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5.111 Principles of Chemical Science, Fall 2008
Transcript – Lecture 22

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PROFESSOR: -- All the things would be relevant, so here are some examples from a couple of lectures ago. And so here we're thinking about what happens when we add an inert gas. And remember, it's all about the partial pressure. So, you always have to ask yourself did the partial pressure change, and partial pressure's going to change if there's a change in volume.

So, the secret in this problem is realizing that if inert gas is added, and the total pressure is kept constant, what had to have happened? Yup, the volume would have had to increase, and so the system is put at stress, and it responds in a way to minimize the stress. So it's going to respond in a way to go from fewer numbers of molecules to more molecules. So, on one side of the equation reactants there are three, and on products there are two, so it's going to shift toward reactants.

All right. So today we're going to have another clicker competition, and because it is Halloween, this is the prize for the recitation that has the most correct answers. So, let's see how we do today.

All right. So we're going to continue where we left off on Wednesday, and so these are your notes -- I've added them to today's handout and they're also in the handout from the last class. And I want to make a note that it's a good idea to start this problem-set early. You don't know everything you need to know to do the problem-set, but you do know a number of them, so there's some questions on thermodynamics and equilibrium, and Le Chatelier's principle, you can do all those problems. So next week -- today we're going to talk about bases and buffers, and then we're going to move into acid-base titrations on Monday.

And so, the problem-set looks like it's not that long, it's not that many questions, but the acid-base titrations have many parts, and each part is actually quite long. So it's a very deceptive problem-set. So don't be fooled by the total number of questions.

All right, so we were talking about acid and water and base and water and pH , and so we're going to continue with base and water right now. So here we have a base in water, and so in this case, the water is acting as an acid. It's giving up a hydrogen ion or proton to the NH_3 , causing it to form its conjugate, NH_4^+ plus ammonia ion, and also hydroxide ion. So here we have a base in water, and when we're talking about a base in water, we're going to talk about base ionization constant, or K_b . So at the end of last class we talked about the acid ionization constant, or K_a , and when you're talking about bases, you're going to talk about K_b 's.

So, K_b , it's an equilibrium constant for this reaction of a base in water, and so it'll be equal to the products in H_4O^+ and hydroxide ion over the reactant, NH_3 . The water is the solvent here, and since this is all pretty dilute, it's mostly pure and its concentration isn't going to change, so it's not included in that equilibrium constant. So we have a K_b when we're talking about a base in water. And we were talking about a base in water, the equation should work that you have hydroxide ions on one side of it.

So here, the K_b is 1.8×10^{-5} at 25 degrees, so that's a fairly small number. And so the small value tells us that only a little bit of the NH_3 is going to ionize when it's in solution. So only a little bit it's going to form NH_4^+ and hydroxide ions. So that's what that small number tells us. So that tells us that it's going to be a weak base. So a strong base is something that's going to react pretty much completely to go to hydroxide ion concentration. A weak base only ionizes a little bit in water. And you can tell about whether something's strong or weak by its K_b value, or if it's an acid, it's K_a value or pK_a value.

So here are some general ways to write these equations. We have a base in water and so the water's going to act as the acid, base is going to accept that proton or hydrogen ion forming a base, H^+ , and hydroxide ion. So the base is just written as B . You could also write the base as a minus, something a minus in water going to H^+ plus hydroxide ion. So sometimes you might see that when you're talking about a conjugate base of a weak acid. So these are two expressions that you'll see that are fairly generic that expresses what happens when you have bases in water. Now remember, you know it's a base in water, you better have hydroxide ions on the other side, because a base in water is going to be forming hydroxide ions, and acid in water would be forming hydronium ions.

So, a strong base, again, almost completely ionizes to OH^- when in water, and here we can know what's strong or weak by the K_b , so the larger the K_b the stronger the base. And like there is the pK_a , there's also a term pK_b . pK_b is $-\log$ of the K_b . And the larger the pK_b , the weaker the base.

