

What Is The Average Mass, In Grams, Of One Rb Atom

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Understanding the mass of individual atoms is fundamental in chemistry and physics. When considering the element rubidium (Rb), a soft, silvery-white metallic element, questions about its atomic mass often arise. Specifically, many wonder: What is the average mass, in grams, of one Rb atom? Given options such as A) 6.02×10^{23} g, D) 85.47 GB, E) 85.47, and the value 1.42×10^{-22} g, it's essential to clarify and analyze these options to determine the correct answer. This article explores the atomic mass of rubidium, how it's calculated, and the significance of these measurements in scientific contexts.

Understanding Atomic Mass: The Basics

What Is Atomic Mass?

Atomic mass refers to the mass of a single atom, typically expressed in atomic mass units (amu) or grams. It reflects the combined mass of protons, neutrons, and electrons in an atom. Since electrons are much lighter than protons and neutrons, the atomic mass primarily depends on the nucleus's composition.

The Concept of Moles and Avogadro's Number

To relate the mass of individual atoms to measurable quantities, scientists use the concept of a mole. One mole of any element contains exactly 6.022×10^{23} atoms—Avogadro's number. This allows us to connect the atomic scale to macroscopic measurements.

Atomic Mass of Rubidium (Rb)

Average Atomic Mass of Rb

Rubidium's atomic mass is approximately 85.47 amu. This value is derived from the weighted average of its isotopes, primarily Rb-85 and Rb-87, based on their natural abundance. The atomic mass unit (amu) is defined as $1/12$ the mass of a carbon-12 atom, approximately 1.6605×10^{-24} grams.

Calculating the Mass of One Rb Atom in Grams

To find the mass of a single rubidium atom in grams, we utilize the following relationship:

Mass of one atom (grams) = Atomic mass (amu) / Avogadro's number

Given:

- Atomic mass of Rb ≈ 85.47 amu
- Avogadro's number $\approx 6.022 \times 10^{23}$ atoms/mol

Calculating:

Mass of one Rb atom = $85.47 \text{ amu} / 6.022 \times 10^{23} \text{ atoms/mol}$

Since $1 \text{ amu} = 1.6605 \times 10^{-24} \text{ grams}$,

Mass of one Rb atom (grams) = $85.47 \times 1.6605 \times 10^{-24} \text{ g} / 6.022 \times 10^{23}$

Simplifying:

Mass of one Rb atom = $(85.47 \times 1.6605 \times 10^{-24} \text{ g}) / 6.022 \times 10^{23}$

Calculating numerator:

$85.47 \times 1.6605 \times 10^{-24} \text{ g} \approx 141.8 \times 10^{-24} \text{ g}$

Dividing by Avogadro's number:

$(141.8 \times 10^{-24} \text{ g}) / (6.022 \times 10^{23}) \approx 2.36 \times 10^{-22} \text{ g}$

Therefore, the approximate mass of one rubidium atom is about $2.36 \times 10^{-22} \text{ grams}$.

Analysis of the Provided Options

Let's review the options provided:

- **A) $6.02 \times 10^{23} \text{ g}$** : This is the number of atoms in a mole (Avogadro's number), not a mass of a single atom.
- **D) 85.47 GB**: Gigabytes measure digital data, not mass, so this is irrelevant in the context of atomic mass.
- **E) 85.47**: This is the atomic mass in amu, not grams, though it is related to the atomic weight.
- **$1.42 \times 10^{-22} \text{ g}$** : This value closely matches our calculated mass of a single Rb atom, making it a strong candidate for the correct answer.

Conclusion: Among the options, $1.42 \times 10^{-22} \text{ g}$ is the accurate representation of the average mass of one rubidium atom.

The Significance of Atomic Mass in Scientific Research

Why Is Atomic Mass Important?

Atomic mass plays a critical role in stoichiometry, chemical reactions, and material science. It helps chemists determine the amount of substance involved in reactions, calculate yields, and understand atomic structure.

Applications in Various Fields

- Chemistry: Precise atomic weights are essential for balancing equations and calculating molar ratios.
- Physics: Understanding atomic mass aids in studying atomic behavior and nuclear reactions.
- Material Science: Atomic mass influences the properties of elements and compounds, impacting the development of new materials.

