

welcome everybody to the lecture number three on chemical kinetics

so again a brief recap of ah you know what we were doing in last class was that especially in the latter part of the class we entered into this rate of a chemical reaction

and we were saying that this rate of a chemical reaction means that we are following how the reaction is progressing as a function of time and now to follow this we can either look at

the change in concentration of the reactants or the change in concentration of the

products and we use certain techniques certain analytical techniques right it can be you

know pH change it can be color changes you know it can be a change in pressure it can be change in

conductivity there are many ways by which you can monitor a reaction or the progress of a reaction

and again the progress of the reaction can be monitored either by looking at the change in the

concentration of the reactants or the change in the concentration of the products or both ok

now there is also a very important point that we made the point was that you know reactions

are temperature dependent right

so if you are not interested in the temperature dependence of that reaction then you please make sure that the reaction you are performing is being

done at a constant temperature that means you are maintaining the temperature which we typically

call as isothermal conditions and then you go ahead and do the reaction provided the temperature

dependence is not your goal however it is obvious that if you really want to measure the temperature

dependence of the reaction rate then you have no other option but to allow the change in

temperature to happen

so that you can get the temperature dependence ok

so then after that

you know having you know said all these what it did was we moved on to a reaction and the reaction

is as its given out here i will not write it again

so the reaction is ah that of hypochlorite

ion with bromide giving hyper bromide and chloride all of these are in the aqueous

phase that is a homogeneous reaction taking place in the same phase ok

so we

say that this is an example of a homo genus reaction ok that means the reactants are

in the same phase and

so are the products okay as again i mentioned a few minutes ago the kinetics of this reaction are being studied at a fixed temperature of 25 degree celsius or

298 kelvin that is again you are maintaining isothermal conditions ok good then we had just

started to draw a reaction profile now what does this reaction profile mean  
this is a kinetic  
reaction profile the kinetic reaction profile is a plot is a plot of what it  
is a plot of the change  
in the concentrations of your reactants and or products as a function of time  
so let us  
go back and take a closer look at the plot  
so on the x axis you have time in seconds that  
means the time is increasing in this direction ok  
so the time is increasing in this direction  
and on the y axis you have the concentration which we are expressing in moles  
per liter or molarity  
and the concentration is also increasing in this direction ok  
so that means along the y axis you  
start from zero and then the concentration is increasing along the x axis  
again you start from  
zero and the time is increasing in this direction now what do you see out here  
what have we  
plotted first if you look at this two blue lines see the first blue line  
corresponds to the  
concentration change of hypochlorite the second blue line corresponds to the  
concentration change  
of bromide right and what about the green line the green line corresponds to  
the concentration change  
of hypobromite and  $\text{Cl}^-$  that means either you are looking at hypobromite  
that is bromide ah  
that is  $\text{Br}^-$  or  $\text{Cl}^-$  and both of them change exactly in the same  
way that means if  
you are looking at  $\text{Br}^-$  only the hypobromite it will follow this line  
green line again it will  
if you look at  $\text{Cl}^-$  separately it will follow exactly the same line that  
means these two are  
super impossible on each other they are identical ok that means the change in  
concentration of the  
products with time is identical that is why we have only one curve one green  
line let us think  
about this a little more deeply about this plot  
so when you look at these circles when you look at  
these circles all these circles out here you know these circles  
so these circles on all the three  
lines the two blue lines and the green line these circles are your  
experimental time points  
which means that suppose if you consider this line of you know three circles  
this one say  
corresponds to  $t_1$  then this corresponds to  $t_2$  this corresponds to  $t_3$   
three this  
corresponds to  $t_4$  this corresponds to  $t_5$   
so what does it mean what it  
means is now suppose you look at  $t_1$   
so let us focus on  $t_1$  at  $t_1$  you have one  
circle on the green line which is that of the products then you have another  
circle on the line  
signifying the concentration change of  $\text{Br}^-$  then you have another circle  
exactly at the same time point on the line signifying the change in

