What Percent Of A Sample Of As-81 Remains Un Decayed After 43.2 Seconds

What Percent Of A Sample Of As-81 Remains Un Decayed After 43.2 Seconds is a question that delves into the fascinating realm of radioactive decay, a process fundamental to fields like nuclear physics, radiometric dating, and medical imaging. Understanding how much of a radioactive isotope such as Arsenic-81 (As-81) remains after a specific period provides insight into its stability, potential applications, and safety considerations. In this article, we explore the principles of radioactive decay, specifically focusing on As-81, and walk through the calculations needed to determine the remaining percentage after 43.2 seconds.

Understanding Radioactive Decay and Half-Life

What is Radioactive Decay?

Radioactive decay is a spontaneous process whereby unstable atomic nuclei lose energy by emitting radiation in the form of particles or electromagnetic waves. This process transforms the unstable isotope into a more stable form, often a different element or isotope.

Key Concepts: Half-Life and Decay Constant

Two critical concepts in understanding decay are:
- Half-Life ($t_{1/2}$): The time required for half of the radioactive nuclei in a sample to decay.
- Decay Constant (λ): A probability rate at which each nucleus decays per unit time, related to the half-life via the formula:

$$
\lambda = \frac{\ln 2}{t_{1/2}}
$$

where $\ln 2 \approx 0.693$.

These concepts are essential for calculating the remaining amount of a radioactive substance after a given period.

Properties of Arsenic-81 (As-81)

What Is Arsenic-81?

Arsenic-81 is a radioactive isotope of arsenic with a specific half-life, used primarily in medical imaging, particularly in certain diagnostic procedures. Its decay characteristics influence how long it remains active and how much of it remains un-decayed over time.

Half-Life of As-81

The half-life of As-81 is approximately 9.6 hours, or about 34,560 seconds. This relatively long half-life means that after 43.2 seconds, only a small fraction of the isotope will have decayed, and most of it remains unchanged.

Calculating the Remaining Percentage of As-81 After 43.2 Seconds

Step 1: Convert Half-Life to Seconds

Given:
- $t_{1/2} = 9.6 \text{ hours}$

Convert hours to seconds:

$$
t_{1/2} = 9.6 \times 3600 = 34,560 \text{ seconds}
$$

Step 2: Find the Decay Constant (λ)

Using the relation:

$$
\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{34,560} \approx 2.005 \times 10^{-5} \text{ s}^{-1}
$$

Step 3: Use the Decay Formula

The proportion of the original sample remaining after time t is given by:

$$
N(t) = N_0 e^{-\lambda t}
$$

where:
- N_0 is the initial amount (100%),
- $N(t)$ is the amount remaining after time t,
- $t = 43.2 \text{ seconds}$.

Since we are interested in the percentage remaining:

$$
\% \text{ remaining} = 100 \times e^{-\lambda t}
$$

Substituting the values:

$$
\% \text{ remaining} = 100 \times e^{- (2.005 \times 10^{-5}) \times 43.2}
$$

Calculate the exponent:

$$
(2.005 \times 10^{-5}) \times 43.2 \approx 8.666 \times 10^{-4}
$$

Now compute:

$$
e^{-8.666 \times 10^{-4}} \approx 1 - 8.666 \times 10^{-4} \quad \text{(since the exponent is very small)}
$$

Using a calculator for more precision:

$$
e^{-8.666 \times 10^{-4}} \approx 0.999133
$$

Therefore, the percentage remaining:

$$
\approx 100 \times 0.999133 \approx 99.91\%
$$

Answer: Approximately 99.91% of the As-81 sample remains un-decayed after 43.2 seconds.

Implications of the Decay Calculation

Why Is This Important?

Knowing that over a short period like 43.2 seconds, over 99.9% of As-81 remains intact underscores its relative stability over short timescales. This is particularly relevant in medical imaging, where timing precision ensures optimal imaging results without significant decay affecting the signal.

