next we are going to discuss one very important
topic under colligative property that is cosmetic pressure osmosis and osmotic pressure ok let us try to understand what is this
osmotic pressure is let's have two bigger in this beaker i have pure solvent only pure
solvent and another beaker i have solution solution and now these two
beaker are connected by a tube but in between there is something
called semi permeable membrane semi permeable membrane what is the semi permeable
membrane it will allow the small solvent molecule to pass through but it will not allow
any solute molecule to pass through so here we have pure solvent here we have a solution
so this side we have ah some solute molecules
so that will not go
through
so here it will always remain pure solvent only solution the solvent molecule can pass
through from this ah semi permeable membrane and then we will see the rise there will be some
ah solvent molecule passing through from this side to this side and then there will this side will go
down and this thread will rise and this change in height which can be directly related to the
pressure and that is called osmotic pressure ok and this again i can apply a pressure over here such that the such that the concern the
height becomes same on both side that pressure has to be equal to the osmotic pressure and this osmotic pressure is experimentally verified it is equal to the
osmotic pressure is equal to concentration this is molarity gas constant multiplied by
temperature this is a very important quantity this is exactly used to get clean wire water by
reverse osmosis that is if i apply pressure more than the osmotic pressure then i can send i can
transfer solvent which is going to go through the semi permeable membrane to other side and this
side will have only pure solvent drinkable water okay and but it has a lot of technological importance also as we have seen if i
have a one more point one molal solution if i have a 0.
1 molal solution then the
change in boiling point is going to be delta t is going to be kb m and that kb is around
0.
5
so delta t is going to be approximately 0.
05 degree centigrade very small change
in boiling ah point but what about this let's see okay i can assume in this case
this is a very dilute solution
so 0.
1 molal is approximately equal to 0.
1 molar okay let us
look at the definition of molality molarity is moles of solute divided by

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weight of solvent what is molarity molarity the moles of solute divided
by volume of the solution
so if we assume one liter solution a dilute solution has a more
or less one kg of it which is a fairly good assumption for water in that case
molality and
molarity is going to be same now
so 0.
1 molar at room temperature is going to be approximately
0.
1 molal is going to be approximately 0.
1 molar
so for 0.
1 molal solution delta t the
change in the boiling temperature is 0.
052 but in case of osmotic pressure let's
calculate it
so for 0.
1 molar solution this is going to be 0.
1 multiplied by
less assume the temperature is around 0 degree centigrade
so this r t is
22.
4 liter atm
so i am going to get 2.
2 atm change in pressure that is huge its easily measurable that is more than
the
twice of the pressure exerted by atmosphere you see that this is a point zero
five
four point one mole and this is 2.
2 atm
so this quantity this osmotic pressure becomes
very important when we are trying to calculate the concentration or molecular
weight of ah in
a biological system where the molecules are huge very big they have a very
large weight but the
concentration is quite small because the moles may be one mole might have a
thousands of gram weight
so when the concentration is very very small still less concentration is like
a millimole
and one is smaller we are delta t is going to be negligible but we still can
get
appreciable change in osmatic pressure and that would be very useful to
calculate the
concentration or if we know the concentration then the molecular weight of
these
biological proteins and things like that okay let's do a an example uh 200
centimeter cube of an aqueous solution
of a protein contains 1.
2 6 gram of the protein the osmotic pressure of such a solution at 300
kelvin is found to be 2.
57 into 10 power 3 bar calculate the molar mass of the protein let
me read out one more time 200 centimeter cube of an aqueous solution volume
is
200 centimeter cube that is 0.