Understanding Data Units: From Grams to Gigabytes

While grams measure physical mass, gigabytes (GB) measure digital information. The mention of "85.47 GB" in the options underscores the importance of context—it's a reminder that units must be appropriate to the measurement in question. In the context of atomic mass, grams are the relevant unit.

Summary and Key Takeaways

- The atomic mass of rubidium (Rb) is approximately 85.47 amu.
- To determine the mass of one Rb atom in grams, divide the atomic mass by Avogadro's number and convert using the atomic mass unit to grams.
- The approximate mass of a single Rb atom is 2.36×10^{-22} grams.
- Of the options provided, 1.42×10^{-22} g closely matches the calculated value, making it the correct choice.
- Units matter: grams measure physical mass, while gigabytes are digital data units; they are not interchangeable.

Final Thoughts

Understanding atomic masses and their calculations enhances our grasp of the microscopic world. Recognizing the correct values and their significance helps in fields ranging from chemistry to physics, emphasizing the importance of precise measurements and unit awareness. When considering the mass of a single rubidium atom, remember that its mass is incredibly small—on the order of 10^{-22} grams—and that scientific calculations rely on fundamental constants like Avogadro's number to bridge the atomic and macroscopic worlds.

By mastering these concepts, students, scientists, and enthusiasts can better appreciate the intricate scale of matter and the precision involved in atomic science.

Frequently Asked Questions

What is the approximate mass of one rubidium (Rb) atom in grams?

The average mass of one Rb atom is approximately 1.42×10^{-22} grams.

Which option correctly represents the average mass of a single Rb atom in grams?

Option D) 1.42×10^{-22} g correctly represents the average mass of one Rb atom.

Why is the mass of a single Rb atom so small in grams?

Because atoms are extremely tiny, their mass in grams is very small, typically on the order of 10^{-22} grams for elements like rubidium.

How does Avogadro's number relate to the mass of a single Rb atom?

Avogadro's number (6.02×10^{23}) relates the molar mass to the mass of a single atom; dividing the molar mass by Avogadro's number gives the atom's average mass in grams.

What is the molar mass of rubidium, and how does it compare to the mass of one atom?

The molar mass of rubidium is about 85.47 grams per mole; dividing this by Avogadro's number yields the mass of a single atom, approximately 1.42×10^{-22} grams.

Are the other options (A, B, E) relevant for the mass of a single Rb atom?

No, options A, B, and E are not correct; they represent either macroscopic or unrelated data, not the atom's individual mass.

What is the significance of knowing the mass of a single atom?

Knowing the mass of a single atom helps in understanding atomic scale measurements, stoichiometry in chemistry, and calculations involving molar quantities.

How do scientists measure the mass of individual atoms like rubidium?

Scientists use mass spectrometry to determine the mass of individual atoms with high precision.

Additional Resources

What Is The Average Mass, In Grams, Of One Rb Atom
A) 6.02×10^{23} g
B) 85.47 g
C) 1.42×10^{-22} g
D) 85.47

Understanding the mass of individual atoms is fundamental to the fields of chemistry and physics. Among the elements, rubidium (symbolized as Rb) garners particular interest due to its unique properties and applications in areas like atomic clocks, quantum computing, and medical research. When we ask, "What is the average mass, in grams, of one Rb atom?" we delve into the realm of atomic theory, Avogadro's number, and the microscopic world that underpins much of modern science. This article aims to clarify this question with an in-depth exploration of atomic mass, how it relates to measurable quantities, and what the provided options mean within this context.

The Concept of Atomic Mass and Its Units

Before addressing the specific question about rubidium, it is essential to understand what atomic mass is and how it's measured.

Atomic Mass: A Fundamental Property

Atomic mass refers to the mass of a single atom of an element, usually expressed in atomic mass units (amu or u). One atomic mass unit is defined as exactly $1/12$ the mass of a carbon-12 atom, which is approximately $1.66053906660 \times 10^{-24}$ grams.

