When The Nuclide Thorium-230 Undergoes Alpha Decay:The Name Of The Product Nuclide Is: _____The Symbol

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Understanding the processes of nuclear decay is fundamental to nuclear physics, radiometric dating, and various applications in energy production and environmental science. One such process is alpha decay, where an unstable nucleus emits an alpha particle, transforming into a different nuclide. In this article, we will explore the specific case of thorium-230 undergoing alpha decay, focusing on the resulting nuclide, its name, symbol, and broader implications.

Introduction to Thorium-230 and Alpha Decay

Thorium-230 is a radioactive isotope, part of the uranium decay series, with significant relevance in geological dating and nuclear science. Alpha decay, a common mode of radioactive disintegration, involves the emission of a helium nucleus (composed of two protons and two neutrons). When thorium-230 undergoes this process, it transforms into a different element, changing its atomic number and mass.

What is Thorium-230?

Thorium-230 (symbol: Th-230) is a radioactive isotope of thorium, with an atomic number of 90. It has a half-life of approximately 75,400 years, making it a key isotope in uranium-series dating methods, especially for dating geological formations and sediments.

Key Characteristics of Thorium-230:
- Atomic number: 90
- Atomic mass: approximately 230.0368 u
- Half-life: about 75,400 years
- Decay mode: alpha decay
- Occurrence: naturally in uranium-rich minerals and as part of the decay chain of uranium-238

Understanding Alpha Decay

Alpha decay is a type of radioactive decay where an unstable nucleus emits an alpha particle, which is a helium-4 nucleus (two protons and two neutrons). This process results in the transformation of the original nuclide into a different element with an atomic number decreased by two and a mass number decreased by four.

General features of alpha decay:
- Emission of helium-4 nucleus (α particle)
- Decreases atomic number by 2
- Decreases mass number by 4
- Typically occurs in heavy, unstable nuclei

Alpha Decay of Thorium-230

When thorium-230 undergoes alpha decay, it emits an alpha particle and transforms into a different nuclide. The key to understanding this transformation lies in the changes to its atomic number and mass number.

Decay process:
- Thorium-230 (Th-230) undergoes alpha decay
- Emission of an alpha particle (helium-4 nucleus: 2 protons, 2 neutrons)
- Resulting nuclide: ??? (To be determined)

Calculating the Product Nuclide:
- Original nucleus: Th-230 (Z=90, A=230)
- After alpha emission:
- Atomic number: 90 - 2 = 88
- Mass number: 230 - 4 = 226

Therefore, the decay product has:
- Atomic number: 88
- Mass number: 226

The Name and Symbol of the Product Nuclide

The element with atomic number 88 is radium (Ra). The isotope with mass number 226 is radium-226, which is a significant isotope in the uranium decay series.

Name of the product nuclide: Radium-226
Symbol of the product nuclide: Ra-226

Summary:
- When thorium-230 undergoes alpha decay, it transforms into radium-226.
- The decay can be summarized as:

Th-230 → Ra-226 + α particle

Alpha particle:
- Symbol: α
- Composition: 2 protons, 2 neutrons

Implications of Thorium-230 Decay to Radium-226

The transformation from thorium-230 to radium-226 is not just a simple nuclear change; it has broader scientific and practical implications.

Significance in Geological Dating

Radium-226 is part of the uranium-238 decay series, which is extensively used in radiometric dating to estimate the ages of rocks and minerals. The presence of radium-226 provides clues about the geological history and the timing of mineral formation.

How this process aids dating:
- Measuring the ratio of radium-226 to other decay products
- Estimating the age of geological samples
- Understanding the decay chain dynamics

Health and Environmental Concerns

Radium-226 is a radioactive element known for its health risks due to its emission of alpha particles, which can damage living tissue if ingested or inhaled.

Risks associated with radium-226:
- Carcinogenic potential
- Environmental contamination concerns
- Handling precautions in nuclear laboratories

Decay Chain and Further Transformations

Radium-226 itself is radioactive and undergoes further decay, eventually leading to stable isotopes of lead.

Decay chain overview:
1. Radium-226 decays via alpha emission to radon-222
2. Radon-222 decays to polonium-218
3. Continuation of decay steps until reaching stable lead-206

Note: The entire decay chain underscores the importance of understanding each nuclide’s behavior for applications in dating, nuclear science, and environmental safety.

Applications and Uses of Radium-226

Radium-226 has historically been used in various applications, though its use has declined due to

health risks.

Historical applications include:
- Radiotherapy for cancer treatment
- Industrial radiography
- As a neutron source in scientific experiments

Modern considerations:
- Disposal and containment due to its radioactivity
- Replacement by safer isotopes in medical applications

Summary and Conclusion

In conclusion, when the nuclide thorium-230 undergoes alpha decay, the product nuclide is radium-226, symbolized as Ra-226. This transformation illustrates fundamental principles of nuclear decay, where the nucleus loses an alpha particle, decreasing its atomic number by two and its mass number by four. Understanding this process is crucial for fields like geology, environmental science, and nuclear medicine.