Now you won't see pK_b very much. It's not used very much, most things are converted to a pK_a . So you'll see pK_a 's quite a bit, and you will see pK_b 's if you take organic chemistry, if you take biochemistry, if you take biology, you'll be hearing a lot about pK_a 's as we go along. Not so much about pK_b 's, but pK_b 's. And so what I want you to do when you hear about pK_a 's, is remember that you've learned about it. Because I have been confronted by some of my colleagues who teach in advanced levels, and they said our students tell us that you never talked about pK_a 's in freshman chemistry. And I assure them that I did. So I'll be emphasizing this.

And so I want to make sure that by the end of this unit you're really familiar with pK_a 's because you'll need them later on, and I want you to really impress my colleagues in later classes, and they'll say oh, that's a 511-1 student, of course, they know what a pK_a is. Even my six month old daughter who's over there, she's like what, people didn't know what a pK_a is? You don't want to get her upset.

OK. So all of these things are related with the acids and the bases, because for every acid it has a conjugate base, every base is a conjugate acid. And so, if you have a stronger acid, the stronger the acid, the weaker its conjugate base. And the stronger

the base, the weaker its conjugate acid. And this becomes very important in doing these problems.

So here's a little table that emphasizes that fact. So we talk about a strong acid. Most people are familiar with HCl , hydrochloric acid. So it's a very strong acid. And its conjugate base, Cl^- , is not really a base, it's completely ineffectual as being a base. It doesn't really do anything at all. A strong acid really drives you all the way to hydronium ion concentrations. It doesn't go back the other way, it's not really equilibrium, it's just going to completion there.

So the conjugate is really, really weak, basically not a base at all. Then we get into this middle range and here things that are moderately weak or very weak acids also have their conjugates in the weak range. But if you get to something that is a very strong base down here, its conjugate is going to be also ineffectual as an acid. So if something is very strong, its conjugate is pretty much non-existent in those properties, but when you have weak-weak, then you can start talking about buffers, which we're going to get into later in today's class.

OK. So let's prove that, in fact, it has to be true that there's a relationship between the conjugate acid and its conjugate base or conjugate base and its conjugate acid, that they both can't be strong. One has to be -- you have to be weak-weak, strong or ineffectual.

All right, so let's look at the first one up here. So first let's look at what is this acting as? What is NH_3 acting as, an acid or a base in this equation? So it's acting as a base. And that means water is acting as an acid. The water gives up a proton or hydrogen ion to the NH_3 forming the conjugate acid of that base. And then the conjugate base is the hydroxide ion.

All right, so now let's write term for K_b , and so we're talking about a base in water, so we're talking about K_b . So K_b is going to equal what -- what do I put up here? Tell me one thing to put up there. Yup. OK, $\frac{[\text{NH}_4^+][\text{OH}^-]}{[\text{NH}_3]}$. OK, so we don't have water in there.

All right, so let's look at the next reaction. So what is NH_4^+ acting as? It's acting as an acid here, so it's giving up its proton or hydrogen ion to the water, which is going to act as a base and accept that hydrogen atom. And when this gives up its hydrogen ion or proton, it forms its conjugate base, and the water is conjugate here, is an acid, hydronium ion. So we have our conjugate acid base pairs here. So now am I talking about a K_a or a K_b ? I'm talking about a K_a , so I'm talking about an acid in water, and we know this is an acid in water if we look at what's happening over here. So we have an acid in water, and so we'll put our concentration of hydronium ions and NH_3 over NH_4^+ . So now we have K_a 's and K_b 's written for the conjugates, the conjugate acid of NH_3 and NH_3 itself.

So now, we can think about what happens if we take these K 's and we multiply them out together. All right, so we have a K_a and we have a K_b . All right, so we have a K_a and a K_b , so if we take our K_a and times our K_b , we're going to just multiply these out together. So I'll do this one first, K_a -- just copy from above -- times K_b , hydroxide ion, over NH_3 . And things are going to cancel out, and so I'm left with hydronium ion and hydroxide ion. What is this, when you have hydronium ion times hydroxide ion? What is that called? It's another K . K_w . So we just showed that K_a times K_b equals K_w .

