hello students in the last lecture we discussed about ionic equilibrium question based on ionic equilibrium we took different solutions solution of acid solution of bases and solution of salt then we also looked at the when we titrate we case it with a strong base and then we calculated we tried to see how to calculate ph of the solution how to calculate ph of the solution

so suppose we start titration of weak acid such as acetic acid and acetic acid with sodium hydroxide with the addition of sodium hydroxide there will be different kind of species in the solution and based on the species in the solution we will use different concepts to calculate your ph of the solution

so for example if we are starting with acetic acid 50 ml of 0.
1 molar acetic acid 0.
1 molar acetic acid and you started titrating with 0.
1 molar n o h when there is zero ml of noh in solution we have v acid acid which is weak and

so we will utilize the relationship that h plus ion is equal to root under k a into c c s a when we add suppose 10 ml of noise in the solution we have salt which is formed by the reaction between acetic acid and no h and you have v k said in the solution and this solution is called buffer solution buffer solution and i showed you in the last lecture how to calculate ph of this solution ph is equal to pka plus log solved by s at the equivalence point at the equivalence point at the equivalence point we have only salt

so if i add 50 ml of 0.
1 molar noh to 50 milliliter of 0.
1 molar acetic acid you have only salt left

so you will get 100 ml of r you will get salt the concentration will be number of millimole milli mole of salt form divided by total volume total volume and that is your number of millimole is

so what you have done is you have added 5 millimole of noise to 5 milli mol of acetic acid it means you will get 5 millimole of salt and volume is equal to 50 plus 50

so 100 ml 100 ml

so you have point zero five point zero five mole per liter mole per liter

so this is your concentration

so five milli mole you have this thing five millimeter of salt has been formed and you have 100 ml of solution 100 ml of solution

so you see here what we have done here multi multiplication

so millimole is equal to volume in milliliter multiplied by molarity molarity and

so if i want to calculate molarity is equal to number of millimole divided by volume

so this is the way you can calculate your concentration of the solution similarly we can ah do titration of titration of weak base weak base with a strong acid a strong acid when no acdi for example ammonia solution with scl s u

so the ammonia solution is weak base and s c l is a strong acid when no acid is added you can calculate o h minus ion is equal to k v into concentration of base when we add a c l before equivalence point equivalence point you will get a buffer buffer and in this case poh will be given by pkb plus log solved by base solved by this at the equivalence point equivalence point we have salt of weak base with with base with a strong acid

so you can calculate h plus ion concentration is equal to k h which is a hydrolysis constant into c of into c of weak base c of salt c of salt and kg in this case will be given by kw by kb into salt concentration and finally after the equivalence point after the equivalence point you have salt plus a strong acid but most of the h plus ion will come from the strong acid and

so ph will be minus log h plus from acid or concentration of h plus from ac is plus concentration from missing

so this is all about titrations

so you if you start with a weak acid and started treating with no h i started titration with no h and how to calculate ph and similarly if you start with a weak base and started titrating with a strong acid what should be the ph of the solution

so once you understand the concept it is quite easy to calculate ph of the solution next application of ionic equilibrium is calculating solubility of a sparingly soluble soil sparingly soluble

so so salts are of three types one is your soluble but which are non-electrolyte non-electrolyte doesn't break into the solution you have soluble salt which breaks in water breaks complete dissociation here there is complete dissociation for example nacl there will be complete dissociation in water it will be l plus plus c l minus equals and last one is sparingly a sparingly soluble salt and here we need to apply concept of solubility how much soluble this is and this is very important from point of view of ionic equilibria

so a sparingly soluble salt a sparingly soluble salt

so lot of salts are sparingly soluble sparingly soluble further that mean is if we take water and if you have solved like this this is positive charge this is negative charge if i add in water what we are going to get is initially a small amount will get solubilized but but on addition more salt it will get start precipitating

so very small amount of very small amount of salt will be in solution salt will be in solution one of the example of a sparingly soluble salt is a gcl when you put into water it will break into a g plus aqueous plus chloride ion aqueous

so this is your sparingly soluble sword both dissociated species dissociated species sorry undissociated species and dissociated species the species are in equilibrium area equilibrium

so we can apply the concept of concept of ionic equilibrium you can apply concept of ionic equilibrium

