11.4: Positron Emission

A **positron**, also called an **antielectron**, is an exotic bit of matter, or more correctly, an example of **antimatter**. A positron is the antimatter equivalent of an electron. It has the mass of an electron, but it has a charge of +1. Positrons are formed when a proton sheds its positive charge and becomes a neutron, as shown below:

$$ {}^{1}_{1}\rho \rightarrow +{}^{0}_{+1}\beta + {}^{1}_{0}n $$

Again, in the nuclear equation for positron emission, the sum of protons (atomic numbers) on the right equals the number of protons on the left and the masses all equal one. When an element emits a positron, the identity of the element changes to the one having one fewer protons on the periodic table. An example of a nuclear equation showing positron emission is shown below:

$$ {}^{11}_{6}C \rightarrow +{}^{0}_{+1}\beta + {}^{11}_{5}B $$

Boron has one fewer protons in its nucleus than carbon, but the mass is unchanged because the proton has been replaced by a neutron.

$$ {}^{18}_{9}F \rightarrow +{}^{0}_{+1}\beta + {}^{18}_{8}O $$

Positron emission from Fluorine-18, as shown above , has become an important medical diagnostic tool; Positron Emission Tomography (a *PET* scan). The heart of this technique is based on the fact that positrons undergo instant annihilation when they collide with an electron (an example of *matter-antimatter annihilation*). When this occurs, two high-energy gamma rays are produced and exit the scene of the annihilation in exactly opposite directions. During a PET scan, a patient is given an injection containing fluorodeoxyglucose (FDG), a sugar analog. The glucose analog is absorbed by metabolically active cells, where the FDG accumulates and undergoes positron decay. After a short waiting period, the patient is *scanned* using a circular array of gamma-radiation detectors. The fact that the gamma rays are emitted in opposite directions allows the attached computer to “draw a line” through the patient, where the line passes through the point of annihilation. Because this occurs through many directions, the exact location of the emission can be accurately calculated and then imaged as a three-dimensional picture showing the intensity of the emission.