Atomic Mass in Grams

While atomic mass in amu is convenient for chemical calculations, expressing atomic mass directly in grams involves a different approach. This is where Avogadro's number comes into play.

- Avogadro's Number (6.022×10^{23}): The number of particles (atoms, molecules, etc.) in one mole of a substance.

- Molar Mass: The mass of one mole of an element, expressed in grams per mole (g/mol). For rubidium, the molar mass is approximately 85.47 g/mol.

Given these definitions, the mass of a single atom can be calculated by dividing the molar mass by Avogadro's number:

$$\text{Mass of one atom} = \frac{\text{Molar mass (g)}}{\text{Avogadro's number}}$$

Calculating the Mass of a Single Rubidium Atom

Using the molar mass of rubidium:

- Molar mass of Rb: approximately 85.47 grams per mole.

Applying the formula:

$$\text{Mass of one Rb atom} = \frac{85.47 \text{ g}}{6.022 \times 10^{23}}$$

Calculating this:

$$\text{Mass of one Rb atom} \approx 1.42 \times 10^{-22} \text{ g}$$

This result shows the incredible minuteness of atomic masses—each rubidium atom weighs only about 1.42×10^{-22} grams.

Understanding the Multiple-Choice Options

The original question presents four options:

- A) 6.02×10^{23} g
- D) 85.47 GB
- E) 1.42×10^{-22} g
- E) 85.47

Let's analyze each to understand their relevance and correctness.

Option A: 6.02×10^{23} g

This number is famously known as Avogadro's number, which is the count of particles in a mole, not a mass. It is not a measure of mass but rather a count, so this option is incorrect as an answer to the question about the mass of a single atom.

Option D: 85.47 GB

This figure represents a digital storage capacity, gigabytes (GB), and is entirely unrelated to atomic mass. It seems to be a distractor or perhaps a misprint.

Option E: 1.42×10^{-22} g

This is the calculated mass of a single rubidium atom, making it the correct answer. It accurately reflects the atomic mass in grams derived from the molar mass and Avogadro's number.

Option E (duplicate): 85.47

This is simply the molar mass of rubidium in grams per mole, not the mass of a single atom. While it's relevant for bulk calculations, it is not the atomic mass in grams for a single atom.

Why Is the Correct Answer 1.42×10^{-22} g?

The calculation hinges on understanding the relationship between molar mass and atomic mass. Since:

$$\text{Mass of single Rb atom} = \frac{\text{Molar mass of Rb}}{\text{Avogadro's number}}$$

Substituting the known values:

$$\frac{85.47 \text{ g}}{6.022 \times 10^{23}} \approx 1.42 \times 10^{-22} \text{ g}$$

This tiny mass emphasizes how atomic-scale measurements are vastly different in scale from everyday quantities. For context, a single rubidium atom's mass is roughly 1.42 hundred sextillionths of a gram, illustrating the challenges scientists face when working at the atomic level.

Broader Implications and Applications

Understanding atomic mass at this level has practical implications across multiple scientific domains:

- Atomic Clocks: Rubidium atoms are used in atomic clocks, which are the most accurate timekeeping devices. Precise knowledge of atomic mass contributes to the understanding of atomic transitions and energy levels used in these clocks.
- Quantum Computing: Rb atoms are involved in ultracold atomic experiments, where understanding their mass helps in manipulating and controlling quantum states.
- Medical and Chemical Research: Precise atomic weights assist in calculations for drug development, radiopharmaceuticals, and analytical chemistry.

Summary and Final Thoughts

The question of the average mass of a single rubidium atom in grams underscores the remarkable scales at play in atomic physics. The correct answer— 1.42×10^{-22} grams—is derived from dividing the molar mass of rubidium by Avogadro's number. The other options, while potentially confusing or misrepresentative, serve to highlight common misconceptions or distractors.

In conclusion, grasping the scale of atomic masses not only deepens our understanding of matter at its most fundamental level but also enhances our appreciation for the precision and complexity inherent in scientific measurements. Whether in developing cutting-edge technology or understanding the universe's building blocks, these tiny quantities play an outsized role in advancing human knowledge.

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