11.3: Beta Particle Emission

In an element with an “excess” of neutrons, one of these neutrons can break down to form an electron and a proton. In this process, an *antinutrino* is also produced, but because it has no mass, it is generally ignored in this process. The nuclear equation for the decomposition of a neutron can be written:

$$ {}^{1}_{0}\mathrm{n} \longrightarrow {}^{0}_{-1}\beta + {}^{1}_{1}\mathrm{p} $$

where the neutron has the symbol, ${}^{1}_{0}\mathrm{n}$, the proton has the symbol, ${}^{1}_{1}\mathrm{p}$, and the electron that is produced is called a beta particle, with the symbol ${}^{0}_{-1}\beta$. Because the nuclear equation must balance for mass and atomic numbers, the “atomic number” of the beta particle must be –1. Adding the atomic numbers on the right side of the equation shown above gives {(-1) + (+1) = 0}; identical to the “atomic number” in the neutron (${}^{1}_{0}\mathrm{n}$); (even though a neutron can break down to produce a proton, there are no actual protons in a neutron, hence its atomic number is zero). Likewise, the “mass number” of the beta particle must be zero because the proton (the product) and the neutron (the reactant) each have a mass of one. Therefore, when a nucleus loses a beta particle, the number of neutrons in the nucleus decreases by one, but the mass number does not change; the neutron is converted into a proton, also having a mass number of one. Because the neutron is converted into a proton, the atomic number of the element increases by one unit, changing the identity of the element to the next highest in the periodic table. For example, thorium-234 undergoes loss of a beta particle to form protactinium-234 by the equation shown below:

$$ {}^{234}_{90}\mathrm{Th} \rightarrow +{}^{0}_{-1}\beta + {}^{234}_{91}Pa $$

Again, with a beta-particle emission, the mass number does not change, but the atomic number *increases* by one unit.

? Exercise 11.3.1: Beta-Particle Emission

Bismuth-210 and **lead-214** both undergo loss of a beta 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 11.3.2: Beta-Particle Emission

Chlorine-39 and strontium-90 both undergo loss of a beta 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.

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