7. If you had the ultimate subatomic particle collider that would allow you to add protons, electrons and neutrons at will to any atom to make any other atom, how many protons, neutrons and electrons would you need to add to Cr to make an atom of Sn?
   - The first thing to do is to obtain the atomic numbers and atomic weights for these two elements from the Table.
     - Cr is chromium, atomic number 24 with atomic mass 51.966 (round to 52).
     - Sn is tin, atomic number 50, atomic mass 118.710 (round to 119).
   - At this point, you know that Cr has 24 protons and 24 electrons and Sn has 50 protons and 50 electrons, so a little subtraction will get you 2/3 of the way to the answer.
     - You find you'd need to add 26 protons to Cr: Cr has 24 protons and Sn has 50, which means you need 50 minus 24 protons = 26 protons to add to chromium to get its nucleus to have the necessary number of protons to make it a Sn nucleus.
     - And, since the protons in an atom = the number of electrons, you'd need to add the same number of electrons to Cr to make it have the same number as Sn.
   - Then, the final thing is to figure out how many neutrons you need to add, which is just a little more math.
     - Cr has 52 (atomic mass) – 24 (protons) = 28 neutrons and Sn has 119 (atomic mass) – 50 (protons) = 69 neutrons. So, the Cr nucleus is 69 – 28 = 41 neutrons short of a Sn nucleus.

   You would therefore answer that in order to make Cr into Sn in your subatomic particle collider, you would add 26 protons, 26 electrons and 41 neutrons to the Cr atom.

4.9 ANATOMY OF THE PERIODIC TABLE OF THE ELEMENTS – ADVANCED

This last section explains why atomic masses are not whole numbers and is exactly what I notated in the header—"advanced." I don't expect you to be able to perform calculations like this in chapter questions or on an exam, but I do expect that you'll be able to understand the concept of isotopes and follow the general logic behind "why atomic masses are not all whole numbers." The details are for the clarity.

Note that none of the elements—except those from Periods 6 and 7 with their atomic numbers listed in brackets—have atomic masses that are whole numbers, yet I have stated several times that you can't have part of a neutron or a proton. So, if that is the case, why aren't atomic masses all whole numbers? If carbon has 6 protons and 6 neutrons, why isn't its atomic mass just 12? Or, from our examples above, why isn't Bi's atomic mass an even 209 and Cr's 52? Because all elements naturally exist in multiple forms, and these multiple forms are called **isotopes**. An isotope is two or more forms of the same element, each of which contains the same number of protons, but a different number of neutrons. Another way of defining isotopes is "atoms that have the same atomic number but different atomic masses." If there weren't any isotopes, then all the atomic numbers would be whole numbers, but since there are isotopes, atomic masses are not all whole numbers. Let's see how that works.

For example, there are three (common) isotopes of carbon that exist in nature. These three isotopes are called carbon 12 (notated chemically as ^{12}C, which has an atomic mass of 12), carbon 13 (^{13}C, which has an atomic mass of 13) and carbon 14 (^{14}C, which has an atomic mass of 14). Since an element is defined by the number of protons in its nucleus, that means all three of these carbon isotopes have 6 protons; they must have 6 protons because if they didn't all have 6 protons, then they would not be carbon. So, since we know that these three carbon isotopes are all carbon, and they must all have 6 protons, yet their atomic masses are different, then the difference is that the number of neutrons of these three carbon isotopes is different. And that, indeed, is the case. ^{12}C has 6 neutrons (6 protons + 6 neutrons=12), ^{13}C has 7 neutrons (6 protons + 7 neutrons = 13) and ^{14}C has 8 neutrons (6 protons + 6 neutrons = 14).