so adcl solid is in in equilibria with a g plus aqueous plus c l minus aqueous if suppose solubility of soluble t of salt is x then it will give you a gcl a g plus aqueous

so when it breaks it will give you s mole of mole per liter of a g plus or x sorry this is s then s small per liter means it will give a small per liter of kg plus and a small per liter of chloride ion now since we can apply the concept of ionic equilibrium for this salts

so your equilibrium constant will be a g plus aqueous into c l minus equals concentration of a g plus aqueous into c l minus aqueous divided by a g c l solid and by convention we take the concentration of c l is equal to one and

so k is equal to a g plus into c l minus and this k is known as solubility product this k s p is called solid b dt product solubility

so there is a relationship between solubility and solubility and solubility product lets again understand solubility solubility means suppose if i have taken energy cl a g plus plus c l minus ion aqueous

so how much amount of agcl has gone to solution

so suppose s mole per liter of s mole per liter of h is here a gcl goes to solution goes to solution that means that s solubility is is mole per liter and then a g plus concentration ion will be a small per liter and c l minus concentration will be a small per liter a small per liter

so ionic product or solubility product will be your a g plus ion into c l minus sign a g plus sign into c l minus i n and then your a g plus i n into c l minus i n and this is s into s is equal to s square

so solubility

so this is the relationship between ksp and solubility ksp is equal to s square

so suppose i want to know solubility i can just take a square root of case p and that will give you solubility solubility of the salt of the salt solubility of the salt

so lets do some questions

so for example solubility of a to x three is y mole per liter

so what should be is solubility product

so a two x three a two x three when you put into the solution what you are going to get is 2 a 3 plus plus 3 x 2 minus 3 x 2 minus and you can see that now charge is charge on total charge on a 2 into 3 plus and y is 3 into 2 minus 6.

so this is 6 plus 6 minus

so total should be neutral okay

so if suppose s is the solubility here y is the solubility and what you are going to get is 2 y of a 3 plus and 3 y of x 2 minus and we know that k s p is equal to a 3 plus s square into x 2 minus concentration of x two minus cubic

so a three plus this is the ion square stoichiometry is two

so this will be a square here stoichiometry is three and

so there will be q what is the a three plus ion concentration this is two y

so two y square into concentration x two minus a three y

so 4 y square into sorry this will be q yeah

so 3 into 3 into 3 is 27 9 3 27 into y cube

so 4 7

so this 1 0 8 y 5.

so this is the way you calculate solubility you can come across different salts like a b it goes to a plus plus b minus aqueous this is solid and this gas ksp will be your s into s is equal to s square for a b 2 type of salt you have a 2 plus plus two b minus and

so if solubility is s you are going to get s small per liter of a two plus and two s more per liter of b minus

so solubility will be your ksp will be s power one stoichiometry is one two s power two stoichiometry is two

so this is your s into four s square is equal to 4 sq

so it is quite easy to get a relationship between your ksp and solubility product

so if you know solubility you can calculate solubility product and if you know solubility product you can calculate solubility now similar kind of question for a sparingly soluble salt a p b q the relationship of solubility product and its solubility is

so a p b q a p b q if this dissociates p mole of a which charge q plus you will get plus q mole of b with charge p plus q mole of b sorry z cube mole of b charge your charge p plus now you see the total cha p minus

so total charge is p q and this is p q

so this is plus p q this minus p this will be 0 and if solubility is s

so what we are going to get is p s and this is q s mole per liter

so you have p s mole per liter of a q plus and q s mole per liter of b p minus

so if i want to get a solubility product which has non rotation l s

so l s will be your a q plus power stoichiometry is p into v p minus v p minus s trichometry is your q q

so p s power p and

so this is p s p s is the concentration

so p s power p and q s is equal to this q s power q

so you have p p q q and s p plus q p p q q and your this thing is s p plus q
now let us take another here solubility is given and you have to calculate k s p
m x four again m x four
so it will break and give you m plus four equals plus four x minus four x minus
so if solubility of molar solubility of salt is s then you are going to get s
and then four s at equilibrium four s at equilibrium
so your ksp will be s power r you simply write m 4 plus into x minus 4
so this is s into 4 s 4 is equal to 4 into 4 16 into 4 64 into 4 into s power
5.