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2 liter contains 1.
26 gram mass of solute is 1.
26 gram of the protein the osmotic pressure
of such a solution at 300 kelvin is found to be 2.
57 into 10 power minus 3 bar calculate the molar mass of the protein okay
so we are given pi this is exactly here c is a concentration okay the
concentration over here
is a molar concentration
so that is defined as moles of solute divided by volume of
the solution
so i am going to assume that since the concentration
is going to be extremely low
so volume of the solute is equal
to the volume of the solution
so we are going to get this quantity
0.
2 molecular weight n2 is simply weight of the solute 1.
26 gram divided by
um molecular weight of the solute that is the unknown quantity
so we plug in all this
information and we get 1.
26 w 2 into 0.
2 is equal to r in a proper unit
so i need this
in a bar unit and that is going to be 0.
083 083 liter bar per mole per kelvin
into temperature that is 300 kelvin
so only unknown is w2
so let me rewrite it
so w 2 is going to be 1.
26 into 0.
083 into 300 divided by 0.
2 into
2.
57 into 10 power minus 3
so if i plug in all this information
i am going to get w two as sixty one thousand zero two two gram per mole ok
so this is a huge protein molecule
now i will leave it as an exercise for ah for the viewers that if i for the
same
solution if i ask to ah calculate the change in freezing point and boiling
point is going to
be really negligible and won't be able to we will probably measure it
experimentally
okay let's do another problem at 300 kelvin 30 gram of glucose present in a
liter
of its solution has an osmatic pressure of 1 4.
98 bar if the osmotic pressure of the
solution is 1.
52 bar at the same temperature what would be its concentration it at 300
kelvin
so temperature is given temperature is important for asthmatic pressure at 300
kelvin 36
gram of glucose

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so solid weight of solute is 36 gram is present in 1 liter
so volume
is 1 liter has automatic pressure of 4.
98 bar if the osmotic pressure of
the solution is 1.
52 bar then what is its concentration ok
so in
this equation pi is equal to c r t
so four point nine bar is equal to c is 36 gram divided
by molecular weight of glucose that is c 6 c6h12o6
so 72 plus 12 plus 96
so 6 10 a 180 in
1 liter r t now is asking if 1.
52 bar is osmatic pressure then what
is concentration ok looks like this information has no value not required
so c is simply given by 1.
52 divided by 0.
083 into 300 kelvin and the answer would come out to be divided by
point zero eight three divided by three hundred point zero six point zero six
one molar ok
lets discuss now ah abnormal molar masses ok
so we have seen using the colligative
properties we can calculate ah molar mass for example using delta t of boiling
using
this equation we have calculated molar mass of solute but we have been talking
about
non-ionic solute what about ionic solute what happens if ah solute goes into
the solution
and it might dimerize or it might dissociate for example if i take nscl put it
in a water is going
to dissociate to n a plus request plus c l minus x if i took point molal
solution to begin
with invert in water then this being a very strong electrolyte it's pretty
much going to
less assume it's going to dissociate completely and we are going to get 0.
1 molal and a plus
and 0.
1 molal cl minus and nothing will left so that's the assumption fairly good
one okay and we
know the colligative property doesn't depend upon what solute you are using it
depends on
simply the concentration of each and in every individual ah solute added up
so to calculate
qualitative properties now we have zero point one molar and applied zero point
one molar cl
minus and total concentration which is going to go into this equation is going
to be 0.
2 molar
if for example it dissociate only 50 percent we know it's not going to
dissociate it is going to
dissolve much more but let us assume that is going to dissociate only fifty
percent then out of zero
point one mole nacl what is left is zero point zero point zero five molar nscl
and remaining will

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convert into n a plus and c l minus 0.
05 and 0.
05
so the total concentration molarity which is going
to get into this equation is going to be you add these three individual quantities
so in solution
initial is present any plus is present cl minus is present
so for this equation it doesn't matter
what is present you just want the concentration of all the solute present
so the total concentration
is now going to be not 0.
1 molal but 0.
15 mole if we can define the degree of dissociation for
example if ah degree of dissociation is alpha then 0.
1 into 1 minus alpha will remain in the
solution and rest will convert into in this n a plus and c l minus i that would be 0.
1 alpha and 0.
1 l
so the total concentration is going to
be simply add up these three quantities and that will go to this and using if i know
delta t if i know kb and if i know how much nacl i added to begin with i can calculate degree
of dissociation that is a very important quantity not only dissociation sometimes we
can have a diameterization we have some compound which put in the solution at my
diameters it might polymerize polymerizable so in that case if i start with concentration
of n and degree of polymerization is alpha then what is left is n one minus alpha
and how much a 2 we are going to get is
so out of n moles n alpha moles has
converted to a 2 and giving rise to n alpha by 2 moles of a 2.

