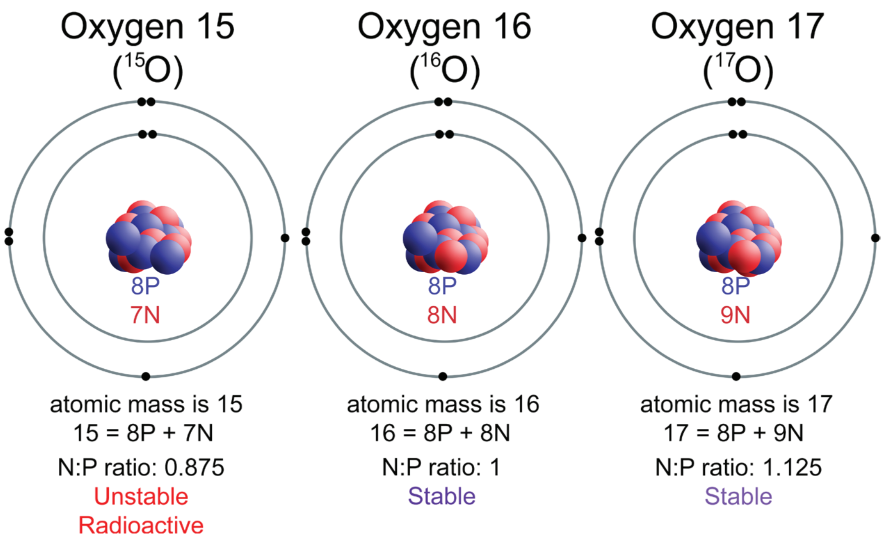
Let's look at some isotopes of oxygen as an example of this optimal 1:1 neutron:proton ratio for the elements with atomic numbers less than 20. Oxygen is element number 8, atomic mass of 15.999. There are multiple isotopes of oxygen, but let's focus on the most commonly occurring one—^{16}O, which is not radioactive (99.762% of all oxygen atoms have an atomic mass of 16)—and two others—^{15}O, which is radioactive (i.e. unstable), and ^{17}O, which is not. Here they are, with their atomic masses, protons, neutrons and N:P:



I just want to reinforce that all three isotopes have the same number of protons and electrons. ^{16}O has the optimal ratio—1.0—for elements with atomic numbers less than 21. Its N:P is 8 neutrons:8 protons, which is a ratio of 1.0. Therefore, it is stable and not radioactive. The N:P for ^{17}O, with 9 neutrons:8 protons, is 1.125. As we discussed, frequently a N:P in the range of 1.0–1.537 will result in a stable nucleus, but it needs to be assessed on a case by case basis. It turns out that for ^{17}O, a N:P of 1.125 creates a stable nucleus, so it isn't radioactive. Another way to think of this is that the N:P of 1.0 for ^{16}O and 1.125 for ^{17}O generates the strong force needed to offset the positive charges of the protons and keep the nucleus together, without being too many neutrons to generate an ineffective strong force.

Figure 13.3.4

Band of Stability
This is a nice visualization of N:P ratios, and whether a given ratio results in a stable or unstable isotope. Neutrons are on the y axis and protons on the x axis, and notice the black line represents an N:P of 1.0 for all elements. The green shaded area represents the N:P of radioactive elements and the blue shading within the green zone is the line that indicates elements with a stable N:P. It's aptly named the **band of stability**. Note how the band of stability deviates from the N:P=1 line, which reinforces that as elements increase in protons above 20, it takes a disproportionately larger number of neutrons to stabilize the nucleus. Notice, finally, that the element with the largest number of protons that is NOT radioactive is bismuth, with 84 protons. All elements with atomic numbers 85 through 118 are radioactive.