

>> Okay, I'd like to show you a few more rule-breakers. Again, this has to do with octets. We know that usually an element is stable when it has an octet in its valence shell. But what happens in a situation like this, we have  $\text{PCl}_5$ ? Phosphorous gives us five electrons in its valence shell, each of the chlorines gives seven, and there's five, so that's 35 electrons, total of 40 electrons. Chlorines can only form one bond, that means phosphorous has to be in the center and it has to be bonded to five chlorines. Well, every bond is two electrons, so 5 times 2 is 10. This phosphorus has ten electrons in its valence shell. Now, how can that happen? We see everything else, all the chlorine, stick with what they're supposed to, they all have their octets. And we're referring to this now as our expanded octet. So, there's an expanded octet in  $\text{PCl}_5$ . Question is, how can phosphorus end up with ten electrons when S and P orbitals only hold eight? Well, let's take a look at phosphorus. Phosphorus has the atomic number 15, which means it has 15 protons, 15 electrons. So if we do the electron configuration, we have  $1s^2, 2s^2, 2p^6, 3s^2, 3p^3$ . Three and 2 is 5, 6 is 11, 12, 13, 14, 15, that is our electron configuration. Now you notice I put one more in here, and I just erased it, I put also in here 3d. Well, look what happens, there's nothing in 3d, but any time you have the third energy level, you have available all the different parts of the energy level. There's a S shell, there's a B shell and there's a D shell. And so even though we don't use the 3d subshell, we still have the ability to use it if we need to. So, it's kind of like having company. If the company comes and you have four vacant bedrooms that aren't being used, are you going to send your company to go stay at a motel or something? No, you're going to go ahead and put them up in the bedrooms. Well, phosphorus has ten spaces here. Beyond the three and P, it can also accommodate ten more. So what happens when we end up with one extra chlorine? Well, those two electrons can be accommodated here. And so that's what happens. Anytime you have a central element that goes into the third energy level, it automatically will have available to it empty D orbitals. And if it has those empty D orbitals, it can then become expanded. Some of those will use the orbitals, but if they're not using the orbitals, then they can become expanded like this one. Another example would be  $\text{SF}_6$ ; sulfur hexafluoride. Sulfur has six electrons, fluorine has 6 times 7 is 42, for a total of 48 electrons. Sulfur has to be the center one because remember we said all the halogens only form one bond, so none of these fluorine's can be in the center. Sulfur has to accept all six of the pairs of electrons. So this sulfur actually has two, four, six, eight, ten, 12 electrons in its valence shell. Again, it's because it has an empty d orbital, that they can go ahead and take those extra electrons and find room for them. And so again, here's our octets for all the fluorine's, and then each one of these lines represents two electrons, so this sulfur has 12 electrons in its valence shell. And so these are a couple of nice examples of expanded octets.