so so when calculating
the total concentration the amount the moles which is going to go into the calculation is this plus
this
so in this case the concentration has gone down for example now if i have a
general ah compound let's say a am bn the concentration is c degree of
dissociation is one minus alpha sorry degree of dissociation alpha then this
compound which will remain in the solution is this much and we are going to get a ion that
the concentration of that ion is going to be c alpha m and the concentration
of b ion is going to be c alpha ah n
so the total concentration is going
to be this plus this plus this okay let's do some exercise to understand this concept
so this is the example 2.
12 let me read 2 gram of benzoic acid is dissolved in
25 gram of benzene

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so is a depression and freezing point equal to 1.
62 kelvin molar depression
constant of benzene is 4.
9 kelvin kg per mole what is the percentage association of acid if
it forms dimer in solution okay
so we are given 2 gram of benzoic acid
so that is solute
so weight
of solute is 2 gram benzoic acid that is c6h5 cooh dissolved in 25 gram of
benzene
so that
is solvent
so it dissolving 25 gram of benzene
so the depression in freezing point
equal to 1.
62 kelvin
so delta t is 1.
62 kelp molar depression constant for benzene is constant is kf is 4.
9 kelvin kg per mole what is the percentage dissociation of acid if it forms
diameter solution
so this benzoic
acid in the solution is going to give me c6h5cooh twice of that and not all of
it is going
to be damn rice is asking what percentage is going to have or and percentage
association okay
so percentage is asking okay
so we will start with our familiar equation
so that is delta t is equal this is to freezing point
so depression
so this is k f m k f is given
right here and we need the molality of all the species present the species
which are present is
c6h5coh and its dimer benzaic acid and its dimer
so we started with 2 gram to calculate the
molality we need to convert this 2 gram to moles of benzoic acid
so we need the molecular
weight
so molecular weight is going to be ah say one carbon
so that is 84 690
plus 32
so twenty two
so we get ah moles of benzene acid as
two dividers one twenty two and then we are going to have a
some diagonalization
so present diagonalization let's say the degree of dimension
is alpha
so we are going to get 1 minus alpha and we are going to get this
diameterization 2
by 122 alpha that many benzoic acid diameterized and the concentration of the
due to
diameter is going to be half of that
so the total concentration
is going to be this plus this okay i'm sorry we need to still need to calculate
the concern the number of moles of benzoic acid present in the solution is

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going to be this and
moles of diameter present in the solution is going to be this
so we are given weight of the solvent
so the molality the total molality of both the ah species both the solute is going to be just
added up
so we are going to get 2 divided by 1 22 one plus one minus alpha plus alpha by two
so this is the moles divided by twenty five gram and that we need to convert into kg
so just multiply with also zero point zero point six six one minus alpha by two so
that is going to be the molarity
so now we have all the information we need to just calculate
alpha and just multiply by 100 that will give me ah percentage association so delta tf 1.
62 kelvin equal to 4.
9 into 0.
661 minus alpha by 2.

so we are going to get 1 minus alpha by 2 as 1.
62 divided by 4.
9 divided by 0.
66 0.
500
so alpha by two is going to be point five zero zero
so alpha is going to
be one
so this is a nearly hundred percent uh association
so nothing will remain practically
nothing will remain of this everything will convert into diamond if i put banjoic acid
in benzene okay let's do another problem the next exercise okay let me read it out
0.
6 meter of acetic acid having density 1.
06 gram per meter is dissolved in one
liter of water the depression in freezing point observed of this strength of estimate
0.
0205 degree centigrade calculate the volta factor and the dissociation constant of s okay
let me first define what is one top factor is
so one top factor is concentration of the species present in
the solution let me call that experimental concentration and divide by theoretical
concentration theoretical concentration is the concentration which ah i am calculating
that is the concentration before any reaction happens in the in the solution that is
any dissociation or polymerization happens
so that is the concentration
theoretical concentration ok and this this concentration can be in
a molality it could be in ah and molarity whichever one

