Section 7.2: Radioactive Decay

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1. The atomic number of plutonium, Pu, is 94.

$^{239}_{94}\text{Pu} \rightarrow {}^{239-4}_{94-2}\text{Y} + {}^{4}_{2}\text{He}$

The new element has atomic number 92 and mass number 235.

$^{239}_{94}\text{Pu} \rightarrow {}^{235}_{92}\text{Y} + {}^{4}_{2}\text{He}$

The element with atomic number 92 is uranium, U. The daughter atom is uranium-235.

$^{239}_{94}\text{Pu} \rightarrow {}^{235}_{92}\text{U} + {}^{4}_{2}\text{He}$

2. The atomic number of neptunium, Np, is 93. Neptunium-239 is $^{239}_{93}\text{Np}$.

$^{239+4}_{93+2}\text{X} \rightarrow {}^{239}_{93}\text{Np} + {}^{4}_{2}\text{He}$

The original isotope has atomic number 95 and mass number 243.

$^{243}_{95}\text{X} \rightarrow {}^{239}_{93}\text{Np} + {}^{4}_{2}\text{He}$

The element with atomic number 95 is americium, Am.

$^{243}_{95}\text{Am} \rightarrow {}^{239}_{93}\text{Np} + {}^{4}_{2}\text{He}$

The unknown isotope is americium-243.

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1. The atomic number of cerium, Ce, is 58.

$^{141}_{58}\text{Ce} \rightarrow {}^{141}_{58+1}\text{Y} + {}^{0}_{-1}\text{e}$

The new element has atomic number 59 and mass number 141.

$^{141}_{58}\text{Ce} \rightarrow {}^{141}_{59}\text{Y} + {}^{0}_{-1}\text{e}$

The new element is praseodymium-141.

$^{141}_{58}\text{Ce} \rightarrow {}^{141}_{59}\text{Pr} + {}^{0}_{-1}\text{e}$

2. The atomic number of chromium, Cr, is 24.

$^{46}_{24}\text{Cr} \rightarrow {}^{46}_{24-1}\text{Y} + {}^{0}_{+1}\text{e}$

The new element has atomic number 23 and mass number 46.

$^{46}_{24}\text{Cr} \rightarrow {}^{46}_{23}\text{Y} + {}^{0}_{+1}\text{e}$

The new element is vanadium-46.

$^{46}_{24}\text{Cr} \rightarrow {}^{46}_{23}\text{V} + {}^{0}_{+1}\text{e}$

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1. The atomic number of plutonium is 94.

$^{240}_{94}\text{Pu}^{*} \rightarrow {}^{240}_{94}\text{Pu} + {}^{0}_{0}\gamma$

2. Gamma decay is not an example of a transmutation because a different element is not formed. Energy is emitted, but no particles are emitted.

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1. (a) The atomic number of curium, Cu, is 96. The new element will have mass number 248 and atomic number 94. From the periodic table, the element with atomic number 94 is plutonium, Pu.

$^{248}_{96}\text{Cu} \rightarrow {}^{244}_{94}\text{Pu} + {}^{4}_{2}\text{He}$

(b) The atomic number of radium, Ra, is 88. The new element will have mass number 219 and atomic number 86. From the periodic table, the element with atomic number 86 is radon, Rn.

$^{223}_{88}\text{Ra} \rightarrow {}^{219}_{86}\text{Rn} + {}^{4}_{2}\text{He}$

2. (a) The atomic number of sulfur, S, is 16. The new element will have mass number 35 and atomic number 17. From the periodic table, the element with atomic number 17 is chlorine, Cl.

$^{35}_{16}\text{S} \rightarrow {}^{35}_{17}\text{Cl} + {}^{0}_{-1}\text{e}$

(b) The atomic number of gold, Au, is 79. The new element will have mass number 80 and atomic number 198. From the periodic table, the element with atomic number 80 is mercury, Hg.

$^{198}_{79}\text{Au} \rightarrow {}^{198}_{80}\text{Hg} + {}^{0}_{-1}\text{e}$

3. (a) The atomic number of sodium, Na, is 11. The new element will have mass number 22 and atomic number 10. From the periodic table, the element with atomic number 10 is neon, Ne.

$^{22}_{11}\text{Na} \rightarrow {}^{22}_{10}\text{Ne} + {}^{0}_{+1}\text{e}$

(b) The atomic number of calcium, Ca, is 20. The new element will have mass number 39 and atomic number 19. From the periodic table, the element with atomic number 19 is potassium, K.

$^{39}_{20}\text{Ca} \rightarrow {}^{39}_{19}\text{K} + {}^{0}_{+1}\text{e}$

4. Answers may vary. Students' reports should include information such as the following: A positron is a particle with positive charge and mass equal to that of an electron. When a positron and an electron come into contact, they annihilate each other and produce gamma rays. Positrons are used in medical PET scans to create gamma rays, which can be detected to create images of internal body structures. When two protons fuse to create deuterium, enough energy is created to form a positron.

5. (a) The atomic number of potassium, K, is 19. The new element will have mass number 40 and atomic number 18. From the periodic table, the element with atomic number 18 is argon, Ar.

$^{40}_{19}\text{K} + {}^{0}_{-1}\text{e} \rightarrow {}^{40}_{18}\text{Ar}$

(b) The atomic number of carbon, C, is 6.
The new element will have mass number 11 and atomic number 5. From the periodic table, the element with atomic number 5 is boron, B.

$$^{11}_{6}\text{C} + {}^{0}_{-1}\text{e} \rightarrow {}^{11}_{5}\text{B}$$

6. The strong nuclear force reverses from strong attraction to strong repulsion when the distance between two particles is less than 0.5 femtometres because the quarks in individual nucleons are forbidden to be in the same area by the Pauli exclusion principle or to allow for nuclear fission to occur.