

Math Skills- Nuclear Decay

Nuclear Decay

After you study each sample problem and solution, work out the practice problems on a separate piece of paper. Write your answers in the spaces provided.

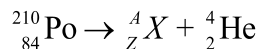
PROBLEM

Polonium is the scarcest natural element and was the first to be discovered by the Curies. Write the equation for the alpha decay of polonium-210, and determine what isotope is formed by the reaction.

SOLUTION

Step 1: Write down the equation with the original element on the left side and the products on the right side.

Use the letter X to denote the unknown product. Note that the mass and atomic numbers of the unknown isotope are represented by the letters A and Z .



Step 2: Write math equations for the atomic and mass numbers.

$$210 = A + 4$$

$$84 = Z + 2$$

Step 3: Rearrange the equations.

$$A = 210 - 4$$

$$Z = 84 - 2$$

Step 4: Solve for the unknown values, and rewrite the equation with all nuclei represented.

$$A = 206$$

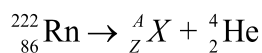
$$Z = 82$$

The unknown decay product has an atomic number of 82, which is lead, as you can see on a periodic table. The isotope is

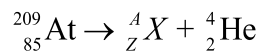
${}_{82}^{206}\text{Pb}$

PRACTICE

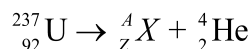
1. Radiation emitted during radon's decay process was discovered to be useful in cancer therapy. Identify the element X formed in the following reaction, in which radon-222 undergoes alpha decay.



2. Derived from the Greek word *astatos*, the name of the metalloid astatine means “unstable.” Identify the element X formed in the reaction below, in which astatine-209 undergoes alpha decay.



3. Named after the planet Uranus, uranium is the heaviest atom among the natural elements. Identify the element X in the reaction below, in which uranium-237 undergoes alpha decay.

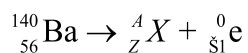


PROBLEM

Barium sulfate is consumed by patients undergoing certain X ray examinations. The white liquid outlines the stomach and intestines to assist doctors in making a diagnosis. Write the equation for the beta decay of barium-140, and determine what isotope is formed by the reaction.

SOLUTION

Step 1: Write down the equation with the original element on the left side and the products on the right side. Use the letter X to denote the unknown product. Note that the mass and atomic numbers of the unknown isotope are represented by the letters A and Z .



Step 2: Write math equations for the atomic and mass numbers.

$$140 = A + 0$$

$$56 = Z - 1$$

Step 3: Rearrange the equations.

$$A = 140 - 0$$

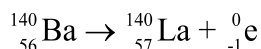
$$Z = 56 + 1$$

Step 4: Solve for the unknown values, and rewrite the equation with all nuclei represented.

$$A = 140$$

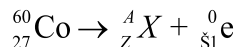
$$Z = 57$$

The unknown decay product has an atomic number of 57, which is lanthanum, according to the periodic table. The isotope is therefore ${}_{57}^{140}\text{La}$.

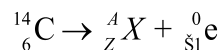


PRACTICE

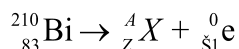
4. One cobalt radioactive isotope is used to treat cancer. Identify the element X in the reaction below, in which cobalt-60 undergoes beta decay.



5. Natural forms of carbon include diamonds, charcoal, and graphite. Identify the element X in the reaction below, in which carbon-14 undergoes beta decay.



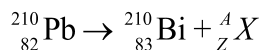
6. Discovered in 1450, bismuth is the most metallic member of its family. Identify the element X in the reaction below, in which bismuth-210 undergoes beta decay.

**PROBLEM**

Lead is a highly durable element that was used in the plumbing industry for centuries. Some of the lead pipes that were used to drain the baths of ancient Rome have been uncovered still in working order. Determine whether alpha or beta decay occurs in the reaction in which lead-210 decays to bismuth-210.

SOLUTION

Step 1: Write down the equation with the original element on the left side and the products on the right side. Use the letter X to represent the unknown decay particle. The mass and atomic numbers of the unknown particle are represented by the letters A and Z .



Step 2: Write math equations for the atomic and mass numbers.

$$210 = 210 + A$$

$$82 = 83 + Z$$

Step 3: Rearrange the equations.

$$A = 210 - 210$$

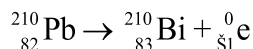
$$Z = 82 - 83$$

Step 4: Solve for the unknown values, and rewrite the equation with all nuclei represented.

$$A = 0$$

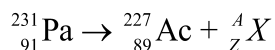
$$Z = -1$$

The unknown particle is an electron, which is emitted as a beta particle.

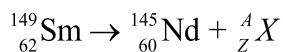


PRACTICE

7. Protactinium, discovered in 1917, is the third-rarest of the naturally occurring elements. Identify the decay particle emitted and the decay process that occurs when protactinium-231 decays to actinium-227.



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8. Samarium is one of the so-called rare earths, elements with similar chemical and physical properties that were first isolated from a mineral found in Sweden. Identify the decay particle emitted and the decay process that occurs when samarium-149 decays to form neodymium-145.



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9. Actinium, the second rarest of the naturally occurring elements, was discovered in 1899. Identify the emitted particle in the following reaction, and indicate whether alpha or beta decay occurs.