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so if i am trying to
calculate say automatic pressure pi is equal to c r t
so if i substitute c as a theoretical then
pi is the going to the calculated one and if i substitute c as the experimental the actual
concentration present in the solution then it will be experimental one
so it's clear to see that this
is basically going to be pi experimental by pi vertical or if i am calculating let's say
freezing point depression or boiling point ah then delta t is again kb by m this is a
molarity and again we are going to get
so if i substitute theoretical concentration then
i am going to get what delta t i calculate by putting the concentration which i am using
or experimental would be or the concern ah experimental change in temperature would be ah
using the molarity of the ah component present in the solution
so again we can substitute
ah concentration equal to delta t by kb kb will cancel out in both ways and again i will
get delta t experimental and delta t calculated or theoretical
so you can see one tau factor
is simply experimental qualitative properties experimental qualitative properties divided by calculated calculated calculated colligative properties
so that is how the one top factor is defined
so for example if nacl is going to dissociate
completely then one nacl is going to give me two ah species one n a plus and another c
l minus
so my uh experimental concentration would be twice of theoretical concentration so
one top factor in case of nscl is going to be two if is going to dissociate completely ok so
the problem which we are going to attempt is asking for to calculate one top factor okay
so in
this problem we are given 0.
6 meter of acetic acid liter of acetic acid having density it dissolved in one liter of water
so volume of solvent is one liter the depression and freezing point delta
t f was observed to be zero point zero two zero five degree centigrade calculate
the want of factor
so we need to calculate i and dissociation constant for the
av ok
so dissociation constant of kb is defined as follows
so first let me
write the reaction acetic acid that is cs3cooh when it goes into water it
is dissociates and gives me acetate ion and h plus of course it
is a acid it has to give h plus okay and
so the kb is defined as concentration of
h plus concentration of acidic ion divided by concentration of c s three c o h and the

concentration unit which is used here is molarity okay and we need to you use this equation also
that is defined as kf multiplied by m
so this is molality
so but in this problem we are going to
consider molarity and molarity happen to be same why is that we are going to consider that
one liters water is equal to one kg of water and if i add 0.
6 ml of acetic acid it is not
going to change the volume of solution
so we are going to assume 1 liter of water is equal to
1 kg of solvent and that is equal to 1 liter of ah solution
so if i am going to calculate
the concentration that would be moles of solute
so that is weight of
solid that we can calculate by volume of solute multiplied by density so the weight of solute is 0.
6 into 1.
06 divided by ah this is the weight of solute and we if we
divide by molecular weight of solute that would be 12 or 24 plus 4.
38 plus 32 12 15 20 60 60
so weight of solute divided molecular
weight that is moles of solute divided by weight of solvent since we are assuming
1 liter water is equal to 1 kg of water
so we can divide by 1 kg so
this will give me molality and if i want to calculate molarity i again
have assumed that 1 kg of water or 1 liter of solvent if i add solute to it is not going to
change its volume
so instead of one carry i use one liter and i again get
the same answer it's simply 0.
6 into 1.
06 divided by 60 i can either
molarity or molar d it's a same number
so so i am going to get 1.
06
into 10 power minus 2 molar or molar it doesn't matter
so we
have calculated the concentration if degree of dissociation is alpha then if the
initial concentration was c which is right here and degree of dissociation is alpha then c
multiplied by 1 minus alpha that much acetic acid will remain in the solution and remaining part
will convert dissociate and is going to give me c alpha of acetate ion and c alpha h
plus n then if i take that all that information and put it right here i'm going
to get c alpha square divided by c 1 minus ok and where c is given right here ok
so we need to calculate k b we need to
calculate i
so now the total concentration which i am going to use while calculating
the colligative property that is going to be concentration of all the

