Hi I'm Jocelyn and today we're going to go over fall 2009 exam 1, problem 1. So to begin with, we always want to read the whole problem. So in this one it says uranium metal can be produced by the reaction of uranium tetrafluoride with magnesium in a sealed reactor heated to 700 degrees C. So we know that we're dealing with a chemical reaction here. The byproduct is magnesium fluoride. To ensure that all the magnesium is consumed in the reaction, the reactor is charged with excess uranium fluoride, specifically 10% more than the stoichiometric requirement of the reactor. To produce 222 kilograms of uranium, how much uranium tetrafluoride must be introduced into the reactor? So that's what the question is asking us. Then it says we assume complete conversion of magnesium, express your answer in kilograms.

So we know that the question is asking us for the uranium tetrafluoride needed to make 222 kilograms of uranium. Right? That's the last sentence. The sentence that's before that, however, also gives us very important information. It tells us that we need the stoichiometric equivalent plus 10%. And that's very important to keep in mind because, as you'll see later, that's where a lot of people got tripped up on this problem.

So then let's go to the first two sentences in this problem and extract the information given there. We know that we're dealing with a chemical reaction. So when we are dealing with one of those we always want to put down the chemical equation. So we have uranium tetrafluoride reacting with magnesium to give uranium with a byproduct of magnesium fluoride. And it tells us that it that it's at 700 degrees C. That's superfluous information but you can always put reaction conditions above the arrow just to keep track.

So now that we have this equation are we ready to move on? No. Right? We need to have a mass conservation. We need to balance this equation. So to determine if this is balanced or not, we want to keep track of the amount of uranium, fluoride and magnesium on each side of the equation. So we have uranium, fluoride and magnesium. And then we have on the product side-- and that's not right. This is the reactant side, right? And over here is the product side. So on the reactant side we have 1 uranium, 4 fluoride and 1 magnesium. On the product side we have 1 uranium, 2 fluoride and 1 magnesium.

So we see that we have an imbalance in fluoride. To fix that we can put a stoichiometric coefficient in front of the magnesium fluoride on the product side in order to have 4 fluorides. We put a 2 there. And we change that to 2. But we also have to change the magnesium. Right? Now, although we fixed the problem in the fluoride, we have an imbalance in the magnesium. So to fix that, we put a stoichiometric coefficient in front of the magnesium, switch our accounting down here, and we see that we now have conservation of mass. The two sides are balanced.

So with our balanced equation we can now move on to what the question is actually asking us. And we know that we have, we want to make 222 kilograms of uranium. We then need to figure out how much uranium tetrafluoride is needed. This chemical reaction gives us mole ratios. But we are, right now, have kilograms. So the first thing we need to do is convert kilograms to moles. And we do that using stoichiometry or unit conversion.

So the other thing we need to know is the molar mas of uranium. So this is something you can look up on your periodic table, online, whatever resources you have available. So the molar mass of uranium is 238 grams per mole. Now we just do a simple unit conversion to get the moles uranium that we want. So first we need to convert to grams. That's 1,000 grams. And then using the molar mass, we convert to moles. And because I have grams up top here I need to put the molar grams down here in order to cancel everything out. And that gives us 933 moles uranium.

OK so we have the number of moles uranium we want to make. Now we can use the chemical equation over here to determine how much uranium tetrafluoride we need. So the chemical equation tells us that we need a 1:1 ratio of uranium tetrafluoride. However this is where we need to go back to what the problem was actually asking us. And remember that we need the stoichiometric equivalent, which is given by this mole ratio, plus 10%. So the amount of uranium tetrafluoride we need is the stoichiometric equivalent plus 10% times that stoichiometric equivalent. And that equals 1,026 moles of uranium tetrafluoride.

So we found the amount of uranium tetrafluoride we need. Are we done? No. Right? If we go back to the question we see that it asks for our answer expressed in kilograms. So that's why it's always important to keep track of what the question is actually asking you and to make sure you've answered that.

So we have uranium tetrafluoride in moles. Now we need to convert it to kilograms. Again we need the molar mass. This time of uranium tetrafluoride. And it equals-- so we have 1 uranium per molecule and 4 fluoride. And again we just look up that molar mass of fluoride on the periodic table. And that equals 314 grams per mole.

So we do our unit conversion again. And this is my favorite way of doing stoichiometry unit conversions. You may have another way that you learned in high school or later on. But this way I know that I'm keeping track of my units and everything's canceling out correctly. So we have 1,026 moles uranium tetrafluoride. We use the molar mass we just determined. And remember that this is an industrial scale process, so we actually care about the amounts in kilograms. And we get 322 kilograms uranium tetrafluoride. Going back to what the question was asking us, we know that we now have the correct answer. And we can put a box around it. So that on the exam whoever's grading you knows that that is your answer.