The half-life of $^{234}_{90}\text{Th}$, about 24 days, is indicated on the chart. It decays by giving off beta particles. This increases its atomic number, and thus its horizontal position, by one. The mass number, and thus its vertical position, remains the same.

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

The remaining atomic number and mass number changes shown on the decay chart are also explained in terms of the particles given off. In the final step, $^{210}_{84}\text{Po}$ loses an alpha particle to form $^{206}_{82}\text{Pb}$. This is a stable, nonradioactive isotope of lead. Notice that $^{206}_{82}\text{Pb}$ contains 82 protons, a magic number. It contains the extra-stable nuclear configuration of a completed nuclear shell.

extension

Historical Chemistry

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Artificial Transmutations

Artificial radioactive nuclides are radioactive nuclides not found naturally on Earth. They are made by **artificial transmutations,** *bombardment of nuclei with charged and uncharged particles.* Because neutrons have no charge, they can easily penetrate the nucleus of an atom. However, positively charged alpha particles, protons, and other ions are repelled by the nucleus. Because of this repulsion, great quantities of energy are required to bombard nuclei with these particles. The necessary energy may be supplied by accelerating these particles in the magnetic or electrical field of a particle accelerator. An example of an accelerator is shown in **Figure 9.**

FIGURE 9 This is an aerial view of the Fermi International Accelerator Laboratory (Fermilab), in Illinois. The particle accelerators are underground. The Tevatron ring, the larger particle accelerator, has a circumference of 4 mi. The smaller ring (top left) is a new accelerator, the Main Injector.