So we can take the logs of all our K terms here, and if we take the log of K_a plus the log of K_b equal the log of K_w , or $pK_a + pK_b = pK_w = 14$.

So there's this relationship with a conjugate acid and its base between its K_a and its K_b . So if one is really big, the other has to be small or they can both be sort of in the middle. But they're always going to add up in terms of the pK_a and the pK_b to 14. And the thing about these problems is if you're given a K_a for an acid, you can calculate the K_b for its conjugate base, and you'll be doing that a lot in titration problems that are coming up.

All right, so there's this relationship between the strength of an acid and the strength of its conjugate base, and let's just think for a minute again about this concept of strong and weak, because this is really important for the next unit. So if we have a strong acid, H^+ , in water, it's going to go pretty much completely over to hydronium ion and the conjugate, and this conjugate is going to be really ineffective as a conjugate base, as a base at all. So it's going to really go all to that hydronium ion concentration.

And so, in talking about a strong base, you don't really have to worry about an equilibrium situation. Just remember it goes pretty much to completion, and so you can do complete subtractions when you're doing this. And the same is true for a strong base. So, for a strong base, any B^- , in water, it's going all the way down, it's driving the reaction all the way over here, and you're forming, you can consider it that however much strong base you added is how much hydroxide ion you have here. How much strong acid you add is equal to how much hydronium ion concentration you have here. So however much of a strong acid or a strong base, you think they go all the way to completion, but for a weak acid we're going to have equilibrium, and so you'll have to set up equilibrium tables to figure out if you added this much weak base, how much did it ionize.

So remember that -- people get worried about the strong acid, and you just assume it goes right to completion. And you can tell again by the K_a 's and the K_b 's what's going to be strong or not. And so our definition for strong acids is that you have a K_a greater than one, strong base pretty much, the only problems you use, people are adding sodium hydroxide or potassium hydroxide, there are not a lot of options for strong bases. But for strong acids, people are always worrying about whether they've identified those correctly or not.

OK. So let's look at this relative strength of acid problem and do an example here. So in this equation we have acid in a base going on one side, another different acid on the other side. So we can look at whether the reaction is favored toward this direction, toward the right or the left, depending on which acid is stronger. Will the reaction ride to the right or left. So if this acid is stronger, then it should drive the reaction this way. If this is the acid on the other side, if it's stronger, then you would expect to drive the reaction the other way. So we can take a look at that.

So we can consider the K for the overall reaction, again, just products over reactants here. And we can also consider the reaction from just each acid alone in water. So we can consider it separately as well. So first we can take a look at one acid. So if we take a look at this acid alone in water, it'll form H_3O^+ plus and H_2O . So when it gives up its hydrogen ion to the water and then it forms its conjugate over here. So now are we going to look at a K_a or a K_b ? K_a ? So we're going to have our

products over our reactants, and the number is quite large, 20, for that K_a . And now we can look at the other reaction as well.

So we can look at this acid in water here and form your hydronium ion concentrations and your conjugates -- again, we're looking at that acid in water, so it's a K_a , and we have our products over reactants. Now we have a number of 5.6×10^{-10} .

So, we can consider those two equations back together, and this time we're going to be subtracting the equations from each other to get our sum equation. And because we are subtracting, we're going to end up to dividing the equilibrium constants. So when we add the equilibrium constants together, we multiply things, and if we're subtracting we divide.

So the K in this case is going to be equal to the K_a of the first acid over the second acid, and you can prove this to yourself, you write up the K_a here, and the K_a here, and then some of your terms, the hydronium ions cancel, and you get the K overall equilibrium constant that we wrote in the beginning, again products over reactants. We know the value for K_a for one acid, we know the value of K_a for the other acid, and we can divide those to get the K for the overall reaction. And then you can tell me what that K means in terms of which is the stronger acid of the two, and which side of the equation does the reaction lie to, the right or the left?

All right, let's give 10 more seconds. Yup, people did pretty well on this. So you could have thought about it in terms of the overall K or of the individual K_a 's. So, the stronger acid is the one with the larger number. And HNO_3 had a number of 20, so that was pretty big, so that's a really strong acid. And because it's a strong acid, it'll lie to the right, so it's going to push toward products -- it's a strong acid, so it wants to disassociate a lot, so would push it that direction.