hypochlorite

which means which means that at  $t_1$  at  $t_1$  you have measured the concentration of all the species which are hypochlorite this one then bromide which is this one and the hypobromite

or  $Cl^-$  which is this circle

so at  $t_1$  you have these three circles

so to repeat at this time

point  $t_1$  in seconds you have made measurements with respect to what you have made measurements

to rest with respect to what is the concentration of hypochlorite which is given by this one

then what is the concentration of bromide at  $t_1$  which is given by this one and then what

is the concentration of hypobromite or  $Cl^-$  which is given by this circle on the green line

now similarly what you are doing is because it is a kinetic plot that means you are looking

at the reaction as a function of time

so you do not stick to just one time point which means

that you have to go and collect you know do your experiments at other time points too

so then what

you do is you go ahead and say that ok let me take another time point  $t_2$  at this time point  $t_2$  say

at this time point  $t_2$  what i do is i again make these measurements

so i see i get another blue

circle for this bromide right then this green circle for this either hypobromite or chloride

and then another circle for this  $Cl^-$  again all these three circles if you see are

falling right at  $t_2$  that means at  $t_2$  you have made measurements of concentrations of all

these species right

so likewise what you do is you collect more time points that means you go to  $t_3$   $t_4$   $t_5$  and that is why according to the time points you will

see that especially on

this plot you have three circles according to each time point

so in a nutshell what you have done is

you have followed the reaction how you follow the reaction by looking at the change in concentration

of bromide looking at the change in concentration of hypochlorite and also looking at the change

in concentration of hypobromite and  $Cl^-$  and because hypobromite and  $Cl^-$  give you

exactly the same change that is why you do not see two different curves you have one curve which both

of which are rather which signifies that both  $BrO^-$  and  $Cl^-$  they are following the same

trend ok good now before i proceed further i would also like to make one more point the point is see

these circles which we were just talking about at length these circles are your experimental points

experimental point means that at  $t_1$  at  $t_1$  right you have measured the

concentration say of hypobromide or  $Cl^-$  then at  $t_1$  you have measured the concentration of this is bromide and at  $t_1$  you have measured the concentration of hypochlorite like this you do the same thing at  $t_2$   $t_3$   $t_4$  and  $t_5$  now what I was trying to say was that you should understand that that these points all the circles are your experimental data points right so the experimental data points if I can make the you know comment right now the the circles seen on the plot are experimental data points so that means at every time point say  $t_1$   $t_2$   $t_3$   $t_4$   $t_5$  in seconds since the start of the reaction you have measured the concentrations so you have measured the concentration of say  $Br^-$  you measure the concentration of  $Cl^-$   $BrO^-$  then you measure the concentration of  $BrO^-$  you also measure the concentration of  $Cl^-$  again when you go to  $t_2$  you repeat so that means again you at  $t_2$  you measure the concentration of  $Br^-$  you measure the concentration of  $Cl^-$   $BrO^-$  you measure the concentration of  $BrO^-$  you measure the concentration of  $Cl^-$  and then you repeat ok at the other time points having done this what you have now is that at each and every time point you know exactly based on your experimentation or based on your experimental results what the concentrations are of your products and also of your reactants if you are looking at this you know time point then one thing I should mention out here is this zero what is zero this  $t_0$  we say or the zero point if I if you consider this to be my zero point the zero point is often referred to the time zero the time zone is essentially just at or before the start of your reaction which means that you have said your watch right or your experimental time now what you are doing is you are saying that zero time is the time just before the reaction is starting right at that instant it is zero just before the reaction is starting and then you see you allow your clock to run whatever you know means of recording the time you have so then once I have  $t_0$  out here then related to that  $t_0$  I have  $t_1$  then  $t_2$   $t_3$   $t_4$   $t_5$  and so on so that means your time is always in relation to a certain starting time and that starting time is your zero time or time zero which is this zero it is extremely important you understand this concept that when you start looking at a reaction as a function

of time that time needs to start from somewhere and the point from where it starts is a zero time that means zero time is the time where you say that ok this is where the reaction is just before the start and now you start your time record and you get the rest of the time values ok

