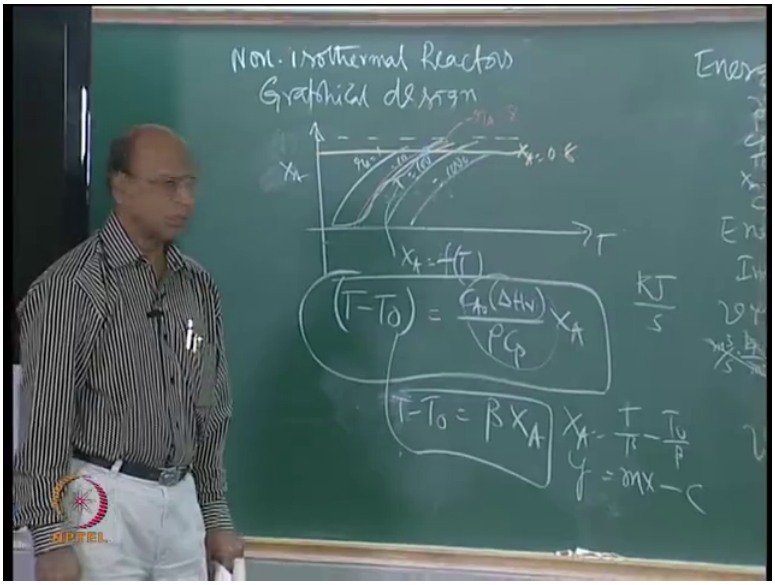

Here I will write T minus T not equal to see that whether I am writing correctly or not C A not Delta H r by rho C P into X A, check this you get it? Good very good so now this is what we are calling as beta, so T minus T not equal to beta into X A okay. Now how do I plot this information on this graph? Or shall I draw a fresh graph X A versus T yes I mean what is the slope? Do I know the slope? 1 by…

Student: (())(55:51)

Professor: Excellent it is 1 by beta right because X A is Y this is T so I can write this equation only as X A equal to 1 by beta okay this is T by 1 by beta minus T not by beta not 1 by beta, so that means this is y this is a max and this is C okay or plus A that depends on that okay good so now this is the one what is slope now for me 1 by beta.

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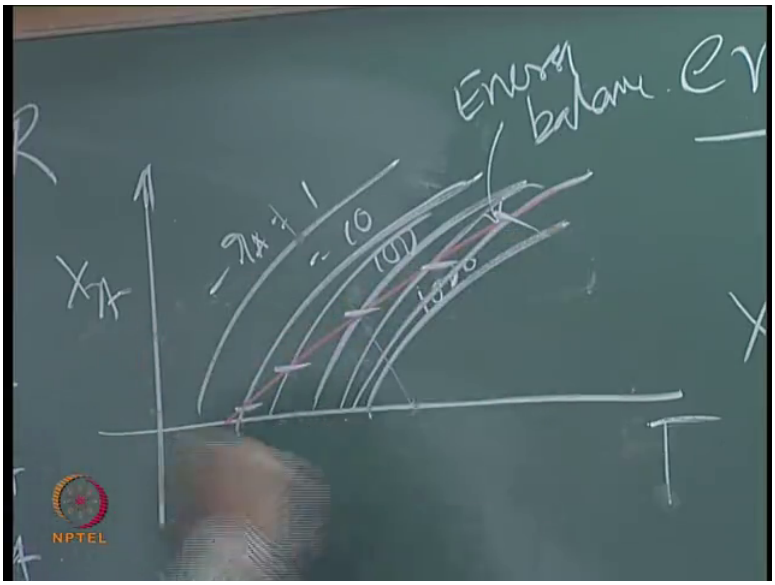