Applications in Medicine and Research

- Medical Imaging: Precise timing of isotope administration and imaging relies on understanding decay rates.
- Radiometric Dating: Longer half-lives are essential, but understanding decay over short intervals can help calibrate instruments.
- Nuclear Physics: Studying decay processes and isotope behavior.

Factors Affecting Radioactive Decay Calculations

Assumptions in Decay Calculations

- The decay follows a perfect exponential decay model.
- The sample is isolated, with no external influences affecting decay.
- The decay constant remains constant over the period.

Real-World Deviations

- External radiation sources can influence decay rates (rare).
- Measurement inaccuracies in initial quantities or decay constants.
- Isotope purity and sample handling.

Conclusion

In summary, after 43.2 seconds, a sample of Arsenic-81 retains approximately 99.91% of its initial amount, demonstrating its relatively long half-life and stability over short timeframes. This understanding is crucial in applications ranging from medical diagnostics to nuclear physics research. Accurate decay calculations enable scientists and medical professionals to optimize procedures, ensure safety, and interpret data correctly. As with all radioactive decay processes, the key lies in understanding the specific properties of each isotope and applying fundamental exponential decay principles to derive meaningful insights.

References:
- Knoll, G. F. (2010). Radiation Detection and Measurement. John Wiley & Sons.
- Sharma, S. K. (2013). Nuclear Medicine Physics. Elsevier.
- National Nuclear Data Center. (2023). Radioactive Decay Data and Half-Lives.

Frequently Asked Questions

What percentage of a sample of As-81 remains undecayed after 43.2 seconds?

Approximately 50% of the As-81 sample remains undecayed after 43.2 seconds.

How is the decay percentage of As-81 calculated after a certain time?

It is calculated using the exponential decay formula: $N(t) = N0\ e^{(-\lambda t)}$, where λ is the decay constant and t is time.

What is the half-life of Arsenic-81 (As-81)?

The half-life of As-81 is approximately 32.2 seconds.

How do you determine the remaining percentage of As-81 after 43.2 seconds?

By calculating the decay using the formula $P = (1/2)^{(t / T_{1/2})}$, where $T_{1/2}$ is the half-life.

Is 43.2 seconds longer or shorter than the half-life of As-81?

It is longer than the half-life of As-81, which is about 32.2 seconds, so more than half of the sample would have decayed.

What approximate percentage of As-81 remains after twice its half-life?

Approximately 25% remains after twice the half-life, which in this case would be around 64.4 seconds.

How accurate is the decay calculation for As-81 over

43.2 seconds?

The calculation is highly accurate assuming exponential decay and no external influences, based on known half-life.

Can the decay of As-81 be considered complete after 43.2 seconds?

No, since about 50% of the sample remains undecayed after one half-life of 32.2 seconds, and less than that after 43.2 seconds.

What is the decay constant (λ) for As-81?

The decay constant λ can be calculated as $\lambda = \ln(2) / T_{1/2}$, which is approximately 0.02155 per second for As-81.

Why is understanding decay percentages important in radioactive sampling?

It helps in determining sample ages, radiation exposure, and safety measures in scientific and medical applications.

Additional Resources

What Percent Of A Sample Of As-81 Remains Un Decayed After 43.2 Seconds is a question that delves into the fascinating world of nuclear physics and radioactive decay. Understanding how much of a radioactive isotope remains after a certain period is fundamental in fields like radiometric dating, nuclear medicine, and nuclear energy. In this article, we will explore the principles governing radioactive decay, how to calculate the remaining percentage of a sample after a given time, and apply these concepts specifically to the isotope arsenic-81 (As-81).

Introduction to Radioactive Decay

Radioactive decay is a spontaneous process in which an unstable atomic nucleus loses energy by emitting radiation. This process transforms the original atom into a different element or isotope. The decay rate is characterized by the isotope's half-life, the time it takes for half of the radioactive sample to decay.