so that's then how you did the experiment so think about ah you know think you know visualize yourself doing the experiment so that means you have clocked 0 you have said ok let the reaction start and then you have started taking these time points  $t_1$   $t_2$   $t_3$   $t_4$   $t_5$  and  $t_e$  at each and every time point what you have done is you have measured the concentrations of your reactants and your products once you have once you have done that then you what you got was you got this plot you got this plots that means you got the circles you got the circles once you got the circles to aid visualization to help people and yourself visualize better what you did was you draw smooth lines through the data points so always understand that first you have the experimental data points like you have out here and then what you do is you draw smooth lines through the data points so that it is easier for you to understand how the plot looks like and how the changes are taking place i hope i have emphasized you know the nature of this plot enough that when you look at a plot like this you would be able to figure out what the different components are of this plot and what they mean to you and how they appeal to you here that's something always you should think about and visualize yourself doing the experiment yourself

so let us look at you know let us look at some features of the plot so then say some features of the plot say feature number one in feature number what you see is that the concentrations of the reactants the concentrations of the reactants that are  $c_1$  and  $b_r$  decrease with increase in time ok second feature concentrations of the products that are  $b_r$  and  $c_1$  increase with increase in time ok so these are important decrease with increase in time and then increase with increase in time ok so let's go back to the plot again if you look at this kinetic reaction profile again which are in reactants your reactants are the hypochlorite and bromide so what has happened pay attention this is a zero time that is just before the start of the reaction just at the start of the reaction and then the time has progressed as you move to the right along the x axis okay now as you move to the right at your respective time points  $t_1$   $t_2$   $t_3$  what you

see is that say suppose  
 at zero at zero time suppose at zero time this is the concentration of bromide  
 and this is the  
 concentration of hypochlorite  
 so this one i can write as the concentration of hypochlorite  
 the initial concentration with a 0 or not as a subscript meaning initial  
 concentration again  
 here also i can write the initial concentration of bromide ok  
 so initial concentration means that  
 just at time zero when no reaction has taken place these are my initial  
 concentrations that is  
 the concentrations of the reactants that we have started with now see what  
 happens as time  
 progresses as the time progresses slowly we will see that the next point for  
 hyper chloride  
 comes here the next point for bromide comes here this is at t one now you go  
 to t two this point  
 comes at a lower concentration than this point this point comes at a lower  
 concentration than  
 this point right i repeat this y axis this y axis is where you have your  
 concentration when you go  
 up along the y axis it means there is an increase in concentration when you  
 are moving down the y  
 axis it means there is a decrease in concentration right now follow say the  
 trace for or the trace  
 or the line for the hyperchloritan at this point the hyperchloride ion is  
 initial  
 concentration  
 so we write hyperchloride concentration then with the zero at the  
 subscript saying initial concentration ok now we go to the next point you see  
 that this concentration value this concentration value of hyperchloride  
 is less than this one is less than this one right  
 so which means suppose i write this one  
 is say  $c_1$  ok and suppose you know this one is  $c_0$  for hyperchloride then  
 immediately what i  
 can say is the concentration based on this plot what i can say is that  $c_1$   
 is less than  $c_0$   
 right again just look at this i have said  $c_1$  is less than  $c_0$  this is  
 $c_1$  i am coming down  
 along the y axis thats how my reactant you know you know the concentration of  
 my reactant  
 is progressing as a function of time  
 so  $c_1$  is less than  $c_0$  ok now suppose  
 i go to  $c_2$  what is  $c_2$  let this be  $c_2$  you know i am moving along i am  
 moving along the  
 line which features the change in concentration of the chloride ion  $ClO^-$   
 then i can say that  
 now  $c_2$  is less than  $c_1$  say this is now  $c_3$  ok then again i say  $c_3$   
 three is less  
 than  $c_2$  ok say this is the next circle says  $c_4$  and if i said  $c_4$   
 then  
 i can say that  $c_4$  is less than  $c_3$  and likewise now you can figure  
 out  $c_5$  is less than  $c_4$   
 so this is  $c_5$  i am saying  $c_5$  is less than  $c_4$