so 64 into 4 is equal to 6 256.

so 256 is 5.

so if you understand the concept of solubility how solubility you will be able
to tell how much ions are formed and with the concept with the understanding of
concept of ionic equilibrium will be able to get asp for the salt
so this very simple example your solubility is given
so suppose this is calcium sulphate this breaks to give you calcium two plus
plus sulphate two minus sulphate two minus and solubility is given
so solubility if solubility is s then you write s s and here s is equal to 4.
9 into 10 to the power minus 3 mole per liter at 298 k
so ksp will be simply s into s that is s square and that will be your four
point nine into ten to the power minus three s square
so it is quite simple to calculate solubility product if solubility is known
now see this question solubility product of salt having general formula this is
given now in this case solubility product is given and what you need to do is
you need to calculate the concentration of iron in aqueous solution of the salt
so again m x two if this breaks m two plus two x minus and
so if solubility is s s then k s p will be s this will be two s
so s into two s square and this is s into four s square four s q and you have
been given 4 sq 0 ksp is equal to 1 4 into 10 to the power minus 12 and this
equal to 4 into sq for 4 cancels out
so s will be 10 to the power 1 into 10 to the power minus 4
so solubility can be calculated if we know solubility product and concentration
of m 2 plus is s
so that is equal to 1 into 10 to the power minus 4 whereas if you want to
calculate concentration of x minus then it will be 2 s minus 2 into 10 per power
minus 4.
now once you understand solubility and solubility product we can also see what
are the things which can affect solubility and most common one is your common
ion effect
so what does that mean is that if suppose you have salt m x solid going to m
plus aqueous plus x minus equals x minus aqueous
so if i add common and what are the common ions m plus or x minus
so if we add one of them we know that it equilibrium will shift towards left
hand side
so we are basically decreasing the solubility we are basically decreasing the
solubility for example if suppose we start with agcl which is a sparingly
soluble salt a sparingly soluble salt
so it breaks into a g plus aqueous plus c l minus x this is in solid form
so suppose if i add a g plus ion or c l minus i the equilibrium will shift
toward this and solubility will decrease solubility will decrease
so for example if i add a g n o three this is a soluble salt when i put into

water this gives you a g plus plus n o three minus

so if you have agcl and if you add a gno3 agno3 will give silver plus ion and this will show effect on this equilibria and ag the solubility of agcl will decrease

so let us see one question the ksp of ag2cro4 is 1.

1 into 10 to the power minus 12 at 298 k at 298 k

so this is your sparingly soluble salt and ksp will be given by

so let us see a g two c r o four if this breaks it will give you two a g plus plus c r o four two minus

so if we write ksp this is simply your a g two plus s square sorry a g plus square a g plus s square and c r o four two minus c r o four two minus c r o four two minus

so if suppose if we have we do not have a gno3 solution then we have simply we can just write solubility is s then a g plus ion concentration will be two s c r o four concentration will be s then it is simply two s square into s four s q 4 s cube and that is around 4 sq will be equal to 1.

1 into 10 to the power minus 12 1.

1 into 10 to the power minus twelve but if suppose we have a g n o three then what will happen

so a g two c r o four a g two a g plus plus c r o four two minus a g n o three we added we added zero point one molar a g n o three it will give you a g plus plus n o three minus and this is since this will completely dissociate

so concentration will be if we start with point one molar a g n o three will get point one molar a g plus and point one molar a g n o three now this a g plus will affect this equilibrium and now if suppose solubility is solubility of a g two c r o four is y

so suppose this is y solubility is y mole per liter in presence of y mole per liter in presence of a g n o three then you will get two y here y and your a g plus concentration will be equal to zero point one from a g n o three zero point one molar from a g n o three and two y mole per liter from your a g two c r o four and this will be y but we know that since this is a sparingly soluble salt a g plus obtained will be very less and

so this is simply equal to 0.

1 simply equal to zero point one and k s p for your a g two c r o four will be k s p four a g two ah c r o four will be a g plus s square into c r o four two minus and case p we know case p is given your one point one into 10 to the power minus 12 and should be equal to a g plus s square is your 0.