And you can see that also in terms of the equilibrium. Overall equilibrium constant, if we go back to the slides for a minute. So this number overall, K , is also quite large, very large, so that means a lot more products than reactants at equilibrium. So again, those are what you can determine if you're given a table of K_a values, which on the test you will get a table of K_a values, you can tell me a lot about different reactions knowing that information about K_a 's.

All right. So in this unit there are different types of acid base problems, and sometimes it feels for people like there's an infinite number of different types of acid base problems. But, in fact, there are really only five. And so one of the things I strongly recommend in this unit and working problems is figuring out which type of problem it is, and that will help you a lot in solving it. So you can either have a weak acid in water, a weak base in water, and sometimes you can be fooled and say oh, it's a salt and water problem, but a salt and water problem actually breaks down to a weak acid and water problem and a weak base and water problem.

So it's really not a different kind of problem, and we'll see that in a few minutes. And you can have a strong acid in water and a strong base in water, and then you can have my good friend the buffer type of problem. So those are the type of problems and being able to recognize them is key to doing well in this unit. So let's work a problem in the first type of a weak acid in water problem.

All right, so what's a weak acid? Well, vitamin C is a weak acid. And so sometimes when you're taking your vitamins you get a bad taste in your mouth. And if you did take a vitamin C tablet here, which is 500 milligrams in this vitamin C tablet, and dissolved it in water -- this is not scientifically measured -- but dissolved it in water, so you would say taking your vitamin with a lot of water, and it was starting to dissolve and being pretty unpleasant, then we could calculate at equilibrium what kind of p h we would have in that mixture. Now, these vitamins, this Nature's Bounty, they do a really good job of isolating the vitamin, so it is pretty much impossible for it to dissolve. So they have a nice coating around it that's highly protective, at least at normal water p h's, so it doesn't really dissolve. And one year I thought I would do the actual experiment, we could talk about significant figures, but I could not get the tablet to dissolve -- I heated it, I stirred it, I did everything at neutral p h, at room temperature. I want to do it at room temperature, it just didn't work, even the high temperature didn't work. So if you buy Nature's Bounty, it will not dissolve in the water that you're taking, so just for that little bit of information.

But if you had, say, an inferior brand of vitamin C that readily, that didn't have a nice coating around it, then you could do this experiment. So let's take a look at that. So the first thing that we have to do is calculate the molarity of the acid that we've added. So here, just have to make sure that your units are going to be correct. So we have grams, we're converting it with a molecular weight to moles, and then we have the number of moles in the amount of water, and we can calculate the molarity of that solution. And one of the mistakes that people often make in doing these problems, they forget to do all of the conversions that are necessary, sometimes they stop at moles, and you're talking about concentrations here, so don't forget about your friend the volume.

All right, so then you can write an equation, and I highly recommend that people do this on the test because it helps them figure out what type of problem it is and it voids people making silly mistakes. So if we're talking about an acid in water, you should make sure that your equation reflects an acid in water. If you have hydroxide ion on the other side, something is very wrong that's going on, and acid and water is going to be giving hydronium ion concentrations and a conjugate base.

So then we can set up an equilibrium table here. We calculated the initial molarity. And in the beginning there's nothing over on this side, so we've just added our weak acid to water. And so then the change, there's going to be some amount of this that ionizes minus x, some amount of this that's formed, and some amount out of the conjugate that's formed. So we have 0.0284 minus x plus x plus x. Now we're talking about a weak acid in water, so what term am I going to want to use next? K a. So I'm going to want to use k a next -- k a value is here, $8 \cdot 10^{-5}$, we have products over our reactant here, and we have x^2 over 0.0284 minus x.

Now you can make an assumption when you're working on these problems and check it later. So you can make the assumption that x is really kind of small compared to this 0.0284, and you can just drop this x out of the term here. And then check later and see if that worked or not.

So that makes the math easier, and so now we can just solve for x, and x comes out to be 0.00151. The really two significant figures, but we're going to carry an extra one for the moment, so they're just two figures right here, two significant figures here.