ok

so what does this mean that what it means is that as i move from  $c_0$  to  $c_1$  to  $c_2$  to  $c_3$  to  $c_4$  to  $c_5$  what is happening what is happening is my concentration is decreasing along with time this is obvious isn't it why isn't it why is it obvious it is obvious because it is a reactant because it is a reactant a reactant by definition is supposed to react and go to the product side or to the product species which means as i let the reaction go as i let the reaction go the signature of the reaction progressing that means going towards the product side is that my reactant concentration starts decreasing and thats what i am having so  $c_0$  is the initial concentration of  $ClO^-$  repeat then you go to the next time point which is  $t_1$  you get  $c_1$  which at this point  $c_1$  is less than  $c_0$  then i go to time point  $t_2$  where i have  $c_2$  for  $ClO^-$  then this  $c_2$  is less than  $c_1$  and so on ok so along the time points from  $c_0$  to  $c_5$   $c_5$  is the minimum and  $c_0$  is having the maximum value based on the plot we are looking at ok good so it means that the reaction definitely is progressing right because the concentration of  $ClO^-$  is decreasing with time now having you know spent some time on the plot for  $ClO^-$  just look up  $Br^-$  which is the other reactant species ok for  $Br^-$  you start from here so this is  $Br^-$  zero which is the initial concentration of  $Br^-$  then you go to the next point right which is the concentration of  $Br^-$  at time  $t_1$  then you go to the next point which is the concentration of  $Br^-$  at time  $t_2$  and you go on what you see is at successive time points the concentration of bromide ion goes on decreasing again it makes sense because this is the reactant so we have double confirmation what is the double confirmation the double confirmation is of what of the reaction progressing because both the reactants are getting lost that means are getting used up that means the concentrations of the reactants are getting lower and lower as the time is progressing why because the reaction is happening and because the reaction is happening then more and more products are getting formed so last but not the least since you have already monitored the progress of the reactants which are decreasing it makes sense

then the concentration of the products as a function of time should go the other way that means they should increase and that is exactly what you see

so look at the green line now look at the green line look at the green line this green line either belongs to  $\text{Br}^-$  or  $\text{Cl}^-$  and I say that they are identical so if you look at time zero the way the reaction was set was that at zero time there was no formation of any product and hence the concentrations of  $\text{Br}^-$  and  $\text{Cl}^-$  start from zero

so then another you know feature remember we were talking about the features of the plot we are talking about some features of the plot then feature number three then feature number three what we can write is that at time zero there was no product present there was no product present that is that is I can write the initial concentration of  $\text{Br}^-$  at time 0 is equal to the initial concentration of  $\text{Cl}^-$  at time zero which is equal to zero because that's how the reaction was said and when we started the reaction there was no formation of hypobromite or formation of chloride none of these products were present in the reaction vessel

at the time you started the reaction ok then let's look at feature number four so at feature number four you go back and again take a look at this as we just said feature number three was that the products were not present out there at all at the start of the reaction then feature number four is what you look at the initial concentrations of  $\text{Br}^-$  and  $\text{Cl}^-$  you see you know you can ask yourself yourself a question the question is I said that ok the products  $\text{Br}^-$  and  $\text{Cl}^-$  they are super impossible that their kinetic traces are super impossible that means whether I do  $\text{Br}^-$  or whether I do  $\text{Cl}^-$  they will exactly follow the same data points and that is why we have written  $\text{Br}^-$  and  $\text{Cl}^-$  because both of them if you measure the concentration separately they would lie on this line okay however the same thing does not happen for hypochlorite and hypobromite or rather bromide hypochlorite and bromide why is this

so it should be very evident of you look at the initial concentration of bromide and look at the initial concentration of hypochlorite the way we have started with the reaction is such that the initial concentration of hypochlorite is more than the initial concentration of bromide

so we can write here that at time 0 the concentration of hypochlorite is greater than the concentration of bromide right hence the concentration

of  $[\text{ClO}^-]$  at time zero which is the initial concentration greater than the initial concentration of bromide ok

