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Topic: Radioactive Decay
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The ability of radiation to pass through a material depends on the type of radiation. Alpha particles can usually be stopped by a piece of paper, beta particles can penetrate a few millimeters of aluminum, and gamma rays can penetrate several centimeters of lead.

Helium nuclei are emitted in alpha decay

When a nucleus undergoes alpha decay, it emits an alpha particle ($^{4}_{2}He$). Thus, the nucleus loses two protons and two neutrons. This makes the nucleus lighter and decreases its positive charge. (Because the electrons around the nuclei do not participate in nuclear reactions, they are ignored.)

For example, the nucleus of uranium-238 ($^{238}_{92}U$) can decay by alpha emission to a thorium-234 nucleus and an alpha particle, as follows:

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

This expression says that a parent nucleus, $^{238}_{92}U$, emits an alpha particle, $^{4}_{2}He$, and thereby changes to a daughter nucleus, $^{234}_{90}Th$ (thorium-234). This nuclear reaction and all others follow the rules summarized in **Table 4.** These two rules can be used to determine the unknown daughter atom when a parent atom undergoes alpha decay.

Table 4 Rules for Nuclear Decay

The total of the atomic numbers on the left is the same as the total on the right because charge must be conserved.
The total of the mass numbers on the left is the same as the total on the right because nucleon number must be conserved.

ADVANCED TOPICS

A positron is the *antiparticle* of the electron. See "Antimatter" in **Appendix J: Advanced Topics** to learn more about antiparticles.

Electrons or positrons are emitted in beta decay

When a radioactive nucleus undergoes beta decay, the nucleus emits either an electron or a positron. (A positron has the same mass as the electron but is positively charged.) The atomic number is increased or decreased by one, with an opposite change in the neutron number. Because the daughter nucleus contains the same number of nucleons as the parent nucleus, the mass number does not change. Thus, beta decay does little to change the mass of a nucleus. Instead, the ratio of neutrons to protons in a nucleus is changed. This ratio affects the stability of the nucleus, as seen in Section 1.

A typical beta decay event involves carbon-14, as follows:

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e \quad \text{(partial equation)}$$

This decay produces an electron, written as $^{0}_{-1}e$. In this decay, the atomic number of the daughter nucleus is increased by 1.