Now we can check and see if x was really small, if that assumption worked right. So, is $0.0284 - 0.00151$ really the same as 0.0248 , and we let you make the assumption that it is, we say it's OK if it's less than 5% of the value. So, in this case, it's actually not, it's 5.3 , so that violates our policy. So it's more than 5%, so then you have to use the quadratic equation to solve the problem.

I just want to note that this term, this percentage, can be called sometimes percent ionized or percent deprotonated, so that you're not thinking that's some kind of bizarre term if you see that. And if you use the quadratic equation, you get an answer of 0.00147 , again, that's really two significant figures. So it's not a whole lot different, actually, than the number you got making the approximation.

So, once you know what x is, x is the hydronium ion concentration in this problem, and so we can plug that in, pH is minus log of this, so that's 2.83 . And so we had really two significant figures here, and so we are going to have two significant figures after the decimal point here. And if you haven't reviewed your sig fig rules and need more help if that seems wrong, then you should definitely review it before the next test.

All right, so now we'll continue with today's lecture notes, and we're just going to continue right on and we're going to talk about weak bases, and well, we're start working on our way through, we're also going to try to get to buffers today.

So, we've done a problem for a weak acid in water. So now let's talk about a weak base in water, and you can start us off. So in this problem we're given a molarity, so you didn't have to calculate that, and now you can help me fill out the table so we know what to do here. OK, let's just do 10 more seconds.

Very good. So you're going to be losing some of the amount -- some of the amount of the weak base you have in, it's going to ionize, and so then you'll be forming the conjugate acid plus x , and you're going to be forming hydroxide ions plus x . And so the one with the minus sign is important, and sometimes there will be 2's involved, and that depends on the stoichiometry of the reaction.

All right, so we can use that information now and go on and look at -- actually you could leave that clicker question up for a minute, and we're going to talk about the K_b . So the K_b is going to be equal to our products, nH_4^+ plus and our hydroxide ion concentration over nH_3 . And so now I can fill in the values that you told me. So we have, on the top we're going to have x squared, on the bottom we're going to have $0.15 - x$. And now we can make an approximation here that x is going to be small compared to 0.15 , and so we can say that's just going to be equal to x squared over 0.15 , and the K_b value that was given was 1.8×10^{-5} .

So now we can solve for x using this approximation, and using this approximation x comes out to be $.00164$, and we can look at whether that approximation was OK. So is this number less than 5% of 0.15 , so we can say $0.00164 / 0.15 \times 100$, and that comes out to be 1.1% , so that's OK, that's less than 5%. So that's good, we don't have to use the quadratic equation here.

So now, we want to calculate the pH . So can I just plug that number for x into my pH equation? What is x ? What is x equal to here? It's equal to two different things. What's one of them? Hydroxide ion concentration. So what we can do is calculate a pOH . So, pOH is minus log of the hydroxide ion concentration, or minus log of $.$

001647, and we really only have two significant figures here, and that is going to come out to 2.79. And so, we would have two significant figures after the decimal point, because this number had two significant figures in it. But I'm not done. I've calculated pOH and the problem wanted pH . So how do I go from pOH to pH ? $14 - pOH$, yup. So 14.00 at room temperature minus 2.79 is going to be equal to 11.21 . And so that makes sense.

Now in doing these problems always consider, sometimes you're rushing and you get done you say OK, my pH is 2. But go back and think about the type of problem you're doing. It's a base in water problem. Would it make sense that the pH was 2 if it was a base in water problem? No. And so then you realize oh, I have to do another step. So that kind of thinking can save you a lot of points on the exam, to remember what it is you're trying to calculate and go back and make sure that your answer makes sense. And sometimes people run into weird math problems and some they'll write and say this pH should be above 7, it's 2, I don't know what I did wrong, clearly I did something wrong. I know that's wrong but I don't have time to figure out what I did wrong. That will get you points. So just recognizing that if something makes sense or not tells us you know what's going on, and sometimes math issues can get you into a place that you can't get out of quickly. So just thinking about whether the problem makes sense is a big step.