so if i just have to make it a little more clear i can say that what is  $[\text{ClO}^-]_0$  this is the initial concentration of  $[\text{ClO}^-]$  what is meant by  $[\text{Br}^-]_0$  with the zero subscript at the bottom it is the initial concentration of  $[\text{Br}^-]$

so then what was feature number four feature number four was that at time zero the concentrations of the species the reactants  $[\text{ClO}^-]$  and  $[\text{Br}^-]$  are not the same right and how are they not the same in this

way or in this manner that the concentration of hyperchloride the initial concentration which is given by  $[\text{ClO}^-]_0$  at the subscript it is greater than the initial

concentration of bromide right

so just you know quickly if you want to recap the features of the plot

so what are the features the first feature was the concentrations of the reactant species or the reactants which are hyperchloride and bromide they are decreasing with increase in time you

can see for each and every blue circle each and every blue circle along the two blue

lines these are belonging to the reactants as the time is progressing these reactants the

concentrations of these reactants are decreasing feature number two the concentrations of the

products that are that are the hypo bromine  $[\text{BrO}^-]$  and the chloride  $[\text{Cl}^-]$

increase with increase in time

so this is aptly represented by the green curve out here you know on the green curve you see these green points right if you start from time zero as i said at time zero

you have no hypobromide or chloride present that means there is no product species in the reaction

vessel at time  $t_1$  you can see that this is  $c$  this  $c$  is greater than or this concentration is

greater than what you have at time zero right where here no species at all product species at

all now you go to time  $t_2$  you have more product formation taking place you go to time  $t_3$  you

have again more product formation taking place you go to time  $t_4$  again you have more product

formation taking place you go time  $t_5$  ok and based on this plot this is where you are having

the maximum product formation taking place

so the concentrations of the reactants they decrease

as a function of time and the concentration of the products they are increasing as

a function of time and this is typically what happens in in any reaction or for any

kinetic reaction profile this is a general feature now the next question that will come to you

is having looked at these

so we will you know always refer to this plot more and more times  
is the next question you ask yourself is this how do the concentrations change  
as a function of time this is a question that  
you are asking based on the plots now what would you see out here or what  
would

you look at from the plot two things one you are looking at the rate right  
that means

the change in concentration over a time period or as a function of time  
so one is the rate of

disappearance of the reactants

so i can write the rate of disappearance of the reactance or the other way

i can write is the rate of appearance of the products

so you can express the rate of the reaction

that means what is happening to the reaction as a function of time in two ways  
one is

the rate of disappearance of the reactants and the other one is rate of  
appearance of

the products it is the rate of disappearance that means because the reactants  
are being

used up thats why they are disappearing right and then the rate of appearance  
because

the reactants are consumed products are being found hence products are  
appearing they are

coming into existence and it is called the rate of appearance of the products  
because

the products are formed as a function of time ok

so based on this you know what we

can write is i can write say the rate of disappearance of say  $c_1$  minus is  
given by  $-\frac{d c_1}{dt}$  or i can write in more finite terms of  $t$  i will come back  
to you later why i change

from  $d$  to  $\Delta$  means an infinite symbol thing small change and this big  
 $\Delta$  means

a finite change over whether it is a you know big change over long term or  
long time

interval what i will stick to now is this one what i will stick to now is this  
one

so the  $\frac{\Delta c_1}{\Delta t}$  ok now let us go back to our reaction

profile suppose i am looking at this i am trying to you know i am trying to  
find out this value  $c_1$  minus over  $\Delta t$  what is this equal to so

i should put a negative sign out here i come back to this negative

sign right now now when i say this when i say this when i say a change

$\Delta$  means a change over a finite time interval or finite concentration

range right what i am looking for is say i look for two time points what are  
the two time

points say look for the time point  $t_3$  and the time point  $t_1$  then i say  
that my  $\Delta t$  what

is my  $\Delta t$  out here in the denominator i say my  $\Delta t$  is  $t_3 - t_1$  right