1 s square because all a g plus almost all a g plus has come from the salt and then this is the solubility of the a g two c r o four in presence of a g n o three if solubility is y then c r o four two minus concentration will be y and

so y is equal to your one point one into ten to power minus twelve divided by one point one sorry divided by zero point one square and this is almost equal to one point one into ten to the power minus ten mole per liter now if you remember that solubility of a g 2 cro4 was this 1.

1 into 10 to the power minus 12.

so s q will be around point two five into ten to the power minus twelve and

so s will be around your one point ah

so point one two something like that point one or point one five into ten to the power minus four is around point one five into minus four or minus five

so but you can see that solubility of a g2 cro4 in water is quite greater than your the solubility in presence of a gno3 solubility in presence of a g n a three

so solubility decreases in presence of h n o three and that is because of that

is because of common iron effect that is because of common ion effect
 so lets discuss ionic product of salt and solubility product and this we will do for a sparingly soluble salt for example as is here
 so suppose you start dissolving a gcl into water
 so this is your water and you start putting a gcl
 so initially all agcl will be go to solution and you have something like a g plus into cl minus
 so till all agcl is going to solution the multiplication of a g plus into cl minus and concentration will give you ionic product ionic k salt or you can say this is ionic product ionic product but when you add adjacent more more of a gcl when you add more of a gcl what will happen is your solution will first become saturated first becomes saturated at this condition there will be equilibrium between a g c l solid energy plus plus c l minus in solution in solution
 so multiplication of this a g plus iron into c l minus ion in a saturated solution saturated solution is called solidity product solubility product solubility product application of application of the concept of of the concept of solubility product solubility product
 so solubility product concept of solubility product of solubility product can be used can be used to know under what condition what condition precipitate precipitate will form under what condition a precipitate will fall
 so when ionic product is ionic product is less than solubility product product then your solution is solution is not saturated solution is not saturated when ionic product an ionic product is equal to solubility product product then your solution is saturated and further addition of further addition of salt will lead to precipitation rashi mutation when ionic product is last one is when ionic product is your ionic product is greater than your solubility and that means your solution is solution is over saturated solution is over saturated
 so based on that we can also look at this question it is given solid barium nitrate is gradually dissolved in a this molar na2 co3 solution at what concentration of barium two plus will precipitate beacon to form precedent begin to form ok ksp of barium carbonate is given that is five point one into ten to the power minus nine five point one into ten to the power minus nine
 so let's see n a two c o three gives you when you break it it gives you two n a plus plus co three two minus and when we add n a two c o three solution to barium nitrate a sparingly soluble sol barium carbonate which is sparingly soluble and that will form and
 so since this is sparingly soluble barium carbonate will be in equilibrium with barium two plus and carbonate ion barium two plus and carbonate ion
 so now question is at what concentration of what concentration of barium 2 plus the precipitate will start to form
 so barium 2 plus will barium carbonate will start to form when ksp of barium carbonate is equal to barium two plus into carbonate ion ok and your carbonate ion is coming from na2co3 and
 so its concentration will be equal to concentration of nr2 co3 because nsu na2co3 is completely dissociated and the concentration of carbonate your sodium carbonate is 1 into 10 to the power minus 4 molar
 so your concentration of carbonate and will also be 1 into 10 to the power minus 4 molar and then we know that ksp is equal to five point one into ten to the power minus nine and this should be equal to barium two plus ion multiplied by carbonate and
 so since we know carbonate ion and we need to calculate barium two plus
 so barium two plus will be five point one into ten to power minus nine divided by one into 10 to the power minus 4 ok barium 2 plus ion is ksp divided by carbonate ion concentration