All right. So now, we're going to talk about salt problems and I'm going to try to convince you that salts are actually the same as the weak acid and weak bases that we just did.

So a salt is formed when you mix an acid and a base together. So, for example, if you have HCl and sodium hydroxide, you're going to get table salt and H_2O and water. So the pH of a salt in water is not always neutral. Sometimes it's neutral, sometimes it's not neutral. Well, when would it not be neutral? Well, if a salt contained a conjugate acid of a weak base, then that conjugate acid is going to make it weakly acidic. Salts that contain things like iron 3 plus also may be acidic. So when you're drinking water and you measure the pH of that water and it's not neutral, this could be part of the reason that there's some salt in the water, some different ions in the water.

So a general rule from the periodic table group one and group two metals, so lithium, calcium, sodium, those are all going to be neutral in solution, so you can just remember that. And if a salt contains a conjugate base of a weak acid, then it'll form a basic solution. So it's all about whether the salt derived from a weak acid or a weak base that's going to give you a clue as whether it's an acid or a basic solution. If it derived, say, from a strong acid mixed with a strong base, then it's going to give you a salt that's neutral.

So let's look at some examples. So here we have NH_4Cl . So we can break this down and think about where a salt like this would have come from. So it would have come from NH_4^+ and Cl^- . So NH_4^+ , let's think about where this came from. What is it? So, we want to ask the question is NH_4^+ a conjugate acid of a weak base? And what is its conjugate base? Well, its conjugate base is NH_3 . If you lose a hydrogen ion or proton from NH_4^+ , you get NH_3 . And so you're really asking, if that's a weak base, then its conjugate is also going to be weak. So you need to know about these guys to see what would happen if you have NH_4^+ in solution.

So how do you know about this. Well, you know about things being weak or strong based on their K_a 's and their K_b 's. So, is ammonia a weak base? It has a K_b of 1.8×10^{-5} , so yeah, that's a small number, so that's a weak base. And so it's actually in this table, so if you have something that's weak over here, then its conjugate is also going to be weak over there. These are totally lined up right. And so the conjugate over here is also going to be weak. And if you weren't really sure you could always look it up, so here you have ammonium ion and it has a K_a of 5.6×10^{-10} . Yup, that's a very small number, that is a weak acid.

So yes, the conjugate is weak, the base is weak, and the conjugate acid of that weak base is also weak. So, NH_4^+ does have acidic properties. It's not a strong acid, it's a weak acid, but it will make things acidic. So this should be acidic. What about Cl^- ? Do you think it's going to do anything useful for you? Where do you think Cl^- came from? From HCl . So we could ask again, is Cl^- a conjugate base of a weak acid. The acid is HCl , is that a weak acid? No. So we can look it up if you didn't remember it, 10^7 , definitely not weak -- very, very, very strong acid, and if something is strong acid, its conjugate is ineffective as a base. So Cl^- is ineffective as a base so it's going to be neutral here.

So overall, you have something that's going to be acidic with something that's going to be neutral. So overall it'll be acidic. So this particular salt and water is going to be acidic because the things that were mixed together to get it, one of them included a weak base, and so that's going to form a weak conjugate acid, so it'll be acidic in solution.

All right, so let's look at another one. I'm giving you the K_a value in this problem, and knowing that particular K_a value, tell me what you think is going to be true about this particular salt in solution, whether it'll be acidic, neutral, or basic. OK, 10 more seconds.

So, some people were a little fooled by the information I gave you, so let's take a look at this. So if we go to my presentation here. So we can break this up into Na^+ and CH_3COO^- . Na^+ is that a conjugate acid of a weak base? Is that going to be acidic? What do we know about things in group one, a column of the periodic table. They're going to be neutral. Where do you think that this came from, Na^+ , where might it have come from? It might have come from NaOH , that might have been a base that was added. So it's not going to do anything for you -- things in group one and group two are going to be neutral.