so what i say

then is i look at the plot i look at the plot when i look at the plot what i  
say is i look at  $t_3$

ok i look at  $t_3$  and then i look at  $t_1$  i want to say or i want to  
figure out then

in between these two time points  $t_3$  and  $t_1$  how has the concentration of hyperchloride changed

ok

so then at  $t_3$  if i extend this dotted line i hit  $c_3$  right

so which means at  $t_3$

at  $t_3$  the concentration of hyperchloride is  $c_3$  right from this curve right now  $t_1$

one

so when i go to  $t_1$  i again extend this if you just look at the dotted lines i hit  $c_1$

which means that if at  $t_3$  the concentration of hypochlorite was  $c_3$  then at  $t_1$  the

concentration of hypochlorite if i track along  $t_1$  it is  $c_1$

so you write  $c_3 - c_1$  right now

when i write  $c_3 - c_1$  and  $t_3 - t_1$  then you have done or you have taken a very very important

step what is the step the step is this  $c_3$  is less than  $c_1$  right you see the concentration

of  $c_3$  is less than the concentration of  $c_1$  which means which means that  $c_3 - c_1$  is a negative quantity why because  $c_3$  is less than

$c_1$  now if you look at  $t_3$  and  $t_1$  which are the two time points

i can say  $t_3$  is greater than  $t_1$  if  $t_3$  is greater than  $t_1$  if  $t_3$

is greater than  $t_1$  then i can say that  $t_3 - t_1$  is a positive quantity ok

so  $t_3 - t_1$  is a positive

quantity  $c_3 - c_1$  is a negative quantity why because  $t_3$  is greater than

$t_1$

but  $c_3$  is less than  $c_1$ .

so i bring it down a little more

so i can have you know so

here if i have it like this you can see  $c_3$  and  $c_1$   $c_3$  is less than  $c_1$  and  $c_3 - c_1$  is negative

$t_3$  is greater than  $t_1$

so  $t_3 - t_1$  is positive what has happened is this that now you go back to this original expression that we had written and we say that this is a

negative quantity over a positive quantity which gives me a negative

quantity now remember the quantity is negative what is negative what is

negative is the change of

the concentration of hyperchloride as a function of time that quantity is negative the rate of the

reaction is defined to be positive okay

so that is why we always go for the positive reaction rate

so let me write it down the rate of the reaction by definition is taken to be positive right or conventionally

we say that the reaction rate is positive

so now you go back and see what we have

written out here what we have said is that the rate of disappearance of hyperchloride is given

by this  $\Delta c_{\text{O}} - \text{concentration } c_1 - \text{minus over } \Delta t$  that means change of  $c_{\text{O}} - \text{minus}$

in consideration minus over the change in time over this time interval  $\Delta t$  which we have

defined as  $t_3 - t_1$  because if you do not consider this because this  $\Delta c$  minus over  $\Delta t$  itself is a negative quantity the rate has to be positive hence what we do is to make sure we have a negative sign in front of the change so that is why no matter what happens whenever you look at some kinetic profiles you will see that the rate in terms of a reactant is always preceded by a negative sign the negative sign indicates that this is a reactant and its concentration is decreasing as a function of time so let me write that so what i meant was that rate of disappearance rate of disappearance of reactant is having a negative sign before the expression  $\Delta r$  over  $\Delta t$  where  $r$  is your reactant which you know so what you are doing is before this if you are considering the rate of the reaction in terms of the rate of disappearance of the reactant so the rate is given by the negative of this the negative of this so the rate is given by the negative of this why because  $\Delta r$  itself is negative  $\Delta t$  is a positive quantity  $\Delta r$  over  $\Delta t$  is negative and because it is negative rate has to be positive by definition hence we have a negative sign out there so repeat so for any reactions if you are expressing the rate as a function of the change in concentration of the reactant then there is always a negative sign before the change in constant of the reactant over the time interval  $\Delta t$  to make sure or to make you understand that the concentration of the reactant is decreasing as a function of time ah hopefully you know from this plot we have been able to figure out what a kinetic reaction profile is so if you are plotting your data points and then you know as a function of time so data points means your concentration of your reactants and products as a function of time that is your reaction profile the data points are given by these circles out here then what you do is to for convenience sake to make it easier to understand to make it easier to see conceptualize visualize you draw smooth lines to those experimental points right to make it easy for us to understand so that we can see the trend right once you have done that then the next question you ask yourself is how does the concentration change as a function of time so what you do is then you say you look at the disappearance of chloride so the rate of the disappearance of the reactants in this case i have taken the hyperchloride is given by this minus  $\Delta c$