Key takeaways:
- Thorium-230 decays into radium-226 via alpha emission
- The resulting nuclide plays a vital role in radioactive dating
- Radium-226’s properties influence its applications and safety considerations
- The decay chain continues until a stable isotope is formed

By studying these decay processes, scientists gain insights into Earth's history, nuclear physics, and safety protocols, making the knowledge of specific nuclide transformations an essential part of scientific literacy.

References and Further Reading

- "Radioactive Decay Series," Nuclear Physics Textbooks
- "Radiometric Dating Techniques," Geochronology Journals
- "Radium-226 and Its Uses," Health Physics and Radiation Safety Resources
- United States Nuclear Regulatory Commission (NRC) publications on radioactive isotopes

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Note: The specific product nuclide resulting from thorium-230 alpha decay is radium-226, symbolized as Ra-226.

Frequently Asked Questions

What is the name of the nuclide produced when Thorium-230 undergoes alpha decay?

The nuclide produced is Radon-226.

What is the symbol of the product nuclide when Thorium-230 undergoes alpha decay?

The symbol of the product nuclide is Rn-226.

How does alpha decay affect the atomic number and mass number of Thorium-230?

Alpha decay decreases the atomic number by 2 and the mass number by 4, transforming Thorium-230 into Radon-226.

Why does Thorium-230 undergo alpha decay in nuclear processes?

Thorium-230 undergoes alpha decay to achieve a more stable nuclear configuration, reducing its excess nuclear energy.

What is the significance of knowing the product nuclide after Thorium-230's alpha decay?

Knowing the product nuclide helps in understanding decay chains, nuclear stability, and applications in nuclear science and geology.

Is Radon-226 a radioactive or stable nuclide, and what are its implications?

Radon-226 is radioactive; its decay contributes to radioactive decay chains and has health implications due to its gaseous nature.

Additional Resources

When The Nuclide Thorium-230 Undergoes Alpha Decay: The Name Of The Product Nuclide Is: Protactinium-226 (Pa-226)

Understanding the decay processes of radioactive nuclides is fundamental in nuclear physics, radiochemistry, and various practical applications such as nuclear energy and radiometric dating. One intriguing example is when Thorium-230 (Th-230) undergoes alpha decay, transforming into a different element altogether. This process not only exemplifies the complex nature of nuclear transformations but also highlights the importance of decay chains in understanding the stability and longevity of radioactive isotopes. In this article, we delve into the specifics of Th-230 alpha

decay, explore the resulting nuclide—Protactinium-226 (Pa-226)—and discuss its properties, significance, and implications.

Understanding Thorium-230 and Its Role in the Decay Chain

What is Thorium-230?

Thorium-230 is a radioactive isotope of thorium, characterized by having 90 protons and 140 neutrons, making its atomic number 90 and atomic mass approximately 230 atomic mass units (amu). It is a decay product within the uranium-238 decay series and is notable for its relatively long half-life of about 75,400 years. Due to its presence in uranium-rich rocks and its role in geological processes, Th-230 is frequently encountered in radiometric dating, especially in determining the age of sediments and geological formations.

The Significance of Thorium-230 in Decay Chains

Th-230 is part of the uranium-238 decay series, which begins with uranium-238 and ends with the stable isotope lead-206. Its position within this decay chain makes it a crucial intermediate product in understanding radioactive decay sequences, dating methods, and the evolution of radioactive materials over geological timescales.

Alpha Decay of Thorium-230: The Reaction and Its Mechanics

The Alpha Decay Process

Alpha decay is a type of radioactive decay where an unstable nucleus emits an alpha particle, which consists of two protons and two neutrons (a helium-4 nucleus). This process reduces the atomic number by 2 and the mass number by 4, transforming the original nuclide into a different element.

For Th-230, the alpha decay can be written as:

$$
\text{Th-230} \rightarrow \text{Pa-226} + \alpha
$$

\]

or more explicitly,

\[
^{230}_{90}\text{Th} \rightarrow ^{226}_{88}\text{Ra} + ^{4}_{2}\text{He}
\]

However, in practice, Th-230 decays into Protactinium-226 (Pa-226), not directly into radium. The decay chain involves a series of steps, but the primary alpha decay from Th-230 produces Pa-226 as the immediate daughter nuclide.

The Decay Equation

The decay can be summarized as:

\[
^{230}_{90}\text{Th} \xrightarrow{\alpha} ^{226}_{89}\text{Pa} + \alpha
\]

where:

- Th-230 (atomic number 90) emits an alpha particle (atomic number 2, mass 4) and becomes Pa-226 (atomic number 89).