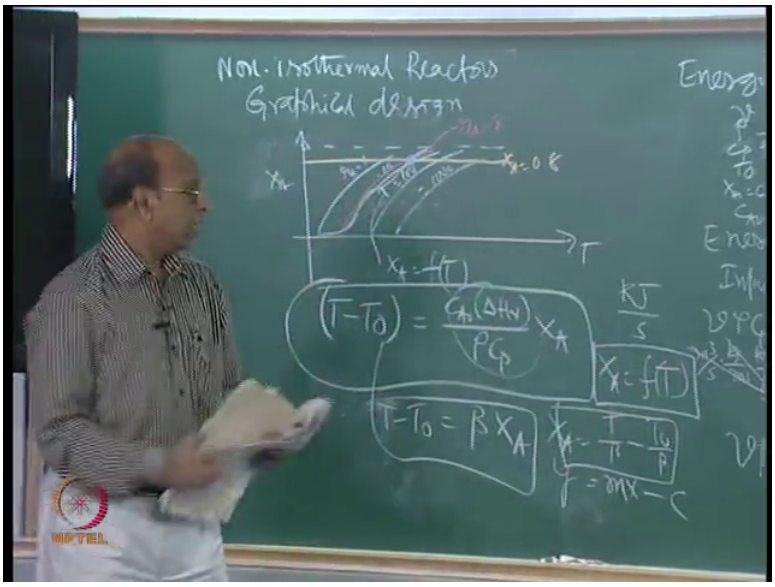

So when I plot that here if it is exothermic reaction the temperature must increases right, so okay good so this now it goes something like this right so this is minus R A equal to may be 1, 10, 100, 1000 like this so this is energy balance right so then I can also draw number of lines here uhh.

Student: (())(57:20)

Professor: For exothermic?

Student: (())(57:21)

Professor: For exothermic it is positive in fact for endothermic it is negative it goes like this, it goes like this for endothermic okay yes how can you say that because for exothermic as conversion is increasing temperature much increase or as temperature is increasing conversion must increase okay good. So this one yes now here this is a point, this is a point, this is a point, this is a point and in between another line here this is a point.

So now you can see this point X A versus minus r A, X A versus minus r A, X A minus r A, X A minus r A list out like that exactly and then plot 1 by minus r A versus X A then area under the curve that will give you diagram. Abhijeet okay yes because this is the functionality what you are telling. This we say now T you know XA this one as XA as a function of T this is what you have to… Now if I add this Q and then solve that equation because there is another T also here because that is T minus T C in this Q okay did I write that?

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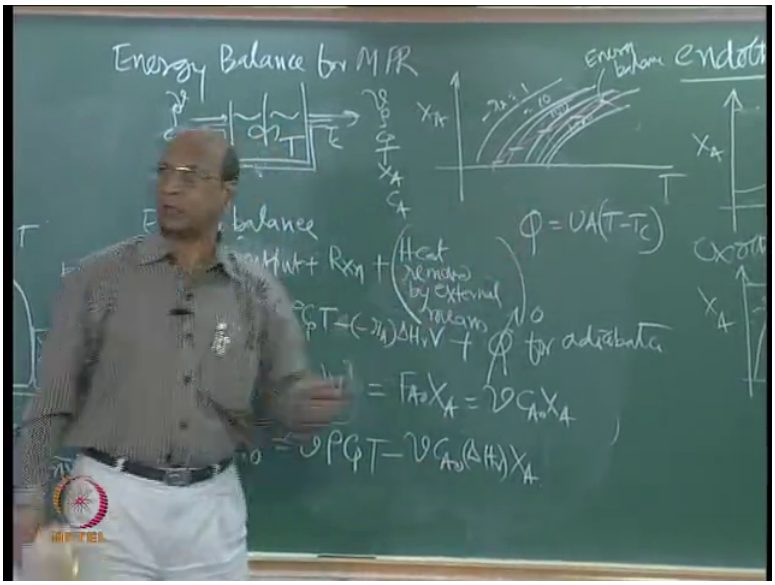

Okay this Q is U A delta T which is nothing but T minus T C that I have to substitute there yes in this one. Now then depending on my Q values how I am operating sometimes you know I may operate sometime only with some Q afterwards some other Q then it may take any other part crazy? Yes so that is the one what you are talking that energy balance gives X A as a function of temperature energy balance giving the functionality the relationship between conversion and temperature.

This is what is the simplest case what we have taken and I will draw for each reactor and we will derive for each reactor the energy balance equation material balance equations and then we will try to find out how do you solve those equations for finding out the actual volume of the reactor okay so that is what you will do in the next class and I know you will be unhappy if I include this in the examination Monday right yes so I think Monday all this will not be included or shall I include? Very simple right.

Student: (())(59:52)

Professor: 3rd tests you will have okay good, so then I think till multiple reactions we will have you know it does not mean that I am giving only multiple reactions. Multiple reactors and multiple reactors only we have done, so portion for the 2nd quiz is from 0 to multiple reactions from beginning to multiple… What is the other thing? Once you understand multiple reactors and multiple reactions the other one is LKG single reactors and single reactions are LKG only, so that you should not crib okay yes.