All right, so we can ask the question about CH_3COO^- . Is it a conjugate base of a weak acid? So then we can say is the acid that it came from a weak acid? Is its conjugate a weak acid? Well, how do we know about that? Well, we know about that from the K_a value that I gave you. So is this a weak acid? Yes. So is its conjugate going to be a weak base? Yes. So, given that information we can say yes. So its conjugate acid is weak, so then it would be a weak base. So if it's a weak base then it'll be basic in solution, and we have something that's neutral plus basic, so overall you get basic.

All right. So let's look at a general example now of this as well. So here we can talk about a general rule. So if you have compound X^+Y^- , we can talk about X^+ and Y^- . And for X^+ you're going to be asking about is it a conjugate acid of a weak base. For Y^- you're going to be asking is it a conjugate base of a weak acid. So

for the first part you're asking about if it's a conjugate acid, in the second half you're asking about if it's a conjugate base. So if something is a conjugate acid of a weak base, and that's yes -- if you know that's a weak base or you know that it's a weak acid, then it's going to be acidic, if it's not, it'll be neutral. Same thing is true over here. You might know about that something is a weak base, you might know that its conjugate is a weak acid, and if you have a conjugate base of something that's a weak acid, then it is a base. If it's a strong acid it would be ineffectual, but if it's a conjugate of a weak acid, it'll be basic. No, it's neutral.

So overall, you can have three possibilities. Acidic plus neutral is acidic, basic plus neutral is basic, and neutral plus neutral is neutral. Now some people might come up with another option here. What other thing am I leaving off of this overall? Acidic plus basic. That's because I'm never going to ask you that when it comes to a salt. Because pretty much, salts are formed when you're doing a titration, and you're going to be either titrating a strong acid, a strong base, you're going to be titrating a weak acid with a strong base, or you're going to be titrating a strong acid with a weak base. You are never going to titrate a weak acid with a weak base. That would yield no interesting results of any kind. So you're not going to be forming salts that are conjugates of both those things.

So, if you want to think about it that way that's fine, or you could just remember that that is not what I'm going to ask you. These are great little short answer questions on an exam, so if you're good at thinking about this, it'll definitely give you a couple of points on one of the exams.

All right, so now and last, just a couple minutes, I just want to introduce very briefly buffers. So a buffer is something that maintains the p h of a solution, so it's going to buffer that solution. So if you add a little bit of strong acid or a little bit of strong base, it doesn't matter the p h is going to stay the same. So there are two kinds of buffers. You have an acid buffer, which is going to buffer/maintain the p h on the acidic side of neutral. And a basic buffer, which will maintain the p h on the basic end of the p h scale.

So let me just give you a brief example of a buffer and just get you thinking about buffers. So here, in about a buffer problem you're going to mix an acid with its conjugate base. So, you have acetate, and then probably the acetate salt of the acetic acid. So over here, you have the acetic acid, on this side you have its conjugate base usually added in the form of a salt. And then you have an equilibrium. So, what's going to happen if you add a strong acid to this solution? If you add strong acid, if you add more H^+ , what happens if you add more? What direction will the reaction shift? So you'll get the back reaction, it'll try to minimize that stress and move the other way, and it'll use up some of that acid and maintain the p h. Then you can think, so these amount of acid added is effectively removed and the p h stays the same.

What about if you add a strong base? Well, that strong base will react with the acid, it will remove protons from this acid, or the hydrogen ion here, forming this water and its conjugate. So you'll make more of these and the p h will also stay the same. So the base is going to be removed by reacting. So they're effectively removed and the p h stays the same.

So in this you have a weak acid, H^+ , it'll transfer protons to OH^- supplied by the strong base. The conjugate of that weak acid, which would be a weak base, is

going to accept protons from any acid that is going to be supplied. So, in this way, you maintain the p h.

And so I just to emphasize that in a buffer solution you have h a, acidic buffer solution, you have h a, and you have its conjugate. And if you only have one or the other, it's not going to make a good buffer. So, I want you to remember that in buffers you have both conjugates -- one alone is not going to work. And people forget this in the class, and so you can remember that for Halloween, your chemistry professor dressed up as a buffer to help you remember that in a buffer you're going to have both. You've got to have the conjugate acid base set, otherwise it will not buffer.