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individual
ah component in the solid
so these all these three are solute in the solution
so the
total concentration is simply going to be this plus this plus this and that is going to be c 1
plus alpha ok
so i have now all the information i just need to calculate alpha since i know c
if i know the alpha then i can calculate the kb and of course i can calculate i also
on the one top factor and that would be the experimental concentration that is this
concentration that is after dissociation and the concentration before dissociation
that is c
so it's simply one plus alpha
so i just need to calculate alpha and i will
have all the ah answer i require okay
so i am just going to plug in all the information in
this equation
so for this i of course need kf and kf is given in the table and if i take it
from there it is 1.
86 ah kelvin kg per mole 1.
86 and the molality is you already defined c that is one point zero six into ten
power minus two multiply one plus alpha and now i can calculate one plus alpha
that is going to be point zero two zero five
divided by one point eight six divided by point zero one zero six and answer is one point zero three nine seven or one
point zero four one point zero three nine seven
so alpha is going to be
point zero three nine seven
so one top factor we have already calculated
that is one point zero three nine seven now what about kb
so if i put all this information 1.
0 into 10 minus 2 alpha square that is 0.
0397 square divided by 1 minus alpha
so 1 minus 0.
0397 let's see what answer we got
so okay the answer which we are going
to get is 1.
74 into 10 power minus 5
so within round of error
this is i think is the answer okay let's discuss one more problem from the text this is 3.
32 from insert ebook calculate the depression in the freezing point of water when
10 gram of ch3 ch2 chcl coh is added to 250 gram of water
so he's asking calculate the depression
and freezing point
so he's asking delta t f ah when 10 gram
so weight of solute it and

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tandrum and the solute is ch3 ch2 ch cl cooh
so 10 gram of this is added to 250 gram of water
so weight of solvent is 250 gram and we are given ka is equal to dissociation constant for
this acid is 1.
4 into 10 power minus 3 and kf for water is 1.
86 kelvin kg per mole ok
so we need to calculate depression and freezing
point the usual formula is going to be k b m and where the molarity of all the component
present ok just for the simplicity let me write this as a
so this whole compound is simply h
which is going to dissociate and going to give me h plus plus a minus in solution and again if the
concentration the theoretical concentration is c of h a then after dissociation if
the degree of dissociation is alpha then after dissociation the concentration of
h will become c multiplied by 1 minus alpha concentration of h plus will become c alpha and
concentration of a minus will become c alpha
so now i can write k a which is defined as
concentration of h plus multiply the concentration of a minus divided by concentration of h a ah
we can write this in terms of c and alpha so concentration of h plus c alpha consider a minus c
alpha and concentration of h is c one minus alpha
so putting it and removing one c we are going
to get c alpha square divided by 1 minus alpha ok now let us try to calculate
c that is the concentration of the solute in the solution
before dissociation
so c is if we want to write in molarity
then it is going to be moles of solute divided by ah weight of of solvent in kg
but we are going to consider the molality and molarity to be same because
we are going to assume ah the weight of solute weight of solvent is 0.
250 gram and the volume of
the solution is also 0.
250 liter
so in that case the concentration in terms of molality or molarity
is going to be same to calculate the concentration we need a molecular weight of this compound and so
the molecular weight of this compound is going to be 15 plus 14 plus 13 plus 35.
5 this is 12 plus
113 plus 30 to 45
so this would be 35 plus 45 80 80 plus 1529 plus 13 42 and 0.
5
so this is 122.
5
so molecular weight of this compound is 122.
5
so moles of solute and 2 is simply 10 by 122.
5
so i have all the information now to calculate

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c
so this would be tan divided by 122.
5 divided by weight of solvent that is 0.
250 kg
so kg and if i just evaluate this 0.
3265 point three two six and now i need alpha to cal
so this information i am going
to put it in this equation
so i will get point three two six alpha square divided by one minus
so this is to solve quadratic equation but let's see if we can make
approximation less first make
approximation alpha is negligible with respect to one in that case alpha is
simply ah 1.
4 into 10
minus 3 divided by 0.
326 and square root of that
so the answer is alpha is equal to point zero six five five
so we
ignored point zero six five five with respect to alpha
so if you want to refine the solution
we are just going to substitute this alpha in the denominator recalculator but
this is
a very nice method to if you don't want to solve this quadratic equation or if
some
cases even higher order equation i can do it iteratively just make
approximation over here
calculate alpha and whatever alpha you get just keep on substituting and
couple of iteration most
probably it will converge many times diverge also but i've seen most of the
time it converge so
just replacing back this
so i'm going to get ka is equal to 0.
326 alpha square divided
by 1 minus alpha that would be 0.
9345 and now using this equation where
k is given here i will get 63
so alpha is simply point zero six
three three
so it's quite close all right
so we have calculated alpha
now we need to calculate delta t where m is going to be the total
concentration of all
the species in all the species which are present is h a h plus a minus
so if i add up the
concentration the m is simply going to be c multiply 1 plus alpha
so if i put all the
information here k b is given i am sorry this is k f k f is given is 1.
86 multiplied by c which is i
we have already calculated somewhere that is 0.
326 multiplied by one plus alpha alpha is point
zero six is one plus alpha one point zero six three three and now we can
calculate delta t f is going to be 1.
86 multiplied by 0.
326 multiplied by 1.

