11.2: The Nuclear Equation

In Chapter 1, we described the meaning of the atomic symbol for an element. In the atomic symbol, the atomic number (the number of protons in the nucleus) appears as a subscript preceding the symbol for the element. The mass number appears as a superscript, also preceding the symbol. Thus for uranium (atomic number 92) with a mass of 238, the symbol is $^{238}_{92}\mathrm{U}$. To show radioactive decay in a chemical equation, you need to use atomic symbols. Thus, for the loss of an alpha particle from $^{238}_{92}\mathrm{U}$, you need to show uranium on the "reactant" side of the equation and thorium and the alpha particle on the "product" side. Just like any other chemical equation, a nuclear equation must **balance**. The sum of the mass numbers on the reactant side must equal the sum of the mass numbers on the product side. Because we started with uranium-238 and lost four mass units in the alpha particle, the product (or products) of the decay must have a total mass of (238 – 4) = **234**. We have also removed two protons from the uranium nucleus, dropping the atomic number by two. The newly formed element is therefore thorium-234.

$$^{238}_{92}\mathrm{U} \rightarrow ^{4}_{2}\mathrm{He} + ^{234}_{90}\mathrm{Th}$$

In this equation, we have shown the alpha particle using the atomic symbol for helium ($^{4}_{2}\mathrm{He}$), but this is often shown using the symbol $^{4}_{2}\alpha$. Compounds that emit alpha particles are *very* toxic, in spite of the poor penetrating ability of the particle. This is especially true if the emitting element is inhaled or ingested. The toxic dose of the alpha-emitter $^{210}\mathrm{Po}$ in a 175-pound person has been estimated to be about one microgram (1×10^{-6} g).

? Exercise 11.2.1

Thorium-230 and **polonium-210** both undergo loss of an alpha particle to form different elements. For each of these radioactive decay processes, write the appropriate nuclear equation and show the nature of the elements that are formed.

? Exercise 11.2.2

Radium-226 and polonium-214 both undergo loss of an alpha particle to form different elements. For each of these radioactive decay processes, write the appropriate nuclear equation and show the nature of the elements that are formed.