Key Concepts:
- Radioactive isotope (radioisotope): An isotope that undergoes radioactive decay.
- Half-life ($T_{1/2}$): The time required for half of the radioactive atoms in a sample to decay.

- Decay constant (λ): The probability per unit time that a single atom will decay.
- Remaining activity or percentage: The proportion of the original sample that has not decayed after a certain time.

Understanding As-81 and Its Decay Properties

Arsenic-81 (As-81) is a radioactive isotope of arsenic. To perform calculations related to its decay, we need to know its half-life.

As-81 Half-life
- Half-life ($T_{1/2}$): Approximately 33.4 seconds

This relatively short half-life makes As-81 useful in certain analytical techniques, such as short-lived tracer studies.

Calculating the Remaining Percentage After a Given Time

The main tool for estimating the remaining fraction of a radioactive sample after a specific time is the exponential decay law:

$$
N(t) = N_0 \times e^{-\lambda t}
$$

Where:
- $N(t)$ is the quantity remaining at time t,
- N_0 is the initial quantity,
- λ is the decay constant,
- t is the elapsed time.

Step 1: Find the Decay Constant (λ)
The decay constant relates to the half-life as:

$$
\lambda = \frac{\ln 2}{T_{1/2}}
$$

For As-81:

$$
\lambda = \frac{\ln 2}{33.4\, \text{seconds}} \approx \frac{0.6931}{33.4} \approx 0.02075\, \text{s}^{-1}
$$

Step 2: Calculate the Remaining Fraction
The fraction remaining after time t:

$$
\frac{N(t)}{N_0} = e^{-\lambda t}
$$

Plugging in $ t = 43.2\, \text{seconds} $:

$$
\frac{N(43.2)}{N_0} = e^{-0.02075 \times 43.2}
$$

Calculating the exponent:

$$
0.02075 \times 43.2 \approx 0.897
$$

Thus:

$$
\frac{N(43.2)}{N_0} = e^{-0.897} \approx 0.407
$$

Step 3: Convert to Percentage
To find the percentage of the sample remaining:

$$
\text{Remaining \%} = 0.407 \times 100\% \approx 40.7\%
$$

Conclusion: Approximate Remaining Sample After 43.2 Seconds

Approximately 40.7% of a sample of As-81 remains un-decayed after 43.2 seconds. This means that more than half of the original arsenic-81 has decayed within this timeframe, which underscores the importance of understanding decay dynamics in applications involving rapid radioactive processes.

Additional Insights and Applications

Why Is This Calculation Important?
- Radiometric Dating: Short half-life isotopes like As-81 are used in specific dating methods that require precise decay knowledge.
- Medical Imaging and Tracing: Understanding decay allows for appropriate timing in diagnostic procedures.
- Nuclear Safety and Handling: Knowing decay percentages helps in managing radioactive waste and safety protocols.

Limitations and Assumptions
- The calculation assumes a purely exponential decay process with no external influences.
- It presumes the sample is closed and no new atoms are added or removed during the time interval.
- The half-life used is approximate; actual measurements can vary slightly depending on experimental conditions.

Summary and Key Takeaways

- Radioactive decay follows an exponential law, characterized by the decay constant λ.
- The decay constant is derived from the isotope's half-life using $\lambda = \ln 2 / T_{1/2}$.
- After calculating λ, the remaining fraction of a sample after any period t is given by $e^{-\lambda t}$.
- For As-81 with a half-life of 33.4 seconds, roughly 40.7% of the original sample remains after 43.2 seconds.

Understanding these principles provides a solid foundation for analyzing radioactive decay processes in scientific and practical contexts.

Final Thoughts
Radioactive decay calculations are essential tools in nuclear science, enabling professionals to predict the behavior of isotopes over time. Whether in medical applications, environmental science, or fundamental research, mastering the use of exponential decay laws and decay constants empowers scientists and engineers to make accurate predictions and informed decisions.

Remember: Always verify the specific half-life and decay properties of the isotope in question before performing precise calculations, as these values can vary slightly depending on measurement methods and sources.

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