minus over delta

t

so i can also write now that for this reaction hypochlorite plus bromide giving you bromide hyper bromide plus chloride i can write that the rate of disappearance of reactants is or can be given as this which we just saw over delta t

so there is a negative sign it is equal to b or minus over delta t with a negative sign because both of these are your reactants and both of these are decreasing as

a function of time that make sense all right so for obvious reasons now when you go

forward and say that ok the rate of appearance of products can be expressed how i

can write delta b r o minus over delta t and this is equal to delta c l minus over delta t and you see there is a positive sign

before these because these by definitions are positive and why is this

so why why are these

by definition positive you come back and take a look at this come back take a look at this right

again suppose for delta t suppose for delta t we are taking t one t three that means t three

minus t one and suppose you are looking at p r o minus the change in concentration of b

r o minus

so at t three this is what the concentration of b r o minus is at t one this is what the concentration of b r o minus is the concentration of b or minus a t three is

greater than the concentration of b or minus at t one why because the products have appeared or

this product has come into existence and it is increasing in concentration as a function of time

hence when you go back and look at this equation when you go back and look at this equation you see

this numerator is a positive quantity

so is the denominator that means the whole thing is positive

same for c l minus because c l minus and you know hyper bromide are given by exactly the same curve

and then you can say an identical statement for this one

so this is also positive right

so then

again like for reactants the rate of reaction is expressed in terms of the negative of the

change in concentration of the reactant over time for the appearance of products it is preceded

with a positive sign

so there is not a negative sign there is a positive sign because the change in concentration of products is positive over the time interval by definition these are

products and products are coming into existence while reactants are being used up hence the for

the products you have a positive sign out here for the reactants however as we saw we have a negative

sign out here ok and this has to be rigorously followed maintained throughout

your course on reaction kinetics or for any kinetic profile you are looking at any reaction looking at this is always maintained now before i you know take one more thing up i want to just tell you that this is a very important set of curves or plots which will come back to later in one of the future lectures may be ah you know after the next lecture or maybe the next lecture itself where we will discuss something referred to as are known as average rates and instantaneous rates and we will talk about these things in more detail at that time now i want to shift ah gears a little bit and try to look at something which is very fundamental to chemical kinetics what is that assume a certain general reaction take any general reaction the general reaction goes how see i have this reaction going on

$$a + b \rightarrow p + q$$

so this is a chemical reaction that is going on and what i am saying in this chemical reaction is that a is my reactant b is my second reactant p is one product and q is the other product q is the other product ok what about small a small b small p small q

so then a b p q r what these are the stoichiometric coefficients these are the stoichiometric coefficients you do not have to worry about the identity of a the idea of b or the id of p or the id of q we do not worry about that neither do you have to worry about what a is what b is what p is or what q is right the only thing you know is that the stoichiometry the stoichiometric coefficient for reactant a is given by small a the stoichiometric coefficient for reactant b is given by small b the stoichiometric coefficient for the product p is given by small p and the stoichiometric coefficient of product q is given by small q as

i said this is a very general reaction scheme what we will do from here is in the next class what we will do from here is we will set up a certain set of equations and try to express the rate of reaction in terms of the disappearance of the reactants or the appearance of the products so that you understand how these relationships or how these expressions about the rate of a reaction given in terms of the disappearance of reactants or the appearance of products came about ok

so we will in the next class we will start from this specific general reaction scheme okay and will take a time to understand how the basic fundamental expressions for chemical kinetics were brought into existence ok

so then thats what we are going to do in the next class thank you you