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0633 and answer is 0.
645
so change in freezing point is going to be
0.
645 degree centigrade or degree kelvin if one want to calculate ah one top factor then we that also
we know it's simply one plus alpha
so one top factor is one plus alpha which we have
discussed in the last class and that is equal to one point zero six three three ok
let us try to solve one last problem in this session okay the next problem nineteen
point five gram of c h two f c coh is dissolved in 500 gram of water the depression and
freezing point of watered observed is 1.
0 degree centigrade calculate the want of factor
and dissociation constant of fluoroacetic acid okay this is a very ah this is quite similar
to the problem which we have discussed earlier okay
so 19.
5 gram of this acid
so weight of solute
is 19.
5 gram and the solute is ch2 f c o o h dissolve in 500 gram of water
so weight of solvent is 500 gram depression and freezing point is water is observed to be 1.
0 degree centigrade
so delta t f which is observed is one point zero
degree centigrade calculate one top factor i and the dissociation constant k a ok again if i write this whole equation
dissociation of h a giving me h plus plus a minus where i am assuming this is a then if initial concentration is c undissociated concentration and after dissociation
degree concentration is going to be one minus alpha then the concentration of h plus is
going to be c l for concentration is here so
so total concentration of each and every
species is going to be c one plus alpha so one top factor as we have already discussed
is going to be c 1 plus alpha divided by c that is 1 and k a is going to be concentration of
h a multiplied by concentration of a minus divided by concentration of h a that is c 1 minus alpha
so that would be alpha square c 1 minus alpha okay and we can calculate c
so c is going to be
molarity or molarity again we are in this dilute aqueous solution molarity and molarity
we are going to assume it to be same so we are given mass and we want to convert it to
moles
so to convert to moles we need a molecular weight again molecular weight of this compound
is going to be 14 plus 9 plus 12 13 plus 30 45
so 4 9 18 1 2 3 7 8.

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so molecular
weight is 78
so the concentration is moles of solute
so that would be 19.
5 gram
divided by uh molecular weight that is 78 divided by either volume of the solution which
we have considering equal to the volume of solvent or weight of the ah solvent
so that is to
calculate molality
so we that is 0.
5
so this is 19.
5 divided by 78 into point five point five
something
so this is oh this comes out to be one by two
so simply zero point five molal or
molar ok
so we have c and we already given tf
so delta tf is kf m where m is the total concentration of
concentration all the species that is c multiply 1 plus alpha
so this is
going to be k f into c 1 plus alpha k f is given the last problem itself so
we can use it point eight six one point eight six multiplied by point
five ah multiplied by one plus l okay
so we can calculate 1 plus alpha
equal to 1.
0 divided by 1.
86 into 0.
5
so 2 divided by 1.
86 okay the problem in these questions in this exercise is how many
significant
figures to carry
so okay let me carry just 1.
075 ah as one plus alpha
so alpha is becomes
simply point zero seven five if i carry just two significant i will not get an
any answer
so alpha point zero seven five
so we already
have the one top factor is simply 1.
075 and ka now it's straightforward c is we
have already calculated that is point five into point zero seven five square
divided by one minus alpha that would be point nine two five and now we can
calculate
this trivially zero seven five square
so three point 0 into 10 minus 3
so that is what we get
the dissociation constant for this acid okay
so that's where we will stop this session you

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