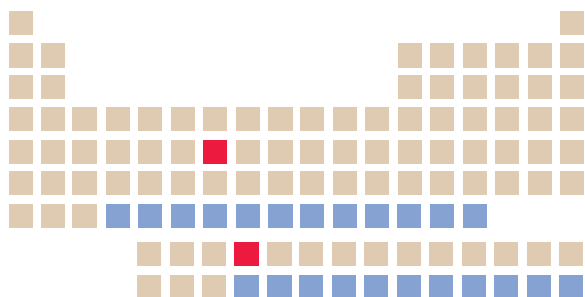


TABLE 3 Reactions for the First Preparation of Several Transuranium Elements

Atomic number	Name	Symbol	Nuclear reaction
93	neptunium	Np	${}_{92}^{238}\text{U} + {}_0^1n \longrightarrow {}_{92}^{239}\text{U}$ ${}_{92}^{239}\text{U} \longrightarrow {}_{93}^{239}\text{Np} + {}_{-1}^0\beta$
94	plutonium	Pu	${}_{93}^{238}\text{Np} \longrightarrow {}_{94}^{238}\text{Pu} + {}_{-1}^0\beta$
95	americium	Am	${}_{94}^{239}\text{Pu} + 2{}_0^1n \longrightarrow {}_{95}^{241}\text{Am} + {}_{-1}^0\beta$
96	curium	Cm	${}_{94}^{239}\text{Pu} + {}_2^4\text{He} \longrightarrow {}_{96}^{242}\text{Cm} + {}_0^1n$
97	berkelium	Bk	${}_{95}^{241}\text{Am} + {}_2^4\text{He} \longrightarrow {}_{97}^{243}\text{Bk} + 2{}_0^1n$
98	californium	Cf	${}_{96}^{242}\text{Cm} + {}_2^4\text{He} \longrightarrow {}_{98}^{245}\text{Cf} + {}_0^1n$
99	einsteinium	Es	${}_{92}^{238}\text{U} + 15{}_0^1n \longrightarrow {}_{99}^{253}\text{Es} + 7{}_{-1}^0\beta$
100	fermium	Fm	${}_{92}^{238}\text{U} + 17{}_0^1n \longrightarrow {}_{100}^{255}\text{Fm} + 8{}_{-1}^0\beta$
101	mendelevium	Md	${}_{99}^{253}\text{Es} + {}_2^4\text{He} \longrightarrow {}_{101}^{256}\text{Md} + {}_0^1n$
102	nobelium	No	${}_{96}^{246}\text{Cm} + {}_6^{12}\text{C} \longrightarrow {}_{102}^{254}\text{No} + 4{}_0^1n$
103	lawrencium	Lr	${}_{98}^{252}\text{Cf} + {}_5^{10}\text{B} \longrightarrow {}_{103}^{258}\text{Lr} + 4{}_0^1n$

**FIGURE 10** Artificial transmutations filled the gaps in the periodic table, shown in red, and extended the periodic table with the transuranium elements, shown in blue.

Artificial Radioactive Nuclides

Radioactive isotopes of all the natural elements have been produced by artificial transmutation. In addition, production of technetium and promethium by artificial transmutation has filled gaps in the periodic table. Their positions are shown in **Figure 10**.

Artificial transmutations are also used to produce the transuranium elements. **Transuranium elements** are elements with more than 92 protons in their nuclei. All of these elements are radioactive. The nuclear reactions for the synthesis of several transuranium elements are shown in **Table 3**. Currently, 17 artificially prepared transuranium elements have been named. Six more have been reported, but not confirmed. The positions of the transuranium elements in the periodic table are shown in **Figure 10**.

SECTION REVIEW

1. Define *radioactive decay*.
2. a. What are the different types of common radioactive decay?
b. List the types of radioactive decay that convert one nuclide into another.

3. What fraction of a given sample of a radioactive nuclide remains after four half-lives?
4. When does a decay series end?

Critical Thinking

5. **INTERPRETING CONCEPTS** Distinguish between natural and artificial radioactive nuclides.