so you just divide 5.
1 into 10 to the power minus 9 divided by 1 into 10 to the power minus 4 and that is equal to around 5.
1 into 10 per power is equal to this 5.
1 into 10 to the power minus 5 and this is mole per liter or molar
 so after this after this till this point there is no precipitation but after this precipitate formation will begin next question is at 25 degree celsius the solubility product of mg os2 is 1.
1 into 10 to the power minus 11 at which ph will mg2 plus ions start precipitating in form of mgos2 from a solution of 0.
01 molar mg2 plus i
 so question is suppose mg 2 plus ion is there and you started adding oh minus ion at what ph your mg2 plus ion will precipitate out
 so ph you are changing ph is going from acidic to alkaline
 so o h minus ion is increasing and you have to tell at what o h minus ion concentration you are going to get precipitated at what o h minus ion concentration you are going to get precipitated and since you know h ion concentration you will be able to tell at what ph precipitation will begin advanced ph precipitation will begin
 so for precipitation to begin k s p should be equal to k k w or k s p is equal to m g two plus ion concentration into o h minus square h minus s square and case p is given one point one into ten to the power minus eleven is equal to m g two plus into o h minus sin square
 so you can calculate two h minus i n square and this is one point one into ten to the power minus eleven divided by point zero zero one and this is ten to the power minus three
 so you have one point one into ten to power minus a
 so o h concentration will be which minus ion concentration will be around 1 into 10 to the power minus 4
 so p o h will be your 4 and
 so p h will be water h will be 10.

 so at this ph your mg 2 plus ion will start
 so at ps10 your mg 2 plus ion will start to precipitate basic heat since at that point mg2 plus iron ksp ksp will be equal to kw and if we kw go up in ph then kw will be greater than ksp and precipitation will begin next question is calculate calculate the molar solubility of molar solubility t of m g o s two in one molar nh four c l ksp of mg mg os2 is given and that is your 1.
8 into 10 to the power minus 11.
 whereas kb of ammonia is given which is 1.
8 into 10 to the power minus 5 we need to calculate mg o s two in solubility of m g o s two in one molar ammonium chloride solution
 so ammonium chloride is soluble salt and that will give you ammonium plus plus your chloride ion if we started with one molar ammonium chloride we will get one molar ammonium plus ions since this is a soluble salt and there will be a complete dissociation and n is 4 plus and this will react with o h minus ion to give you ammonia plus your water ammonia plus water o h minus ion will come from m g o s two
 so we have salt is mgos2 and that gives you this is sparingly soluble salt
 so that will give it mg two plus plus o h minus sin twice o h minus i this o h minus ion is utilized and that is getting utilized with the reaction with ammonium plus iron and that is going to give you ammonia plus water
 so this is your solubility equilibrium and this is your opposite of your this reaction ammonia plus water giving you ammonium plus iron plus o h minus iron we

know equilibrium constant of this that is given

so k b is given and this is one point eight into ten to the power minus phi
so basically you also know k of this reaction this is nothing but one by k b
so suppose s is the solubility solubility of mg os2 in one molar ammonium chloride solution then m g o s two m g two plus plus two h minus ion
so if this is s then this will be two s this o h minus ion is used up in this reaction ammonium plus plus o h minus ion
so initially you have one molar and this is two s molar reaction will take place suppose x and two s minus x then this will be x and this will be x and since both are o h minus ion
so you will write 2 s 2 s minus x
so let us again write both reaction m g o s 2 m g 2 plus plus 2 h minus i ion this is s this is two s minus x at equilibrium and you have reaction this n s three plus s two o this is your at equilibrium this is one minus x which is almost equal to one molar and this is your two s minus x which is basically o h minus ion concentration and x
so we know case p k s p will be equal to s into two s minus x square and second we know k b k b will be equal to your ns4 plus ion
so i am talking about opposite reaction
so this will be in opposite reaction this is the product
so h minus ion by ammonia and this is your ns4 plus is 1 into h minus is your 2 s minus x 2 s minus x by your ammonia is x
so you have two unknowns s x s x this is also two s minus x and you have a two equation
so you will be able to get your o h minus ion concentration and value of s and this value s is your solubility of solubility of salt solubility of salt precipitation is precipitation is the basis of basis of wet chemistry if suppose we want to know we want to know the presence of presence of particular iron particular iron what we will look at is if there is any salt of that iron that iron which is insoluble are sparingly soluble if we know if we know that solve of that particular iron particular ion is sparingly soluble then what we do is we will add the counter iron counter ion counter ion of this particular iron the particular ion which is which makes this ion into insoluble soil insoluble soil and when your insoluble salt is formed it will precipitate out it will precipitate out and we can know that this particular ion is present suppose we have solution and we had a g plus ion solution and we added g plus ion and we see a precipitate precipitated then we can infer that chloride ion or bromide ion or diadem is present is present thanks you