The process decreases the atomic number by 2 and the mass number by 4:

- Atomic number: 90 - 2 = 88

- Mass number: 230 - 4 = 226

But since Pa-226 has atomic number 89, the process must be clarified: the alpha decay reduces the atomic number by 2, transforming Thorium (atomic number 90) into Radium (atomic number 88). However, in the decay chain of Th-230, the primary decay product is Protactinium-226 (Pa-226), which forms via beta decay of Radium-226.

Thus, the alpha decay specifically from Th-230 yields Radium-226 (Ra-226), which then undergoes beta decay to Pa-226.

Summary of the decay sequence:

1. Th-230 undergoes alpha decay to produce Ra-226:

\[
^{230}_{90}\text{Th} \rightarrow ^{226}_{88}\text{Ra} + \alpha
\]

2. Ra-226 undergoes beta decay to produce Pa-226:

$$
^{226}_{88}\text{Ra} \rightarrow ^{226}_{89}\text{Pa} + \beta^{-}
$$

Therefore, the immediate product after Th-230's alpha decay is Radium-226, which then decays into Protactinium-226.

The Product Nuclide: Protactinium-226 (Pa-226)

Properties of Pa-226

Protactinium-226 (Pa-226) is a radioactive isotope with 91 protons and 135 neutrons. It has a half-life of approximately 29 minutes, which is significantly shorter than Th-230. Its decay involves beta emission, converting a neutron into a proton, thus increasing the atomic number from 88 to 89 while keeping the mass number constant.

Key features of Pa-226:

- Atomic number: 89
- Mass number: 226
- Half-life: approximately 29 minutes
- Decay mode: Beta decay (β^{-})
- Decay product: Uranium-226 (U-226)

Physical and chemical properties:

- Pa-226 is a heavy actinide element, chemically similar to uranium and thorium.
- It is highly radioactive and must be handled with appropriate safety measures.
- Its short half-life makes it a transient intermediate in decay chains.

Decay Pathways and Chain Dynamics

Following its formation via beta decay of Ra-226, Pa-226 itself decays further into U-226 through another beta decay:

$$
^{226}_{89}\text{Pa} \xrightarrow{\beta} ^{226}_{90}\text{U}
$$

Uranium-226 is more stable and eventually leads to a series of further decays, ultimately resulting in stable lead isotopes.

Implications of Thorium-230 Alpha Decay and the Formation of Pa-226

Significance in Radiometric Dating

The Th-230 to Pa-226 decay process underpins the uranium-series dating technique, which is used to date geological and archaeological samples ranging from thousands to hundreds of thousands of years old. Since Th-230 decays into Pa-226, measuring the ratio of these isotopes in a sample allows scientists to determine its age with considerable precision.

Advantages:

- Works well for dating calcium carbonate minerals and fossils.
- Provides insights into sedimentation rates and geological events.

Limitations:

- Requires sophisticated equipment for isotope ratio analysis.
- Assumes closed-system behavior since formation.

Applications in Nuclear Science and Safety

Understanding the decay chain of Th-230, including the formation of Pa-226, is vital in nuclear reactor management and waste handling. Protactinium-226's high radioactivity and short half-life mean it contributes to the radiation environment in nuclear waste repositories. Accurate knowledge of its formation and decay helps in assessing long-term safety and containment strategies.

Features:

- Decay heat contribution: Pa-226 contributes to residual heat in spent nuclear fuel.
- Radiation hazards: Its beta radiation necessitates shielding and safety protocols.

Challenges:

- Handling short-lived isotopes requires rapid and precise procedures.
- Decay chain complexity demands comprehensive modeling for safety assessments.

Pros and Cons of Alpha Decay of Th-230 to Pa-226

Pros:

- Predictable decay sequence: Well-characterized decay chain aids in scientific modeling.
- Useful in dating methods: Provides a reliable means for age determination.
- Contributes to understanding nuclear stability: Offers insights into alpha decay mechanisms.

Cons:

- Radioactive hazards: Both Th-230 and its decay products are highly radioactive.
- Short-lived intermediates: Pa-226's brief half-life complicates sampling and measurement.
- Decay chain complexity: Multiple steps require careful analysis to interpret data accurately.

Conclusion

The alpha decay of Thorium-230 exemplifies the intricate and fascinating processes of nuclear transformations. When Th-230 undergoes alpha decay, it produces Radium-226, which further beta decays into Protactinium-226 (Pa-226)—the immediate product nuclide in this decay chain. Pa-226's properties, particularly its short half-life and radioactive nature, make it a crucial intermediate in geological dating and nuclear science. Understanding these decay pathways enriches our knowledge of radioactive behavior, aids in precise dating techniques, and informs safety protocols in nuclear technology. The alpha decay process of Th-230 and formation of Pa-226 underscores the delicate balance of nuclear stability and the ongoing transformations that shape our understanding of the atomic world.

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